

No. 2335

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BATTLE?**

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INDUSTRIAL ORGANIZATION



Centre for Economic Policy Research

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Discussion Paper No. 2335
December 1999

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December 1999

ABSTRACT

Network Effects, Standardization and the Internet: What Have We Learned From The DVD Vs. DIVX Battle?*

Two important welfare implications of network effects are that (1) market forces often result in sub-optimal standardization, that is, left alone the market may fail to achieve standardization when it is socially desirable and (2) even if the market settles on a standard, the chosen standard may be inferior. 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. Others have urged regulators not to intervene despite the presence of network effects, unless owners of proprietary standards take strategic actions to influence the adoption decisions of consumers. One action that has raised regulatory (antitrust) concerns is strategic product pre-announcements or 'vaporware'. In this Paper, we empirically test for network effects and vaporware effects in the DVD market and examine the role played by the Internet.

JEL Classification: K21, L82

Keywords: network effects, standardization, product pre-announcements, vaporware

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* The authors thank David McGowan, Shane Greenstein and seminar participants at the Tel Aviv University Conference on Antitrust and Regulation, the University of Haifa Law School Conference on the Commodification of Information, and the Telecommunications Policy Research Conference for helpful comments. This Paper is produced as part of a CEPR research network on The Evolution of Market Structure in Network Industries, funded by the European Commission under the Training and Mobility of Researchers Programme (Contract No ERBFMRX-CT98-0203).

Submitted 11 November 1999

NON-TECHNICAL SUMMARY

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

- (1) market forces often result in sub-optimal standardization, that is, left alone the market may fail to achieve standardization when standardization is socially desirable and
- (2) 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. Others have urged regulators not to intervene despite the presence of network effects, unless owners of proprietary standards take strategic actions to influence the adoption decisions of consumers. One such action that has raised regulatory (antitrust) concerns is strategic product pre-announcements or 'vaporware'.

In this Paper, we empirically test for network effects and vaporware effects in the Digital Versatile Disc (DVD) market and examine the role played by the Internet. 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 pre-announcement of Digital Video Express (DIVX) significantly slowed down the adoption of DVD technology. This suggests that strategic pre-announcements can indeed affect the outcome of a standards competition.

In the case of DVD vs. DIVX, the product pre-announcement was made by an entrant rather than an incumbent firm and hence was probably not a concern to regulators and there were clearly benefits from the pre-announcement. For example, it's likely that the DVD rental market emerged more quickly due to the DIVX pre-announcement; consumers certainly benefited from the rental market.

Nevertheless, the result that the product pre-announcement by an entrant had such a large effect suggests that a product pre-announcement 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 sub-optimal standardization and the adoption of an inferior standard) associated with competition between incompatible technologies.

1 Introduction

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.¹
- 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.² Others have urged regulators not to intervene despite the presence of network effects,³ unless owners of proprietary standards take strategic actions to influence the adoption decisions of consumers. One such action that has raised regulatory (antitrust) concerns is strategic product preannouncements or “vaporware.”⁴

¹This 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.

²Recently, 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 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.)

³Leibowitz 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.

⁴According 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 simply arrive significantly late due to unexpected technical difficul-

In this paper, we empirically test for network effects and vaporware effects in the DVD market and examine the role played by the Internet. 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 indeed 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 briefly discusses vaporware. In section 4, we describe the DVD market. Section 5 describes our data and section 6 contains our empirical results. Section 7 provides a postmortem on the DVD vs. DIVX battle and section 8 provides brief conclusions.

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,

ties and products that arrive late because of strategic preannouncements. Anticompetitive vaporware allegations refer to the latter.

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.

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 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.

3 Vaporware

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 anticompet-

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

itive.” 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.” 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.” The incentive for “vaporware” – strategic preannouncements of products – depends on the presence of network effects.

Anticompetitive vaporware allegations have been leveled at IBM and Microsoft. Claims of anticompetitive vaporware were leveled against Microsoft in the 1994 Antitrust case. 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)). In April 1990, DR-DOS 5.0 was introduced and received positive reviews. Baseman, Warren Boulton, and Worocho (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.⁷ Despite the antitrust concern about vaporware, there is no empirical work on the issue.⁸

3.1 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, Gandal, Kende, Rob (1997), the CD industry, Park (1997), the VCR market, and Shankar and Bayus (1997), the Home

⁷See McWilliams, B., “Industry Group Issues Software Competition Guidelines,” PC World Communications, February 2, 1998 (<http://pcworld.com/news/daily/data/0298/980202164433.html>).

