3-1-2010

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March 2010

Forthcoming, *Economic Inquiry*.

Abstract:
Our study extends the empirical literature on whether vertical restraints are anticompetitive. We focus on exclusive contracting in platform markets, which feature indirect network effects and thus are susceptible to applications barriers to entry. Exclusive contracts in vertical relationships between the platform provider and software supplier can heighten entry barriers. We test these theories in the home video game market. We find that indirect network effects from software on hardware demand are present, and that exclusivity takes market share from rivals, but only when most games are non-exclusive. The marginal exclusive game contributes virtually nothing to console demand. Thus, allowing exclusive vertical contracts in platform markets need not lead to domination by one system protected by a hedge of complementary software. Our investigation suggests that bargaining power enjoyed by the best software providers and the skewed distribution of game revenue prevents the foreclosure of rivals through exclusive contracting.

* We gratefully acknowledge financial support from the NET Institute (www.NETinst.org) for this project. We are grateful to Matthew Clements and Hiroshi Ohashi for sharing their data, which we used in an earlier version of the paper. We also thank seminar participants at the 2007 NET Institute Conference on Network Economics, the Western Economic Association International 82nd Annual Conference, the 2007 International Industrial Organization Conference, and UT Arlington, and especially the editor, Tim Brennan, for helpful comments.

1. Introduction

Exclusive contracts in vertical relationships feature prominently in antitrust cases in network industries. At issue are contracts a firm with market power signs with its suppliers or buyers that may limit access to the market by its rivals. We focus on the case in which the firm signs exclusive contracts with upstream suppliers. For example, in the 1980's developers of games for Nintendo's video game console agreed not to provide any titles for other platforms (*Atari v. Nintendo*).[1] In *U.S. v. Microsoft*, the dominant software provider was charged with abusing its monopoly power in its contracts with Internet content providers and independent software developers, with the goal of excluding competitors to Microsoft's Internet Explorer browser.[2] Exclusive contracts such as these are an example of vertical restraints, an area in law and economics that has generated as much controversy as any.

We examine the impacts of exclusionary contracts between hardware manufacturers and software providers in the home video game market. An important feature of the market for video game consoles is indirect network effects (Katz and Shapiro, 1985), whereby the consumer valuation of the primary product (the console, or "platform") increases with the number of complementary goods available (gaming software). If platform providers enjoy indirect network effects, then each may want to prevent suppliers of its complementary good from also supplying competing platforms (Evans, 2003; Régibeau, 2004). When a dominant platform provider and the producers of the complementary goods sign such exclusionary contracts, they burden competing platforms and potential challengers with producing the complementary goods themselves or finding alternative suppliers, which may raise rivals' costs and can diminish competition (Brennan,

[1] 975 F.2d 832 (1992).
[2] 253 F.3d 34 (2001). Other charges regarding exclusive contracts in the case include the allegation that Microsoft projected its market power downstream in its contracts with computer manufacturers to exclude competing browsers from the desktops of new computers.

2007). This is the "applications barrier to entry" at issue in the Microsoft case. Foreclosure of competitors can result (Armstrong and Wright, 2007). Whether survival of a single dominant platform is inefficient or to the detriment of consumers depends on the size of duplicated costs among platforms, the heterogeneity of consumers' preferences among platforms and among the complementary goods, and other factors.

We focus on estimating, determining the causes of, and exploring the implications of indirect network effects for exclusively and non-exclusively provided games. Exclusive titles are those games that can only be played on one system, because the console producer either created the game itself or negotiated an exclusive contract with a video game maker. We examine the sixth-generation videogame console market, which comprises Nintendo's GameCube, Sony's PlayStation2, and Microsoft's Xbox, and uncover an interesting finding: although we find strong indirect network effects, and a large impact of exclusivity on rivals' console demand when most games are non-exclusive, the *marginal* exclusive game contributes virtually nothing to console demand. Exclusivity helps a firm establish market share at first, but beyond a certain point additional locking up of software supply no longer hurts rivals. Consequently, there is no ability to capture ever more console consumers through locking in an increasing supply of exclusive games. Such capture of the whole market is often assumed in discussion or derived in theoretical models of the video game industry in specific or platform markets in general.

By itself, a finding that exclusivity does not affect console demand on the margin does not necessarily imply that there is no consumer harm, for with heterogeneous game quality it may be that a console maker need only lock in the best games to harm the rivals' ability to compete. However, our investigation suggests that exclusionary contracts did not hurt consumers, due to two important features of the videogame market. The bargaining power enjoyed by the best software providers, coupled with the existence of "blockbuster" games that enable competitors to establish market share, prevents the fore-

closure of rivals through exclusive contracting suggested by some models (Armstrong and Wright, 2007). As a result, if exclusive contracts in industries sharing these characteristics allow firms to enter and establish market share but not to dominate the market, then antitrust intervention (as requested, but not granted, in *Atari v. Nintendo*), may not be warranted.

We develop our exposition by first laying out the economic and legal issues pertaining to exclusive vertical contracts in the next section. We describe the home video game market in section 3 and present our econometric model and data in sections 4 and 5, respectively. Our econometric results are in section 6, and we address whether there is an applications barrier to entry in the market in section 7. In section 8, we take a closer look at the nature of software provision, which suggests why the harm that exclusive vertical contracts can do to competition is likely to be limited in the video game market. We conclude and discuss open questions raised by our work in the final section.

2. The Law and Economics of Exclusive Vertical Contracts

Exclusive contracts in vertical markets can be attacked with the antitrust laws in the Sherman Act, if they restrain trade, and the Clayton Act, if they lessen competition.[3] An exclusionary contract between a game console manufacturer and a software provider may be illegal if it harms competition among hardware manufacturers. Harm to competition exists if contracts that lock up popular games prevent the entry (or hasten the exit) of rival consoles that would have been valued by consumers into the hardware market. As a practical matter, discouraged potential entrants may not be observed. Therefore, it is important to examine the impact of exclusive contracts on existing competitors, the approach we take. If we show (as we do below) that exclusive contracting between the

[3] See the working paper for a more complete discussion of the law regarding vertical restraints.

dominant platform and its suppliers has little effect beyond a certain point on existing firms, then it is unlikely that the contracts raise significant entry barriers.

