Jeroen L.G. Binken & Stefan Stremersch

The Effect of Superstar Software on Hardware Sales in System Markets

Systems are composed of complementary products (e.g., video game systems are composed of the video game console and video games). Prior literature on indirect network effects has argued that in system markets, sales of the primary product (often referred to as "hardware") largely depend on the availability of complementary products (often referred to as "software"). Mathematical and empirical analyses have almost exclusively operationalized software availability as software quantity. However, though not substantiated with empirical evidence, case illustrations show that certain high-quality, "superstar" software titles (e.g., *Super Mario 64*) may have disproportionately large effects on hardware unit sales (e.g., Nintendo N64 console sales). In the context of the U.S. home video game console market, the authors show that the introduction of a superstar increases video game console sales by an average of 14% (167,000 units) over a period of five months. One in every five buyers of a superstar software title also purchases the hardware required to use the software. Software type does not consistently alter this effect. The findings imply that scholars who study the relationship between software availability and hardware sales need to account for superstar returns and their decaying effect over time, beyond a mere software quantity effect. Hardware firms should maintain a steady flow of superstar introductions because the positive effect of a superstar lasts only five months and, if need be, make side payments to software firms because superstars dramatically increase hardware sales. Hardware firms' exclusivity over superstars does not provide an extra boost to their own sales, but it takes away an opportunity for competing systems to increase their sales.

Keywords: system markets, superstars, indirect network effects, new product introductions, software, hardware, video game industry

> You can have the best technology, the most advanced box in the world. But without the applications, that box will only collect dust on the retail shelves. (Kazuo Hirai, president of Sony Computer Entertainment of America; qtd. in Huffstutter 1999, Part A, p. 1)

Systems are composed of complementary and interdependent products, such as hardware and software (Farrell and Saloner 1986; Katz and Shapiro 1986b; Stremersch et al. 2003; Wuyts et al. 2004). For example, video game systems are composed of both the video game console and video games (Chou and Shy 1990; Clements and Ohashi 2005; Gandal, Kende, and Rob 2000). Other examples are plenty. The compact disc system consists of CD players and CDs. Television consists of television sets and programming. Research in economics and marketing has argued that in such system markets, hardware sales depend mainly on the availability of related software (Farrell and Saloner 1986; Gupta, Jain, and Sawhney 1999; Katz and Shapiro 1986b, 1994). To avoid any misunderstanding, we immediately stress that software availability in this theory never refers to software sales (i.e., demand) but rather to the catalog of software titles available for a particular hardware (i.e., supply).

The major importance of software in system markets has become a prime concern for hardware firms (i.e., system owners). For example, in the video game console industry, system owners spend a fortune on software development to guarantee a sufficient supply of software, either through internal development or through subsidizing independent software developers (Coughlan 2004). For example, Microsoft paid $375 million to acquire just one software development studio (Kent 2002). Sony alone has 14 of these software development studios (GamePro 2006). Sony shipped more than 10,000 PlayStation 3 development kits to software developers before selling even one PlayStation 3 (*The Guardian* 2006) to secure the supply of attractive software titles.

The main shortcoming of the academic literature on this phenomenon is that mathematical and empirical analyses have focused almost exclusively on a single dimension of software availability, namely, software quantity (i.e., the number of software titles introduced; see Stremersch et al. 2007).[1] Though not substantiated with empirical evidence, case illustrations raise the notion that certain individual software titles may have had disproportionately large effects on hardware sales (Allen 2003; Dickson 2008; Frels, Shervani, and Srivastava 2003; Gilroy 1994; Rowe 1999; Shapiro and Varian 1998; Williams 2002). We call these individual software titles of exceptional high quality "super-

Jeroen L.G. Binken is a doctoral student of Marketing, School of Economics, Erasmus University Rotterdam, the Netherlands (e-mail: binken@few.eur.nl). Stefan Stremersch is Chaired Professor of Marketing and Desiderius Erasmus Distinguished Chair of Economics, School of Economics, Erasmus University Rotterdam, the Netherlands, and Visiting Professor of Marketing, Fuqua School of Business, Duke University (e-mail: stremersch@few.eur.nl). The authors are thankful to NPD, especially Martin Zagorsek, for help regarding the data. They also owe their gratitude to Barry Bayus, Barak Libai, Harikesh Nair, and Sriram Venkataraman, who provided many excellent comments on a previous draft of this article.

[1]Prior literature has also referred to software quantity as software availability or software variety.

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stars."[2] Prior literature has studied superstars in the music industry (Chung and Cox 1994), major league baseball (MacDonald and Reynolds 1994), and the movie industry (Collins, Hand, and Snell 2002). However, the possible returns of software superstars on hardware sales in system markets remain unexamined. This lack of academic inquiry does not match the importance of the role of such software titles in system markets. The current study aims to fill that void.

We examine the extent to which superstars may increase hardware unit sales in the context of the U.S. home video game console industry. We find that the introduction of a superstar software title significantly increases hardware unit sales by an average of 14% (167,000 units) beyond the effects of other hardware and software attributes. This positive effect persists only for the first five months after the superstar's introduction. Software type does not substantially alter this effect. Therefore, the traditional operationalization of software quantity (i.e., the number of software titles introduced) may be limited because it overlooks both superstar power and potential time decays. We also find that superstars display increasing returns (i.e., hardware unit sales) to software quality.

We gather data on 11 home video game consoles in the United States between January 1993 and December 2004. The video game console industry is an appropriate context because it is a system market in which software (i.e., video games) is believed to be crucial to promote hardware (i.e., video game console) sales (Clements and Ohashi 2005; Williams 2002).

We organize the remainder of this article as follows: In the next section, we develop the theory on superstar introductions and other determinants of hardware sales. Then, we discuss the video game console industry and present the sample, data collection, and measurement of the variables. In the following section, we present the model. Then, we present the results, along with further analyses. In the final section, we discuss the results and their implications and note the limitations of this research.

Superstar Introductions and Other Determinants of Hardware Sales

First, we explain the concept of software superstars and discuss how their introduction may affect hardware unit sales. Second, we argue how this relationship may be dependent on software type. Third, we add variables that may also affect hardware unit sales, for which we need to control in our empirical testing. We tailor the theory development to our empirical context—the U.S. home video game console market. However, the theory we develop is also applicable in many other system markets, such as the DVD market (e.g., the effect of superstar introductions, such as *The Matrix*, on DVD player sales) or the satellite radio market (e.g., the effect of radio superstars joining a satellite radio network, such as Howard Stern, on satellite radio sales).

Superstars

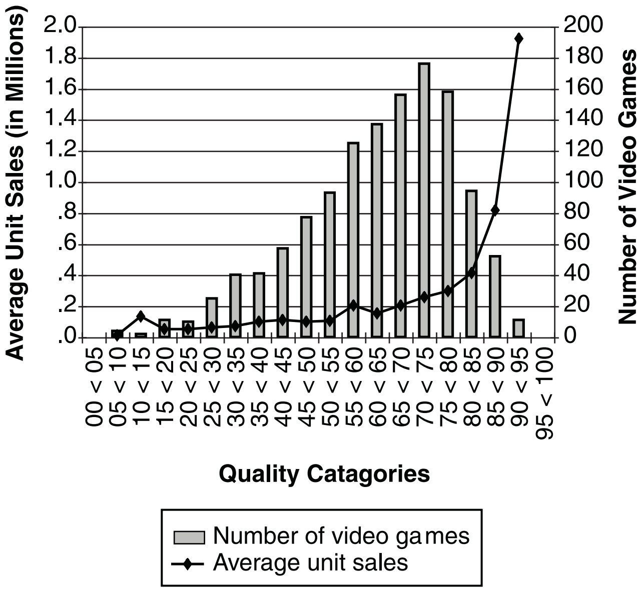
Superstars possess unique and superior attributes or skills that command a disproportionately large payoff (Rosen 1981). In a superstar industry, a small number of high-quality superstars demand disproportionately large compensation packages and dominate their respective industry (Rosen 1981). A superstar industry displays increasing returns to quality because of the scarcity of high quality (Mayer 1960; Rosen 1981). There is a monotonic increasing returns relationship between quality and the payoff. As Cox and Kleiman (2000) note, "If a golfer is, on average, but one stroke better than other competitors then a disproportionate number of tournament championships would be won by said athlete." It is difficult for competing golfers to copy Tiger Woods's skills. Similarly, competitors find it difficult to copy the quality characteristics of other superstars, such as The Beatles, *Star Wars*, or *Super Mario Brothers*, especially after they have introduced their products on the market, because the quality is often unknown until the product is in the hands of the consumer.

Examples of superstar industries are plenty. Chung and Cox (1994) find a high concentration of output among top music performers; the top 10.8% of artists with gold records collected 43.1% of all gold records from 1958 to 1989. De Vany and Walls (1996) report that just 20% of films earned 80% of box office revenues. Exploratory research by Liebowitz and Margolis (1999) suggests that the highest-quality software titles conquer a disproportionately large part of the total software market.

The video game industry is also a superstar industry. Figure 1 categorizes video game quality for the Sony PlayStation into 20 quality categories, from 0–5 to 95–100 (we discuss the operationalization of video game quality in the "Data" section). The first conclusion we can draw from this figure is that this market shows a disproportionate response of software sales to software quality and that there is a monotonic increasing returns relationship between software quality and software unit sales. The second conclusion is that the frequency distribution of quality follows a bell-shaped curve, with a negative skewness, indicating scarcity of high-quality products, which results in the increasing returns to quality (e.g., Mayer 1960; Rosen 1981). Both conclusions imply that the video game industry is indeed a superstar industry, showing disproportionate returns to quality, with a small number of high-quality games that are very popular. Other video game systems depict similar patterns. Using software dollar sales instead of software unit sales does not alter this picture. Recent examples of superstar video games are *Grand Theft Auto: Vice City* and *Halo 2*, both of which sold more than 4 million copies in the United States alone within the first three months after introduction.

[2]There is considerable confusion between terms such as "superstars" and terms such as "blockbusters," "hits," "killer applications," or, more specifically in the case of the video game industry, "killer games" or "triple A games." Our focus is on software titles of exceptional quality, which yields a disproportionate payoff, a concept most akin to the superstar concept as originally introduced by Rosen (1981). Therefore, we consistently use the term "superstars" throughout this article. Concepts such as "hits" or "blockbusters" often refer to software titles with a high sales volume rather than high quality. The term "killer applications" refers to specific games that allowed a system to "kill" or dominate another.

