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November 2000

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THE DVD VS. DIVX STANDARD WAR: EMPIRICAL EVIDENCE OF VAPORWARE

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Abstract

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1 Introduction

In most cases, the premature announcement of a future product cannot be anticompetitive. As Fisher, McGowan, and Greenwood, (1983,p. 289) note “In general, there is no reason to inhibit the time when a firm announces or brings its products to the marketplace. Consumers will be the final arbiter of the product’s quality and the firm’s reputation...Advance announcements of truthful information cannot be anticompetitive.” Farrell and Saloner (1986, p.942) note, however, that when there are strong network effects, “the timing of the announcement of a new incompatible product can critically determine whether a new product supersedes the existing technology.”¹ Lemley and McGowan (1998, p.505) remark that “by preannouncing a product, a large company may therefore influence the outcome of a standards competition in an industry characterized by network effects.” Other things being equal, a firm’s incentive to strategically preannounce products is greater in the presence of network effects.²

Strategic product preannouncements are often referred to as “vaporware.” According to the 1991 Microsoft Press Computer Dictionary, vaporware is defined as “promised software that misses its announced release date, usually by a considerable length of time.” Thus vaporware includes products that arrive significantly late due to unexpected technical difficulties and products that arrive late because of strategic preannouncements. Anticompetitive vaporware allegations refer to the latter.³

The legality of product preannouncements is unclear. According to McGowan (2000), “Judge Sporkin the Department of Justice Antitrust Division argued that ‘product preannouncements do not violate the antitrust laws unless those preannouncements are knowingly false and contribute to the acquisition, maintenance, or exercise of market power’ ” (p.8). But others believe that truthful preannouncements might violate antitrust laws. See McGowan (2000) for further discussion.

Anticompetitive vaporware allegations have been leveled at IBM and Microsoft.

¹See Levy (1997) for a recent theoretical manuscript on vaporware.

²Of course, false preannouncements can benefit firms in non-network industries. But the potential gain to firms is much greater in net industries. Other things being equal, a firm would be less inclined to risk its reputation with a false announcement in a non-network industry than in a network industry. We thank Dennis Carlton for this point.

³For an interesting discussion of the origin of the term “vaporware,” see Bayus, Jain, and Rao (2000).

One of the main claims in the IBM case was that IBM increased its market share by preannouncing products that were in very early stages of development (see Fisher, McGowan, and Greenwood (1983)).

Claims of anticompetitive vaporware were leveled against Microsoft in the 1994 Antitrust case. In April 1990, DR-DOS 5.0 was introduced and received positive reviews. Baseman, Warren Boulton, and Woroch (1995) noted that “within a month of DR-DOS 5.0’s inauguration, Microsoft reported development of MS-DOS 5.0. Curiously, it boasted nearly all of the innovative features of the DRI product (p.7).” MS-DOS 5.0 was eventually released in June 1991.

Concerns about vaporware led the Software Publishers Association (the computer software industry’s largest trade association) to include prohibitions (in February 1998) against vaporware in the associations’ eight principles of competition.⁴ The concern seems well founded. Bayus, Jain, and Rao (2000) documented that just slightly more than 50 percent of 123 software products announced during the 1985-1995 period were shipped within three months of the announcement date. More than 20 percent of the products were not shipped within nine months of the announcement date.

Despite the antitrust questions and the software industry’s concern, there is no analytical empirical work on the issue. In this paper, we empirically measure the effect of the DIVX preannouncement in the DVD market. We do this by measuring the effect of potential (incompatible) competition on a network undergoing growth. We find that there are network effects in the DVD market and that the preannouncement of DIVX slowed down the adoption of DVD technology. This suggests that strategic preannouncements can indeed affect the outcome of a standards competition.

The paper proceeds as follows. In section 2, we provide an introduction to network effects while section 3 describes the DVD market. Section 4 describes our data and section 5 contains our empirical results. Section 6 provides brief conclusions.

⁴See McWilliams, B., “Industry Group Issues Software Competition Guidelines,” PC World Communications, February 2, 1998 (<http://pcworld.com/news/daily/data/0298/980202164433.html>).

2 A Brief Introduction to Network Effects

A network effect exists when the value that consumers place on a particular product increases as the total number of consumers who purchase identical or compatible goods increases. In the case of an **actual (or physical) network**, such as the telephone network, the value of the network depends on the total number of subscribers who have access to the network.

In the case of virtual networks, that are not linked physically, the network effect arises from **positive feedback from complementary goods**.⁵ Examples of virtual networks in which the value of the “base” product increases as the variety of complementary products increases include computer operating systems, videocassette recorders (VCRs), compact disc players (CD-players), and Digital Versatile Disc players (DVD-players). In the case of computer operating systems, the complementary goods are the applications software programs, while in the case of VCRs, the complementary goods are the VCR cassettes or tapes; similarly in the case of CD-players, the complementary goods are the compact discs, while in the case of DVD-players, the complementary products are the DVD-discs. The positive feedback mechanism works as follows: the value of the base product is enhanced as the variety of (compatible) complementary products increases; hence consumers will be more likely to purchase a base product with many compatible complementary products. The variety of complementary products, in turn, will depend on the total number of consumers that purchase the base product. As the number of consumers that purchase the base product increases, there is a greater demand for compatible complementary products. This increases the profitability of supplying complementary products. Since there are typically fixed or sunk entry costs, production of the complementary products is characterized by increasing returns to scale. Hence more complementary products will be produced or developed for a base product with a large share of the market. This further enhances the value of the base product. Thus there is positive feedback in such a system: an increase in the sales of the base product leads to more compatible complementary products, which further increases (the value of and) sales of the base

⁵In the case of computer application software, virtual network effects also arise because consumers want to move files among application programs. Here the horizontal technical compatibility between different application programs leads to a virtual network effect.

product.⁶

As Katz and Shapiro (1994) note, the positive feedback means that there is a “natural tendency towards *de facto* standardization” (p.105). They note that these system markets are often characterized by tipping: once a system has gained an initial lead, there is a snowball effect. One system ends up being the market standard with large amounts of compatible complementary products; the other system has a very small market share, if any at all. The value of the base product with little or no complementary software is essentially zero, since the base product itself provides little or no standalone benefits.

2.1 The Theoretical Literature on Network Effects

The theoretical literature on network effects has extensively examined the tradeoff between “standardization” (all consumers adopt compatible products) and “variety” (several incompatible products have positive market shares). Two important welfare implications of this tradeoff are

- Market forces often result in suboptimal standardization, that is, left alone the market may fail to achieve standardization when standardization is socially desirable.⁷
- Even if the market settles on a standard, the standard may be inferior, that is, social welfare would have been higher had an alternative standard been chosen.

Some policy makers have interpreted these results to mean that when there are strong network effects, regulators should play an active role in setting standards. This is especially true when a new technology emerges and backwards compatibility is an issue.⁸ Others have urged regulators not to intervene despite the presence of network

⁶See Chou and Shy (1990) and Church and Gandal (1992).

⁷This result is robust to both physical networks and virtual networks. For the physical networks case, see Farrell and Saloner (1986). For the virtual network case, see Chou and Shy (1990) and Church and Gandal (1992). The latter shows that suboptimal standardization is most likely to occur when consumers place a relatively high value on software variety.

