The Effect of Superstar Software on Hardware Sales in System Markets

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ABSTRACT AND KEYWORDS	
Abstract	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 argues 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, while not substantiated with empirical evidence, case illustrations show that certain "superstar" software titles of very high quality (e.g., Super Mario 64) may have had 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, we show that the introduction of a superstar increases video game console sales on average by 14%, over a period of 5 months. Software type does not consistently alter this effect. Our 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, over and above a mere software quantity effect. Hardware firms should maintain a steady flow of superstar introductions, as the positive effect of a superstar only lasts for 5 months, and make, if need be, side-payments to software firms, as superstars dramatically increase hardware sales. Obtaining exclusivity over superstars, by hardware firms, does not provide an extra boost to their own sales, but it does take away an opportunity for competing systems to increase their sales.
Free Keywords	system markets, superstars, indirect network effects, new product introductions, software, hardware, video game industry
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Abstract

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 argues 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, while not substantiated with empirical evidence, case illustrations show that certain "superstar" software titles of very high quality (e.g., Super Mario 64) may have had 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, we show that the introduction of a superstar increases video game console sales on average by 14%, over a period of 5 months. Software type does not consistently alter this effect. Our 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, over and above a mere software quantity effect. Hardware firms should maintain a steady flow of superstar introductions, as the positive effect of a superstar only lasts for 5 months, and make, if need be, side-payments to software firms, as superstars dramatically increase hardware sales. Obtaining exclusivity over superstars, by hardware firms, does not provide an extra boost to their own sales, but it does take 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.

Introduction

"*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 (Huffstutter 1999)

Systems are composed of complementary and interdependent products, such as hardware and software (Farrell and Saloner 1986; Katz and Shapiro 1986a; Stremersch et al. 2003; Wuyts et al. 2004). For instance, video game systems are composed of the video game console, on the one hand, and video games, on the other hand (Chou and Shy 1990; Clements and Ohashi 2005; Gandal, Kende and Rob 2000). Other examples are plenty. The Compact Disk consists of CD Players and CD's. Television consists of TV sets and TV programming. Research in economics and marketing has argued that in such system markets, hardware sales depend mainly on the available software (Farrell and Saloner 1986; Gupta, Jain and Sawhney 1999; Katz and Shapiro 1986a and 1994). To avoid any misunderstanding, we should immediately stress that software availability in this theory never refers to software sales (= demand), but rather refers to the catalog of software titles that is available for a particular hardware (= supply).

The major importance of software in system markets has made it into the prime concern for hardware firms (i.e., system owners). For instance, 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). Microsoft put $375 million in cash on the table to acquire just one software development studio (Kent 2002). Sony alone has 14 of these software development studios (GamePro 2006). Sony shipped over 10,000 Playstation 3 development kits, to software developers, before selling even one Playstation 3 (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 almost exclusively focused on a single dimension of software availability, namely software *quantity*[1], i.e., the number of software titles introduced (for an overview, Stremersch et al. 2007). While not substantiated with empirical evidence, case illustrations raise 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 "superstars"[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 returns software superstars may have on hardware sales in system markets remains unexamined. This lack of academic inquiry does not match the importance of the role such software titles may play in system markets. The present study aims to fill that void.

We examine to what extent 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, with on average 14% (167,000 units), over and above the effects of other hardware and software attributes. This positive effect persists only for the first 5 months after their 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, as it overlooks both superstar power, and potential time decays.

[1] Prior literature also refers to software quantity as software availability or software variety.
[2] There exists 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 pay-off, a concept most akin to the "superstar" concept, as originally introduced by Rosen (1981). We therefore will consistently use the term "superstars" throughout this paper. 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 one system to "kill" or dominate another.

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 U.S., between January 1993 and December 2004. The video game console industry is an appropriate context, as it is a system market, in which software (i.e., video games) is thought to be crucial to promote hardware (i.e., video game console) sales (Clements and Ohashi 2005; Williams 2002).

We organize the remainder of the paper as follows. The next section develops the theory on superstar introductions and other determinants of hardware sales. The third section discusses the video game console industry, and presents the sample, data collection, and the measurement of the variables. The fourth section presents the model. The fifth section presents the results, and further analyses we conducted. The sixth section presents the discussion of the results, their implications, and the limitations of the paper.

Superstar Introductions and Other Determinants of Hardware Sales

This section first explains the concept of software superstars and discusses how their introduction may affect hardware unit sales. Second, it argues how this relationship may be dependent upon software type. Third, it adds other variables that may also affect hardware unit sales, for which we need to control in our empirical testing. We will tailor the theory development to our empirical context, the U.S. home video game console market, for clarity of exposition. 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 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, due to the scarcity of high quality (Mayer 1960; Rosen 1981). There is a monotonic increasing returns relationship between quality and the payoff. Or as Cox and Kleiman (2000) put it "*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 very hard for competing golfers to copy Tiger Woods' skills. Similarly, competitors will find it hard 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, as often the quality is unknown until the product is in the hands of the consumer.

Illustrations of superstar industries are plenty. Chung and Cox (1994) find a high concentration of output among top music performers, the top 10.8% of gold record receivers collected 43.1% of all gold records during the period 1958 to 1989. De Vany and Walls (1996) report that just 20% of the 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 in 20 quality categories from [0-5] to [95-100] (we discuss the operationalization of video game quality in the data section). The columns in Figure 1 represent the number of video games in each quality category. The line with diamonds represents the average unit sales of a video game in each quality category. The first conclusion we can draw, 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 of these 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 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', which both sold over 4 million copies in the U.S. alone, within the first three months after introduction.

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 those highly desirable video games. Shapiro and Varian (1998) believe that Walt Disney's Wonderful World of Color was the prime reason why 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 (Frels, Shervani and Srivastava 2003; Gilroy 1994). Business press has claimed that the video game Tetris has been a major driving force behind the success of the original Nintendo Gameboy (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, then 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 only have a limited life expectancy, due to continuous innovation and changing consumer tastes, thereby limiting the sales potential of software titles to only a short period after their introduction. Sales of a software title peak during or soon after introduction, and subsequently decline. This sales pattern is observed across many, similar markets: CD's, DVD's, LP's, PC software applications, television and radio broadcasts, and video cassettes (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 non-superstar 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 subsequently decline. Superstars achieve software unit sales of around 1.3 million units on average, while non-superstar software titles achieve unit sales of just 187,000 units. Software unit sales of superstars turn flat after 6 months, and subsequently the sales evolution of superstars and non-superstars depicts a similar pattern, of slow declining sales over time.

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

Software Type

Software type may influence the effects we posited above. While one can typify video games along multiple dimensions, three are particularly salient and relevant, as 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, like movies and music use similar software types.