FIGURE 1
The Video Game Industry Is a Superstar Industry



In system markets, high-quality software titles are likely to have a positive effect on hardware unit sales (Frels, Shervani, and Srivastava 2003). Superstar software titles are so desirable that they can easily trigger the adoption of the system by consumers. Williams (2002) argues that superstar video games entice consumers to spend several hundred dollars to buy the video game console and accessories required to play the games. Shapiro and Varian (1998) believe that *Walt Disney's Wonderful World of Color* was the prime reason consumers invested in color television sets. The spreadsheet (e.g., VisiCalc, Lotus 1-2-3, Excel) and the word processor (e.g., WordStar, WordPerfect, Word) are credited for selling millions of personal computers (PCs) (Frels, Shervani, and Srivastava 2003; Gilroy 1994). The business press has claimed that the video game *Tetris* has been a major driving force behind the success of the original Nintendo Game Boy (Allen 2003; Rowe 1999). Therefore, we expect the introduction of a superstar software title to increase hardware unit sales in system markets. Moreover, if superstars display increasing returns from software quality to software unit sales, we may expect superstars in system markets to display increasing returns from software quality to hardware unit sales (e.g., Liebowitz and Margolis 1999; Mayer 1960; Rosen 1981).

Software Life Cycle

In many system markets, software titles have a limited life expectancy because of continuous innovation and changing consumer tastes, thus limiting the sales potential of software titles to a short period after their introduction. Sales of a software title peak during or soon after introduction and then decline. This sales pattern is observed across many similar markets: CDs, DVDs, LPs, PC software applications, television and radio broadcasts, and videocassettes (e.g., Ainslie, Drèze, and Zufryden 2005; Krider and Weinberg 1998; Luan and Sudhir 2007).

Video games also have a short life expectancy—approximately 3 months—but this life cycle can stretch to 12 months for very successful video games (Gaume 2006). Figure 2 depicts the evolution of software unit sales of superstar and nonsuperstar software titles from the month of introduction at t and later. The software unit sales of superstars also peak during introduction (291,000 units) and then decline. Superstars achieve average software unit sales of approximately 1.3 million units, while nonsuperstar software titles achieve unit average sales of 187,000 units. Software unit sales of superstars become flat after 6 months, and the sales evolution of superstars and nonsuperstars depicts a similar pattern of slowly declining sales over time.

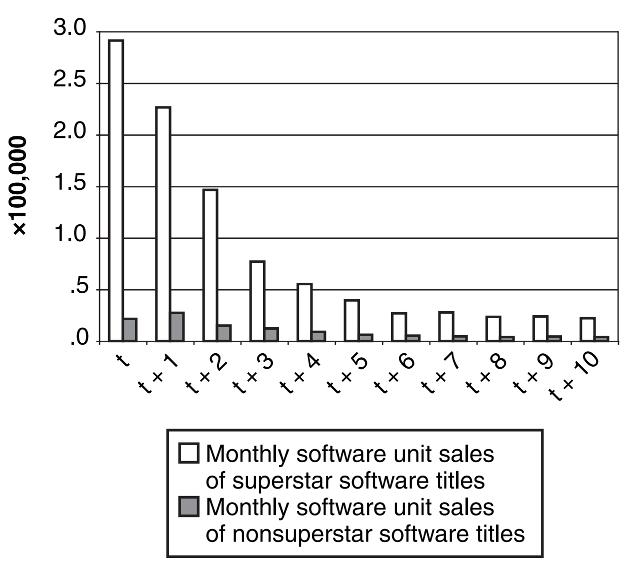
Because of the limited life expectancy of software, we expect the introduction of a superstar software title to affect hardware unit sales positively during the month of introduction and for a limited number of months after introduction. In addition, we expect this effect to peak during the month of introduction and then decline.

Software Type

Software type may influence our posited effects. Although video games can be typified along multiple dimensions, three are particularly salient and relevant because they are often used in the video game industry to describe the differences between individual video games (Clements and Ohashi 2005; Venkatraman and Lee 2004; Williams 2002). Other software markets, such as movies and music, use similar software types.

The first dimension is whether a superstar software title is exclusively available for only one system or for multiple

FIGURE 2
Software Unit Sales of Superstar and Nonsuperstar Software Titles



Source: NPD.

systems. Prior literature has suggested that exclusivity of software (i.e., content) is a valuable commodity in system markets because it creates a competitive advantage (Shapiro 1999). System owners often pay software publishers top dollar for the exclusive availability of their attractive software. For example, Sony paid a sum in the tens of millions of dollars to software publisher Take-Two to make the superstar franchise *Grand Theft Auto* exclusive to the PlayStation 2 (IGN 2002). Toshiba (the system owner of the high-definition DVD [HD-DVD] standard) paid Paramount and DreamWorks Animation $150 million in incentives for their exclusive commitment to HD-DVD and for dropping their support for Sony's competing Blu-ray standard (Barnes 2007). Sony allegedly paid Warner Brothers $400 in incentives to drop Toshiba's standards (Edwards and Grover 2008). System owners (e.g., Microsoft) want exclusive content (e.g., *Halo 3*) because it (supposedly) increases hardware sales (e.g., video game console sales) (Gibson 2007). If a superstar software title is introduced on multiple systems, the new hardware adopters will be dispersed across multiple systems. If the introduction of a superstar title is exclusive to just one system, the new hardware adopters will all adopt the same system. In line with this, exclusive superstar software titles could prove to be a crucial factor in positive feedback markets because of their ability to tip the market outcome toward one specific system during a systems war (i.e., standards war) (e.g., Arthur 1989, 1996; Shapiro and Varian 1998). Therefore, we expect exclusive superstar software titles to have a larger effect on hardware unit sales of the system in question than nonexclusive superstar software titles.

The second dimension is whether the software title is a sequel to a prequel for the same system. Research on movies has shown that sequels have an already established brand name and a higher awareness among consumers, and therefore they tend to have higher sales than the prequel (Ainslie, Drèze, and Zufryden 2005; Basuroy, Desai, and Talukdar 2006; Sawhney and Eliashberg 1996). Because consumers are more aware of superstar sequels than original superstars (i.e., nonsequel superstars) and because sequels have a proven record, it may be expected that the introduction of superstar sequels will have a larger effect on hardware unit sales than the introduction of original superstars. Conversely, consumers who buy the superstar sequel are likely to have already bought the prequel, which means that they already own the hardware. In addition, original superstars are introduced earlier in the life cycle of the system, meaning that the hardware installed base is smaller, leaving more potential hardware adopters available. However, Luan and Sudhir (2007) recently found that sequels in the DVD market perform worse than nonsequels. According to this reasoning, superstar sequels may have a smaller impact on hardware unit sales than original superstars. Because of these contradictory arguments, the direction of the effect is a worthwhile empirical issue to explore.

The third dimension is the genre to which the superstar software title belongs. The video game market consists of six different genres. Two are large genres (i.e., action and platformer), and four are small, niche genres (i.e., first-person shooter [FPS], racing, role playing [RPG], and sports). Software titles from the large genres appeal to a broad range of gamers, from hardcore gamers to casual gamers. The small genres serve a smaller, more specialized niche market. The introduction of software in popular genres helps hardware sales grow more rapidly (Basu, Mazumdar, and Raj 2003). Therefore, we expect the introduction of superstars from the large genres to have a larger impact on hardware unit sales than the introduction of superstars from the small genres.

Other Variables

Next, we discuss other variables that may also affect hardware unit sales. We carefully identified which variables are key in determining the attractiveness of the hardware and software of a system by examining the prior literature (e.g., Basu, Mazumdar, and Raj 2003; Brynjolfsson and Kemerer 1996; Clements and Ohashi 2005; Gandal 1994; Gandal, Kende, and Rob 2000; Nair, Chintagunta, and Dubé 2004; Shankar and Bayus 2003; Shy 2001; Stremersch et al. 2007). We control for these variables in our empirical testing.

Variables we include that are related to the attractiveness of the software side of the system are software catalog (i.e., all software introduced up to and including $t - 1$) and software introductions (in t); we expect both to affect hardware unit sales positively (e.g., Basu, Mazumdar, and Raj 2003; Clements and Ohashi 2005; Gandal, Kende, and Rob 2000; Nair, Chintagunta, and Dubé 2004). An increase in the catalog of past software introductions increases the utility a consumer may derive from the system. In addition, a larger number of software introductions may also increase the utility a consumer derives. The latter effect may be greater than the former because entertainment products typically have short life cycles (Luan and Sudhir 2007; Williams 2002); in addition, video games typically have short life cycles. We expect software quality (the average quality of all video games available to consumers) to affect hardware unit sales positively. Although prior literature has not examined the effect of the overall quality of the software available on hardware unit sales, there are several reasons to expect higher catalog quality to translate into higher hardware unit sales. One reason is that higher average quality of the software catalog reflects positively on the perceived quality of the system. Another reason may be that a high-quality catalog increases the probability that consumers have positive experiences with the console before buying it (e.g., when playing at a friend's house, when trying it out in the store). We expect software price to influence hardware unit sales negatively, but we expect this effect size to be small (prices show relatively little variance in this industry). The reason is that as the price of software decreases, the attractiveness of the hardware increases.

We also include a variable related to the attractiveness of the hardware side of the system—hardware price, which we expect to affect hardware unit sales negatively, though we expect the effect size to be small (prices show relatively little variance in this industry). As the price of hardware decreases, consumers become more inclined to adopt the system (e.g., Clements and Ohashi 2005; Shankar and Bayus 2003). We also include hardware age, which we expect to affect hardware unit sales negatively. The hardware becomes less attractive as it ages because it becomes less "cutting edge." Hardware age can also be interpreted as the time trend in the hardware unit sales series, which is common in this area (e.g., Basu, Mazumdar, and Raj 2003; Brynjolfsson and Kemerer 1996; Gandal 1994; Shy 2001; Stremersch et al. 2007).

Finally, we include a December dummy variable, which controls for the December holiday effect—that is, the holiday buying spree that typically drives consumer electronic markets (i.e., the video game market). We expect the sign of the December dummy parameter to be positive (Christmas and New Year's shopping).