⁸Recently, the FCC set down the guidelines for the new digital television (HDTV) standard. NTSC televisions will be able to view new broadcasts with a “down-converter” box, which will provide a somewhat improved image. New HDTVs will be able to watch old NTSC programs if they have a

effects,⁹ unless owners of proprietary standards take strategic actions to influence the adoption decisions of consumers. As noted above, strategic product preannouncements have raised regulatory concerns.

2.2 Empirical Evidence for Virtual Network Effects

A small but growing literature has empirically (statistically) found evidence of virtual network effects. See Greenstein (1993), Gandal (1994, 1995), Brynjolfsson and Kemerer (1996), and Gandal, Greenstein, and Salant (1999) for empirical evidence of network effects in the computer software industry.

Other papers that provide empirical evidence of virtual network effects include Saloner and Shepard (1995), the ATM industry, Park (1997), the VCR market, Shankar and Bayus (1997), the Home Video Game Industry, Berndt, Pindyck, and Azoulay (1999) and Gandal, Kende, Rob (2000), the CD industry.¹⁰

3 The Development of the DVD Market

Throughout the 1990s, video hardware and software manufacturers sought a digital format to replace VCRs. Keen to avoid another Beta/VHS format war, hardware manufacturers led by Sony, Toshiba, and Panasonic, in conjunction with movie studios led by Warner and Columbia (a division of Sony), worked together to establish a single standard. The result was the DVD (digital video disc or digital versatile disc). DVD discs are identical in appearance to compact discs, but store ten times as much information - more than enough for a feature film with twice the visual clarity of a videocassette - as well as providing a five channel surround soundtrack.

In September 1996, the “DVD forum” of hardware and software firms published

second (analog) tuner built-in. The speed of adoption of HDTV has some ramifications; the FCC has scheduled an end to NTSC broadcasts by the year 2006. (See “HDTV: How the Picture Looks Now,” *Business Week*, May 26, 1997, and “Should you Roll Out the Welcome Mat for HDTV?” *The New York Times*, April 27, 1997.)

⁹Leibowitz and Margolis (1994) criticize the literature on network effects in part because it cannot tell us whether effects identified by the theoretical literature (such as the failure to achieve compatibility) are privately or socially important. They argue that until the literature is able to estimate such effects in a meaningful fashion, the public policy debates are premature.

¹⁰See Berndt, Pindyck, and Azoulay (1999) for a nice survey of the literature.

the DVD specifications.¹¹ The timing was ideal because by the end of 1996, fully 90 percent of all US households owned a VCR player and fully 67 percent of all US households owned a CD player. Figure 1 shows that by the end of 1996 that the penetration rate for these two technologies had flattened out.

DVD would be an “open format,” meaning that all machines carrying the DVD logo could play all DVD discs. All DVD discs would be encoded with the Dolby Digital sound process, and could also be encoded with other sound processes, such as Dreamworks’ DTS surround process, as they became available.¹² All DVD players would be capable of outputting the Dolby Digital bitstream to external decoders; some manufacturers included internal decoders as an added feature of their DVD players. DVD-ROM drives for computers would also be able to play DVD movies (though DVD video players need not be able to play DVD software designed specifically for the personal computer.) All DVD discs would be forward compatible with the high definition television, through a technology known as progressive scan.¹³

Warner Home Video (and its sister companies such as HBO and New Line), Columbia Tri-Star, MGM/UA, and Polygram committed to providing DVD videos even before there were any DVD players available. Smaller firms that held distribution rights to movies, documentaries, and IMAX films, also committed to the format.¹⁴ When the first DVD players were released in the U.S. in early 1997, there were forty software titles to choose from, including *Batman*, *Blade Runner*, *Singing in the Rain*, and the IMAX film *Africa: The Serengeti*. In July and August 1997 respectively, Universal and Disney’s live-action Buena Vista division entered the market. But other studios adopted a wait-and-see approach, and it would take another year before other major studios came on board. (See table 1.)

¹¹We list this and other important dates in Table 1.

¹²Due to a combination of higher software prices, special hardware requirements, and lack of support from competing studios, the DTS format never caught on. Sales of DTS encoded disks account for a minute fraction of total software sales.

¹³The first progressive scan DVD players reached the market in Fall 1999. With features that can only be enjoyed with high definition television, and prices several hundred dollars above standard players, progressive scan players have yet to catch on.

¹⁴IMAX are ultra-high resolution films usually shown in specially-designed theaters with enormous screens and state-of-the-art sound systems. Most IMAX films are short (about 40 minutes) and have subject matter that best shows off the technology, such as automobile racing, volcanoes, and whales. Many home theater buffs initially used IMAX films on DVD to show off their systems.

Some studios were concerned about piracy. Because DVD is digital, it offers opportunities for pirates to make perfect digital copies. The DVD consortium had included some protection against piracy in the DVD format, including Macrovision, which prevents direct copying onto videotape or a recordable DVD player. They also adopted regional coding, so that players designed for sale in the U.S. region could only play discs designed to play in the U.S. (There are seven regions altogether.) But many studios were concerned that these precautions were inadequate, and were reluctant to release films on DVD unless demand from the installed base of DVD players was large enough to offset the risks of piracy. In addition, studios may have been waiting for a larger installed base so as to receive a larger sales “bounce” when they finally did enter the market. Paramount did not commit to DVD provision in April 1998, while 20th Century Fox did so in August 1998.

Despite the lukewarm support of several studios, DVD was cautiously welcomed by “early adopters” - electronics enthusiasts who derive utility from being the “first on their block” to own a new technology. Some of the early adopters were among the two million Americans who owned laserdisc players, which came close to matching DVD’s visual clarity and sound. Early adopters established several Internet “chat sites,” in which they debated the relative merits of DVD and laserdisc, and speculated about the future of the new format. All agreed that DVD had two advantages over laserdisc. First, it was much cheaper to master and produce DVD software. DVD software retail prices range from \$10-\$30 per movie, compared with \$30-\$70 for films on laserdiscs. Second, the laserdisc market had peaked without becoming mainstream, leaving laserdisc enthusiasts searching for stores that rented or sold discs. With lower prices and renewed interest from hardware and software makers, DVD held out the promise of finally replacing the inferior VCR format. When Best Buy (the nation’s second largest electronics retailer) indicated that it would fully support DVD with special in-store displays, wide selections of hardware and software at discounted prices, and heavy advertising, many believed that the format would quickly become mainstream.

Sales of DVD hardware (see figure 2) in the first few months were well within industry expectations, and much higher than sales of CD players during its first few months on the market. As the market grew, more brands of hardware became available, and most major electronics retailers, including Circuit City (the nation’s leading

electronics retailer), jumped into the market. By the end of 1997, manufacturers introduced second generation DVD players with enhanced features such as a higher video bitstream rate for superior video imaging, 96/24 audio resolution for playing DVD audio (expected to eventually replace CDs), and component outputs for direct connection to projection televisions. In early 1999, manufacturers introduced third and fourth generation players. Other than incorporating progressive scan technology (capable of producing razor sharp images on digital televisions), these newer players represented only minor improvements over the earlier generations. However, they were considerably less expensive than their predecessors.