The first dimension is whether a superstar software title is exclusively available for only one system, or is available for multiple systems. Prior literature suggests 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. Sony paid a sum in the tens of millions of dollars to software publisher Take-Two to make the superstar franchise 'Gran Theft Auto' exclusive to the Playstation 2 (IGN 2002). Toshiba (the system owner of the HD-DVD standard) paid Paramount and DreamWorks Animation $150 million in incentives for their exclusive commitment to HD-DVD, and 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 resulting new hardware adopters are dispersed across multiple systems. If the introduction of a superstar title is exclusively for just one system, the new hardware adopters will all adopt the same system.

Following this line of thought, exclusive superstar software titles could prove to be a crucial factor in positive feedback markets, because of their ability to tip the market outcome towards one specific system, during a systems war (i.e., standards war) (e.g., Arthur 1989 and 1996; Shapiro and Varian 1998). We therefore expect exclusive superstar software titles to have a larger effect on hardware unit sales of the system in question, compared to non-exclusive 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 have higher sales than the prequel (Ainslie, Drèze and Zufryden 2005; Basuroy, Desai and Talukdar 2006; Sawhney and Eliashberg 1996). As consumers are more aware about superstar sequels compared to original superstars (i.e., non-sequel superstars) and sequels have a proven record, one may expect the introduction of superstar sequels to have a larger effect on hardware unit sales, compared to the introduction of original superstars. On the other hand, consumers who buy the superstar sequel are likely to have already bought the prequel, which means that they already own the hardware. Also, 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. In addition, a recent study of Luan and Sudhir (2007) finds that sequels in the DVD market perform worse than non-sequels. According to this reasoning, superstar sequels may have a smaller impact on hardware unit sales, compared to original superstars. Because of these contradictory arguments, the direction of the effect is an interesting, empirical matter.

The third dimension is the genre to which the superstar software title belongs. The video game market consists of six different genres. There are two large genres (action and platformer), and four small – niche – genres (first-person shooter (FPS), racing, role playing (RPG), sports).

Software titles from the large genres appeal to a very 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). We therefore expect the introduction of superstars from the large genres to have a larger impact on hardware unit sales, compared to the introduction of superstars from the small genres.

Other Variables

We next 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, relating 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 positively affect hardware unit sales (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 present software introductions may also increase the utility a consumer derives. The latter effect may be greater than the former as entertainment products typically have short life cycles (Luan and Sudhir 2007; Williams 2002); also video games typically have short life cycles. We expect *software quality* (the average quality of all video games available to consumers) to positively affect hardware unit sales. While 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 prior to buying it, e.g. when playing at a friend’s house, or when trying it out in the store. We expect *software price*, to negatively influence hardware unit sales, but we expect the 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.

Variables we include, relating to the attractiveness of the hardware side of the system, are *hardware price*, which we expect to negatively affect hardware unit sales, but we expect the effect size to be small in our application (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 included *hardware age*, which we expect to negatively affect hardware unit sales. 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).

We also include a *December dummy*, which controls for the December holiday effect, due to 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 shopping).

Data

This section first discusses the video game industry and the sample. Next, it presents the data collection procedures, and it ends with providing the measures for our variables.

Video Game Industry

Playing video games isn't child's play anymore. American households rate playing video games as the most fun entertainment activity, beating watching television, surfing the Internet, reading books and going to, and renting, movies (IDSA 2001). Many young gamers spend more time playing games than watching TV (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 over 7 hours per week (ESA 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 like CD's, (e)books, DVD's, 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 dollars in the U.S. 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 $0.5 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, a 110% increase. Figure 3 depicts the evolution of PC and video game sales over time. The dotted line with triangles depicts video game sales, the dashed line with circles depicts PC game sales, and the dashed line with triangles depicts console hardware sales; all depicted against the left y-axis. The solid line with squares depicts PC hardware sales and uses the right y-axis. Figure 4 decomposes video game sales and PC game sales according to the six game genres.

During our sample period, consumers bought over 127 million video game consoles and over 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 around $152, consumers spend around $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 clearly indicates the importance of software in this system market. This is similar to other system markets, like CD-player and CD's or DVD-player and DVD's, where buyers also spend most of their money on software (e.g., Bayus 1987).

Sample

The data covers 11 home video game consoles (e.g., 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 period January 1993 to December 2004 (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 around 5,800 software titles.

The monthly hardware unit sales range between 3 units and almost 2.7 million units. However, about a third of these monthly observations, contain very few hardware unit sales. 195 observations contain hardware unit sales of less than 5,000 units, because hardware unit sales very slowly dry up, after consumers and software publishers have abandoned the system. Nintendo sold more than 16 million units of its SNES console in the U.S., but during the last 36 months, less than 2,500 units were sold, and no new software was introduced. Thus, there are two regimes, the 'life' regime (i.e., when typically substantial sales occur), and the 'death' regime (i.e., when very few sales occur). As we are only interested in the 'life' regime, we will eliminate the data observations of the 'death' regime, 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 the system to be abandoned, if software providers do not introduce any software titles for the next three months, or if hardware unit sales drop below 5,000 units. Using these two cutoffs, leaves us with 513 observations (see Table 1).[3] The number of observations reduces by 32%, but the total amount of hardware units sold decreases by less than 4%, to 120 million units.

Data Collection

The data originated from two databases, which we subsequently integrated. NPD provided retail hardware unit sales, hardware price, software unit sales, software price and software introductions. NPD is a market research firm that covers the video game industry and their data has been previously used by other researchers (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 5,800 video games in our data set by hand. Gathering these data was a long, labor-intensive process. We used leading U.S. video game magazines, and websites, like Electronic Gaming Monthly (EGM), Gamespot, and the Imagine Games Network (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).

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[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 (-0.797; P<0.01). The findings in this paper are robust to selecting somewhat stricter, or more lenient, cutoffs.

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

Measures

We will now briefly discuss our measures, all of which are at a monthly periodicity for the system of interest. We start with the variables at 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 bone 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.

At the software side, we first discuss the operationalization of our focal construct, the introduction of superstars.[5] As stated above, superstars are characterized by their high quality (Frels, Shervani and Srivastava 2003; Rosen 1981). Therefore, we have developed a heuristic. To

[4] We follow this procedure, as it enhances the quality of the data, by increasing the accuracy through averaging individual-level errors and biases that are random (Rousseau 1985). It also fits the behavior of consumers as 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 (inter-rater reliability = .652; n=5,650). This correlation is somewhat depressed, because a large number of software titles are of low quality and achieve only 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 inter-rater reliability between expert and user ratings. The inter-rater agreement for video games for which there are at least 5 expert and at least 5 user ratings available is .828 (n=3,748). The conclusion is that experts do not seem to systematically rate video games differently from users. This is because experts, have been, and are, themselves active gamers. In addition, by publishing the quality rating of videogames, experts and users are open to public scrutiny by other experts and users, and this will help to minimize biases (Kane 1981).