Data

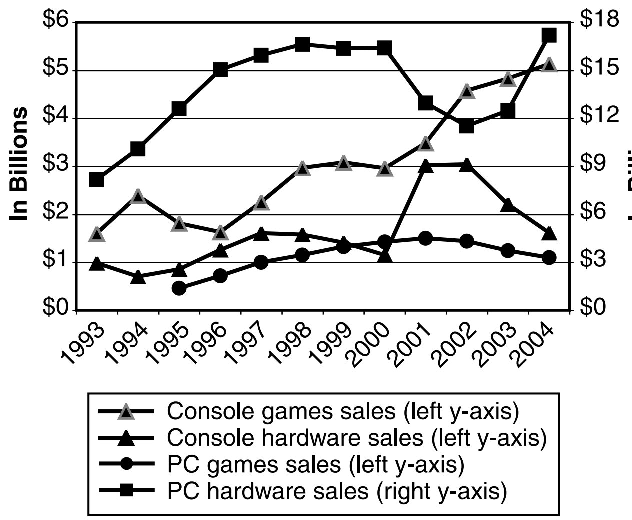
Video Game Industry

Playing video games is not child's play anymore. Households in the United States rate playing video games as the most fun entertainment activity, over watching television, surfing the Internet, reading books, and going to or renting movies (Interactive Digital Software Association 2001). Many young gamers spend more time playing games than watching television (Bloom 1982; Funk and Buchman 1996). The average game player is 33 years old, has been playing games for 12 years, and plays games for more than seven hours per week (Entertainment Software Association 2007). The video game industry has become a mature industry, dominated by mainstream content (Williams 2002). The business of publishing video games is highly similar to that of other software markets, such as CDs, (e)books, DVDs, radio shows, videocassettes, and television shows (e.g., Greco 2000; Komiya and Litman 1990; Williams 2002).

In 2007, sales of PC and video games, video game consoles, and video game accessories exceeded $18.8 billion in the United States alone (NPD 2008). During our sample period, video game software sales increased from $1.8 billion in 1993 to $5.4 billion in 2004 (a 200% increase), while video game hardware sales increased from $1.0 billion in 1993 to $1.6 billion in 2004 (a 65% increase). Game sales in the PC market also show an increase, from $.5 billion in 1995 to $1.1 billion in 2004 (a 137% increase), while PC hardware sales increased from $8.2 in 1993 to $17.2 billion in 2004 (a 110% increase). Figure 3 depicts the evolution of video game and PC sales over time, and Figure 4 decomposes video game sales and PC game sales according to the six game genres.

During our sample period, consumers bought more than 127 million video game consoles and more than 1 billion software titles. Thus, on average, a hardware adopter buys more than 8 software titles. For every hardware unit sold, for which consumers pay approximately $152, consumers spend approximately $287 on software, spread out over the entire life cycle of the hardware. Thus, consumers spend 65% of their allocation on software and only 35% on hardware. This reinforces the importance of software in this system market. This is similar to other system markets, such as

FIGURE 3
Hardware and Software Sales of Consoles and PCs



Source: Consumer Electronic Association, NPD.

CD players and CDs or DVD players and DVDs, in which buyers also spend most of their money on software (e.g., Bayus 1987).

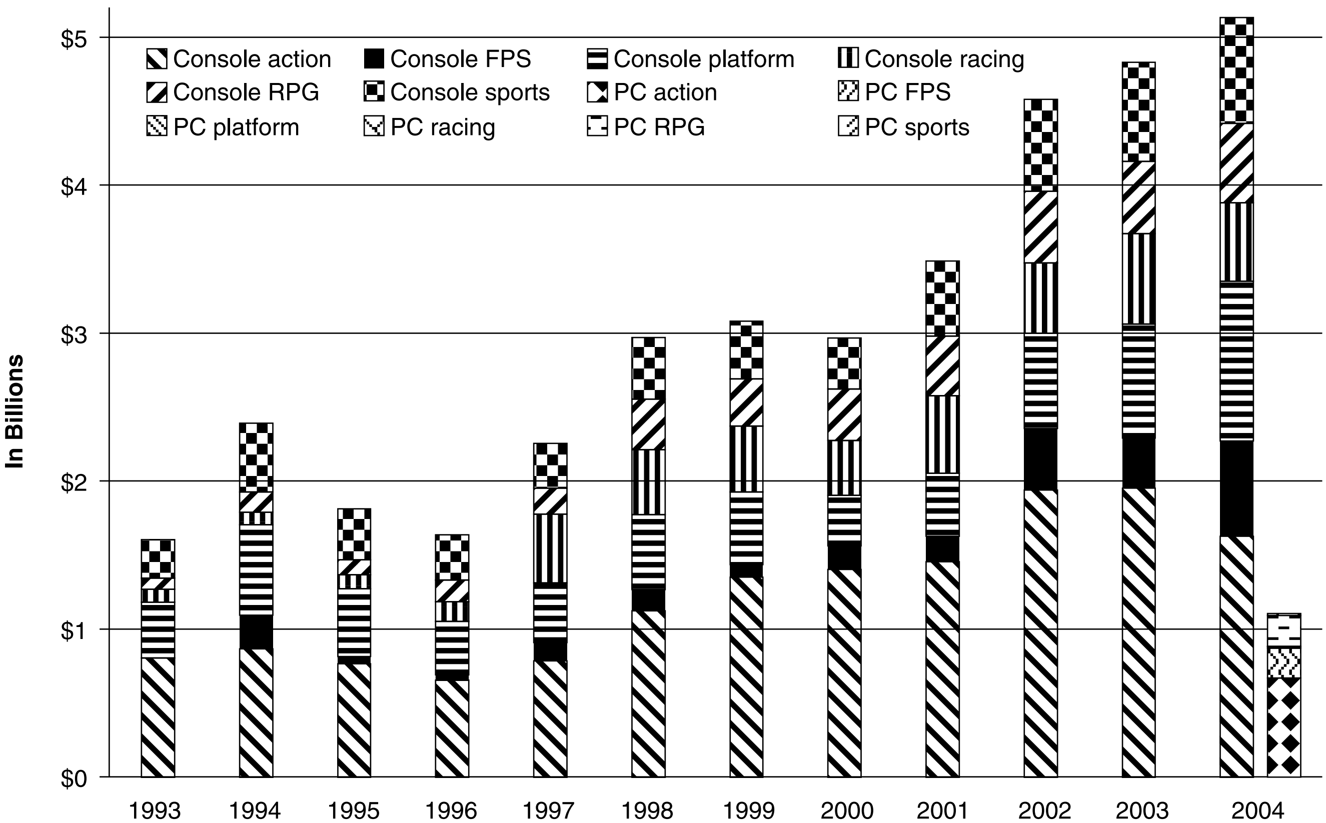
Sample

The data cover 11 home video game consoles (i.e., 3DO Multiplayer, Atari Jaguar, Microsoft Xbox, Nintendo 64, Nintendo GameCube, Nintendo Super NES, Sega Dreamcast, Sega Genesis, Sega Saturn, Sony PlayStation, and Sony PlayStation 2) in the U.S. home video game industry during the January 1993–December 2004 period (144 consecutive months). The data cover the entire population of home video game consoles available to U.S. consumers during this period. The data also cover all information we require on the software for these 11 systems, which comprises approximately 5800 software titles.

The monthly hardware unit sales range between 3 units and approximately 2.7 million units. However, about one-third of these monthly observations contain few hardware unit sales. A total of 195 observations contain hardware unit sales of less than 5000 units because hardware unit sales slowly dry up after consumers and software publishers have abandoned the system. Nintendo sold more than 16 million units of its Super NES console in the United States, but during the last 36 months the console was on the market, fewer than 2500 units were sold, and no new software was introduced. Thus, there are two regimes, the "life" regime (i.e., when substantial sales occur) and the "death" regime (i.e., when few sales occur). Because we are interested only in the life regime, we eliminate the death-regime data from our observations because using one model across these two regimes is likely to create biases.

Therefore, we remove all monthly observations at the end of a system's life, after which either consumers or software publishers have abandoned the system. We assume

FIGURE 4
Video Game and PC Game Sales According to Game Genre



Notes: Information on PC genres is available only from 2004.

that the system has been abandoned if software providers do not introduce any software titles for the next three months or if hardware unit sales drop below 5000 units. Using these two cutoffs, we are left with 513 observations (see Table 1).[3] The number of observations is reduced by 32%, but the total amount of hardware units sold decreases by less than 4%, to 120 million units.

[3]Tests indicate that at our cutoff point (i.e., breakpoint) of the dependent variable, a large negative structural change (i.e., regime switch) is present (–.797, $p < .01$). Our findings are robust to selecting somewhat stricter, or more lenient, cutoffs.

Data Collection

The data originated from two databases, which we subsequently integrated. The market research firm NPD provided data on retail hardware unit sales, hardware price, software unit sales, software price, and software introductions. NPD covers the video game industry, and other researchers have previously used NPD data (e.g., Clements and Ohashi 2005; Shankar and Bayus 2003; Stremersch et al. 2007; Venkatraman and Lee 2004).

We collected information on video game quality ratings and software type for all 5800 video games in our data set

TABLE 1
The Video Game Consoles Studied

System	Start to End	Number of Months
3DO Multiplayer	September 1993 to September 1996	37
Atari Jaguar	November 1993 to December 1995	26
Microsoft Xbox	November 2001 to December 2004	38
Nintendo 64	September 1996 to November 2001	63
Nintendo GameCube	November 2001 to December 2004	38
Nintendo Super NES	January 1993 to January 1996	37
Sega Dreamcast	September 1999 to December 2001	28
Sega Genesis	January 1993 to December 1996	48
Sega Saturn	May 1995 to March 1998	35
Sony PlayStation	September 1995 to December 2004	112
Sony PlayStation 2	October 2000 to December 2004	51

by hand. We used leading U.S. video game magazines and Web sites, such as *Electronic Gaming Monthly*, GameSpot, and IGN, to obtain expert quality ratings of video games. Prior research has also used magazine expert ratings as an indicator for product quality (e.g., Archibald, Haulman, and Moody 1983; Conlon, Devaraj, and Matta 2001; Liebowitz and Margolis 1999).

In addition to collecting expert ratings, we collected consumer quality ratings of video games through these publications. In total, we collected more than 132,000 expert ratings and more than 3.8 million user ratings. To obtain the quality of an individual video game, we averaged these ratings, giving the same weight to the overall expert rating as to the overall user rating.[4]

Measures

We now briefly discuss our measures, all of which are at a monthly periodicity for the system of interest. We begin with the variables on the hardware side. Hardware unit sales are the monthly number of video game consoles sold for the system of interest. Hardware price for a video game console is the price of the bare-bones version of the video game console in that month. Hardware age (i.e., the time trend) of a video game console is equal to the number of months the hardware has been on the market.

On the software side, the operationalization of our focal construct is the introduction of superstars.[5] As we stated previously, superstars are characterized by their high quality (Frels, Shervani, and Srivastava 2003; Rosen 1981). Therefore, we developed a heuristic: To be considered a superstar, a software title must have a quality rating of 90 or above. A quality threshold of 90 identifies only the very best software titles as superstars. This threshold identifies 89 games of approximately 5800 software titles as superstars. Typically, these software titles sell more than 1 million copies. Software unit sales of 1 million are considered an important threshold in the video game industry (Cadin and Guerin 2006; Pereira 2002). This threshold is also the point at which there are increasing returns to quality. We list all 89 superstars, per system, in Table 2. Representatives of the NPD video game division viewed our heuristic and list of superstars as valid. The findings we report are robust across a wide range of thresholds (see the “Results” section).