The economic literature considering vertical restraints in markets with indirect network effects is still small.[4] As in the traditional literature on vertical restraints (e.g., Segal and Whinston, 2000), the welfare impacts of vertical restraints in network markets are ambiguous. Church and Gandal (2000) show that foreclosure following a merger in a market with indirect network effects may raise or lower consumer surplus.[5]

Vertical restraints through exclusive contracts in markets with indirect network effects, the most germane literature for our study, are explored in Armstrong and Wright (2007) and Caillaud and Jullien (2003). Equilibrium in these models is sensitive to the choice of parameters and the structure of the model, and we mention a few results only. The former show that when consumers prefer using one platform over another, partial foreclosure equilibria may result from exclusive contracts. The winning platform locks in all software supply, its buyers pay higher prices, and the losing platform survives only by creating its own software. Armstrong and Wright (2007) also show that without intrinsic differentiation among platforms,[6] exclusive contracts lead to a single platform surviving (complete foreclosure), which, though efficient, leaves buyers with no surplus. In the related model of Caillaud and Jullien (2003), an incumbent platform with high enough quality will choose exclusivity to deter entry.

[4] However, the economic analysis of exclusive agreements with suppliers in markets with indirect network effects, as Régibeau (2004) notes, is similar in many respects to traditional analysis of exclusive outlets, exclusive dealing, and foreclosure. See the working paper (Prieger and Hu, 2007) for discussion and citations to the literature.

[5] Foreclosure may increase consumer surplus in the model of Church and Gandal (2000) when the transport cost in consumers' preferences along the Hotelling line differentiating the platforms is relatively high and the foreclosing firm captures the entire platform market. When transport costs are high, to entice all consumers away from the rival platform requires that the foreclosing firm set a low platform price, which benefits consumers.

[6] That is, there is neither an intrinsic benefit from subscription to a platform (apart from consumption of the complementary good) nor a transport cost in consumers' preferences along the Hotelling line for platforms.

In both Caillaud and Jullien (2003) and Armstrong and Wright (2007), the software suppliers have no market power.[7] However, we find evidence of considerable bargaining power on the part of game publishers. We show in section 7 that the top publishers have large market share and games of above-average quality, and are much more likely than smaller publishers are to make their games available for multiple platforms. When large suppliers have enough negotiating power to resist demands for exclusivity from console makers, the anticompetitive impact from the exclusive contracts (mostly signed by smaller suppliers) may be minimal on the margin. We indeed find that the marginal exclusive game title has virtually no impact on console demand.

3. The Market for Sixth Generation Home Video Games

A video game system is a hardware platform that allows demanders (the video game consumers) to trade with suppliers (the video game publishers). Different brands of hardware are not compatible with each other—gamers cannot play software designed for one console on another.[8] Because of the mutual incompatibility among consoles, buying a console is akin to choosing a platform to trade with software providers—a "two-sided market," as it is often called in the literature.

The home video game market is a promising setting to look for applications barriers to entry. Exclusive contracts play an important role in the market and the market is large. Sales of consoles, portable devices, and software in the video game industry total about $10 billion, greater than that of Hollywood's box office.[9] We focus on sixth gen-

[7] Hogendorn and Yuen (2007) allow a complementary good supplier to have market power, but design their model to preclude the possibility of foreclosure.
[8] The exception is the backward compatibility of different generations of hardware produced by the same manufacturer. For example, the software for PlayStation (5th generation) can be played in PlayStation 2.
[9] Entertainment Software Association, "Essential facts about the computer and video game industry," May, 18, 2005.

eration video game consoles, which include Sony's PlayStation2, Microsoft's Xbox, and Nintendo's GameCube.[10]

PlayStation2 entered the US market in October 2000, and Xbox and GameCube appeared one year later. Table 1 shows characteristics of the consoles. Microsoft introduced the console with the best hardware quality, evaluated in terms of processing speed and memory (RAM). Table 1 shows that Microsoft priced Xbox similarly to PlayStation2, while Nintendo set GameCube's price well below the other two. The sixth generation began to be superseded near the end of 2005 when Microsoft introduced the Xbox 360. Our data covers March 2002 to December 2004.

PlayStation2 enjoys the largest amount of available software (Table 2). During our data period, PlayStation2 started with the most software and provided almost half of the new software available in the market. PlayStation2's leading position in software availability strengthened hardware sales, due to the complementary nature of hardware and software, and helps to explain why PlayStation2 was the best-selling console in the market given its higher price and poorer hardware quality. The monthly figures for sales (Figure 1) show that PlayStation2 had the highest console sales until Xbox overtakes its market-leading position in 2004.

There are different sources of revenue for console producers: revenue from sales of consoles and games produced in-house, and license fees and royalties charged to independent game publishers. However, as in most two-sided markets, profits are extracted from one side only (Rochet and Tirole, 2003): console makers hope to earn their profit from the sales of gaming software. In fact, there is evidence that Microsoft and Sony set console prices below marginal cost.[11]

[10] The sixth generation also includes its pioneering member, Sega's Dreamcast console. Sega dropped out of the market in 2000 (before the period for which we have data) and was never a major player, and we do not include Dreamcast in the analysis.

[11] D. Becket and J. Wilcox ("Will Xbox Drain Microsoft?" *CNET News.com*, March 6, 2001) estimate that Xbox initially cost Microsoft $375 per unit. This is the marginal cost of the hardware only, not including

The business model of the gaming industry—hardware as a loss leader for software—explains why console makers charge game developers no access fees and even subsidize creation of games by providing development tools for their platform (Rochet and Tirole, 2003). Table 2 shows that independent software publishers produce the most software for each console (91% of the total), with a far smaller amount created by the console manufacturers. A software publisher may produce its games in-house or contract out to independent developers. Games sold by independent publishers profit the console maker through royalty agreements. The average cost of developing a 128-bit game is about $6 million.[12]

A game publisher will consider a console's current and expected installed base when deciding for which platforms to write a game. Negotiations over license fees and royalties hinge in part on whether the game is exclusive to the console. In Table 2, we also show the proportion of software that is provided exclusively, which is one measure of product differentiation among systems. PlayStation2 has the greatest proportion of exclusive software, showing its bargaining strength with software publishers and developers. Software publishers undertake their own marketing as well through advertising and trade show participation. Costs are certain but rewards are not: only a small portion of games is profitable.[13] The distribution of returns is highly skewed: a mega-hit such as *Grand Theft Auto – San Andreas* has a return more than 40 times the average development cost.