[5] We use superstar introduction and not superstar software sales, to model the effect of superstars on hardware unit sales, for a number of 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, thereby increasing hardware sales (Church and Gandal 1992; Katz and Shapiro 1986b). 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, are 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, due to its dependence on hardware unit sales.

be called a superstar software title, 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 out of approximately 5,800 software titles as superstars. Typically, these software titles sell over 1 million copies. Software unit sales of 1 million is considered to be an important threshold in the video game industry (Cadin and Guerin 2006; Pereira 2002). This threshold is also the point at which increasing returns to quality kick in. We list all 89 superstars, per system, in Table 2. Representatives of the NPD video game division perceived our heuristic and our list of superstars as valid. The findings in this paper 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, prior to the month of interest for the system of interest. *Software introductions* refers 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, given prior literature (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 needs 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_{it}^{S}.

$$\log H_{it}^{S} = \mu_i + \alpha_1(\log H_{it}^{P}) + \alpha_2(H_{it}^{A}) + \beta_1(\log S_{it}^{P}) + \beta_2(\log S_{it-1}^{CAT})$$
$$+ \beta_3(\log S_{it}^{INT}) + \beta_4(S_{it}^{QL}) + \sum_{p=0}^{N} \beta_{5p}(S_{it-p}^{SS}) + \gamma_1(C_t^{DEC}) + u_{it} \tag{1}$$

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

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 Lagrangian multiplier test for random effects rejects a random effects model, in favor of a fixed effects model. Also conceptually, a fixed effects model is more appropriate than a random effects model, as the selection of systems from the population is not random. Next, we include the price of video game console *i* in month *t* (denoted as H_{it}^{P}), and the age of video game console *i* in month *t* (denoted as H_{it}^{A}). These independent variables model the hardware attractiveness of the system.

At the software side, we include software price of video game console *i* in month *t* (denoted as S_{it}^{P}), software catalog of past software introductions of video game console *i* in month *t-1* (S_{it-1}^{CAT}), present software introductions of video game console *i* in month *t* (S_{it}^{INT}), and software quality of video game console *i* in month *t* (S_{it}^{QL}). 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 literature (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, etc.). To examine the persistence of the effect superstars have 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 if 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 (e.g., see 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 OLS is not appropriate, because there is evidence of serial correlation (both from Wooldridge's (2002) test (F(1,10) 35.64; Prob.>F=0.00) and Arellano-Bond's (1991) test (z=8.03; Prob.>z=0.00) for autocorrelation), most likely due to the presence of social contagion, and heteroskedasticity (using a modified Wald statistic for groupwise heteroskedasticity following Greene (2003) (χ^2(11) =846.09; Prob.> χ^2=0.00)) 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 AR(1) autocorrelation, thus capturing the social network exposure (i.e., social contagion) (e.g., Hedstrom 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

We first discuss how superstar software introductions affect hardware unit sales, controlling for the other variables we discussed earlier. Then, we discuss our findings on the moderating role of software type on the effect of superstar software introductions on hardware unit sales.

The Effect of Superstars

We present the results of estimating equation (1) in Table 4, model 1. The adjusted R^2 shows that the model fits the data very well, which is not surprising, given that it also includes software introductions, the December holiday effect, and a time trend (through hardware age). We next 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 and positive effect for the first 5 months, in the month of introduction ($\beta_{50} = 0.058$, $p < 0.01$), and 1 ($\beta_{51} = 0.081$, $p < 0.01$), 2 ($\beta_{52} = 0.077$, $p < 0.01$), 3 ($\beta_{53} = 0.064$, $p < 0.01$), and 4 months after introduction ($\beta_{54} = 0.040$, $p < 0.05$). The 5th 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 $p < 0.01$ 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 5 months after their introduction ($t+5$). Figure 5 depicts this graphically. The monthly effect peaks during 1 to 2 months after introduction, and decays afterwards. Remember that software unit sales flatten around the same time. A superstar software title increases hardware unit sales by 14% (167,000

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[6] We start with a large number of superstar lags (e.g., a large N) as suggested by Greene (2003), and reduce the number of lags until only the last lag (e.g., $t+5$) is not significant. By including the last not significant lag, we make sure that the coefficients are not biased and inconsistent because of this (Greene 2003; Judge et al. 1985).

units) on average, during these first 6 months[7] (29,000 units during the month of introduction (*t*), 39,000 (*t+1*), 38,000 (*t+2*), 32,000 (*t+3*), 21,000 (*t+4*) and 8,000 (*t+5*)). 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 allows us to compare the hardware effect, with the software effect, of superstars. However, we advise caution when interpreting these hardware unit effects, due to the large variance between and within systems. A superstar achieves software sales of 835,000 units on average, during these first 6 months (see Figure 2). Meaning that during these first 6 months, on average, 1 in every 5 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 = 0.274, $p < 0.01$) and software quality (β_4 = 0.013, $p < 0.05$) are significant. Hardware price (α_1 = -1.073, $p < 0.01$) has a significant and negative effect on hardware unit sales, while the system becomes less popular as it ages (α_2 = -0.008, $p < 0.01$) (i.e., a negative time trend)[8]. The effect of the software catalog (β_2 = -0.019) is not significant, because consumers do not seem to value old non-superstar software titles. Also the effect of software price (β_1 = 0.345) is 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 = 0.550, $p < 0.01$), due to the holiday effect.

We can re-estimate Model 1, using different software quality thresholds to identify superstars, in order 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 the superstar theory formulated by Rosen (1981),

[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.
[8] Using trends that are even more flexible such as $t^2 + t$, or $t^2 + t + \log t$, to estimate equation (1) gave similar results.

we again find a monotonic increasing returns relationship between software quality and hardware unit sales (See Figure 6), similar to the one between software 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 with only 4% (48,000 units) on average during the first 6 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 with 26% (285,000 units) on average during the first 6 months (See Figure 6).

We subsequently examine if this apparent monotonic increasing returns relationship, between software quality and hardware unit sales is significant, by dividing the 89 identified superstar software titles into 3 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 3 superstar quality groups. Using these parameters, we can again estimate the monthly and cumulative effects of these 3 superstar quality groups on hardware unit sales, using a similar methodology as before.

The highest quality superstars increase hardware unit sales with 21% (242,000 units), the medium quality superstars increase hardware unit sales with 13% (160,000 units), while the lowest quality superstars increase hardware unit sales with only 8% (101,000 units).[9] We can

[9] Estimating the cumulative superstar effects presented in this section, using only the first 4 or 5 months, confirm the findings presented here.

reject that the cumulative superstar effect 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. 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, as 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 non-exclusive superstars that are available for multiple systems (n=33). Model 3 in Table 5 shows the estimated parameters of the exclusive superstar and non-exclusive superstar effects. Using these parameters, we can again estimate the monthly and cumulative effects of exclusive and non-exclusive superstars on hardware unit sales, using a similar methodology as before.

Exclusive superstars increase hardware unit sales with 16% (196,000 units), while non-exclusive superstars increase hardware unit sales with only 9% (117,000 units). We can reject that both the cumulative exclusive superstar effect and the cumulative non-exclusive superstar effect are equal to zero. However, we cannot reject that these two cumulative effects are statistically equal to one another, due to the large standard errors and numerous non-significant parameter estimates. We can therefore not confirm the theoretical rationale, that exclusive superstars have a larger effect on hardware unit sales compared to non-exclusive superstars.