We operationalize the other software variables as follows: Software catalog is the size of the available software catalog, which is equal to the number of video games available to consumers and sold at least once before the month of interest for the system of interest. Software introductions refer to the number of video games introduced in the month of interest for the system of interest (e.g., Basu, Mazumdar, and Raj 2003; Clements and Ohashi 2005; Gandal, Kende, and Rob 2000; Nair, Chintagunta, and Dubé 2004). Software price is the average price of all the software titles available in the software catalog for the system in the month of interest. Software quality is the average quality of all software titles available in the software catalog for the system in the relevant month. Table 3 shows the descriptive statistics of the variables of interest.

Model

To capture the influence of our explanatory variables on hardware unit sales, we specify a dynamic panel data model, taking the log-transform of specific effects when appropriate (e.g., Basu, Mazumdar, and Raj 2003; Cottrell and Koput 1998; Dranove and Gandal 2003; Gandal 1995; Gandal, Kende, and Rob 2000; Stremersch et al. 2007). The log-transform functional form of the model is appropriate given the need to pool data across video game consoles that represent different sales volumes. The dependent variable is the log-transform of hardware unit sales of console i in month t, denoted as H^S_{it}:

$$\text{(1)}\quad \log H^S_{it} = \mu_i + \alpha_1(\log H^P_{it}) + \alpha_2(H^A_{it}) + \beta_1(\log S^P_{it}) + \beta_2(\log S^{CAT}_{it-1}) + \beta_3(\log S^{INT}_{it}) + \beta_4(S^{QL}_{it}) + \sum_{p=0}^{N} \beta_{5p}(S^{SS}_{it-p}) + \gamma_1(C^{DEC}_t) + u_{it},$$

$$u_{it} = \delta(u_{it-1}) + \varepsilon_{it} \quad -1 < \delta < 1,$$

where μ_i is a fixed effect that captures heterogeneity across the different consoles i and controls for time-invariant, unobserved, console-specific variables. The Breusch and Pagan Lagrange-multiplier test for random effects rejects a random-effects model in favor of a fixed-effects model. In addition, a fixed-effects model is conceptually more appropriate than a random-effects model because the selection of

[4]We followed this procedure because it enhances the quality of the data by increasing the accuracy through averaging random individual-level errors and biases (Rousseau 1985). It also fits the behavior of consumers because they often combine multiple separate pieces of information into an overall evaluation by averaging them (Anderson 1996; Kahn and Ross 1993). From our data, we also learn that experts have tastes similar to users (interrater reliability = .652; n = 5650). This correlation is somewhat depressed because a large number of software titles are of low quality and achieve very low sales, for which there are only a few expert and user ratings available. Eliminating these video games and their ratings greatly increases the interrater reliability between expert and user ratings. The interrater agreement for video games for which there are at least five expert and at least five user ratings available is .828 (n = 3748). The conclusion is that experts do not seem to systematically rate video games differently from users. This is because experts have been and are active gamers themselves. In addition, by publishing the quality rating of video games, experts and users are open to public scrutiny by other experts and users, and this helps minimize biases (Kane 1981).

[5]We use superstar introduction, not superstar software sales, to model the effect of superstars on hardware unit sales for several reasons. First, in the analytical literature, the introduction of a single software title by a software firm has a positive effect on the utility of the hardware, thus increasing hardware sales (Church and Gandal 1992; Katz and Shapiro 1986a). Given this literature, there is no reason to assume that superstar software sales should affect the hardware utility. Second, the introduction of software titles, especially superstar titles, is a clear signal of software developer support, whereas superstar sales are not. Third, the strong presence of seasonality in the video game industry, as in many other software markets, makes the use of sales less desirable. Fourth, using superstar software sales instead of superstar introductions would make this variable highly endogenous because of its dependence on hardware unit sales.

TABLE 2
The Superstars Identified in the Video Game Industry

Sega Genesis
Earthworm Jim
Lunar: Eternal Blue
Snatcher

Nintendo Super NES
Xenogears
Chrono Trigger
Donkey Kong Country
Donkey Kong Country 2: Diddy's Quest
Final Fantasy III
Secret of Mana
Super Mario All Stars
Super Mario RPG: Legend of the Seven Stars
Super Mario World 2: Yoshi's Island
Super Metroid

Atari Jaguar
Tempest 2000

Sony PlayStation
Castlevania: Symphony of the Night
Chrono Cross
Final Fantasy VII
Final Fantasy IX
Gran Turismo
Metal Gear Solid
Resident Evil 2
Tekken 3
Tony Hawk's Pro Skater
Tony Hawk's Pro Skater 2

Nintendo 64
Conker's Bad Fur Day
James Bond 007: GoldenEye 007
Legend of Zelda: Majora's Mask
Legend of Zelda: Ocarina of Time
Perfect Dark
Super Mario 64

Sega Dreamcast
NBA 2K1
NFL 2K
NFL 2K1
Resident Evil Code: Veronica X
Skies of Arcadia
Soul Calibur
Tony Hawk's Pro Skater
Tony Hawk's Pro Skater 2
Virtua Tennis

Sony PlayStation 2
Burnout 3: Takedown
Devil May Cry
Final Fantasy X
Gran Turismo 3: A-Spec
Grand Theft Auto 3
Grand Theft Auto: Andreas
Grand Theft Auto: Vice City
Madden NFL 2004
Metal Gear Solid 2: Sons of Liberty
Metal Gear Solid 3: Snake Eater
NBA Street Vol. 2
NCAA Football 2003
NCAA Football 2004
Prince of Persia: The Sands of Time
Ratchet & Clank: Going Commando
Ratchet & Clank: Up Your Arsenal
Soul Calibur 2
SSX 2 Tricky
SSX 3
Tiger Woods PGA Tour 2004
TimeSplitters 2
Tony Hawk's Pro Skater 3
Tony Hawk's Pro Skater 4
Tony Hawk's Underground
Virtua Fighter 4: Evolution
Winning Eleven 6 World Soccer
Winning Eleven 7 International

Nintendo GameCube
Eternal Darkness: Sanity's Requiem
Legend of Zelda: The Wind Waker
Madden NFL 2004
Metroid Prime
Metroid Prime 2: Echoes
Paper Mario: The Thousand-Year Door
Pikmin 2
Prince of Persia: The Sands of Time
Soul Calibur 2
SSX 3
Super Smash Brothers 2 Melee
Viewtiful Joe

Microsoft Xbox
Burnout 3: Takedown
Grand Theft Auto (3 and Vice City)
Halo 1: Combat Evolved
Halo 2
NCAA Football 2004
Ninja Gaiden
Prince of Persia: The Sands of Time
Project Gotham 2
Star Wars: Knights Republic
Tom Clancy's Splinter Cell
Tom Clancy's Splinter Cell: Pandora Tomorrow

systems from the population is not random. Next, we include the price of video game console i in month t (denoted as H^P_{it}) and the age of video game console i in month t (denoted as H^A_{it}). These independent variables model the hardware attractiveness of the system.

On the software side, we include software price of video game console i in month t (denoted as S^P_{it}), software catalog of past software introductions of video game console i in month t – 1 (S^{CAT}_{it-1}), present software introductions of video game console i in month t (S^{INT}_{it}), and software quality of video game console i in month t (S^{QL}_{it}). We do not take the log of software quality, because we model software quality as increasing returns to quality, as suggested by superstar theory and as modeled by prior empirical superstar litera-

TABLE 3
The Descriptive Statistics of the Relevant Variables

	Correlation								
	1	2	3	4	5	6	7	8	9
1. Hardware unit sales									
2. Hardware price	–.09								
3. Hardware age	–.02	–.63							
4. Software catalog	.17	–.55	.80						
5. Software quality	.17	–.25	–.14	–.05					
6. Software price	–.06	.52	–.68	–.76	–.05				
7. Software introductions	.40	–.06	–.03	.23	.09	–.11			
8. December holidays effect	.58	.02	–.00	.03	.00	.01	.04		
9. Introduction superstar	.17	–.01	–.07	.08	.20	–.09	.39	–.04	
M	223,121	164.89	35.12	308.86	67.07	34.37	9.93	.09	.13
SD	328,757	102.00	26.82	255.70	4.26	13.23	9.71	.29	.34

ture (e.g., Jones and Walsh 1988). Next, S_{it}^{SS} denotes the number of superstar software titles introduced in month t for console i (0 if no superstar was introduced, 1 if a superstar was introduced, 2 if two superstars were introduced, and so forth). To examine the persistence of the effect of superstars on hardware unit sales over time, we also add N lagged terms of this variable. We do not impose a structure on this effect, because we do not know whether there is an effect, how long this effect lasts, or the shape of this effect over time (e.g., decaying, linear, inverted U shape). This method is widely used in marketing (see, e.g., Mitra and Golder 2006). These independent variables model the software attractiveness of the system. Finally, the model also includes a dummy variable for the December holiday effect (C_t^{DEC}).

Estimating this model with ordinary least squares is not appropriate, because there is evidence of serial correlation (both from Wooldridge's [2002] test [$F(1, 10) = 35.64$, $p > .00$)] and from Arellano and Bond's [1991] test [$z = 8.03$, $p > .00$] for autocorrelation), most likely due to the presence of social contagion and heteroskedasticity (using a modified Wald statistic for groupwise heteroskedasticity, in line with Greene [2003]—$\chi^2[11] = 846.09$, $p > .00$) in the error term. Therefore, we use a Prais–Winsten model with panel-corrected standard errors to estimate Equation 1 for all video game consoles jointly (Baltagi and Li 1991). We assume panel-level heteroskedastic errors and a panel-specific first-order autocorrelation, thus capturing the social network exposure (i.e., social contagion) (e.g., Hedström 1994; Strang 1991; Van den Bulte and Lilien 2001; Van den Bulte and Stremersch 2004). This procedure is also appropriate with unbalanced panel data sets such as ours. The required diagnostic tests for descriptive models (Franses 2005) did not reveal any need to revise the model.

Results

The Effect of Superstars

We present the results of estimating Equation 1 in Table 4, Model 1. The adjusted R-square shows that the model fits the data well, which is not surprising, given that it also includes software introductions, the December holiday effect, and a time trend (through hardware age). Next, we discuss the model's parameter estimates.