During this time, a DVD culture was emerging over the Internet. Early adopters tended to be frequent Internet users, and it was no surprise when several on-line hardware and software vendors established DVD-related sites. In the period shortly after the introduction of DVD, the most popular DVD chat sites received more than 1000 posts weekly, many from individuals who did not own a DVD player. By late 1998, there were at least four on-line chat sites receiving as many as 10,000 postings weekly.¹⁵ At the same time, new Internet vendors such as DVD Express and DVD Depot emerged, offering discounted prices on DVD hardware and software.

3.1 The DIVX Threat

Tempering the early enthusiasm for DVD were occasional rumors about a competing technology known only as “zoom,” which was supposed to be a pay-per-view alternative to open DVD. Rumors on the Internet about zoom died down during the summer of 1997, only to come true on September 8, 1997, when Circuit City announced its intention to introduce DIVX (Digital Video Express).¹⁶ DIVX players would play all DVD discs. But they would also play special DIVX discs (that could not be played on DVD players). DIVX discs are “locked” by an encryption technology. They would be unlocked when the user started playing them, and remain unlocked for 48 hours. Once time expired, the user could replay the disc by contacting a computer operated by a firm working for Circuit City. (This was done via a modem connection that came

¹⁵Today, chat sites such as the *Home Theater Forum* have over 10,000 members and receive 50,000 postings weekly.

¹⁶DIVX was a joint venture between Circuit City and the law firm of Ziffren, Brittenham, Branca & Fischer.

with the DIVX player.) Circuit City charged \$4 to \$5 for the first time use of each disc, with a similar fee for each reuse. In this way, DIVX offered an alternative to rental.

Circuit City gave no firm date for the introduction of DIVX, and, indeed, it would not begin test marketing for nearly a full year. Even so, the DIVX preannouncement shocked DVD enthusiasts. Circuit City was the leading seller of home electronics in the U.S. and could be expected to heavily promote DIVX. It also had commitments from Disney, Paramount, Universal, and Dreamworks to release DIVX discs “day and date” with VHS tapes. These studios had not been enthusiastic supporters of DVD, so it appeared that the market was becoming divided.

One Internet site summed up the problem this way: “The confusing situation where two formats exist, supported by different companies, was what DVD was supposed to avoid. The DVD forum was set up to stop a format war but it now looks like the introduction of DIVX could result in just that...The fact some studios are supporting only open DVD and some are supporting only DIVX will lead to confusion and ultimately be harmful to DVD.”¹⁷ To add to the confusion, there seemed to be no technological reason for studios to support only one format. Once a digital master is created for either format (at a cost ranging from \$50,000 to a few hundred thousand dollars per movie), the incremental cost of creating a disc in the other format was negligible. The studio merely had to add or delete the encryption code. Apparently, the only reason that certain studios, notably Disney, released any titles exclusively to DIVX was that Circuit City had paid them handsomely to do so.

Many suspected that Circuit City prematurely announced DIVX in order to slow the growth of DVD. A December 13, 1998 editorial in the popular Internet site *DVD Resource Page* noted that the DIVX preannouncement created “confusion in a marketplace a year ago (fall of 1997) when DVD sales SHOULD have taken off, but did not because people wanted to know how they were going to watch movies on a format not supported by all the studios.”¹⁸

In the months following the DIVX announcement, there were countless debates on internet chat sites about whether early adopters should buy DVD players. Those who

¹⁷DVD Centre Webpage <http://web.ukonline.co.uk/Members/s.roberts/index.htm>.

¹⁸See the DVD Resource Page at <http://www.dvdresource.com>.

had already made purchases exhorted others to support the open DVD format. But many fence sitters responded that they preferred to see which format emerged as the dominant one, with some posters referring specifically to the demise of the Betamax. It appears that there was a dip in DVD sales in the fourth quarter of 1997, despite that fact that there is usually a spike in consumer electronics sales during the holiday season. (See figure 2.)

Circuit City had two reasons to prematurely announce DIVX. First, if DVD established itself quickly, it would all but eliminate the market for DIVX. Second, Circuit City rival Best Buy had embraced DVD from the beginning, and was firmly established as the nation's leading seller of DVD hardware and software. If DVD continued to grow, more electronics shoppers might be drawn to Best Buy, costing Circuit City sales in other categories.

Claims of vaporware appeared almost immediately after the DIVX announcement. For months after the announcement, Circuit City had neither DIVX hardware nor software to demonstrate. To make matters worse for Circuit City, it appeared that only one regional electronics retailer (The Good Guys) agreed to carry DIVX players and no studios made firm commitments to release movies exclusively in DIVX format.

3.2 The Rise and Fall of DIVX

The market gradually realized that DIVX was a long way from becoming a reality. Share values of Circuit City declined 24 percent through mid-January 1998. During the same period, Best Buy's shares climbed 89 percent. On January 17, 1998 Dick Sharp made an announcement that seemed to settle the DVD market. He demonstrated a DIVX prototype to the media, but announced that test marketing of DIVX (in San Francisco and Richmond, Virginia) would not begin until the summer, with a nationwide release expected in the fall. He also indicated that initially all DIVX players would be manufactured by Zenith, which was not a significant force in the audio/video hardware market and was on the verge of bankruptcy; he also announced that only one retailer (The Good Guys) had agreed to join Circuit City in offering DIVX products. Finally, he indicated that DIVX would be marketed as an advanced

feature of DVD, rather than as an alternative standard.¹⁹

With this second announcement, fears of format wars died down. Chat groups on the internet voiced confidence that the DVD format would survive. Investors seemed resigned to the fact that Circuit City would not become the dominant force in the digital video market. In the three-day window surrounding the January 17th, announcement, Circuit City shares lost 0.35 percent of their value while Best Buy climbed 3.2 percent. Numerous press reports attributed a substantial portion of Circuit City's Wall Street woes to the unsuccessful launch of DIVX. According to a June 1999 online article appearing in e-town.com (another popular DVD site), Circuit City had invested more than \$207 million on DIVX (as of February 28th, 1999), nearly seven percent of the firm's total assets.²⁰ The article also noted that quarterly earnings per share were off by 16 cents due to charges for DIVX.

DIVX did reach the market in the fall of 1998. A major television ad campaign caused some DVD backers to fear that the format war would heat up again, but DIVX faced an uphill battle. Studio support for DIVX had weakened (no new studios had come on board and some of the fence-sitting studios had begun releasing in open DVD). Circuit City still could not convince competitors to carry the product. An online DVD rental firm called Netflix had emerged as a "pay per view" alternative for the open DVD format, and offered special promotions in conjunction with several open DVD hardware makers. Lastly, early DVD adopters had used the delay in the launch of the DIVX format to spread the anti-DIVX gospel. (Many chat room participants reportedly visited Circuit City stores and confronted sales people with their concerns about DIVX just as shoppers were preparing to purchase a player!) These obstacles combined to stymie DIVX sales. While Circuit City reported that it sold as many as 80,000 DIVX players in the crucial Christmas 1998 shopping season, this represented less than 25 percent of the sales of open DVD players during the same period. The handwriting was on the wall: at best, DIVX would be a niche format.