Next, we distinguish between superstars that are original titles (n=49) from 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 is equal to zero. However, we cannot reject that these two cumulative effects are statistically equal to one another. We can therefore not confirm any of the two theoretical rationales.

Last, we distinguish superstars according to their genre. As stated before, there are 6 genres. The two large genres are action (n=36) and platformer (n=12). The four small genres are first-person shooter (FPS) (n=7), racing (n=5), role-playing (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 a number of insignificant parameters. First-person shooter (FPS) (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 role-playing (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 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 one another. We can therefore not 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 superstars have on hardware unit sales. However, this may be different in other system markets. Take for instance, the High Definition DVD market. Superstar movies will likely stimulate sales of High Definition 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 instance, action movies full of computer-generated images (CGI) are likely to have a larger impact on hardware unit sales, as compared to drama movies, which depend less on the high screen resolution and the large number of sound channels, therefore being less suitable to sell High-Definition DVD players.

Robustness and Further Analyses

Our estimations of various models show stability in parameter estimates. We conducted the following analyses to further test the robustness of our estimates.

We used different estimation methods (than our Prais-Winsten model) such as OLS and GMM, and different sub-samples, to estimate equation (1). All these analyses confirm our findings reported above. We also estimated a model that included competition, through contemporaneous (0.509, $p < 0.01$) and lagged competitor hardware unit sales (-0.076, $p < 0.01$). This model again yielded similar findings. Finally, we also estimated a model lagging independent variables, which again confirmed our findings. In sum, our findings are highly robust to alternate model specifications.

One could also study 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 have done so, and found the effect of the accumulation of superstars on hardware unit sales to be positive (0.017, $p<0.01$), while all other estimated parameters were similar.

The correlation matrix in Table 3 shows high correlations between 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 between the independent variables do not create harmful multicollinearity. The values of the condition indices are below

35, and variance inflation factors are below 5. In addition, the correlation between the different superstar types and their lags is low (i.e., below 0.25). Second, we dropped independent variables that showed a high correlation with another independent variable, one by one. The parameter estimates we obtained are very similar to the model that included the dropped independent variable, parameter estimates do not fluctuate dramatically, and parameter estimates do not change sign. Overall, we can conclude that our results are highly robust.

Discussion

We find that superstars are as attractive as popular belief suggests, and helped to sell over 14.8 million systems, which is around 12.4% of total hardware unit sales. During the first 6 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 miserably. Surprisingly, while 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, and thus displays an inverted U-shape 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 because of the relative slower diffusion of information about superstars among non-adopters (i.e., potential hardware buyers), compared to 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, as they invalidate prior operationalizations of software availability. Using 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). Using the number of software titles introduced may paint an incomplete picture, as it does not account for increasing returns to quality and thus the abnormal returns on superstars. Future research should use a software availability measure, which accounts for both software titles of varying superstar power, and varying durability (given the decay in effects over time we found with respect to superstars, and the non-significant 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 quality and hardware unit sales (See Figure 6). Thereby, 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). As superstars only have a positive effect on hardware unit sales 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

[10] We thank a reviewer for this insight.

development process, that software developers of past superstars are developing new superstars, to manage expectations and in order 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 additionally increasing their own hardware sales - compared to a non-exclusive superstar software title - but that they are eliminating an opportunity for competing systems to increase their hardware unit sales. Eliminating competitor hardware sales while increasing one's own hardware sales, may well be the deciding factor in a positive feedback market (e.g., Arthur 1989 and 1996; Shapiro and Varian 1998). The Sega Dreamcast had plenty of superstars during its first year, and subsequently hardware sales exceeded expectations. However, when the introduction of superstars dried up during the second year, due to 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 hardware unit sales) to software quality. Cutting corners, while rushing a software title to market, to meet a deadline (e.g., the launch of the hardware, or the December holidays), will not only have an adverse effect on the software sales of the software title itself. It could also 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, in order to improve quality. In addition, system owners should provide resources (e.g., popular franchises, more advanced game engines, etc.), 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.

While our empirical test reflected upon the role of superstar introductions in system markets, in only one system market, namely the U.S. home video game console market, its conceptual conclusions – numbers may vary – are likely to be valid in other markets as well. In the High-Definition DVD market, the absence or presence of support from movie studios who 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, that tipped the market towards Sony's Blu-ray standard. In addition, the Satellite radio market in the U.S. is likely to be also such a superstar system market, in which multiple incompatible systems fought one another for dominance (Sirius and XM). The signing of superstars like Howard Stern, and the exclusive rights to live broadcasts of NFL games, are important events that likely increased sales of one of the two competing systems. In contrast, the lack of superstars (i.e., NFL games, superstar movies) in the HDTV market may well be the cause of the initial sluggish adoption of HDTV sets. Therefore, both hardware and software firms should carefully examine the role superstars play in their industry, as superstars affect both software and hardware sales.

Limitations and Future Research

The present paper is the first one to study the role of superstar software titles in system markets. Thus, this paper is an important contribution to the literature that may provoke further research. At the same time, it also has some limitations that such future research may address.

This paper only examines one system market. Future research could examine if the superstar phenomenon also exists outside the video game market, and if the effect superstars have on hardware unit sales is similar to that of superstars in the video game industry. Markets that may prove fruitful to examine are the High-Definition DVD market and the Satellite radio market.

This paper also only focuses on the hardware adoption side, and largely ignores the software provision side, as this is not the focus of the paper. While this is a common approach in modeling system markets (e.g. Hartman and Teece 1990; Shankar and Bayus 2003), it does raise potential endogeneity concerns. However, in our case, these concerns cannot be addressed by specifying both a demand and supply model (as in, Nair, Chintagunta and Dubé 2004; Sawhney and Eliashberg 1996). The reason is that important data in the supply equation is unavailable (e.g. software costs) and possible instruments (e.g. from a different geographic area) again 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 show the findings from a model that controls for endogeneity to be very similar to the findings from a model that does not (e.g. Dranove and Gandal 2003; Gandal, Kende and Rob 2000; Le-Nagard-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 upon contemporaneous hardware unit sales. The reason is that it takes 12 to 18 months to develop an average video game. Superstars can take many years to develop. Thus, while price may be endogenous, potentially creating a bias in our price parameters, this is very unlikely to occur in the software availability variables. Third, one 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 may yield interesting managerial insights, as they seem to 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 in this area, which does not necessarily focus on addressing shortcomings of the present study. First, the present study focuses on the sales gain from superstar introductions. Obviously, 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 interesting, but challenging to conduct.

We have also shown 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 between Microsoft's Xbox 360, Nintendo's Wii and Sony's Playstation 3). However, our study lacks foresight, in the sense that it studies actual introductions, rather than announcements. It would be highly valuable 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 very 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 would enable us to determine which software titles have superstar potential prior to 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 hardware market, or examining the role side-payments play in system markets, will likely also be fruitful areas of future research.