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sales, marketing, or development costs. The price at launch for Xbox was $299. The article also cites a claim that Microsoft's per-unit loss on Xbox is comparable to Sony's loss on PlayStation2.

[12] Southwest Securities, *Interactive Entertainment Software: Industry Report*, Fall, 2000. The figure includes licensing fees paid to content providers. For example, publishers of NBA basketball games pay license fees to the league.

[13] The fraction of software that earns positive profit has been estimated to be in the five to ten percent range (Coughlan, 2004; DFC Intelligence, *The Business of Computer and Video Games*, March 2004, summarized at http://www.dfcint.com/game_article/feb04article.html).

4. Modeling Console Demand

To address whether vertical exclusive contracts in the industry lead to applications barriers to entry, we model the hardware adoption side of the platform market for video games. The techniques we use are now well established in the empirical literature on indirect network effects (Chou and Shy, 1990; Church and Gandal, 1992, 1993; Nair, *et al*., 2004), and we therefore present them here in abbreviated form. Clements and Ohashi (2005) also apply these techniques to the video game industry. Our empirical models are taken from and described more fully in Prieger and Hu (2006), where we derive and estimate a complete model of consumer utility for hardware and software and competitive, free entry supply of software.[14] Here we focus on the empirical part of the model for console demand, which is similar to that of Clements and Ohashi (2005).

The decision tree for the consumers' choice of console has two levels. In the first stage, consumers decide whether to buy a console or to make no purchase. If a household decides to buy, it next chooses among the $J = 3$ alternative brands. The decision tree, along with suitable assumptions for the random elements of consumers' utility, leads to a nested logit estimating equation:

$$\ln(s_{jt}) - \ln(s_{0t}) = c_j + d_t + \beta_p p_{jt} + \delta \ln(N_{jt}) + \sigma \ln(s_{jt|g}) + \xi_{jt} \qquad (1)$$

where s_{jt} is market share, s_{0t} is the market share of the outside alternative (no purchase), and t indexes the months in our data.[15]

On the right side of equation (1), c_j is a dummy variable for brand j, subsuming the impact on demand of the hardware attributes of a system, which do not change within the generation. Term d_t represents a set of holiday and year indicator variables. We al-

[14] Our model for console demand differs in specification from that in Prieger and Hu (2006). We also use a different source for our software data.

[15] When calculating market shares, we assume that each household buys one console only. This model leads to an intuitive substitution pattern: when a household substitutes away from a console it is more likely to buy another console than to buy none. As described in Prieger and Hu (2006), equation (1) is derived from a model of utility maximizing consumers with preferences for hardware and software.

low console demand to differ during peak game purchasing times: June for the start of summer vacation, and November/December for the year-end holiday season. The hardware price is p_{jt}. N_{jt} is the number of software titles available, so that the important parameter δ measures the strength of the indirect network effect. We remove the skewness of the software distribution and reduce the influence of outliers by choosing N_{jt} to enter (1) in log form. In one specification, we also measure available software with a revenue-weighted average.

The term $s_{jt|g}$ is the within-group market share of console j (defined as $s_{jt}/(1 - s_{0t})$); its coefficient σ is the nested logit inclusive value parameter, and represents the correlation between consumer choices within the nest, and thus is bounded between zero and one. Higher values of σ imply that the cross-elasticities are higher among consoles than between a console and the outside good (no purchase). Thus, higher values of σ reflect that when the price of one gaming console rises, there is a greater likelihood that a consumer substitutes toward purchasing another system rather than buying none at all. The error term ξ_{jt} captures the deviation of average hardware quality of console j known to the consumers but not the econometrician, and we assume that (conditional on exogenous observables) it has zero mean. The variable ξ_{jt} incorporates all variables pertaining to consumer perceptions about the hardware brand not elsewhere included in the data, such as advertising and the "word on the street". Because we include console effects, ξ_{jt} represents deviations over time (net of the average tastes for console j) in consumer tastes for the console brand. Allowing ξ_{jt} to vary over time reflects the non-constant nature of advertising and evolving consumer perceptions of the brand.

We estimate the model via an efficient version of linear instrumental variables, a procedure suggested by Berry (1994) that is commonly used in demand estimation of discrete choice models using aggregate data. We use a GMM procedure that is efficient in

the presence of heteroskedasticity and autocorrelation.[16] It is important to note that we do not estimate a fully dynamic structural model here.[17] In particular, hardware demand is based only on the current stock of software available, without explicitly accounting for expected future software variety. These expectations no doubt contribute to the console-specific and console-year fixed effects in the demand estimation.

5. Data and Endogeneity Issues

The data we analyze is for the sixth-generation home video game market. The potential market size for hardware is the total number of households with at least one television.[18] Monthly console sales data from NPD Fun Group, along with the calculated market size, allows us to create all market share variables from March 2002 to December 2004, giving us 34 months of data per console.[19] The start of the sample period accords with Xbox's entrance into the Japanese market, necessary since we use Japanese market data as instruments. The end of the period is chosen to minimize the possible impact on demand due to the anticipated introduction of Xbox 360, the first next generation system.[20] Summary statistics for the data are in Table 3.