⁸See Levy 1996 for a recent theoretical manuscript on vaporware.

Video Game Industry.

4 The Development of the DVD Market

Throughout the 1990s, video hardware and software manufacturers sought a digital format to replace videocassettes. 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 the DVD specifications. 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. 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 soon to be launched high definition television, through a technology known as progressive scan.

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.⁹ When the first DVD players were released in the U.S. in early 1997, there were forty

⁹IMAX 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 use IMAX films on DVD to show off their systems.

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.

Some studios held back support for DVD because of concerns about whether the technology would succeed and because of concerns about piracy.¹⁰ 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.

Most 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 videocassette 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 1) 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

¹⁰Paramount only committed to DVD provision in April 1998, while 20th Century Fox did so in August 1998. 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.

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.¹¹

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. The most popular DVD chat sites received over 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.) At the same time, new Internet vendors emerged, offering discounted prices on DVD hardware and software sales.¹²

Tempering this early enthusiasm 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 the introduction of DIVX (Digital Video Express).¹³ 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 are unlocked when the user starts playing them, and remain unlocked for 48 hours. Once time expires, the user can replay the disc by contacting a computer operated by a firm working for Circuit City. (This is done via a modem connection that comes with the DIVX player.) Circuit City planned to charge \$4 - \$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.¹⁴

The DIVX announcement shocked DVD enthusiasts. Circuit City was the leading seller of home electronics in the U.S. and could be expected to heavily promote DIVX.

¹¹In early 1999, manufacturers introduced third and fourth generation machines, the latter using progressive scan technology to provide the incredible resolution available on high definition television.

¹²These companies include DVD Express and Netflix.

¹³DIVX is a joint venture between Circuit City and the law firm of Ziffren, Brittenham, Branca & Fischer.

¹⁴Shortly after the DIVX announcement, Netflix began offering DVD rentals through the mail.

It also had commitments from Disney, Paramount, Universal, and Dreamworks to release DIVX discs “day and date” with VHS tapes.¹⁵ (Table 2 lists the major studios and the dates on which they committed to “open” DVD and DIVX.)

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.”¹⁶ 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.”¹⁷ The editorial also noted that while DIVX attempted to “submarine DVD in September of 1997,” DIVX actually embraced DVD a few months later (in January 1998) as a basic component in the DIVX system.

Circuit City had two reasons to prematurely announce DIVX. First, if DVD established itself too 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, electronics shoppers would be drawn to Best Buy, costing Circuit City sales in other categories.

¹⁵At the time of the DIVX announcement, Paramount had not yet committed to DVD.

¹⁶DVD Centre Webpage <http://web.ukonline.co.uk/Members/s.roberts/index.htm>.

¹⁷See the DVD Resource Page at <http://www.dvdresource.com>.

Although DVD supporters were disappointed by the DIVX announcement, investors were reasonably pleased. In the three trading days surrounding the announcement, Circuit City's share values increased by 17.6 percent. In contrast, Best Buy's shares increased by 13.6 percent. Investors might have even reacted more favorably to the announcement had Circuit City offered more concrete plans for DIVX. Indeed, 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.

Finally, 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.¹⁸

With this second announcement, fears of format wars seemed to die down. 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. Indeed, Circuit City had actually been lagging Best Buy ever since its September announcement. Circuit City shares fell by 5.5 percent between the two announcements, while Best Buy's shares increased by 153 percent! Numerous press reports attributed a substantial portion of Circuit City's woes to the unsuccessful launch of DIVX.¹⁹

¹⁸Indeed, some internet reports suggest that most current DIVX owners use their players solely to play "open" DVD disks.

¹⁹According to "Still, business booms for Circuit and others," by David J. Elrich, June 4, 1999 (from e-town.com), Circuit City has invested more than \$207 million on DIVX (as of February 28th, 1999), nearly seven percent of the firm's total assets. The article also notes that quarterly earnings per share are off by 16 cents due to charges for DIVX. During the time that Circuit City was launching DIVX, it had a difficult time digesting its acquisition of the CARMAX Group. This further suppressed the share value.

In the remainder of this paper, we determine whether Circuit City’s vaporware announcement did, indeed, have a chilling effect on DVD sales.