We hope that these research ideas spark more interest in the phenomenon of superstars in system markets, which has remained deprived from academic attention for too long.

Table 1:

The Video Game Consoles We Study

System	Start & End	Number of Months
3DO Multiplayer	Sep-93 to Sep-96	37
Atari Jaguar	Nov-93 to Dec-95	26
Microsoft Xbox	Nov-01 to Dec-04	38
Nintendo 64	Sep-96 to Nov-01	63
Nintendo GameCube	Nov-01 to Dec-04	38
Nintendo Super NES	Jan-93 to Jan-96	37
Sega Dreamcast	Sep-99 to Dec-01	28
Sega Genesis	Jan-93 to Dec-96	48
Sega Saturn	May-95 to Mar-98	35
Sony Playstation	Sep-95 to Dec-04	112
Sony Playstation 2	Oct-00 to Dec-04	51

Table 2:

The Superstars We Identify in the Video Game Industry

Sega Genesis	Sony Playstation 2
Earthworm Jim Lunar: Eternal Blue Snatcher	Burnout 3: Takedown Devil May Cry Final Fantasy 10 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 Eat NBA Street Vol. 2 NCAA Football 2003 NCAA Football 2004 Prince of Persia: The Sands of Time Ratchet & Clank: Going Ratchet & Clank: Up 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: Evo Winning Eleven 6 World Soccer Winning Eleven 7 International
Nintendo Super NES	**Nintendo GameCube**
Xenogears Chrono Trigger Donkey Kong Country Donkey Kong Country 2: Diddy's Que Final Fantasy 3 Secret of Mana Super Mario All Stars Super Mario RPG: Legend of the Seven Stars Super Mario World 2: Yoshi's Island Super Metroid	Eternal Darkness: Sanity's Requiem Legend of Zelda: The Wind Waker Madden NFL 2004 Metroid Prime Metroid Prime 2: Echo Paper Mario: Thousand Pikmin 2 Prince of Persia: The Sands of Time Soul Calibur 2 SSX 3 Super Smash Brothers 2 Melee Viewtiful Joe
Atari Jaguar	**Microsoft Xbox**
Tempest 2000	Burnout 3: Takedown Grand Theft Auto (3 & 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
Sony Playstation	
Castlevania: Symphony of the Night Chrono Cross Final Fantasy 7 Final Fantasy 9 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	

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	-0.09								
3 Hardware Age	-0.02	-0.63							
4 Software Catalog	0.17	-0.55	0.80						
5 Software Quality	0.17	-0.25	-0.14	-0.05					
6 Software Price	-0.06	0.52	-0.68	-0.76	-0.05				
7 Software Introductions	0.40	-0.06	-0.03	0.23	0.09	-0.11			
8 December Holidays Effect	0.58	0.02	-0.00	0.03	0.00	0.01	0.04		
9 Introduction Superstar	0.17	-0.01	-0.07	0.08	0.20	-0.09	0.39	-0.04	
Mean	223,121	164.89	35.12	308.86	67.07	34.37	9.93	0.09	0.13
Standard Deviation	328,757	102.00	26.82	255.70	4.26	13.23	9.71	0.29	0.34

Table 4:

Superstar Introductions Affect Hardware Unit Sales And Display Increasing Returns

	Variables	Model 1 Coefficient	(S.E.)	Variables	Model 2 Coefficient	(S.E.)
α_1	Hardware Price	-1.073**	(0.195)	Hardware Price	-1.109**	(0.192)
α_2	Hardware Age	-0.008**	(0.002)	Hardware Age	-0.008**	(0.002)
β_1	Software Price	0.345	(0.261)	Software Price	0.265	(0.262)
β_2	Software Catalog	-0.019	(0.064)	Software Catalog	-0.021	(0.064)
β_3	Software Introductions	0.274**	(0.025)	Software Introductions	0.265**	(0.025)
β_4	Software Quality	0.013*	(0.006)	Software Quality	0.013*	(0.006)
β_{50}	Superstar	0.058**	(0.016)	Lowest Quality Superstar	-0.009	(0.025)
β_{51}	Superstar L1	0.081**	(0.017)	Lowest Quality Superstar L1	0.074**	(0.028)
β_{52}	Superstar L2	0.077**	(0.017)	Lowest Quality Superstar L2	0.049	(0.030)
β_{53}	Superstar L3	0.064**	(0.017)	Lowest Quality Superstar L3	0.058	(0.031)
β_{54}	Superstar L4	0.040*	(0.017)	Lowest Quality Superstar L4	0.049	(0.032)
β_{55}	Superstar L5	0.015	(0.016)	Lowest Quality Superstar L5	0.003	(0.028)
				Medium Quality Superstar	0.098**	(0.030)
				Medium Quality Superstar L1	0.083*	(0.033)
				Medium Quality Superstar L2	0.090**	(0.033)
				Medium Quality Superstar L3	0.056	(0.031)
				Medium Quality Superstar L4	0.004	(0.030)
				Medium Quality Superstar L5	0.033	(0.029)
				Highest Quality Superstar	0.123**	(0.028)
				Highest Quality Superstar L1	0.097**	(0.031)
				Highest Quality Superstar L2	0.131**	(0.033)
				Highest Quality Superstar L3	0.092**	(0.035)
				Highest Quality Superstar L4	0.093**	(0.036)
				Highest Quality Superstar L5	0.028	(0.033)
γ_1	December	0.550**	(0.023)	December	0.550**	(0.023)
Adj-R^2		0.98			0.98	
Number of observations		503			503	

Standard errors are in parentheses.
Two-sided significance tests: **: $p < 0.01$; *: $p < 0.05$.

Table 5:

The Effect of Superstar Introductions by Software Type

Variables	Model 3		Variables	Model 4		Variables	Model 5	
	Coefficient	(S.E.)		Coefficient	(S.E.)		Coefficient	(S.E.)
Hardware Price	-1.076**	(0.197)	Hardware Price	-1.070**	(0.196)	Hardware Price	-1.065**	(0.199)
Hardware Age	-0.009**	(0.002)	Hardware Age	-0.008**	(0.002)	Hardware Age	-0.008**	(0.002)
Software Price	0.320	(0.263)	Software Price	0.357	(0.262)	Software Price	0.400	(0.273)
Software Catalog	-0.014	(0.064)	Software Catalog	-0.016	(0.063)	Software Catalog	-0.015	(0.066)
Software Introductions	0.266**	(0.025)	Software Introductions	0.274**	(0.025)	Software Introductions	0.277**	(0.026)
Software Quality	0.013*	(0.013)	Software Quality	0.013*	(0.006)	Software Quality	0.012*	(0.006)
Exclusive Superstar	0.096**	(0.023)	Original Superstar	0.066**	(0.024)	Action Superstar	-0.007	(0.026)
Exclusive Superstar L1	0.081**	(0.025)	Original Superstar L1	0.076**	(0.025)	Action Superstar L1	0.077**	(0.029)
Exclusive Superstar L2	0.085**	(0.026)	Original Superstar L2	0.059*	(0.025)	Action Superstar L2	0.050	(0.027)
Exclusive Superstar L3	0.081**	(0.027)	Original Superstar L3	0.065*	(0.026)	Action Superstar L3	0.047	(0.027)
Exclusive Superstar L4	0.056*	(0.028)	Original Superstar L4	0.015	(0.026)	Action Superstar L4	0.038	(0.026)
Exclusive Superstar L5	0.029	(0.025)	Original Superstar L5	-0.003	(0.024)	Action Superstar L5	0.038	(0.026)
Non-excl. Superstar	0.006	(0.024)	Superstar Sequel	0.045	(0.024)	FPS Superstar	0.223**	(0.056)
Non-excl. Superstar L1	0.090**	(0.024)	Superstar Sequel L1	0.080**	(0.025)	FPS Superstar L1	0.127*	(0.059)
Non-excl. Superstar L2	0.076**	(0.025)	Superstar Sequel L2	0.093**	(0.026)	FPS Superstar L2	0.127	(0.067)
Non-excl. Superstar L3	0.057*	(0.025)	Superstar Sequel L3	0.059*	(0.027)	FPS Superstar L3	0.130*	(0.066)
Non-excl. Superstar L4	0.028	(0.025)	Superstar Sequel L4	0.073**	(0.028)	FPS Superstar L4	0.003	(0.065)
Non-excl. Superstar L5	-0.004	(0.024)	Superstar Sequel L5	0.027	(0.026)	FPS Superstar L5	-0.073	(0.063)
						Platformer Superstar	0.102**	(0.044)
						Platformer Superstar L1	0.127**	(0.049)
						Platformer Superstar L2	0.044	(0.047)
						Platformer Superstar L3	0.085	(0.044)
						Platformer Superstar L4	-0.044	(0.045)
						Platformer Superstar L5	-0.015	(0.040)
						Racing Superstar	0.046	(0.063)
						Racing Superstar L1	0.095	(0.071)
						Racing Superstar L2	0.163*	(0.075)
						Racing Superstar L3	0.087	(0.075)
						Racing Superstar L4	0.228*	(0.098)
						Racing Superstar L5	0.125	(0.091)
						RPG Superstar	0.045	(0.038)
						RPG Superstar L1	0.074	(0.042)
						RPG Superstar L2	0.091*	(0.044)
						RPG Superstar L3	0.076	(0.045)
						RPG Superstar L4	0.038	(0.044)
						RPG Superstar L5	0.011	(0.039)
						Sports Superstar	0.146*	(0.059)
						Sports Superstar L1	0.004	(0.062)
						Sports Superstar L2	0.094	(0.066)
						Sports Superstar L3	0.028	(0.070)
						Sports Superstar L4	0.051	(0.074)
						Sports Superstar L5	0.060	(0.068)
December	0.549**	(0.023)	December	0.548**	(0.023)	December	0.550**	(0.024)
Adj-R2	0.98			0.98			0.97	
Number of observations	503			503			503	

Standard errors are in parentheses.
Two-sided significance tests: **: $p < 0.01$; *: $p < 0.05$.

Figure 1:

The Video Game Industry is a Superstar Industry

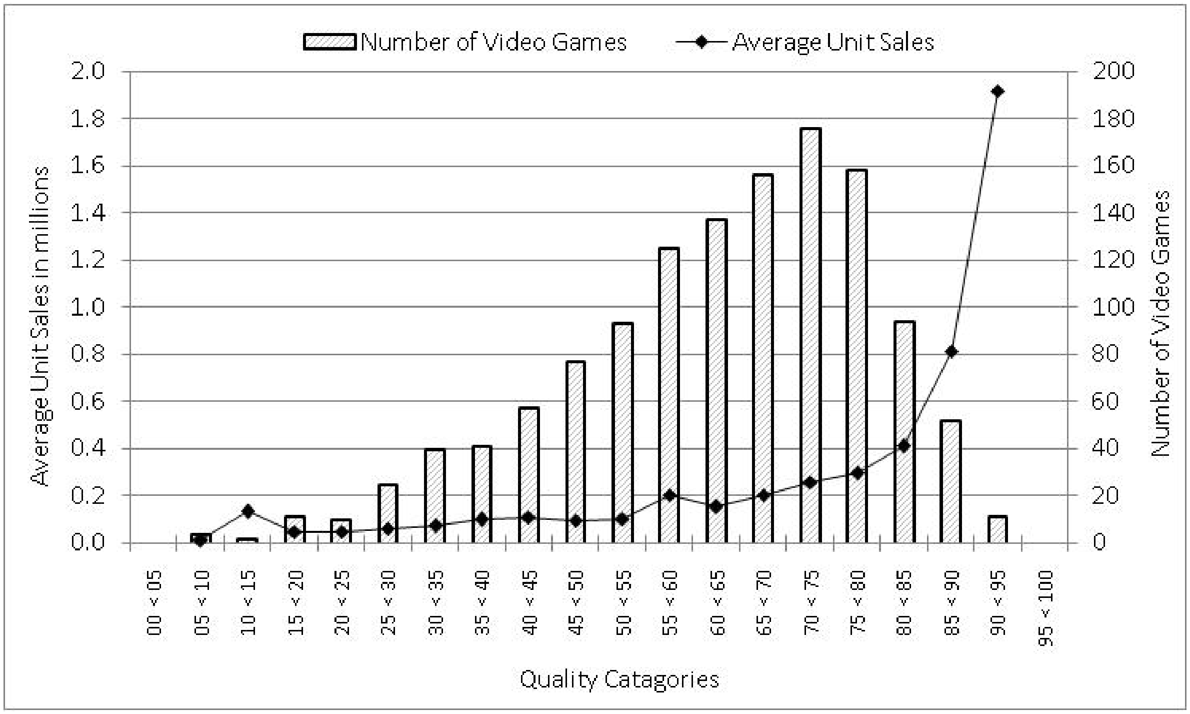
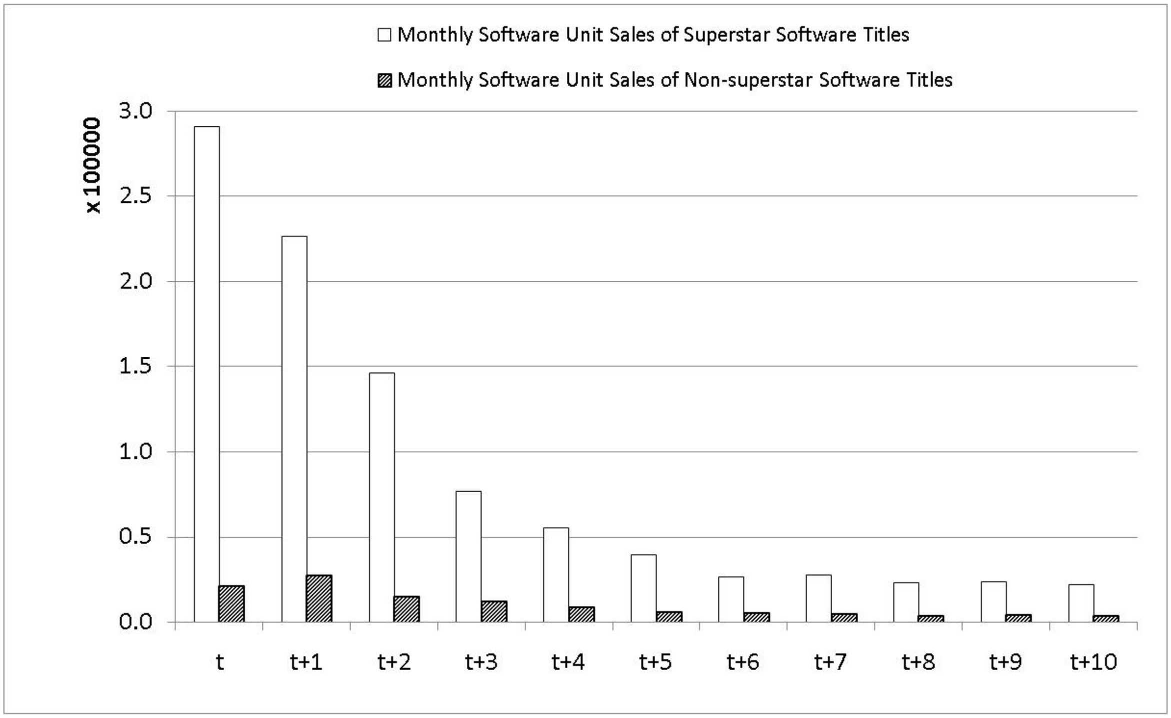