Monthly hardware prices (average of weekly prices) are from the websites of major retail chains.[21] The game title data for software is also from the NPD Fun Group, and includes all games published for the three consoles. For each title, the data include the publisher, date of issue, and monthly revenue by console. When constructing the soft-

[16] See Prieger and Hu (2006) for a discussion of why autocorrelation may arise in this model. We use the two-step efficient GMM estimator, where the covariance matrix used for second-step estimation and calculation of standard errors is robust to heteroskedasticity and autocorrelation. The Newey-West kernel (with bandwidth set to two lags) is used to correct for autocorrelation.
[17] See Lee (2007) for a preliminary attempt at dynamic empirical modeling of the video game market.
[18] Television ownership data are from the US Census Bureau's 2004-2005 *Statistical Abstract of the United States* (data for 2002).
[19] The NPD console sales data were acquired from gaming news site PCvsConsole.com.
[20] Microsoft announced Xbox 360 in May 2005 and launched it in November 2005. Since we do not model forward-looking behavior in our model, we end our sample period well before Xbox 360 was announced.
[21] Prices are from CompUSA, Electronics Boutique, Target, Game Stop, Fry's Electronic, Toys "R" Us and KB Toy Works. Prices are adjusted with the CPI for "all urban consumers, all items".

ware variety variable N_{jt} from these data, we allow the possibility that software is "perishable" in the utility function of consumers. Instead of adopting the measure used in Clements and Ohashi (2005) and other studies of *total* software variety, accumulated since the introduction of the console, we investigate whether potential consumers care more about recent titles. Thus, we split software into two categories: new titles (those issued in the current and previous three months) and the rest of the accumulated (older) titles. Splitting out older software is suggested by evidence that the life cycle of a video game title is often brief, with more than 50% (and sometimes as much as 80%) of sales typically occurring during the first three months after its release (Coughlan, 2001, 2004).[22]

In the rest of this section, we address the potential endogeneity of several of the variables appearing on the right side of the estimating equation for hardware adoption and discuss our solutions. The explanatory variables we suspect may be correlated with the error term in (1) are within group share, console price, and software variety. The endogeneity of within group market share, $s_{jt|g}$, arises by definition: it contains the dependent variable, s_{jt}. Console price p_{jt} is most likely positively correlated with the unobserved attributes ξ_{jt} because an improvement in brand image will increase consumers' willingness to pay for consoles, which affects prices in the market. Finally, the endogeneity of game variety arises from the indirect network effects: positive shocks to hardware demand increase both the installed base and software provision.

To control for endogeneity of console price, we use the retail console price in Japan.[23] Prices in Japan are correlated with US prices because both depend on production costs (all consoles are manufactured at the same location). However, Japanese prices will

[22] In our sample, an average of 59% of total revenue is gained by the end of the first three full calendar months after issue of a title. Almost one-fifth of titles gain more than 75% of their total revenue during the same period. These calculations include only titles out for at least a year.
[23] Japanese console prices are from *Nikkei News*; sales figures are from industry-research firm Media Create.

not be correlated with unobserved console characteristics ξ_{jt} in the US hardware equation if Japanese gamers have different tastes for games and systems. The pattern of console sales in the Japanese market shows evidence for differing tastes. For example, unlike its strong performance in the US market, the sales of Xbox lag in the Japanese market, even with a similar price and game variety comparison to GameCube as in the US market. Johns (2006) attributes the widely differing market shares in US and Japan to cultural biases and specificity, and argues that the Japanese video game market is isolated from the US market.[24] We also instrument for prices with the Japanese-US exchange rate. Since some of the consoles were manufactured in Japan, fluctuations in the exchange rate should affect retail prices in the US (correlation between the exchange rate and US retail prices is 0.70).[25]

To control for endogeneity of the within group market share, we use the revenue-weighted average age of software available for a console. An older average age of titles signals the presence of popular, long-lived games for a platform, which increase market share among consoles (Clements and Ohashi, 2005). Given the indirect network effects, more software would have been available in the past when the installed base of consoles was greater, and so the average age of software variable is also a relevant instrument more generally if past console sales affect present console demand. Software variety is instrumented with the accumulated game variety in Japan.[26] Japanese game variety is correlated with US game variety (Pearson's $r = 0.90$), because (differences in tastes notwithstanding)

[24] Furthermore, conventional wisdom in the trade press holds that Japanese players tend to prefer more relational games, titles based around "cute" characters, continuing story lines, and fantasy-based games, whereas US players tend to prefer more realistic, action-oriented, violent games with exciting graphics and do not demand continuity in the story line between game editions. See, for example, the article "Xbox Courts Japan" at JapanInc.com (http://www.japaninc.com/article.php?articleID=10). Johns (2006) also quotes a game publisher on the differences between Japanese and western markets: "There are huge cultural differences so there isn't really any reason why games should have anything in common".

[25] We use the current exchange rate instead of the lagged rate used by Clements and Ohashi (2005) because the relevant Yen cost at the time of sale from a Japanese wholesaler or factory to a US retailer is the opportunity (replacement) cost of the console, not the embedded, sunk production cost.

[26] The data are from *Famitsu*, a weekly magazine covering the Japanese video game market.

many game titles from Japan are provided in both countries due to scale economies, given that much of the cost to produce a title is up front for development. However, Japanese game variety is not correlated with ξ_{jt} if demand shocks in Japan are uncorrelated with demand shocks in the US.[27] In addition to the instruments above, we follow Clements and Ohashi (2005) and use console age (the number of months since sales began) and a full set of squares and interactions among all instruments.

6. Basic Empirical Results

We now present the results from the GMM estimation for console demand (Table 4). In this section, we confirm the presence of indirect network effects from software, and show that older titles play little role in console demand. In the next section, we further break new software down into exclusive and non-exclusive titles to address directly the role that exclusive contracts might play.

To allow the network effects from older games to differ, while retaining the possibility that only the sum of all games (older and recent) matters, we replace $\delta \ln(N_{jt})$ in the estimating equation (2) with the transformation $f(N^R_{jt},N^O_{jt};\delta_1,\delta_2)$, where f is defined by

$$f(w_1,w_2;\delta_1,\delta_2) = \delta_1 \ln(w_1) + \delta_2 \ln(1 + w_2/w_1) \qquad (2)$$

and N^R and N^O are the stocks of recent and older titles, respectively. In this specification, there are no network effects from older titles when $\delta_2 = 0$, and only the sum of all games

[27] If console demand shocks in the US stimulate software titles for the US market, which in turn (due to scale economies) are also introduced in Japan, then Japanese game variety may not be an exogenous instrument. Thus, we pay careful attention to the statistical exogeneity tests in our regressions, which reveal no cause for concern on this point. There is an important asymmetry in the international video game market that bolsters the case for using Japanese game variety to instrument for US variety: Japanese games do well in the US, but US games typically fare poorly (if introduced at all) in Japan. Thus, "the number of American games that are published at all in the Japanese console market is minor" while for Japanese games, "the games are often developed to be sold both in and outside Japan" (Kiri, 2003). See also Glicker (2006), who notes that in 2005, there was only one US-made title on the top-100 seller list in Japan.