In early June, 1999, rumors swept the internet that Circuit City would soon pull the plug on the DIVX format; those rumors came true on June 16, 1999. The facts

¹⁹It is widely believed that most DIVX owners used their players primarily to play open DVD disks.

²⁰"Still, business booms for Circuit and others," by David J. Elrich, June 4, 1999 (from e-town.com).

on the ground justified the decision. By the end of 1998, the installed base of DVD players (shipped to retailers) was approximately 1.32 million. During the first twenty weeks of 1999, at least 572,000 additional players were sold to retailers, yielding a DVD installed base of at least 1.9 million through mid-1999. The DIVX installed base through that time was at most 165,000.²¹ As of May 31, 1999, there were 3317 software titles available on the DVD format and only 471 titles available on DIVX.^{22,23}

In the remainder of this paper, we determine whether Circuit City's September 1997 preannouncement did, indeed, have a chilling effect on DVD sales. We also explore whether the entry of DIVX into the market in the fall of 1998 and the June 1999 official announcement of the demise of DIVX affected DVD sales.

4 Data

The dataset was compiled from several sources, as described below. We collected monthly data from April 1997 (the first month DVD players were available) through June 2000. We have more than three years of data. We now describe the variables used in the study.²⁴

- We have monthly data on the sales of DVD players (denoted SALES) from manufacturers to dealers.^{25,26} Monthly DVD player sales are shown in figure 2. The natural log of this variable is denoted by LSALES.

²¹87,000 DIVX players were sold to retailers in 1998. Although an exact breakdown of the 650,000 DVD and DIVX players sold to retailers in the first twenty weeks of 1999 is not possible, 12 percent of RCA's player sales were DIVX players. (RCA is a firm that produces both DVD and DIVX players) See <http://etown.com/news/articles/rcadvd050799swa.html> for details. Since RCA was the major producer of DIVX players, all major manufacturers produce DVD players and, only a few of these manufacturers produce DIVX players, it would seem that 78,000 (12 percent of 650,000) is an upper bound on DIVX sales for the first 20 weeks of 1999.

²²The source for these data is <http://www.hom.net/wayneb/nodivx.htm>.

²³It is interesting to ask whether the revised DIVX strategy (of marketing its player as an advanced feature of DVD, rather than an alternative standard) was a mistake. Chou and Shy (1993) show in a theoretical model that if a base product is more compatible with a second base product's software, this will actually reduce the software available for the first machine and also decrease its hardware (base product) market share. We leave this question for future research.

²⁴Descriptive statistics are in table 4.

²⁵We are grateful to the Consumer Electronics Manufacturing Association for supplying these data and for supplying the data on prices.

²⁶The sales data also include DIVX sales. DIVX sales began on a trial basis in June in the San Francisco and Richmond Va. markets. According to "How Circuit City Can Fix What Ails DIVX,"

- The variable LPRICE is the natural log of the average monthly price (denoted PRICE) of DVD players to retailers. Monthly prices of DVD players are shown in figure 3.
- One measure of software availability is when a particular studio committed to releasing films in DVD technology and the importance of that studio as measured by the 100 most successful box office releases of all time.²⁷ These data are displayed at the Mr. Showbiz website under the Movie Guide Box Office Leaders category.²⁸ We sorted the movies by studio and added up the box office revenues in order to obtain an impact measure for each studio. (See table 2.) We then constructed the studio impact measure (denoted SOFT) by using the dates at which each studio *committed* to DVD. (See table 3 and figure 4.) The variable LSOFT is the natural log of the studio impact measure.
- Another measure of software availability is the percent of U.S. Box Office top 100 films (adjusted for inflation) that had been *released* in DVD format by each point in time. This measure of software availability is denoted BOA.²⁹ See figure 5.
- q^i is a dummy variable that takes on the value 1 if the data is from quarter i . The quarterly dummies adjust for seasonal effects.
- The dummy variable DIVX takes on the value 1 from September 1997 (the preannouncement date of the DIVX technology was September 8, 1997) through December 1997, slightly before the DIVX demonstration.³⁰ At the time of the demonstration, Circuit City's CEO Richard Sharp embraced DVD technology as the basic technology of the "DIVX enhanced" player.

Computer Retail Week, September 14, 1998, there were very few sales of DIVX players during the trial period. DIVX was launched nationally on September 25, 1998. As noted above in footnote 21, we estimate that the DIVX installed base through the first twenty weeks of 1999 was at most 165,000, while the installed base of DVD was at least 1.9 million through the same period.

²⁷The box office data have been adjusted for inflation. Since DVD sales began in 1997, we use data on box office releases through 1996 for the construction of this variable.

²⁸See (<http://mrshowbiz.go.com/reviews/moviereviews/numbers/top100adjusted.html>).

²⁹Since BOA is a percentage, there is no reason to employ a logarithm in this case.

³⁰The DIVX player was demonstrated January 17, 1998. If we also include the first half of January in this period, by setting DIVX=.5 for January 1998, the DIVX effect is slightly stronger.

- The dummy variable ENTRY takes on the value one for the three month period (October - December 1998) following the entry of DIVX into the market.
- The dummy variable DEMISE takes on the value 1 from June through August 1999. The Demise of DIVX occurred on June 16, 1999, but the announcement had been expected for a couple of weeks.

5 Estimation and Empirical Results

5.1 The Model

Like other electronics products, consumer demand is likely a function of price and the availability of software as well as seasonal effects and shocks (such as the DIVX announcement). We employ the following consumer adoption equation:

$$lsales = \beta_0 + \beta_1 lprice + \beta_2 lsoft + \beta_3 boa + \beta_4 divx + \beta_5 entry + b_6 demise + \sum_{i=2}^4 \beta_{i+5} q^i + \epsilon. \quad (1)$$

The coefficient β_1 is the price elasticity of demand. The coefficient β_2 is the elasticity of DVD player sales with respect to studio support for the DVD standard, while β_3 measures how increases in the availability of box office hits in DVD format affect DVD player sales. The coefficient β_4 , the DIVX parameter, measures how the DIVX preannouncement affected DVD adoption. β_1 should be less than zero while β_2 and β_3 should be greater than zero. β_4 , the DIVX parameter, should be less than zero if the DIVX preannouncement slowed down DVD adoption.

5.2 Estimation Issues

Although we do not estimate the software entry equation (with LSOFT as the dependent variable) or the software supply equation (with BOA as the dependent variable), LSALES is a right-hand side variable in both of these equations.³¹ This is because studios likely made their decision to release films in DVD format in part on the number

³¹We cannot estimate the software entry equation, since no data are available on fixed costs of DVD production. See Gandal, Kende, and Rob (2000) for a case in which data on fixed costs are available.

of DVD player sales. Hence the variables LSOFT and BOA are endogenous. Given that increased DVD sales likely lead to increases in both LSOFT and BOA, the sign on the LSALES coefficient is positive in both the software entry and software supply equations.

We can get a general idea of the nature of the endogeneity bias in equation (1) by supposing that the right-hand side of the equation consisted of only two variables: LPRICE and a single endogenous “software” variable. In such a case, it can be shown that the Ordinary Least Squares (OLS) estimate of the price coefficient is biased towards zero, while the OLS estimate of the software coefficient is biased away from zero. Hence, although it is not theoretically possible to “sign” the direction of the OLS bias in a regression with two endogenous software variables, intuition suggests that the direction will be as in the two variable case.