5 Data

The dataset was compiled from several sources, as described below. We collected data from the first week in the second quarter of 1997 (the first period for which weekly sales data of DVD players were available) through the end of 1998.²⁰ We now describe the variables used in the study.

- We have weekly data on the sales of DVD players from manufacturers to dealers. These data typically have very large spikes once every four weeks, suggesting that dealers place major orders once a month. We hence smoothed these data by using five-week moving averages. The variable we employ in the analysis, denoted LSALES5, is the natural log of the five-week moving average of DVD-player sales to retailers.²¹
- The variable LPRICE is the natural log of the average quarterly price of DVD players to retailers.
- Our data on software availability measures (i) when a particular studio committed to releasing films in DVD technology and (ii) the importance of that studio

²⁰Although sales data are available through May 1999, we do not have the DIVX vs. DVD breakdown of these sales. Further, our data on prices are available only through the end of 1998.

²¹We are grateful to the Consumer Electronics Manufacturing Association for supplying these data and for supplying the data on prices. The 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,” *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. During the October-December period, DIVX retail sales were as follows: October 1998 - 7,000, November 1998 - 18,000, and December 1998 - 62,000. Wholesale total DVD sales (including DIVX enhanced players) during the October- November period totaled more than 320,000. Hence, except for December 1998, when wholesale DVD sales exceeded 200,000, DIVX sales were a very small share of the total DVD market. Our results are quantitatively unchanged if we eliminate the December 1998 data, the only period for which DIVX sales are at all significant. Indeed, in such a case, the t-statistic on the DIVX coefficient is -0.33 v. -0.27 for the full data and more significant (a t-stat of -2.07 v. -1.71 for the full data).

as measured by the 100 most successful box office releases of all time.²² These data are displayed at the Mr. Showbiz website under the Movie Guide Box Office Leaders category.²³ 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 1.) We then constructed the software availability measure by using the dates at which each studio committed to DVD. (See table 2.) The variable *LSOFT* is the natural log of our software availability measure.

- 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 the preannouncement date of the *DIVX* technology (September 8, 1997) until the date in which a *DIVX* player was demonstrated (January 17, 1998); at the time of the demonstration, Circuit City’s CEO Richard Sharp embraced DVD technology as the basic technology of the “*DIVX enhanced*” player.

Table 3 summarizes descriptive statistics for these variables.²⁴

6 Empirical Results

We estimated the following consumer adoption equation:

$$LSALES5_t = \beta_0 + \beta_1 LPRICE_t + \beta_2 LSOFT_t + \beta_3 q_t^2 + \beta_4 q_t^3 + \beta_5 q_t^4 + \beta_6 DIVX_t + \epsilon_t. \quad (1)$$

The coefficient β_1 is the price elasticity of demand, while the coefficient β_2 is the elasticity of sales with respect to software (studio) variety. β_1 should be less than zero while β_2 should be greater than zero. β_6 , the *DIVX* parameter, should be less than zero if the *DIVX* preannouncement slowed down DVD adoption.

²²The box office data have been adjusted for inflation. Since DVD sales began in 1997, we use data on box office releases through 1996.

²³See (<http://mrshowbiz.go.com/reviews/moviereviews/numbers/top100adjusted.html>).

²⁴Given that two quarterly lags are necessary for the construction of *LSALES*, there are 89 observations.

Table 4 reports ordinary least squares (OLS) results with an AR(1) term. The AR(1) term was included because we smoothed the sales data using five-week moving averages.

Like many consumer electronic products, the DVD player is a fairly standardized product produced by many firms. Hence we assume that the DVD player market is perfectly competitive and we take “hardware” prices as exogenously given. Thus LPRICE and its lagged values are exogenous.

Since studios likely made their decision to release films in DVD format in part on the progress of DVD sales, the variable $LSOFT_t$ is endogenous. This implies that the OLS coefficient estimates in table 4 are biased. Evidence of OLS bias in table 4 include the fact that the sign of the DIVX dummy variable has the wrong sign and the fact the network effect (as measured by the coefficient on LSOFT) is statistically insignificant.

To obtain consistent, i.e., asymptotically unbiased estimates of the coefficients, we employed exogenous instruments for LSOFT, the endogenous variable on the right-hand side of (1). We used lagged values of the price (LPRICE) as instruments for LSOFT. Lagged values of LPRICE are theoretically appropriate instruments for LSOFT because lower hardware prices (from improvements in technology) increase DVD player sales and hence increase the profitability of providing movies in DVD format.²⁵ The results of the instrumental variables estimation are shown in Table 5.²⁶

Table 5 shows that the estimated elasticity of sales with respect to software (movie) variety (the coefficient estimate of LSOFT) is positive and statistically significant. This shows that there are indeed strong positive virtual network effects. As the important studios began to release their films in DVD format, the number of consumers adopting DVD players also increased.