Figure 2:

Software Unit Sales of Superstar and

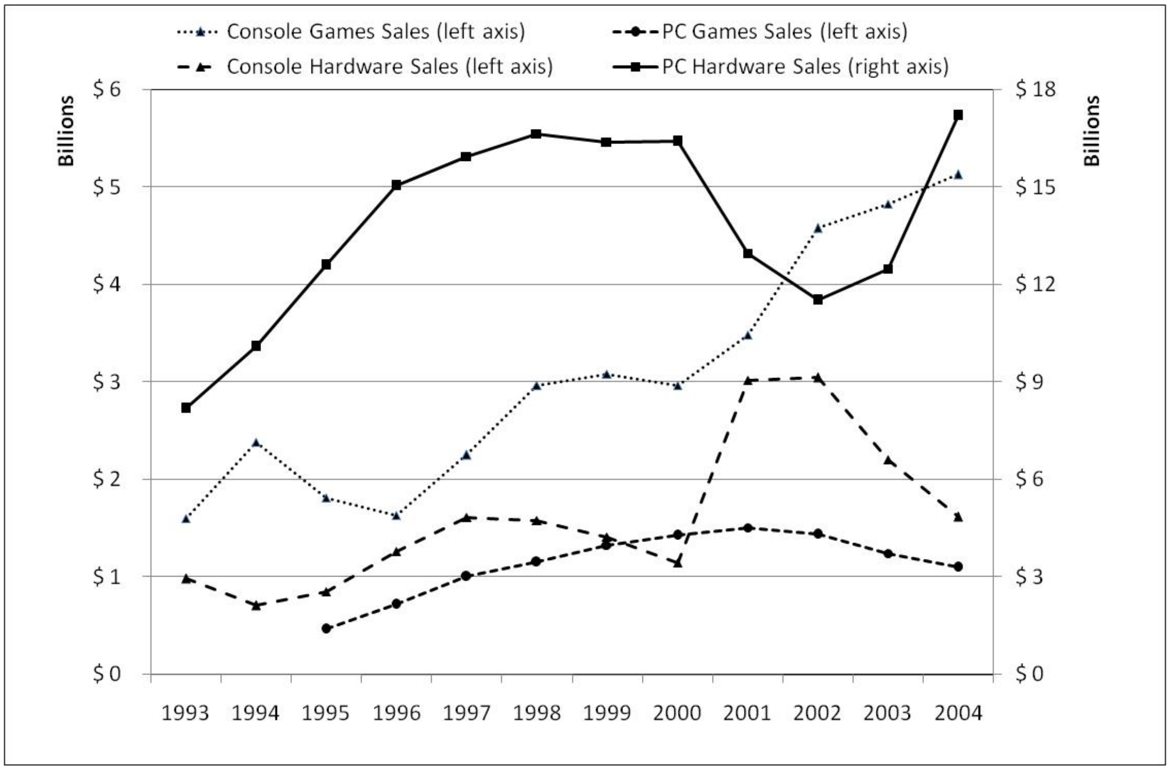
Non-superstar Software Titles



(Source: NPD)

Figure 3:

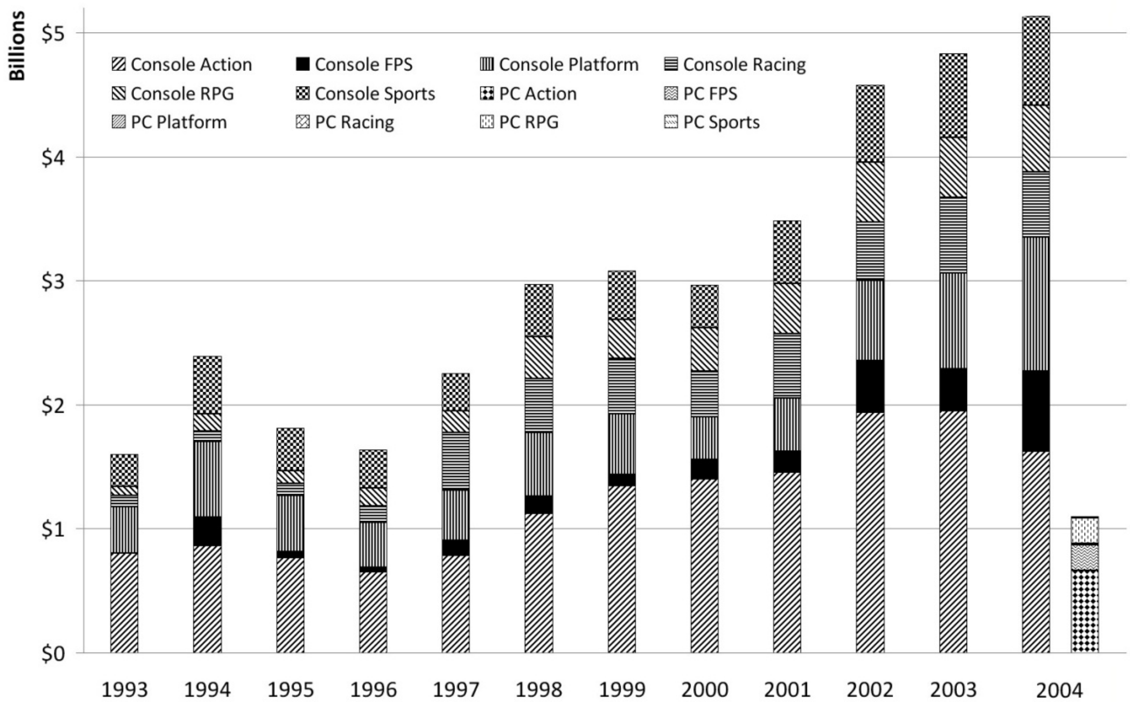
Hardware and Software Sales of Consoles and PC's



(Source: CEA, NPD)

Figure 4:

Video game and PC game sales according to Game Genre*



* Information on PC Genres is only available from 2004.