$N = N^O + N^R$ matters when $\delta_1 = \delta_2$. Rejecting that $\delta_1 = \delta_2$ therefore shows that not only the number but the age of game titles influences console demand.

We begin by examining the relevancy and explanatory power of the instruments in Estimation 1, the nested logit model estimated by GMM. In Table 4, we present a Wald statistic to test the relevancy of the instruments.[28] The Wald test strongly rejects underidentification, suggesting that the instruments are relevant. We also calculate Shea's (1997) partial R^2 from the first stage regressions for each endogenous variable. The partial R^2 is a measure of the explanatory power of the instruments, accounting for correlation among the endogenous variables and among the instruments, and helps to assess whether our instruments are weak. Even the lowest of the partial R^2 statistics for the endogenous variables, that for the within group share (0.44), does not indicate cause for concern due to weak instruments.[29] Since we have more instruments than instrumented variables, we can also make use of an overidentification test (Hansen's J statistic) to assess the validity of the instruments.[30] The J statistic does not reject that the instruments are valid.

The coefficients for price, recent software variety, and within group market share are all individually significant. The coefficient for the transformation of older software, δ_2, is not significant, implying that there is no indirect network effect coming from older game titles. The Anderson-Rubin F statistic, which is robust to weak instruments, shows

[28] The Kleibergen-Paap (2006) *rk* statistic is a Wald test of the null hypothesis that the matrix of reduced form coefficients is underidentified (i.e., is rank-deficient). The *rk* statistic is robust to non-i.i.d. errors, and generalizes the Cragg and Donald (1993) test for underidentification with multiple endogenous variables. Rejection of the null is evidence that the instruments are relevant and that the model is identified.

[29] There is no simple threshold for partial R^2 when assessing instrument strength. However, in all of the cases in Shea (1997) where the finite-sample distribution of 2SLS diverges from the asymptotic distribution, as measured by the empirical size (to two decimal places) of the *t*-test for the coefficient on the endogenous variable in the second stage equation, the partial R^2 was much lower than 0.44.

[30] The J statistic for the Hansen-Sargan test of the overidentifying restrictions imposed by the GMM estimator. The null hypothesis is that the instruments are exogenous (i.e., uncorrelated with the error term) and are correctly excluded from the estimated equation. A rejection of the null hypothesis of the test casts doubt on the validity of the instruments. Our test statistic is robust to heteroskedasticity and autocorrelation.

that the coefficients for price, software variety, and within group market share are jointly significant.

The estimated impact of price is negative, so that the estimated demand curve for consoles is downward sloping in hardware prices. The average price elasticity of console demand (also reported in Table 4) is -2.2, in the elastic region of demand, as the theory of pricing with market power suggests should be the case.[31] Equality of coefficients δ_1 and δ_2 for games is rejected at better than the 1% level, which rejects the hypothesis that recent and older titles are interchangeable in the demand function. Demand is increasing in recent software variety, as expected from the indirect network effects, with an elasticity of 0.95.[32] The estimated elasticity from changes in older software is insignificant, as we expected.[33] We get the same outcome if we let both N^R and N^O enter the specification in simple log form (results not shown): only recent software matters. We provide a more detailed discussion of the elasticities below.

In Estimation 2, we estimate the model via OLS, treating the regressors as exogenous.[34] This allows us to see how much the endogeneity affects the estimates. The same signs are present for all coefficients, although software variety is not as significant and none of the implied elasticities are significant. Thus, the instruments are able to identify a role for software variety in Estimation 1 that endogeneity obscures in Estimation 2. The OLS estimation also allows us to look for evidence of weak instruments, which can show up as standard errors that are much larger in Estimation 1 than those from Estima-

[31] The own-price elasticity of demand share s_{jt} with respect to price p_{jt} is $\beta_p(1-\sigma s_{jt|g} - (1-\sigma)s_{jt})$. All elasticities are calculated as average elasticities in the sample.

[32] The elasticity of share s_{jt} with respect to recent software variety N^R_{jt} is $\delta_1 - \delta_2 r_{jt}(1-\sigma s_{jt}|_g - (1-\sigma)s_{jt})/(1-\sigma)$, following the notation of (2), where r_{jt} is the ratio of software titles that are older.

[33] The elasticity of share s_{jt} with respect to older software variety N^O_{jt} is $\delta_2(1-\sigma s_{jt}|_g - (1-\sigma)s_{jt})/[N_{jt}(1-\sigma)]$, following the notation of (2).

[34] Our OLS estimations use the same formula for robust standard errors as the GMM estimations.

tion 2 are. The comparison of standard errors reveals no suggestion of weak instruments.[35]

We tried other division points between older and newer titles, splitting at six and nine months as a robustness check. In each case, the coefficients display the same pattern of statistical significance, and the share elasticity from changes in older software is negligible and insignificant. The price and recent software elasticities vary among the estimations, but the ratio of software elasticity to price elasticity is about the same as in Estimation 1.[36] For further robustness checking, in an earlier version of the paper we estimated a set of models in which we relaxed the assumption that households buy only one console each. The results are robust to the size of outside alternative market share.[37]

7. Is There an Applications Barrier to Entry?

Can a console maker's exclusive contracts with video game creators create an applications barrier to entry in the console market? Barriers to entry based on software applications for a system received much discussion in the Microsoft antitrust case (Gilbert and Katz, 2001). The government contended in the case that due to the high development costs of making software applications, programmers would not create applications for an operating system unless there were already a large installed base of users. In addition to the "natural" barriers to entry stemming from the network effects inherent in the market, the government also attacked Microsoft's contracts with upstream suppliers, which included inducements to exclude competing browsers. In contracts with Internet content

[35] The one diagnostic for weak instruments we tried that gave opposite results from the partial R^2's, the *rk* Wald statistic, and comparison of standard errors is an LM form of the Kleibergen-Paap (2006) statistic. The weight of the evidence remains against weak instruments, and, regardless, the *F* statistic in Table 4 showing the significance of the endogenous variables is robust to weak instruments.