All parameters have the expected sign and are highly significant, except for software price and software catalog, which are not significant. The introduction of a superstar has a significant, positive effect for the first five months; in the month of introduction ($\beta_{50} = .058$, $p < .01$); and one ($\beta_{51} = .081$, $p < .01$), two ($\beta_{52} = .077$, $p < .01$), three ($\beta_{53} = .064$, $p < .01$), and four months after introduction ($\beta_{54} = .040$, $p < .05$). The fifth lag (e.g., t + 5) and all later lags are not significant.[6] We can also reject that the cumulative superstar effect at t + 5 is equal to zero ($\beta_{50} + \beta_{51} + \beta_{52} + \beta_{53} + \beta_{54} + \beta_{55} = 0$) at the $p < .01$ level.

Using these parameters, we estimate both the monthly effects and the cumulative effect of superstar introductions on hardware unit sales, from their introduction at t until five months after their introduction (t + 5). Figure 5 depicts this graphically. The monthly effect peaks during one to two months after introduction and then decays. Remember that software unit sales flatten around the same time. A superstar software title increases hardware unit sales by 14% (167,000 units) on average during these first six months (29,000 units during the month of introduction t, 39,000 during t + 1, 38,000 during t + 2, 32,000 during t + 3, 21,000 during t + 4, and 8000 during t + 5).[7] We report both the percentage increase in hardware unit sales and the size of this effect in hardware unit sales of a superstar software introduction. This enables us to compare the hardware effect with the software effect of superstars. However, we advise caution when interpreting these hardware unit effects because of the large variance between and within systems.

[6]We begin with a large number of superstar lags (e.g., a large N), as Greene (2003) suggests, and reduce the number of lags until only the last lag (e.g., t + 5) is not significant. By including the last nonsignificant lag, we ensure that the coefficients are not biased or inconsistent (Greene 2003; Judge et al. 1985).

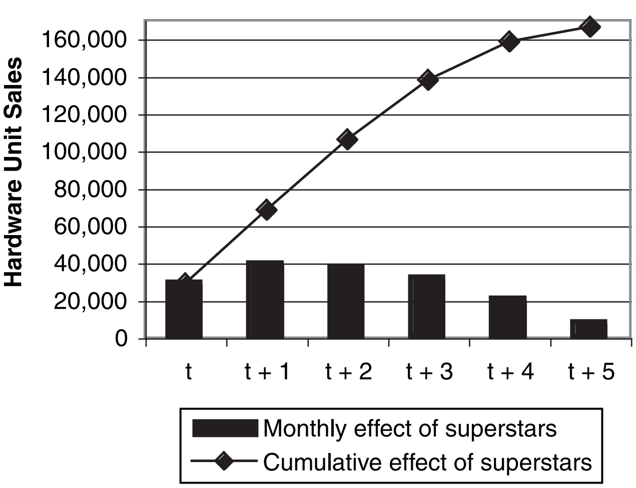
[7]Using only expert ratings or only user ratings instead of the average of both to identify superstar software titles also confirms the presence of a superstar effect, while all other estimated parameters were highly similar.

TABLE 4
Superstar Introductions Affect Hardware Unit Sales and Display Increasing Returns

	Model 1			Model 2		
	Variables	Coefficient	(SE)	Variables	Coefficient	(SE)
α_1	Hardware price	–1.073**	(.195)	Hardware price	–1.109**	(.192)
α_2	Hardware age	–.008**	(.002)	Hardware age	–.008**	(.002)
β_1	Software price	.345	(.261)	Software price	.265	(.262)
β_2	Software catalog	–.019	(.064)	Software catalog	–.021	(.064)
β_3	Software introductions	.274**	(.025)	Software introductions	.265**	(.025)
β_4	Software quality	.013*	(.006)	Software quality	.013*	(.006)
β_{50}	Superstar	.058**	(.016)	Lowest-quality superstar	–.009	(.025)
β_{51}	Superstar L1	.081**	(.017)	Lowest-quality superstar L1	.074**	(.028)
β_{52}	Superstar L2	.077**	(.017)	Lowest-quality superstar L2	.049	(.030)
β_{53}	Superstar L3	.064**	(.017)	Lowest-quality superstar L3	.058	(.031)
β_{54}	Superstar L4	.040*	(.017)	Lowest-quality superstar L4	.049	(.032)
β_{55}	Superstar L5	.015	(.016)	Lowest-quality superstar L5	.003	(.028)
				Medium-quality superstar	.098**	(.030)
				Medium-quality superstar L1	.083*	(.033)
				Medium-quality superstar L2	.090**	(.033)
				Medium-quality superstar L3	.056	(.031)
				Medium-quality superstar L4	.004	(.030)
				Medium-quality superstar L5	.033	(.029)
				Highest-quality superstar	.123**	(.028)
				Highest-quality superstar L1	.097**	(.031)
				Highest-quality superstar L2	.131**	(.033)
				Highest-quality superstar L3	.092**	(.035)
				Highest-quality superstar L4	.093**	(.036)
				Highest-quality superstar L5	.028	(.033)
γ_1	December	.550**	(.023)	December	.550**	(.023)
Adjusted R^2		.98			.98	
Number of observations		503			503	

*$p < .05$ (two-sided).
**$p < .01$ (two-sided).

FIGURE 5
The Effect of Superstars on Hardware Unit Sales over Time



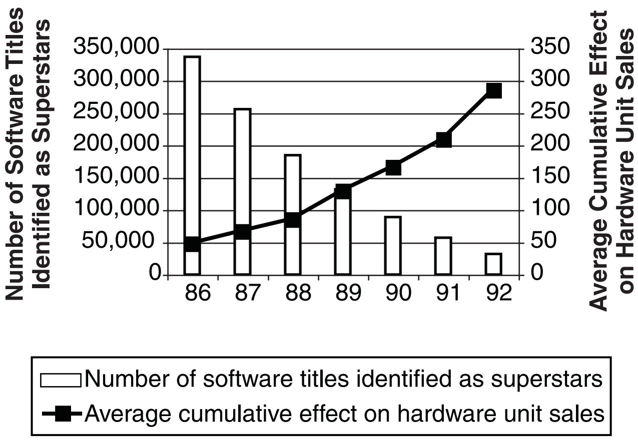
A superstar achieves software sales of 835,000 units on average during these first six months (see Figure 2), meaning that during these first six months, on average, one in every five buyers of a superstar software title also purchases the hardware required to use the superstar software title.

We also find that software introductions (β_3 = .274, p < .01) and software quality (β_4 = .013, p < .05) are significant. Hardware price (α_1 = –1.073, p < .01) has a significant and negative effect on hardware unit sales, and the system becomes less popular as it ages (α_2 = –.008, p < .01) (i.e., a negative time trend).[8] The effect of the software catalog (β_2 = –.019) is not significant, because consumers do not seem to value old nonsuperstar software titles. The effect of software price (β_1 = .345) is also not significant. Reasons for the latter may be that there is little variance in software price or that software price shows a high correlation with hardware age and software catalog, potentially inflating the standard error. We also find that there is a bump in hardware unit sales in December (γ_1 = .550, p < .01) due to the holiday effect.

We can reestimate Model 1 using different software quality thresholds to identify superstars to examine the relationship between the choice of the threshold and superstars' cumulative effect on hardware unit sales. The number of superstars drops sharply with an increasing quality threshold. Consistent with Rosen's (1981) formulation of the superstar theory, we again find a monotonic increasing returns relationship between software quality and hardware unit sales (see Figure 6), similar to the one between soft-

[8]Using even more flexible trends, such as $t^2 + t$ or $t^2 + t + \log t$, to estimate Equation 1 yielded similar results.

FIGURE 6
Varying the Software Quality Threshold to Identify Superstars



ware quality and software unit sales. A software quality threshold of 86—all games with a quality rating of 86 and above are considered superstars—identifies 337 software titles as a superstar. Software titles with a quality rating of 86 and above increase hardware unit sales by an average of only 4% (48,000 units) during the first six months. A quality threshold of 92—all games with a quality rating of 92 and above are considered superstars—identifies just 32 software titles as a superstar. Software titles with a quality rating of 92 and above increase hardware unit sales by an average of 26% (285,000 units) during the first six months (see Figure 6).

We subsequently examine whether this apparent monotonic increasing returns relationship between software quality and hardware unit sales is significant by dividing the 89 identified superstar software titles into three evenly sized groups, according to their software quality rating. The lowest-quality superstars (n = 30) are grouped together and have an average software quality rating of 90.48. The medium-quality superstars (n = 30) are grouped together and have an average software quality rating of 91.45. The highest-quality superstars (n = 29) are grouped together and have an average software quality of 93.25. Model 2 in Table 4 shows the estimated parameters of the three superstar quality groups. Using these parameters, we can again estimate the monthly and cumulative effects of these superstar quality groups on hardware unit sales, using a similar methodology as we did previously.

The highest-quality superstars increase hardware unit sales by 21% (242,000 units), the medium-quality superstars increase hardware unit sales by 13% (160,000 units), and the lowest-quality superstars increase hardware unit sales by only 8% (101,000 units).[9] We can reject that the cumulative superstar effects of the low-, medium-, and high-quality groups are equal to zero. We can also reject that the cumulative effect of the lowest-quality superstars is equal to the cumulative effect of the highest-quality superstars. However, we cannot reject that the cumulative effect of the medium-quality superstar group differs from the other two effects. All these results support our theoretical rationale that superstars display increasing returns of software quality to hardware unit sales because the returns to quality increase over quality tiers (low–medium–high).

The Effect of Software Type

Models 3, 4, and 5 in Table 5 show the effect of superstar introductions on hardware unit sales moderated by software type. We first distinguish between superstars that are exclusively available for just one system (n = 56) and nonexclusive superstars that are available for multiple systems (n = 33). Model 3 in Table 5 shows the estimated parameters of the exclusive superstar and nonexclusive superstar effects. Using these parameters, we can again estimate the monthly and cumulative effects of exclusive and nonexclusive superstars on hardware unit sales, using a similar methodology as we did previously.

Exclusive superstars increase hardware unit sales by 16% (196,000 units), while nonexclusive superstars increase hardware unit sales by only 9% (117,000 units). We can reject that both the cumulative exclusive superstar effect and the cumulative nonexclusive superstar effect are equal to zero. However, we cannot reject that these two cumulative effects are statistically equal to each other because of the large standard errors and numerous nonsignificant parameter estimates. Therefore, we cannot confirm the theoretical rationale that exclusive superstars have a larger effect on hardware unit sales than nonexclusive superstars.