Figure 5:

The Effect of Superstars on Hardware Unit Sales over Time

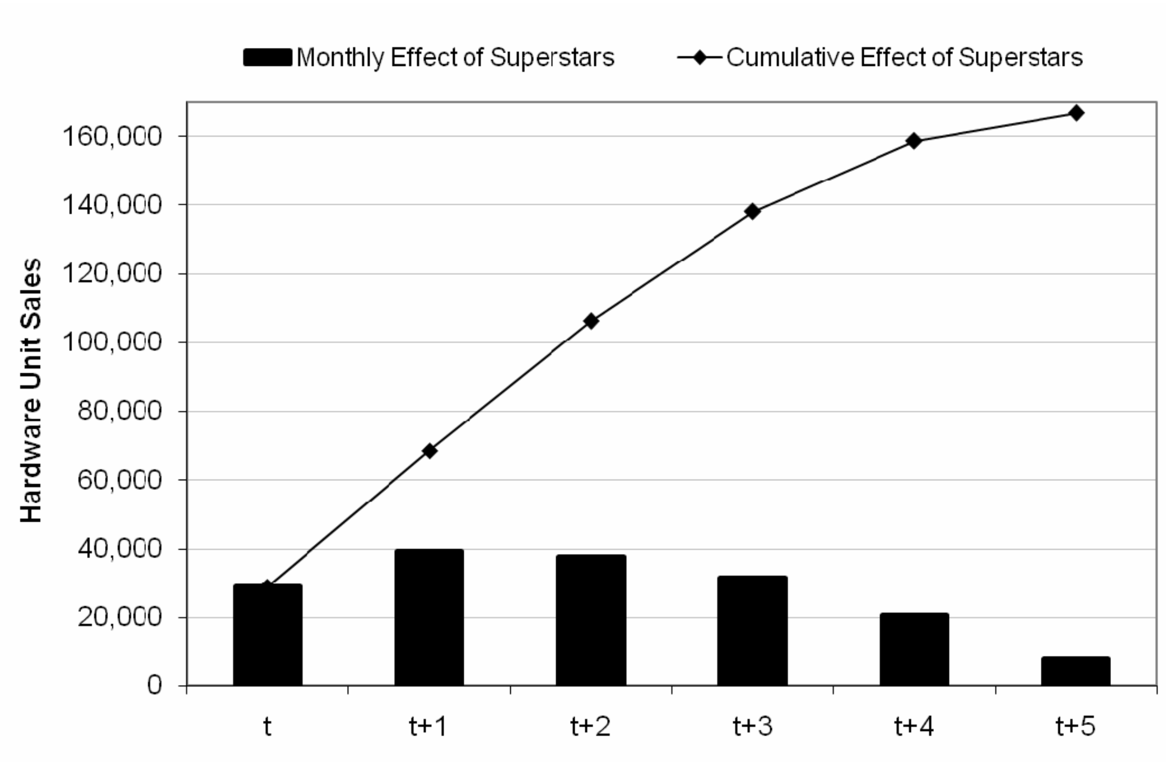
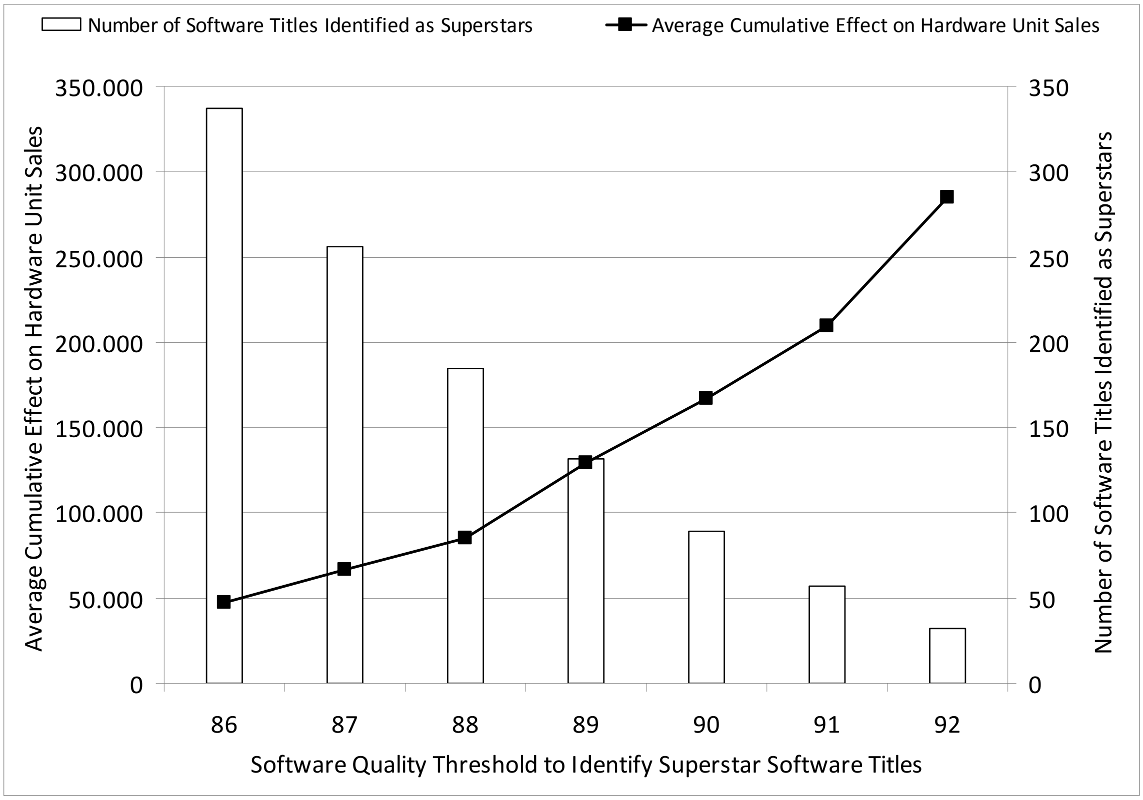


Figure 6:

Varying the Software Quality Threshold to Identify Superstars



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