[36] The ratio shows the relative effectiveness of pricing and software provision strategies: it measures the percentage reduction in console price that has equivalent effect on demand as a one-percent increase in software variety. In Estimation 1, this ratio is 0.4. With an assumed six month life for software, the ratio is also 0.4. With a nine month life, the ratio is 0.3.

[37] The price and software variety coefficients were almost completely insensitive to whether the installed console base depreciates at an annual rate of 0%, 10%, 20%, or (as an extreme) 100%.

providers, Microsoft traded placement on the Windows desktop in exchange for web sites optimized for Internet Explorer.[38] In agreements with third-party software developers, Microsoft traded preferential support and seals of approval in exchange for making web-enabled applications reliant on Internet Explorer. In theory, both of these attempts at vertical restraint through exclusivity could have further heightened the applications barrier to entry.

In the video game industry, if a console has few games created for it, it will die quickly in the market place, as happened in the sixth generation with Sega's Dreamcast and in previous generations with the NEC TurboGrafx-16, the SNK Neo Geo, and the Atari Jaguar. The question of antitrust concern is then whether creating games exclusively for one system, a form of "complementary market monopolization" (Brennan, 2007), locks in enough demand to hinder entry by competitive systems or hasten exit of existing systems. For this strategy to be most successful, indirect network effects must be present: the availability of software must increase hardware demand, which we have shown to be the case in the previous section. We now investigate whether platform providers can exploit the network effects through the creation of exclusive games.

We begin by taking a closer look at the results of the demand estimation, focusing on the firms' ability to increase demand by encouraging the growth of software variety. We show the elasticity of console demand share with respect to software variety implied by Estimation 1, broken out by console and year, in Table 5. The software variety elasticities are in the range 0.7-1.1. The elasticities for PlayStation2 and GameCube rise slightly over the years, and so does the average for all consoles. Since the hardware could not be improved during the generation, perhaps the rising software elasticity reflects that games became increasingly valuable in spurring sales of consoles as develop-

[38] The contracts required the content developers to use Microsoft technology such as dynamic HTML and ActiveX or other differentiated content that would not be available (or available at a lower quality) with competing browsers (*U.S. v. Microsoft*, Civil Action No. 98–1232 (TPJ), Court's Findings of Facts, U.S. District Court for the District of Columbia, November 5, 1999, at 322).

ers created games that were ever more desirable. This suggests a role for console makers to use exclusive games to attract buyers to their own platforms, and potentially to harm rivals' chances of survival in the market (Caillaud and Jullien, 2003; Armstrong and Wright, 2007). However, the inference assumes that the demand-stimulating effects of software variety are the same for exclusive and non-exclusive game titles.

Exclusionary behavior through game provision will be more successful if the indirect network effects are strong for games available only on one console. Sony, in particular, has actively sought exclusivity, with over half of PlayStation2's games unavailable elsewhere (Table 2). To see how the impacts on console share differ from games exclusively available for a single system and games available for multiple systems, we re-estimate the hardware demand equation splitting recent software titles into exclusive and non-exclusive games (Estimation 3 in Table 6). We let exclusive and non-exclusive recent titles enter the estimating equation through transformation $f(N^{RN}_{jt}, N^{RE}_{jt}; \delta_1, \delta_2)$, as defined in (2), similar to how we separated recent from old software in Estimations 1 and 2, where N^{RN} is the count of non-exclusive recent titles and N^{RE} is exclusive recent titles.

Estimation 3 shows that exclusive software titles contribute virtually nothing to the indirect network effects from games in console demand. Equality of coefficients δ_1 and δ_2 is rejected at better than the 1% level, which rejects the hypothesis that exclusive and non-exclusive titles are interchangeable in buyers' utility functions. The coefficient δ_2 is not significant and the elasticity of console demand with respect to recent, exclusive titles is close to zero. Only non-exclusive recent games are significantly and positively associated with console share.[39] This may limit a console maker's options to "starve" its competitors by putting many exclusive games on the market, because such games appear not to materially increase the installed base of the maker's own console. In this estima-

[39] If we let both N^{RN} and N^{RU} enter the specification in simple log form, we get the same result: only recent non-exclusive software matters.

tion, the coefficients and elasticities for price and within group share are again significant, and older game titles again have no significant effect on demand. The various diagnostic statistics and comparison of standard errors to the corresponding OLS estimation (Estimation 4 in Table 6) look about as strong as in Estimation 1.

Our finding that demand is virtually insensitive to the availability of exclusive games appears to contradict some of the conventional wisdom about the home video game market, and bears further investigation. For example, undoubtedly some consumers buy an Xbox mainly to play *Halo*, a PlayStation2 to play *Grand Theft Auto: San Andreas*, or a GameCube to play *Super Smash Bros. Melee*, to mention each system's most popular exclusive title. However, note that by relying on variation in software provided over time and across consoles, our elasticity estimate effectively measures the impact of the marginal title. The few blockbuster games in existence are inframarginal titles, the revenue outliers from the high-variance, skewed distribution of returns to software creation.[40] Our low elasticity estimate shows that a firm should not expect further exclusivity, beyond that seen in the data, to increase console demand. We explore why exclusive games have such a small impact on demand in the concluding section.