LPRICE itself may be endogenous, since the firms likely have some market power.³² If price were the only endogenous variable, the OLS estimate of the price coefficient would be biased towards zero.

This discussion suggests that the OLS estimate of β_1 (the price elasticity) is biased towards zero, while β_2 and β_3 (the software availability coefficients) are biased away from zero. OLS bias is addressed by using instruments. To obtain consistent, i.e., asymptotically unbiased estimates of the coefficients, we employed instruments for LPRICE, LSOFT, BOA, the endogenous variables on the right-hand side of (1).

Since DVD technology is based on, in part, VCR, CD and camcorder technologies, we used the installed base of these technologies (denoted VCRINSTALLED, CDINSTALLED, CAMINSTALLED) and the logarithm of installed base (denoted LVCRINSTALLED, LCDINSTALLED, LCAMINSTALLED) as instruments. In particular, DVD, VCR, and CD technologies share sound decoding and interconnection technologies. These technologies were steadily evolving during the late 1990s. Additionally, “S-video” connections became standard on DVD players, VCRs and camcorders. So it is reasonable to argue that there are some scope economies among the technologies and that the installed bases of VCRs, CD players, and camcorders are

³²Like many consumer electronic products, DVD players are fairly standardized products produced by many firms. Nevertheless, given the nascent stage of the industry, it is likely that firms had market power.

appropriate instruments.³³

5.3 Estimation

Table 5 reports ordinary least squares (OLS) results. Table 5 shows that all of the coefficients have the expected sign. The DIVX coefficient is negative and significant at the 90 percent level of confidence, but not statistically significant at the 95 percent level of confidence. (The p-value for the one-sided test is .94.) This suggests that the DIVX preannouncement somewhat slowed down the adoption of DVD technology.

The coefficient on BOA is statistically significant, while the coefficient on LSOFT is fairly large, although not statistically significant. The estimated price elasticity of demand is not statistically significant. Note that the Durbin Watson statistic in table 5 suggests that there is no serial correlation. Nevertheless, we employ Newey-West standard errors which are robust to unknown serial correlation.

The results of the instrumental variable regression are contained in table 6. It is no surprise that the estimated price elasticity is larger (in a negative sense) in this table, relative to table 5. Additionally, the estimated coefficients of LSOFT and BOA are smaller, although still positive. BOA remains statistically significant (at the 99 level of confidence), while the coefficient on LSOFT is much smaller and not significant. This suggests that as the important studios began to release their films in DVD format, the number of consumers adopting DVD players also increased. This suggests that there are positive virtual network effects.

Table 6 also shows that the DIVX preannouncement somewhat slowed down the adoption of DVD technology. Indeed, there is little difference in the estimated coefficient on DIVX between the OLS and Instrumental Variable estimates. In the case of the instrumental variable regression, the coefficient on DIVX is slightly less significant, although it is still significant at the 90 level of confidence. (The p-value for the one-sided test is .93.) The coefficient estimate on the DIVX dummy variable suggests that the preannouncement reduced DVD sales by approximately 20 percent.³⁴

This is a lower bound on the preannouncement effect. Since movie availability (as measured by studios supporting DVD and the number of box office hits released in

³³We use the installed base beginning with the January 1997 period.

³⁴This follows from that fact that $\exp(-.22) = .80$.

DVD format) is endogenous, studio support for DVD might also have been affected by the preannouncement. In order to precisely measure how much faster DVD technology would have been adopted without the DIVX preannouncement, we would have had to estimate the “studio supply” equation. The DIVX effect is likely underestimated for an additional reason. If the DIVX preannouncement was strategic and was based on the early success of DVD, the DIVX variable itself is endogenous. In such a case, it can be shown that without correcting for the endogeneity, the estimated DIVX coefficient is biased towards zero.

In both tables (as expected), there is a large positive fourth quarter effect (sales of consumer electronic durables usually increase significantly in the fourth quarter of the year) and that the second and third quarter sales are higher than first quarter sales (typically the low point of the year). The Durbin Watson statistic in table 6 again suggests that there is no serial correlation.³⁵

Note from both tables that the the demise of DIVX had essentially no effect on DVD sales. In contrast to the preannouncement in September 1997, this announcement had been expected for some time and its effect on sales of DVD players was minimal. The tables show that the entry of DIVX into the market had a positive but insignificant effect on DVD sales. Although it is insignificant, the sign of this coefficient makes sense because DIVX sales are included in DVD sales and this period is where DIVX had its only real success.

The appropriateness of the instruments can be examined by comparing the estimates in tables 5 and 6. As the two tables show, the direction of the OLS bias for PRICE, LSOFT, and BOA is as predicted by theory. That is, the empirical results in these tables are consistent with the theoretical direction of the bias. This suggests that the instruments are working well. First stage regressions of the endogenous variables on the instruments yield relatively high values of R^2 .

We also estimated the model in equation (1) using the variable DVDINSTALLED, which is the installed base of DVD players, and LDVDINSTALLED (which is the natural logarithm of DVDINSTALLED) as instruments instead of (i) camcorder sales and the logarithm of camcorder sales and (ii) CD player sales and its logarithm. The “moving down the learning curve” effect suggests that the inverse of the installed

³⁵In any case, as noted above, we employ Newey-West standard errors.

base can be thought of as a proxy for marginal cost. As the installed base increases, marginal cost declines. Clearly, DVDINSTALLED should be negatively correlated with LPRICE, and positively correlated with BOA and LSOFT. The estimate of the DIVX effect is virtually unchanged in both cases: (i) $\hat{\beta}_4 = -0.21$, $t=-1.45$, (ii) $\hat{\beta}_4 = -0.21$, $t=-1.49$. We don't include DVDINSTALLED and LDVDINSTALLED as instrumental variables in table 6 because there is some concern that these variables may be endogenous, i.e., people learn about DVD players from neighbors or friends who have already purchased DVD players. We include this discussion simply to emphasize the fact that the DIVX effect is very robust to changes in the instrumental variables that are employed.

5.4 Further Discussion

One alternative explanation for our results is that consumer electronic products do not have “Christmas effects” during the first year they are on the market. To explore this issue, we examined the Compact Disc market. Gandal, Kende, and Rob (2000) employed quarterly data for the CD market from 1985 through 1992 and there were clearly Christmas effects in all years. But compact disc players appeared on the U.S. market in 1983; unfortunately quarterly data are not available until 1985.

News accounts, however, all agree that the very high price of CD players in 1983 (\$1000 nominal price, close to \$2000 in year 2000 dollars) sharply limited the market to people in the music industry and a few high-tech junkies.³⁶ In fact, there were only 35,000 sold all year, less than the number of DVD player sold in the first month the product was on the market. Indeed, in his detailed survey, Grindley (1995) lists 1984 as the year in which CD players were launched in the U.S. So a comparison between DVD players in 1997 and CD players in 1983 does not seem appropriate.