Table 5 also shows that the DIVX preannouncement had a significant effect in slowing down the adoption of DVD technology. The coefficient estimate on the DIVX

²⁵Given that the price observations are quarterly, we used a relatively long lagged structure (3,6,and 9 nine week lagged values of LPRICE) as instruments. The first stage regression of LSOFT on 3,6 and 9 week lags of LPRICE yielded a reasonably high adjusted R^2 of .83.

²⁶Since, we smoothed the data using five week moving averages, we re-estimated the model with both AR(1) and AR(2) terms. The AR(2) is completely insignificant and the estimates of the coefficients and their standard errors are virtually unchanged with the addition of the AR(2) term.

dummy variable suggests that the preannouncement reduced DVD sales by approximately 24 percent.²⁷ This is a lower bound on the preannouncement effect. Since software availability (as measured by studios supporting DVD) 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 to estimate the “studio supply” equation.²⁸

7 An Update on DVD and DIVX

Although the DIVX preannouncement slowed down the adoption of DVD, DVD is thriving and Circuit City recently decided to abandon DIVX.²⁹ The facts on the ground justified the decision. By the end of 1998, the installed base of DVD players (players shipped to retailers) was approximately 1.32 Million; during the first twenty weeks of 1999, at least 572,000 additional DVD players were sold to retailers, yielding a DVD installed base of at least 1.9 million through that period. The DIVX installed base through the first twenty weeks of 1999 was at most 165,000.³⁰ As of May 31, 1999, there were 3,317 titles available on the DVD format and 471 titles available on DIVX.³¹

²⁷This follows from that fact that $\exp(-.27) = .76$.

²⁸Finally note that there is a large positive fourth quarter effect as expected. It is well known that sales of consumer electronic durables typically increases in the fourth quarter of the year.

²⁹For details, see “DIVX DVD Backers Call it Quits,” by Brooke Crothers, CNET News.com, June 16, 1999 at <http://www.news.com/News/Item/0,4,37894,00.html?st.ne.ni.rel>. She notes that DIVX is “being phased out by its creator and national retailer Circuit City, bringing an end to a technology which thousands of customers have already bought into.”

³⁰Although an exact breakdown of the 650,000 DVD and DIVX players sold 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/readvd050799swa.html> for details. Since all major manufacturers produce DVD players and only several 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.

³¹The source for these data is <http://www.hom.net/wayneb/nodivx.htm>.

8 Conclusion

We established that there are network effects in the DVD market and that the preannouncement by DIVX did slow 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.

In the case of DVD vs. DIVX, the product preannouncement was made by an entrant rather than an incumbent firm and there were clearly benefits from the preannouncement. For example, 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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Major Studio	Software Availability 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 1: Software Availability 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 2: Dates On Which Major Studios Committed to DVD and DIVX

Variable	Mean.	Std. Dev.	min	max
LSALES5	9.413	0.642	8.291	10.797
LPRICE	6.053	0.146	5.826	6.234
LSOFT	9.620	0.427	8.769	10.126
DIVX	0.213	0.412	0	1

Table 3: Descriptive Statistics ($N = 89$)

Indpt. Variables	Coeff.	t-Stat
Constant	28.69	5.52
LPRICE	-3.22	-5.16
LSOFT	.019	0.09
q^2	-0.13	-0.97
q^3	0.038	0.28
q^4	0.19	1.37
DIVX	0.034	0.31
AR(1)	0.79	10.66
adjusted R^2	0.94	
Number of Obs.	88	
DW Statistic	2.15	

Table 4: Ordinary Least Squares Results with AR(1) term: Dependent Variable LSALES5

Indpt. Variables	Coeff.	t-Stat
Constant	-1.73	-0.20
LPRICE	-0.36	-0.38
LSOFT	1.36	4.08
q^2	0.15	0.90
q^3	0.15	1.00
q^4	0.50	3.16
DIVX	-0.27	-1.71
AR(1)	.63	5.51
Number of Obs.	82	
DW Statistic	1.97	

Table 5: Instrumental Variable Results: Dependent Variable LSALES5