Next, we distinguish between superstars that are original titles (n = 49) and superstars that are sequels (n = 40). Model 4 in Table 5 shows the estimated parameters of the original superstar and superstar sequel effects. Original superstars increase hardware unit sales by 12% (146,000 units), while superstar sequels increase hardware unit sales by 16% (192,000 units). We can reject that both the cumulative original superstar effect and the cumulative superstar sequel effect are equal to zero. However, we cannot reject that these two cumulative effects are statistically equal to each other. Therefore, we cannot confirm either of the two theoretical rationales.

Finally, we distinguish superstars according to their genre. Again, there are six genres. The two large genres are action (n = 36) and platformer (n = 12), and the four small genres are FPS (n = 7), racing (n = 5), RPG (n = 20), and sports (n = 9). Model 5 in Table 5 shows the parameters of the superstar effects per genre. The small size of some genres is likely a contributing factor to several insignificant parameters. First-person shooter (25%; 280,000 units) and racing (26%; 286,000 units) superstars have the largest (i.e., above average) impact on hardware unit sales. Superstars from the genres RPG (14%; 170,000 units) and sports (16%; 190,000 units) have a moderate effect on hardware unit sales. Surprisingly, superstars from the two large

[9]Estimating the cumulative superstar effects with only the first four or five months confirms the findings we present here.

TABLE 5
The Effect of Superstar Introductions by Software Type

	Model 3			Model 4			Model 5	
Variables	**Coefficient**	**(SE)**	**Variables**	**Coefficient**	**(SE)**	**Variables**	**Coefficient**	**(SE)**
Hardware price	–1.076**	(.197)	Hardware price	–1.070**	(.196)	Hardware price	–1.065**	(.199)
Hardware age	–.009**	(.002)	Hardware age	–.008**	(.002)	Hardware age	–.008**	(.002)
Software price	.320	(.263)	Software price	.357	(.262)	Software price	.400	(.273)
Software catalog	–.014	(.064)	Software catalog	–.016	(.063)	Software catalog	–.015	(.066)
Software introductions	.266**	(.025)	Software introductions	.274**	(.025)	Software introductions	.277**	(.026)
Software quality	.013*	(.013)	Software quality	.013*	(.006)	Software quality	.012*	(.006)
Exclusive superstar	.096**	(.023)	Original superstar	.066**	(.024)	Action superstar	–.007	(.026)
Exclusive superstar L1	.081**	(.025)	Original superstar L1	.076**	(.025)	Action superstar L1	.077**	(.029)
Exclusive superstar L2	.085**	(.026)	Original superstar L2	.059*	(.025)	Action superstar L2	.050	(.027)
Exclusive superstar L3	.081**	(.027)	Original superstar L3	.065*	(.026)	Action superstar L3	.047	(.027)
Exclusive superstar L4	.056*	(.028)	Original superstar L4	.015	(.026)	Action superstar L4	.038	(.026)
Exclusive superstar L5	.029	(.025)	Original superstar L5	–.003	(.024)	Action superstar L5	.038	(.026)
Nonexclusive. superstar	.006	(.024)	Superstar sequel	.045	(.024)	FPS superstar	.223**	(.056)
Nonexclusive superstar L1	.090**	(.024)	Superstar sequel L1	.080**	(.025)	FPS superstar L1	.127*	(.059)
Nonexclusive superstar L2	.076**	(.025)	Superstar sequel L2	.093**	(.026)	FPS superstar L2	.127	(.067)
Nonexclusive superstar L3	.057*	(.025)	Superstar sequel L3	.059*	(.027)	FPS superstar L3	.130*	(.066)
Nonexclusive superstar L4	.028	(.025)	Superstar sequel L4	.073**	(.028)	FPS superstar L4	.003	(.065)
Nonexclusive superstar L5	–.004	(.024)	Superstar sequel L5	.027	(.026)	FPS superstar L5	–.073	(.063)
						Platformer superstar	.102**	(.044)
						Platformer superstar L1	.127**	(.049)
						Platformer superstar L2	.044	(.047)
						Platformer superstar L3	.085	(.044)
						Platformer superstar L4	–.044	(.045)
						Platformer superstar L5	–.015	(.040)
						Racing superstar	.046	(.063)
						Racing superstar L1	.095	(.071)
						Racing superstar L2	.163*	(.075)
						Racing superstar L3	.087	(.075)
						Racing superstar L4	.228*	(.098)
						Racing superstar L5	.125	(.091)
						RPG superstar	.045	(.038)
						RPG superstar L1	.074	(.042)
						RPG superstar L2	.091*	(.044)
						RPG superstar L3	.076	(.045)
						RPG superstar L4	.038	(.044)
						RPG superstar L5	.011	(.039)
						Sports superstar	.146*	(.059)
						Sports superstar L1	.004	(.062)
						Sports superstar L2	.094	(.066)
						Sports superstar L3	.028	(.070)
						Sports superstar L4	.051	(.074)
						Sports superstar L5	.060	(.068)
December	.549**	(.023)	December	.548**	(.023)	December	.550**	(.024)
Adjusted R^2	.98			.98			.97	
Number of observations	503			503			503	

*$p < .05$ (two-sided).
**$p < .01$ (two-sided).

genres—action (10%; 129,000 units) and platformer (11%; 142,000 units)—have the smallest (i.e., below average) effect on hardware unit sales. We can reject that the cumulative effect from each software genre is equal to zero. However, we cannot reject that these cumulative effects are statistically equal to each other. Therefore, we cannot confirm the theoretical rationale that superstars from a larger genre have a larger effect on hardware unit sales.

We are unable to confirm that software type moderates the effect of superstars on hardware unit sales. However, this may be different in other system markets—for example, the HD-DVD market. Superstar movies will likely stimulate sales of HD-DVD players, much like titles such as *The Matrix* did for the DVD format. At the same time, different movie types exist, which may generate different returns. For example, action movies full of computer-generated images are likely to have a greater impact on hardware unit sales than drama movies, which depend less on the high-screen resolution and large number of sound channels, thus being less suitable to selling HD-DVD players.

Robustness and Further Analyses

Our estimations of various models show stability in parameter estimates. We conducted the following analyses to test the robustness of our estimates further: We used different estimation methods (than our Prais–Winsten model), such as ordinary least squares and generalized method of moments, and different subsamples to estimate Equation 1. All these analyses confirm our findings. We also estimated a model that included competition through contemporaneous (.509, $p < .01$) and lagged (–.076, $p < .01$) competitor hardware unit sales. This model yielded similar findings. Finally, we estimated a model that lagged the independent variables, which again confirmed our findings. In summary, our findings are highly robust to alternative model specifications.

We also examined the effect of the accumulation of superstar introductions over time for a certain system (i.e., the superstar catalog size) on hardware unit sales. We found that the effect of the accumulation of superstars on hardware unit sales was positive (.017, $p < .01$), whereas all other estimated parameters were similar.

The matrix in Table 3 shows high correlations among several independent variables (i.e., hardware age, hardware price, software quantity, and software price). We assessed the consequences of these high correlations in two ways. First, we used multiple procedures to assess multicollinearity (e.g., Belsley 1991; Belsley, Kuh, and Welsh 1980; Marquardt 1970). All these procedures indicate that the weak to moderate dependencies among the independent variables do not create harmful multicollinearity. The values of the condition indexes are below 35, and variance inflation factors are below 5. In addition, the correlation among the different superstar types and their lags is low (i.e., below .25). Second, we dropped the independent variables that showed a high correlation with another independent variable, one by one. The parameter estimates we obtained are similar to the model that included the dropped independent variable, they do not fluctuate dramatically, and they do not change sign. Thus, we conclude that, overall, our results are highly robust.

Discussion

We find that superstars are as attractive as popular belief suggests, and they have helped sell more than 14.8 million systems, which is approximately 12.4% of total hardware unit sales. During the first six months a superstar software title is on the market, 1 in every 5 buyers of a superstar software title also purchases the hardware required to use the superstar software title. Systems with no or only one superstar failed. Surprisingly, although superstar software unit sales peak during introduction and decline with each month, the monthly superstar effect on hardware unit sales peaks in the second to third month, displaying an inverted U-shaped effect over time. Thus, high software unit sales of superstars do not automatically translate into a large, or similarly shaped, superstar effect on hardware unit sales. This different time pattern is likely due to the relative slower diffusion of information about superstars among nonadopters (i.e., potential hardware buyers) than among adopters (i.e., software buyers). Software type, such as the exclusivity of a superstar, does not significantly moderate the effect of superstar software releases on video game console sales.

Implications

These findings have important implications for theory and research on system markets because they invalidate prior operationalizations of software availability. Use of the software catalog as an indicator for software availability, which is standard practice in network effects literature, may show insignificant indirect network effects (Stremersch et al. 2007). Use of the number of software titles introduced may paint an incomplete picture, because it does not account for increasing returns to quality and, thus, the abnormal returns on superstars. Further research should use a software availability measure, which accounts for software titles of both varying superstar power and varying durability (given the decay in effects over time we found with respect to superstars and the nonsignificant effect of the old software catalog on hardware unit sales).

We find a monotonic increasing returns relationship between software quality and software unit sales (see Figure 1) and between superstar releases and hardware unit sales (see Figure 6). Thus, we contribute to the literature on quality by extending the relevance and importance of product quality in the product's own market (i.e., the superstar effect in the software market) to complementary and adjoining markets (i.e., the hardware market).

Software firms should examine their inventory of software titles for potential superstars and negotiate with system owners to receive side payments for the increase in hardware unit sales their superstars cause. Software firms could even initiate a bidding war between system owners for the rights to their superstars. System owners should examine the forthcoming software titles for potential superstar power. If a software franchise (e.g., Take-Two's *Grand Theft Auto* franchise) is famous for creating superstar software titles, system owners should proactively act on this knowledge.[10] Microsoft paid $50 million to software publisher Take-Two for producing two downloadable episodes of *Grand Theft Auto* (Schiesel 2007). Because superstars have a positive effect on hardware unit sales only for a limited period, system owners must convince consumers that the introduction of a superstar is not a fluke but that there will be a steady supply of superstar software titles. System owners should inform consumers early on during the software development process that software developers of past superstars are developing new superstars to manage expectations and to create positive expectations, which are so crucial in positive feedback markets (e.g., Shapiro and Varian 1998).

However, system owners must remember that when they pay software firms for the exclusivity of their superstars, they are not also increasing their own hardware sales, because exclusive superstars do not increase hardware sales differently than nonexclusive superstars. However, they are eliminating an opportunity for competing systems to increase their hardware unit sales. Eliminating competitor hardware sales while increasing own sales may well be the deciding factor in a positive feedback market (e.g., Arthur 1989, 1996; Shapiro and Varian 1998). The Sega Dreamcast had plenty of superstars during its first year, and subsequent hardware sales exceeded expectations. However, when the introduction of superstars dried up during the second year because of software publishers switching to the Sony PlayStation 2, so did hardware sales, and Sega was forced to withdraw from the market as a system's owner.