Price reductions in CD players to more reasonable levels in 1984 generated greater interest among early adopters, suggesting that the 1984 holiday season would be a good comparison. That is, 1984 was the first holiday season for which a more typical early adopter might have considered buying the product. The trade press unambiguously suggests that there was a 1984 holiday season boom in CD player sales:

³⁶By contrast, DVD players came into the market with a price tag of about \$500.

- “And there are already signs, in the wake of the recent [1984] holiday sales explosion, that projected hardware and software figures are much too conservative. CDs and CD players are being snapped up so eagerly,” according to Thomas Z. Shepard, the division vice president in charge of RCA’s classical Red Seal label.³⁷
- According to Eugene G. Glazer, an industry analyst and vice-president at Dean Witter Reynolds, the compact disc player attained mass market distribution during the 1984 Christmas season when such major department-store chains as Sears, Macy’s, Lechmere, and Bloomingdale’s were stocking CD players. Lechmere reported that sales were strong during the Christmas season, and at the Manufacturers Warehouse, a discount chain in the Boston area, CD players were selling so well that it was hard to keep them in stock.³⁸

This suggests that there was a “Christmas” effect in CD player sales during the first season that CD players were on the market and suggests that there would have been a Christmas effect in DVD player sales in 1997 had DIVX not made its preannouncement.

6 Conclusion

We established that the preannouncement of DIVX slowed down the adoption of DVD technology. While we cannot say whether the preannouncement was strategic or whether the release of DIVX was delayed due to technical difficulties, we have quantified the effect of the preannouncement. While the future of the technology is bright,³⁹ there was certainly some concern at the time that the potential format war would kill it.

In the case of DVD vs. DIVX, the product preannouncement was made by an entrant rather than an incumbent firm and hence was probably not a concern

³⁷See Rockwell, J., “The Invasion of the Compact Discs,” March 10, 1985, *Sunday, Late City Final Edition, Section 2; Page 1, Column 6; Arts and Leisure Desk*.

³⁸See Scott, D., “Listen Closely, and You Can Hear the Ring of Compact Disc Sales,” December 28, 1984, *The Christian Science Monitor, Business Section p.18*.

³⁹The U.S. installed base of DVD players reached eight million units in June 2000.

to regulators.⁴⁰ Additionally, there were clearly consumer benefits from the preannouncement. First, the announcement provided information to consumers about the future entry of a competing standard. Additionally, it's likely that the DVD rental market emerged more quickly due to the DIVX preannouncement; consumers certainly benefited from the rental market.

Nevertheless, the result that the product preannouncement by an entrant had such a large effect suggests that a product preannouncement by an incumbent would likely have a much larger effect; hence the general antitrust concern about vaporware seems justified.

Finally, the Internet played a key role in helping consumers communicate information and coordinate actions. Since many of the early adopters were also Internet users, the large number of active DVD and DIVX web sites conveyed very useful information to potential adopters in real time. The ability of the Internet to convey information quickly and inexpensively may reduce market failures (such as suboptimal standardization and the adoption of an inferior standard) associated with competition between incompatible technologies.

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⁴⁰We thank David McGowan for this point.

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Date	Event
September 1996	Warner and Columbia announce they will release DVD movies
April 1997	First sales of DVD hardware
July 1997	Universal announces it will release DVD movies
August 1997	Disney (Buena Vista) announces it will release DVD movies
September 8, 1997	Circuit City preannounces DIVX format
January 17, 1998	Circuit City announces delay in DIVX launch
April 1998	Paramount announces it will release DVD movies
August 1998	20th Century Fox announces it will release DVD movies
September 1998	Circuit City launches DIVX
June 16, 1999	Circuit City abandons DIVX

Table 1: Key Dates in the DVD Market

Major Studio	Studio Impact Measure
Warner (HBO, New line)	2022
Columbia	1865
MGM/UA	2544
Universal	3702
Disney (Buena Vista)	4422
Paramount	5218
20 th Century Fox	5204

Table 2: Studio Impact Measure

Major Studio	DVD Date	DIVX Date
Warner (HBO, New line)	Before DVD players were available	Did Not Release in format
Columbia	Before DVD players were available	Did Not Release in format
MGM/UA	Before DVD players were available	March 1998
Universal	July 1997	September 1997
Disney (Buena Vista)	August 1997	September 1997
Paramount	April 1998	September 1997
20 th Century Fox	August 1998	February 1998

Table 3: Dates On Which Major Studios Committed to DVD and DIVX

Variable	Mean.	Std. Dev.	min	max
SALES	208,070	194,510	19,146	654,687
PRICE	357.4	103.2	205.0	557.0
SOFT	20,364	3,524	6431	24977
BOA	0.24	0.14	0.04	0.46
DIVX	0.10	0.31	0	1
ENTRY	0.08	0.27	0	1
DEMISE	0.08	0.27	0	1

Table 4: Descriptive Statistics ($N = 39$)

Indpt. Variables	Coeff.	t-Stat
Constant	11.71	1.69
LPRICE	-0.70	-0.79
LSOFT	0.25	1.18
BOA	5.55	3.74
q^2	0.31	1.82
q^3	0.47	3.36
q^4	0.61	5.75
DIVX	-0.23	-1.61
ENTRY	0.057	0.50
DEMISE	0.015	0.17
Adjusted R^2	0.95	
Number of Obs.	39	
DW Statistic	1.77	

Table 5: Ordinary Least Squares Results: Dependent Variable LSALES

Indpt. Variables	Coeff.	t-Stat
Constant	15.55	1.92
LPRICE	-1.20	-1.24
LSOFT	0.18	0.65
BOA	4.71	3.05
q^2	0.25	1.44
q^3	0.46	3.41
q^4	0.58	5.22
DIVX	-0.22	-1.51
ENTRY	0.082	0.60
DEMISE	-0.016	-0.10
Number of Obs.	39	
DW Statistic	1.82	

Table 6: Instrumental Variable Results: Dependent Variable LSALES: Instruments: CAMINSTALLED, LCAMINSTALLED, VCRINSTALLED, LVCRINSTALLED, CDINSTALLED, LCDINSTALLED.

Figure 1. Diffusion Rate of VCRs and CD players
(Note - VCRs were introduced in 1974, CD players in 1983)