Although the marginal exclusive title cannot heighten entry barriers, some of the inframarginal exclusive titles may actually help overcome (rather than erect) entry barriers. Koski and Kretchmer (2004) point out that game provision need not lead to insuperable entry barriers when there is a critical mass or threshold in the indirect network effects, beyond which additional games increase consumer utility little. The sales distribution of game titles is highly skewed: each system has a few blockbuster games that earn the bulk of the revenue. As long as a critical mass of superstar games is available for a console, it will overcome any entry barriers and survive in the market. In Table 7, we show the 13 games that earned $125 million or more during our sample period (the aver-

[40] The skewness of per-title software revenue in our data is 7.1.

age revenue for all the other titles in the data is only about $10 million). The table shows that despite the huge revenue the Grand Theft Auto games (which were initially exclusive titles) earned for PlayStation2, Microsoft was able to carve out enough market share for Xbox to be viable by providing its exclusive Halo titles. It is also interesting to note that over half the titles among the top 13 are non-exclusive, and therefore do not lock players into any single platform.

To address the inframarginal impact of software exclusivity on console demand suggested by these data, in Estimation 5 we add a regressor A_{jt} for the fraction of game titles in the market that can be played on the console.[41] Revenue from the current and three previous months are used to weight the fraction. A_{jt} measures how much of the complementary good market is available to the owner of a particular console. Variables N^{RN}_{jt} and N^{RE}_{jt} are left in the specification, to control for the indirect network effects stemming immediately from the number of titles available. Exclusivity by the other console makers lowers A_{jt}. Thus, the coefficient on A_{jt} is the impact on a console's demand (additional to the traditional indirect network effects) of decreasing the exclusivity of software offered for rival consoles.

There is a great deal of variation in the software availability fraction: A_{jt} ranges from 36% to 83%, and does not follow a simple time trend. To differentiate the marginal and inframarginal impacts of exclusivity, A_{jt} enters the specification in a linear spline with a knot at 75%.[42] The results from Estimation 5 (Table 6) are similar to that of Estimation 3 for the other regressors—in particular, exclusive titles still have no significant effect on demand—and we do not discuss them further.

[41] The splined variable is treated as endogenous. We do not add additional instruments, because the various diagnostic statistics (in particular the Shea R^2) do not suggest the need. Nevertheless, we also estimated the model adding an analogously constructed (with the exception that we do not weight by revenue) variable from the Japanese market; results were close to that of Estimation 5.

[42] Placing the knot anywhere above the median of 70% yields the same qualitative results and significance.

The software availability fraction, when below 75%, has no significant impact on console demand. This finding reflects our result from Estimation 3 that marginal increases in exclusivity do not affect console demand. More interesting is that when A_{jt} is above 75%, software availability has a large and significant impact on demand. The estimates imply that a decrease in game availability of 10 percentage points (say from 100% to 90%, or 85% to 75%) due to exclusivity lowers average console demand share by about 38%.[43] Thus, exclusivity can help a firm take a lot of demand from rival consoles at first, but eventually additional locking up of software supply no longer stimulates console demand.

8. Characterizing Exclusivity in Contracting

Why is the impact of the marginal exclusive game title so minimal, when it appears that a little exclusivity can take much market share from rivals? An examination of the characteristics of exclusive and non-exclusive titles in Table 8 hints at the answer. In our discussion, we focus on the two market leaders, although statistics for GameCube are also in Table 8. Despite the presence of blockbuster exclusive games among the top earners (Table 7), both PlayStation2 and Xbox garner most of their revenue from non-exclusive titles. For PlayStation2, this is true even though there are more exclusive games than non-exclusive games.[44] Looking at average and median sales per title makes it clear that not all games are created equal: non-exclusive games are more profitable on average. A battery of hypothesis tests, also reported in Table 7, generally confirms that the mean and median revenue per title is higher for non-exclusive games. Furthermore, for PlayStation2 non-exclusive games earn their revenue quicker than do exclusive games,

[43] Market shares for a firm are calculated assuming only the offerings of the other firms changed, and are averaged over the sample.

[44] It is also true even if the Grand Theft Auto games, which were available for Playstation2 long before they were available for Xbox, are classified as exclusive. None of the discussion about mean and median revenue per title in this section would change upon reclassification.

as measured by the percentage of total revenue earned in the first four months of release, so that non-exclusive titles look even more attractive in present-value terms.

Compared to third-party exclusive games created by independent publishers, exclusive, self-provided games garner more revenue on average. The hierarchy, then, is that third-party non-exclusive games earn the most money on average, followed by self-provided games and then third-party exclusive games. The implication: in general (but with notable exceptions provided by inframarginal games) only the lowest quality, least desirable games are available for exclusive contracting with third party publishers. Why?

The game development and publishing industry has changed greatly from the third-generation days of Nintendo's exclusive contracts with suppliers, in which a developer's entire line of games was locked into a single console. One industry marketing report points out that the spiraling cost of video game creation requires unit sales levels so large that only one in twenty titles breaks even.[45] Thus, software publishers simply cannot afford to lock themselves into a single platform, and publishers with enough market power of their own resist signing exclusive contracts.

It appears that there are game publishers with enough market clout to bring substantial bargaining power to the table in negotiations with console makers. In Table 9, we show the characteristics of software produced by the top seven publishers, including console makers Sony, Microsoft, and Nintendo. A full quarter of industry software revenue in our data is garnered by Electronic Arts (EA). EA also accounts for over half the games on the list of top selling titles in Table 7. One reason is that EA's games are of high average quality.[46] Their average quality score (shown in Table 9) is almost 25% higher than the average of publishers outside the top seven. EA's games also earn more

[45] DFC Intelligence, *The Business of Computer and Video Games*, op. cit. Production of modern video games rivals Hollywood in the size and scope of the endeavor. Creating a game requires teams of game designers, programmers, graphic artists, audio technicians, and producers.
[46] The quality scores are from gamerankings.com, and are averages of online reviews from dozens of independent sources online.

revenue per title (nearly $17 million) than any other independent publisher in the top group, and over three times the average of other publishers. Part of EA's success in recent years is due to its leveraging of its market power to secure exclusive contracts of its own in the content market. For example, in 2004 the NFL granted EA a five-year exclusive right to its teams and players for use in video games. EA's desirable products give them the bargaining power to refuse exclusive contracts with console makers. Eighty-seven percent of their titles are available on at least two platforms, the highest percentage of any in the top group and much higher than the mass of other publishers. The other large independent publishers, Take 2, Activision, and THQ, also have a high fraction of their titles (77 to 81%) available for multiple platforms.