Superstars display increasing returns (both in software unit sales and in hardware unit sales) to software quality. Cutting corners to rush a software title to market and meet a deadline (e.g., the launch of the hardware, the December holidays) not only will have an adverse effect on the sales of the software title itself but also could turn a potential superstar into a "me-too" software title without a superstar effect on hardware sales, just because of the slightly lower software quality. System owners should intervene and pay software publishers to continue development to improve quality. In addition, system owners should provide resources (e.g., popular franchises, more advanced game engines) if a software publisher does not have the resources to turn a me-too software title into a superstar because it will increase both software and hardware sales.

Although our empirical test reflected on the role of superstar introductions in the U.S. home video game console market, its conceptual conclusions are likely to be valid in other markets as well. In the HD-DVD market, support from movie studios, which have introduced recent superstar movies, proved to be the deciding factor in the standards war between Toshiba's HD-DVD standard and Sony's Blu-ray standard, tipping the market toward Sony's Blu-ray standard. In addition, the newer satellite radio market in the United States is also likely to be such a superstar system market, and multiple incompatible systems have fought one another for dominance (e.g., Sirius and XM). The signing of superstars, such as Howard Stern, and the exclusive rights to live broadcasts of National Football League games are important events that likely increased sales of one of the two competing systems. In contrast, the lack of superstars in the high-definition television market may well be the cause of the initial sluggish adoption of high-definition television sets. Therefore, both hardware and software firms should carefully examine the role of superstars in their industry because superstars affect both software and hardware sales.

[10]We thank a reviewer for this insight.

Limitations and Further Research

To the best of our knowledge, this article is the first to study the role of superstar software titles in system markets. Thus, we offer an important contribution to the literature that may provoke further research. At the same time, the study has some limitations that further research could address.

This article examines only one system market. Further research could examine whether the superstar phenomenon also exists outside the video game market and whether the effect of superstars on hardware unit sales is similar to that of superstars in the video game industry. Markets that might prove fruitful to examine are the HD-DVD market and the satellite radio market.

In addition, we focus only on the hardware adoption side and largely ignore the software provision side because this is not the focus of the research. Although this focus is common in modeling system markets (e.g., Hartman and Teece 1990; Shankar and Bayus 2003), it raises potential endogeneity concerns. However, in our case, these concerns cannot be addressed by specifying both a demand and a supply model (Nair, Chintagunta, and Dubé 2004; Sawhney and Eliashberg 1996), because important data in the supply equation (e.g., software costs) and possible instruments (e.g., from a different geographic area) are unavailable.

On the positive side, we have several indications that endogeneity is not a major concern in our case. First, prior studies on system markets that explicitly address potential endogeneity have shown that the findings from a model that controls for endogeneity are similar to the findings from a model that does not (e.g., Dranove and Gandal 2003; Gandal, Kende, and Rob 2000; LeNagard-Assayag and Manceau 2001; Ohashi 2003; Park 2004; Rysman 2004). Second, it is unlikely that the variables of focal interest to us, such as superstar introductions, software quantity, and software quality, depend on contemporaneous hardware unit sales because it takes 12 to 18 months to develop an average video game. Superstars can take many years to develop. Thus, although price may be endogenous, potentially creating a bias in our price parameters, this is unlikely to occur in the software availability variables. Third, a way to reduce endogeneity is to lag all independent variables. We found that this did not affect our estimates much, again alleviating endogeneity concerns.

In addition, we do not study the technological characteristics of the hardware. We control for this effect in our model by including a fixed effect. However, the study of such technological characteristics might yield worthwhile managerial insights because they have become more important recently (e.g., What is the effect of Nintendo's unique game controller on hardware unit sales? What is the effect of the Blu-ray capability of the Sony PlayStation 3 on hardware unit sales?).

Our research may also stimulate further research on superstars in system markets, which does not necessarily need to focus on addressing shortcomings of the current study. Our study focuses on the sales gained from superstar introductions. Superstars may require a higher investment and are intrinsically more risky to develop. A study that examines the profitability of investments made by system owners in the supply of superstars would be intrinsically worthwhile but challenging to conduct.

We also show that superstar introductions are an important indicator of hardware unit sales. Thus, the supply of superstars may be critical input in determining who will win system wars (e.g., the current battle among Microsoft's Xbox 360, Nintendo's Wii, and Sony's PlayStation 3). However, our study lacks foresight, in the sense that it focuses on actual introductions rather than announcements. It would be worthwhile to study the effect of superstar announcements on hardware unit sales (foresight by consumers) or firm valuations (foresight by investors). The support of third parties (i.e., independent software publishers) for a certain system may also be valuable information in this regard. Our approach also lacks foresight in the operationalization of superstars. We determine *ex post* which software titles are superstars, given their perceived quality. Studies that enable us to determine which software titles have superstar potential before their introduction would be most valuable. In addition, examining the role of horizontal concentration in the software and hardware market, as well as vertical integration between the software and the hardware market, or examining the role of side payments in system markets would also be fruitful areas for research. We hope that these ideas spark more interest in the phenomenon of superstars in system markets, which has remained deprived from academic attention for too long.

REFERENCES

Ainslie, A., X. Drèze, and F. Zufryden (2005), "Modeling Movie Life Cycles and Market Share," *Marketing Science*, 24 (3), 508–517.

Allen, J. (2003), "Are You Game?" *St. Petersburg Times*, (January 27), 4E.

Anderson, N. (1996), *A Functional Theory of Cognition*. Mahwah, NJ: Lawrence Erlbaum Associates.

Archibald, R.B., C.A. Haulman, and C.E. Moody Jr. (1983), "Quality, Price, Advertising, and Published Quality Ratings," *Journal of Consumer Research*, 9 (4), 11–22.

Arellano, M. and S. Bond (1991), "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations," *Review of Economic Studies*, 58 (2), 277–97.

Arthur, W.B. (1989), "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *The Economic Journal*, 99 (394), 116–31.

——— (1996), "Increasing Returns and the New World of Business," *Harvard Business Review*, 74 (4), 100–109.

Baltagi, B.H. and Q. Li (1991), "A Transformation That Will Circumvent the Problem of Autocorrelation in an Error-Component Model," *Journal of Econometrics*, 48 (3), 385–93.

Barnes, B. (2007), "Two Studios to Support HD-DVD over Rival," *The New York Times*, (August 21), (accessed August 21, 2007), [available at http://www.nytimes.com/2007/08/21/technology/21disney.html].

Basu, A., T. Mazumdar, and S.P. Raj (2003), "Indirect Network Externality Effects on Product Attributes," *Marketing Science*, 22 (2), 209–221.

Basuroy, Suman, Kalpesh K. Desai, and Debabrata Talukdar (2006), "An Empirical Investigation of Signaling in the Motion Picture Industry," *Journal of Marketing Research*, 43 (May), 287–95.

Bayus, B.L. (1987), "Forecasting Sales of New Contingent Products: An Application to the Compact Disc Market," *Journal of Product Innovation Management*, 4 (4), 243–55.

Belsley, D.A. (1991), *Conditioning Diagnostics, Collinearity and Weak Data in Regression*. New York: John Wiley & Sons.

———, E. Kuh, and R.E. Welsch (1980), *Regression Diagnostics: Identifying Influential Data & Sources of Collinearity*. New York: John Wiley & Sons.

Bloom, S. (1982), *Video Invaders*. New York: Arco.

Brynjolfsson, E. and C.F. Kemerer (1996), "Network Externalities in Microcomputer Software: An Econometric Analysis of the Spreadsheet Market," *Management Science*, 42 (12), 1627–47.

Cadin, L. and F. Guerin (2006), "What Can We Learn from the Video Games Industry?" *European Management Journal*, 24 (4), 248–55.

Chou, C. and O. Shy (1990), "Network Effects Without Network Externalities," *International Journal of Industrial Organization*, 8 (2), 259–70.

Chung, K.H. and R.A.K. Cox (1994), "A Stochastic Model of Superstardom: An Application of the Yule Distribution," *Review of Economics and Statistics*, 76 (4), 771–75.

Church, J. and N. Gandal (1992), "Network Effects, Software Provision, and Standardization," *Journal of Industrial Economics*, 40 (1), 85–103.

Clements, M.T. and H. Ohashi (2005), "Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994–2002," *Journal of Industrial Economics*, 53 (4), 515–42.

Collins, A., C. Hand, and M.C. Snell (2002), "What Makes a Blockbuster? Economic Analysis of Film Success in the United Kingdom," *Managerial and Decision Economics*, 23 (6), 343–54.

Conlon, E., S. Devaraj, and K.F. Matta (2001), "The Relationship Between Initial Quality Perceptions and Maintenance Behavior: The Case of the Automotive Industry," *Management Science*, 47 (9), 1191–1202.

Cottrell, T. and K. Koput (1998), "Software Variety and Hardware Value: A Case Study of Complementary Network Externalities in the Microcomputer Software Industry," *Journal of Engineering Technology Management*, 15 (4), 309–338.

Coughlan, P.J. (2004), "Note on Home Video Game Technology and Industry Structure (Abridged)," Harvard Business School Case No. 9-704-488.

Cox, R.A.K. and R.T. Kleiman (2000), "A Stochastic Model of Superstardom: Evidence from Institutional Investor's All-American Research Team," *Review of Financial Economics*, 9 (1), 43–53.

De Vany, A. and W.D. Walls (1996), "Bose-Einstein Dynamics and Adaptive Contracting in the Motion Picture Industry," *Economic Journal*, 106 (439), 1493–1514.

Dickson, G. (2008), “CEA: Super Bowl Boosts HD-Set Sales,” *Cable and Broadcasting*, (January 24), (accessed January 28, 2008), [available at http://www.broadcastingcable.com/article/CA6525439.html].

Dranove, D. and N. Gandal (2003), “The DVD-vs.-DIVX Standard War: Empirical Evidence of Network Effects and Preannouncement Effects,” *Journal of Economics and Management Strategy*, 12 (3), 363–86.

Edwards, C. and R. Grover (2008), “Blu-Ray’s High-Definition Knockout,” *BusinessWeek*, (January 4), (accessed February 21, 2008), [available at http://www.businessweek.com/technology/content/jan2008/tc2008014_928006.htm].

Entertainment Software Association (2007), “Facts & Research,” (accessed August 17, 2007), [available at http://www.theesa.com/facts/top_10_facts.php].

Farrell, J. and G. Saloner (1986), “Installed Base and Compatibility: Innovation, Product Preannouncements, and Predation,” *American Economic Review*, 76 (5), 940–55.