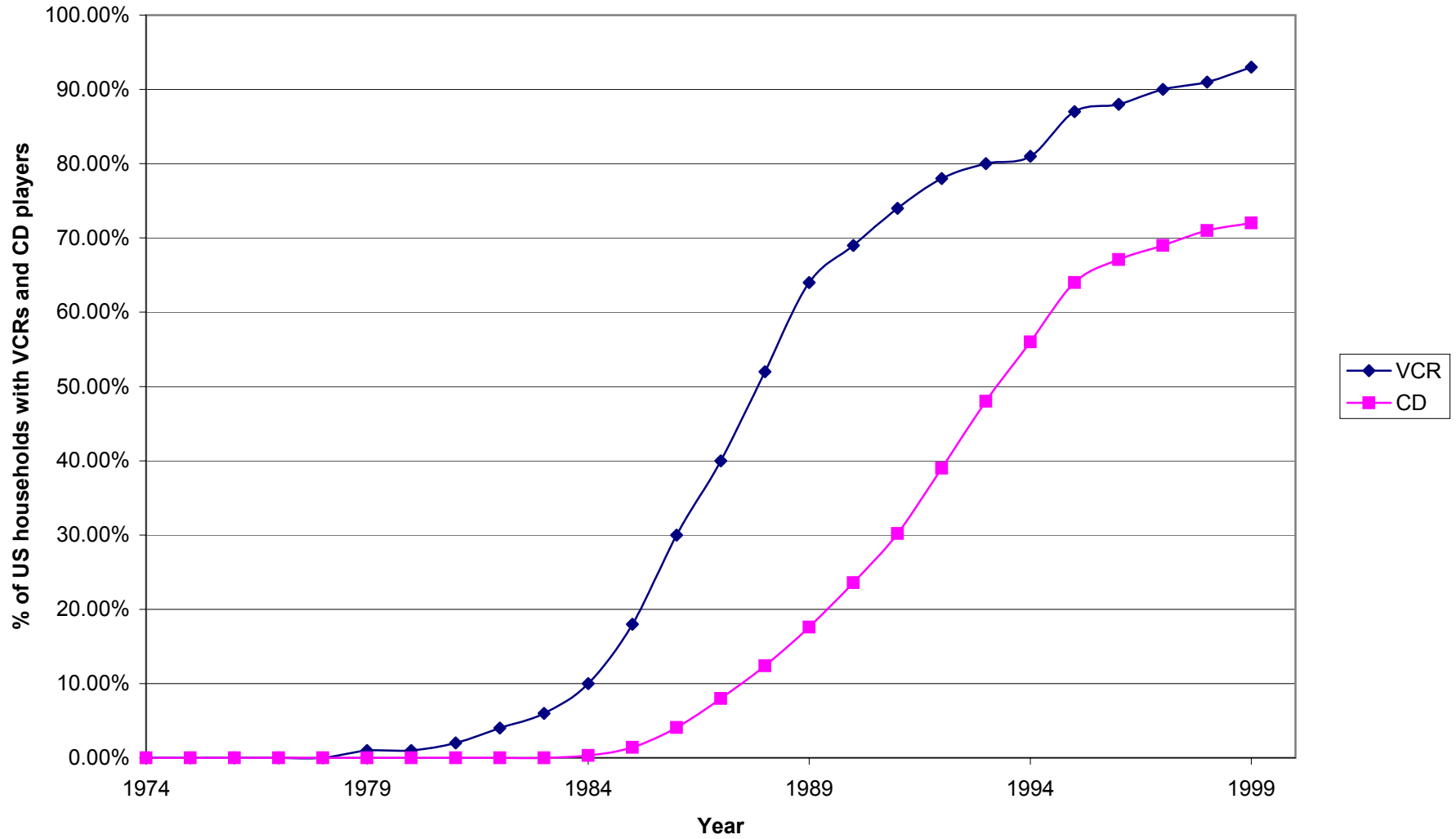


Figure 2. DVD Player Sales

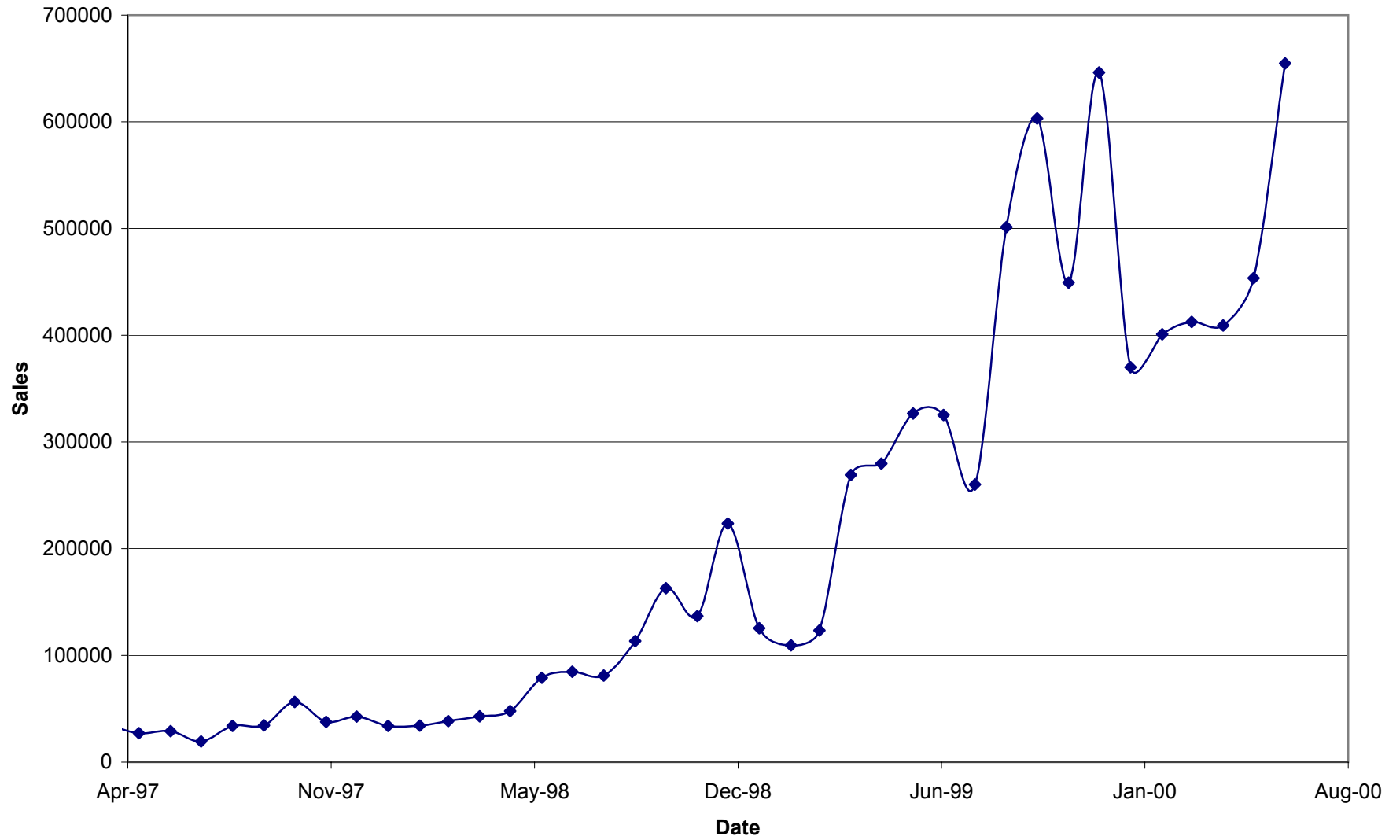


Figure 3. Average Sales Weighted Prices for DVD Players

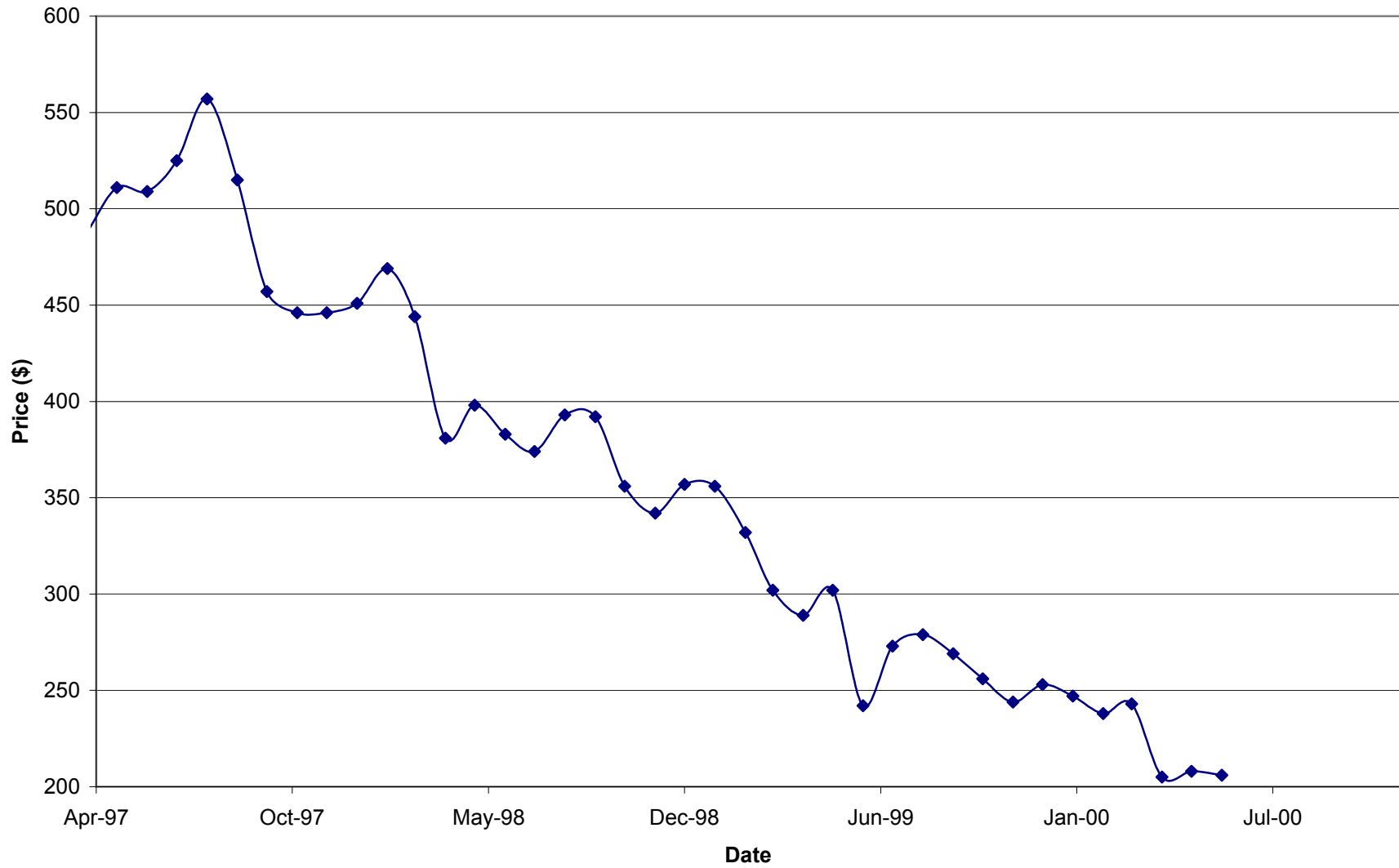


Figure 4. Studio Impact Measure

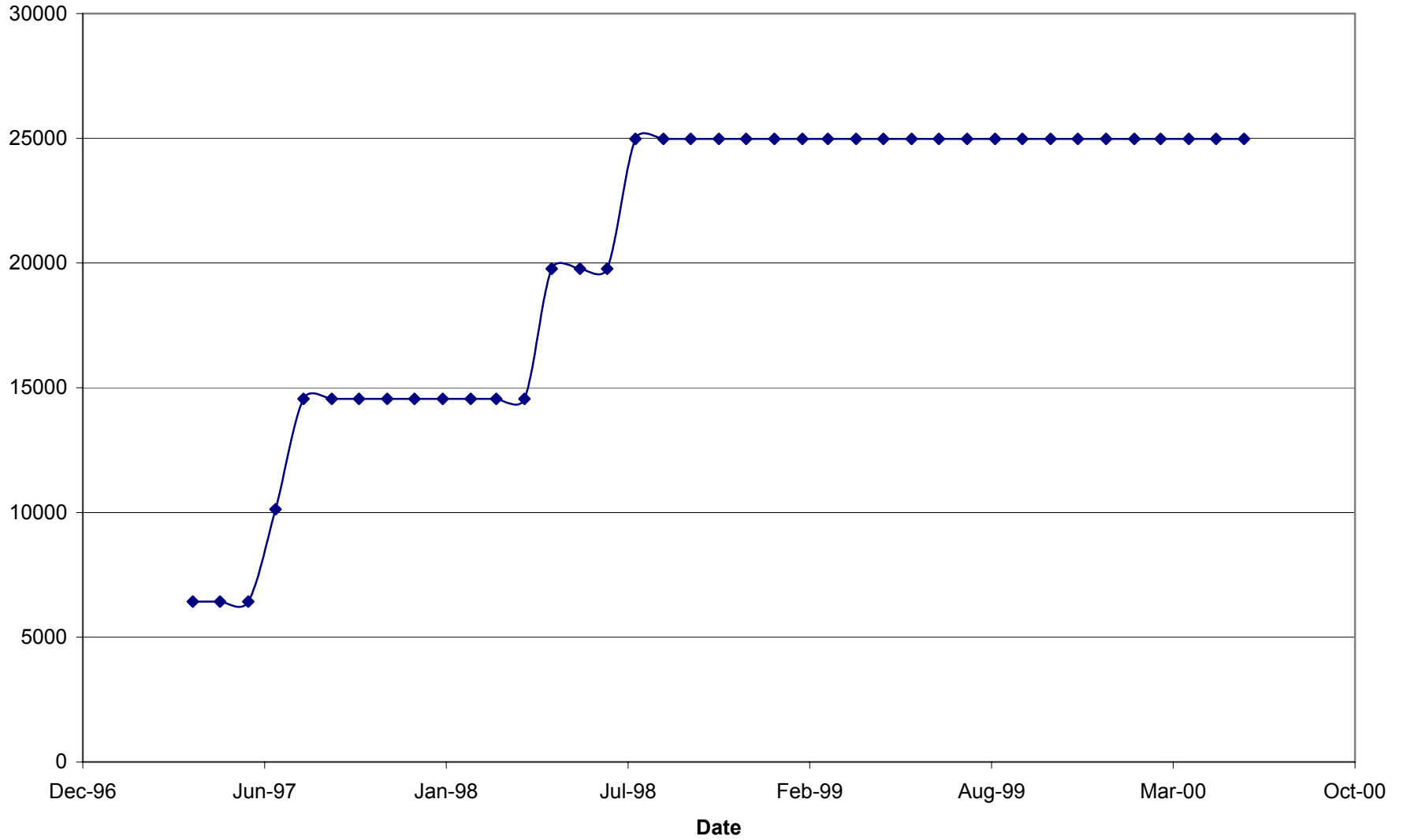


Figure 5. Percentage of top 100 Box Office Hits Released in DVD format