Franses, Philip Hans (2005), “On the Use of Econometric Models for Policy Simulation in Marketing,” *Journal of Marketing Research*, 42 (February), 4–14.

Frels, Judy K., Tasadduq Shervani, and Rajendra K. Srivastava (2003), “The Integrated Networks Model: Explaining Resource Allocations in Network Markets,” *Journal of Marketing*, 67 (January), 29–45.

Funk, J.B. and D.D. Buchman (1996), “Playing Violent Video and Computer Games and Adolescent Self-Concept,” *Journal of Communication*, 46 (2), 19–32.

GamePro (2006), “GamePro Q&A: 5 Questions for Phil Harrison,” *GamePro.com*, (September 24), (accessed May 21, 2007), [available at http://www.gamepro.com/news.cfm?article_id=82268].

Gandal, N. (1994), “Hedonic Price Indexes for Spreadsheets and an Empirical Test for Network Externalities,” *RAND Journal of Economics*, 25 (1), 160–70.

——— (1995), “Competing Compatibility Standards and Network Externalities in the PC Software Market,” *Review of Economics and Statistics*, 77 (4), 599–608.

———, M. Kende, and R. Rob (2000), “The Dynamics of Technological Adoption in Hardware/Software Systems: The Case of Compact Disc Players,” *RAND Journal of Economics,* 31 (1), 43–61.

Gaume, N. (2006), “Nicolas Gaume’s Views on the Video Games Sector,” *European Management Journal*, 24 (4), 299–309.

Gibson, E. (2007), “Halo 3 Will Help Us Sell Consoles, Says Microsoft,” (April 27), (accessed December 3, 2008), [available at http://www.gamesindustry.biz/content_page.php?aid=24613].

Gilroy, J. (1994), “Ask the Computer Guy,” *The Washington Post*, (October 24), F19.

Greco, A. (2000), “The Structure of the Book Publishing Industry,” in *The Media and Entertainment Industries: Readings in Mass Communications*, A. Greco, ed. New York: Allyn & Bacon, 1–25.

Greene, W.H. (2003), *Econometric Analysis*, 5th ed. Upper Saddle River, NJ: Prentice Hall.

The Guardian (2006), “Is Sony Fighting a Losing Battle?” (August 3), (accessed August 8, 2006), [available at http://www.guardian.co.uk/technology/2006/aug/03/sonyplaystation.games].

Gupta, S., D.C. Jain, and M.S. Sawhney (1999), “Modeling the Evolution of Markets with Indirect Network Externalities: An Application to Digital Television,” *Marketing Science*, 18 (3), 396–416.

Hartman, R.S. and D.J. Teece (1990), “Product Emulation Strategies in the Presence of Reputation Effects and Network Externalities: Some Evidence from the Minicomputer Industry,” *Economic Innovation and New Technology*, 1 (1), 157–82.

Hedström, P. (1994), “Contagious Collectivities: On the Spatial Diffusion of Swedish Trade Unions, 1890-1940,” *American Journal of Sociology*, 99 (5), 1157–79.

Huffstutter, P.J. (1999), “Now Video Games Are as Big as the Movies,” *The Los Angeles Times*, (May 10), 1.

IGN (2002), “Grand Theft Auto: Vice City,” (August 27), (accessed November 10, 2007), [available at http://ps2.ign.com/articles/369/369155p1.html].

Interactive Digital Software Association (2001), “State of the Industry Report 2000-2001,” (February), [available at http://www.theesa.com/].

Jones, J.C.H. and W.D. Walsh (1988), “Salary Determination in the National Hockey League: The Effects of Skills, Franchise Characteristics, and Discrimination,” *Industrial and Labor Relations Review*, 41 (4), 592–604.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T. Lee (1985), *The Theory and Practice of Econometrics*, 2d ed. Singapore: John Wiley & Sons.

Kahn, B.E. and W.T. Ross Jr. (1993), “An Experimental Look and How People Combine Forecasts,” working paper, Wharton School, University of Pennsylvania.

Kane, J.S. (1981), “Systematic Error in Appraisals: Alternative Approaches to Their Control,” paper presented at the First Annual Scientist-Practitioner Conference in Industrial/Organizational Psychology, Old Dominion University, Norfolk.

Katz, M.L. and C. Shapiro (1986a), “Product Compatibility Choice in a Market with Technological Progress,” *Oxford Economic Papers*, 38 (3), 146–65.

——— and ——— (1986b), “Technology Adoption in the Presence of Network Externalities,” *Journal of Political Economy*, 94 (4), 822–41.

——— and ——— (1994), “Systems Competition and Network Effects,” *Journal of Economic Perspectives*, 8 (2), 93–115.

Kent, S. (2002), “‘Kong’ Developer Jumps over to Xbox,” *USA Today*, (September 25), 5D.

Komiya, K. and B. Litman (1990), “The Economics of the Prerecorded Videocassette Industry,” in *Social and Cultural Aspects of VCR Use*, J. Dobrow, ed. New York: Lawrence Erlbaum Associates, 25–44.

Krider, Robert E. and Charles B. Weinberg (1998), “Competitive Dynamics and the Introduction of New Products: The Motion Picture Timing Game,” *Journal of Marketing Research*, 35 (February), 1–15.

LeNagard-Assayag, E. and D. Manceau (2001), “Modeling the Impact of Product Preannouncements in the Context of Indirect Network Externalities,” *International Journal of Research in Marketing*, 18 (3), 203–219.

Liebowitz, S.J. and S.E. Margolis (1999), *Winners, Losers, and Microsoft: Competition and Antitrust in High Technology*, 2d ed. Oakland, CA: The Independent Institute.

Luan, Y.J. and Sudhir (2007), “Forecasting Advertising Responsiveness for Short Lifecycle Products,” working paper, Tuck School of Business, Dartmouth College.

MacDonald, D.N. and M.O. Reynolds (1994), “Are Baseball Players Paid Their Marginal Products?” *Managerial Decision Economics*, 15 (5), 443–57.

Marquardt, D.W. (1970), “Generalized Inverses, Ridge Regression and Biased Linear Estimation,” *Technometrics*, 12 (3), 591–612.

Mayer, T. (1960), “The Distribution of Ability and Earnings,” *Review of Economics and Statistics*, 42 (2), 189–95.

Mitra, D. and P.N. Golder (2006), “How Does Objective Quality Affect Perceived Quality? Short-Term Effects, Long-Term Effects, and Asymmetries,” *Marketing Science*, 25 (3), 230–47.

Nair, H., P. Chintagunta, and J. Dubé (2004), “Empirical Analysis of Indirect Network Effects in the Market for Personal Digital Assistants,” *Quantitative Marketing and Economics*, 2 (1), 23–58.

NPD (2008), “2007 U.S. Video Game and PC Game Sales Exceed $18.8 Billion Marking Third Consecutive Year of Record-Breaking Sales,” (January 31), (accessed February 25, 2008), [available at http://www.npd.com/press/releases/press_080131b.html].

Ohashi, H. (2003), “The Role of Network Effects in the U.S. VCR Market, 1978-1986,” *Journal of Economics and Management Strategy*, 12 (4), 447–94.

Park, S. (2004), “Quantitative Analysis of Network Externalities in Competing Technologies: The VCR Case,” *Review of Economics and Statistics*, 86 (4), 937–45.

Pereira, J. (2002), “A Season of Peace, Love—and Decapitation,” *The Wall Street Journal*, (December 17), B1.

Rosen, S. (1981), “The Economics of Superstars,” *American Economic Review*, 71 (5), 845–58.

Rousseau, D.M. (1985), “Issues of Level in Organizational Research: Multi-Level and Cross-Level Perspectives,” *Research in Organizational Behavior*, 7 (1), 1–47.

Rowe, G. (1999), “Where’s Your White Stick, Ref?” *The Irish Times*, (May 3), 18.

Rysman, M. (2004), “Competition Between Networks: A Study of the Market for Yellow Pages,” *Review of Economic Studies*, 71 (2), 483–512.

Sawhney, M.S. and J. Eliashberg (1996), “A Parsimonious Model for Forecasting Gross Box-Office Revenues of Motion Pictures,” *Marketing Science*, 15 (2), 113–31.

Schiesel, S. (2007), “Microsoft Has Deal to Get Exclusive Episodes of Grand Theft Auto IV for Its Xbox Unit,” *The New York Times*, (June 20), (accessed August 17, 2007), [available at http://www.nytimes.com/2007/06/20/arts/20vide.html].

Shankar, V. and B.L. Bayus (2003), “Network Effects and Competition: An Empirical Analysis of the Video Game Industry,” *Strategic Management Journal*, 24 (4), 375–84.

Shapiro, C. (1999), “Exclusivity in Network Industries,” *George Mason Law Review*, 7 (3), 673–84.

——— and H.R. Varian (1998), *Information Rules: A Strategic Guide to the Network Economy*. Boston: Harvard Business School Press.

Shy, O. (2001), *The Economics of Network Industries*. New York: Cambridge University Press.

Strang, D. (1991), “Adding Social Structure to Diffusion Models: An Event History Framework,” *Sociological Methods & Research*, 19 (3), 324–53.

Stremersch, Stefan, Gerard J. Tellis, Philip Hans Franses, and Jeroen L.G. Binken (2007), “Indirect Network Effects in New Product Growth,” *Journal of Marketing*, 71 (July), 52–74.

———, Allen M. Weiss, Benedict G.C. Dellaert, and Ruud T. Frambach (2003), “Buying Modular Systems in Technology-Intensive Markets,” *Journal of Marketing Research*, 40 (August), 335–50.

Van den Bulte, C. and G.L. Lilien (2001), “Medical Innovation Revisited: Social Contagion Versus Marketing Effort,” *American Journal of Sociology*, 106 (5), 1409–1435.

——— and S. Stremersch (2004), “Social Contagion and Income Heterogeneity in New Product Diffusion: A Meta-Analytic Test,” *Marketing Science*, 23 (4), 530–44.

Venkatraman, N. and C. Lee (2004), “Preferential Linkage and Network Evolution: A Conceptual Model and Empirical Test in the U.S. Video Game Sector,” *Academy of Management Journal*, 47 (6), 876–92.

Williams, D. (2002), “Structure and Competition in the U.S. Home Video Game Industry,” *International Journal of Media Management*, 4 (1), 41–54.

Wooldridge, J.M. (2002), *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

Wuyts, Stefan, Stefan Stremersch, Christophe Van den Bulte, and Philip Hans Franses (2004), “Vertical Marketing Systems for Complex Products: A Triadic Perspective,” *Journal of Marketing Research*, 41 (November), 479–87.