Implicit in models of exclusive contracting in platform markets is the assumption that the product attributes of the complementary good are the same whether vertical restraints are imposed (Armstrong and Wright, 2007; Caillaud and Jullien, 2003). We have shown empirically that the ability of the leading complementary good suppliers to resist exclusivity can greatly alter the market outcome from the models' predictions of foreclosure and entry deterrence.

9. Conclusion

We find that allowing exclusive vertical contracts in platform markets need not lead to a market structure dominated by one system protected by a hedge of complementary software. We thus extend the growing empirical literature that finds that anticompetitive outcomes need not follow from vertical restraints (Snyder, 1995; Cooper *et al.*, 2005). Indirect network effects are present and strong in the home video game market—a fact that, by itself, suggests exclusive contracts may lead to foreclosure of the incumbent's rivals. Indeed, starting from a point of little exclusive contracting, controlling more of the software market garners market share from rivals, up to a point. In some in-

dustries, it may be that what looks like a small amount of exclusivity by our measure would be enough to foreclose competitors from all the important sources of supply of the complementary good. However, two important features of the video game market prevent a monopolized market outcome or evidence of consumer harm, even in the presence of vertical restraints. When software exclusive to one platform is of lower quality or otherwise of less interest to buyers than software available for multiple platforms, a platform provider has limited power to take additional market share by monopolizing the complementary good market. Furthermore, when the distribution of software sales is highly skewed, then an entrant platform can thrive as long as it produces a few exclusive blockbuster titles and take some market share from its rivals. These features are lacking in much of the theoretical work on two-sided markets to date, to our knowledge.[47]

There is no evidence, therefore, that allowing additional exclusive vertical contracting would harm competition or welfare in the video game market. In fact, by alleviating the typical problems associated with free riding by rivals on inspecific investment, exclusivity in supply probably enlarged consumers' choice of consoles. Microsoft spent an industry-record $500 million in 18 months for the marketing of Xbox, attempting to catch up to PlayStation2 (Schilling, 2003). If Microsoft could not advertise its popular exclusive, third party titles such as *Star Wars: Knights of the Old Republic* and *Dead or Alive 3* (not to mention its self-provided blockbusters such as *Halo*) without providing a positive externality for its rivals, it is unlikely it would have brought Xbox to market. This suggests that exclusivity in contracting may improve the efficiency of the market we examine.

An interesting extension of the current work would be to examine the game publishers' side of the market for anticompetitive effects from exclusivity in contracting. As

[47] Two promising, recent exceptions are provided by Mantena, *et al.* (2007), who allow a single strategic publisher to have an exogenous quality advantage over its non-strategic rivals, and Hogendorn and Yuen (2007), who explicitly add blockbuster complementary goods to their model.

we discussed in the previous section, publisher EA uses upstream vertical contracts to exclude content providers such as the NFL from licensing content to other software developers. Oster's (1995) work shows (in spirit, at least—her model is designed with a different market in mind) that exclusive licensing may lessen competition from other developers. While we argue here that the market power of publishers such as EA lessens the fear of a console maker using exclusive contracts to gain market dominance, consumers' welfare also depends on game variety. This suggests that there may be an optimal degree of market power in the supply side of the software market, a topic that awaits future exploration.

References

Armstrong, Mark and Julian Wright (2007). "Two-sided Markets, Competitive Bottlenecks and Exclusive Contracts." *Economic Theory*, 32:353-380.

Berry, Steven (1994). "Estimating Discrete-Choice Models of Product Differentiation." *The RAND Journal of Economics*, 25:242-262.

Brennan, Timothy (2007). "Saving Section 2: Reframing U.S. Monopolization Law," in *The Political Economy of Antitrust*, edited by V. Ghosal and Johan Stennek. Amsterdam: North-Holland, 417-51.

Caillaud, Bernard and Bruno Jullien (2003). "Chicken and Egg: Competition among Intermediation Service Providers." *The RAND Journal of Economics*, 34(2):309-328.

Chou, Chien-fu, and Oz Shy (1990). "Network Effects without Network Externalities." *International Journal of Industrial Organization*, 8: 259-270.

Church, Jeffrey and Neil Gandal, (2000). "Systems Competition, Vertical Merger, and Foreclosure." *Journal of Economics & Management Strategy*, 9(1):25-51.

Church, Jeffrey and Neil Gandal (1993). "Complementary Network Externalities and Technological Adoption." *International Journal of Industrial Organization*, 11:239-60.

Church, Jeffrey and Neil Gandal (1992). "Network Effects, Software Provision, and Standardization." *Journal of Industrial Economics*, 40: 85-104.

Clements, Matthew T. and Hiroshi Ohashi (2005). "Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994–2002." *The Journal of Industrial Economics*, 53:515-542.

Cooper, James C., Luke M. Froeb, Dan O'Brien, and Michael G. Vita (2005). "Vertical Antitrust Policy as a Problem of Inference." *International Journal of Industrial Organization*, 23:639– 664.

Coughlan, Peter J. (2001). "Note on Home Video Game Technology and Industry Structure." Harvard Business School Case 9-700-107.

Coughlan, Peter J. (2004). "Note on Home Video Game Technology and Industry Structure (Abridged)." Harvard Business School Case 9-704-488.

Cragg, John G. and Stephan G. Donald (1993). "Testing Identifiability and Specification in Instrumental Variable Models." *Econometric Theory*, 9:222-240.

Evans, David S. (2003). "The Antitrust Economics of Multi-Sided Platform Markets." *Yale Journal on Regulation*, 20(2):325-381.

Gilbert, Richard J. and Michael L. Katz (2001). "An Economist's Guide to U.S. v. Microsoft." *Journal of Economic Perspectives*, 15(2): 25-44.

Glicker, Stephen (2006). "Why Do American Games Fail in Japan?" Posted February 1 at http://www.gamingsteve.com/archives/2006/02/why_do_american_1.php.

Hogendorn, Christiaan, and Ka Yat Yuen (2007). "Platform Competition with 'Must-Have' Components." Unpublished working paper.

Johns, Jennifer (2006). "Video Games Production Networks: Value Capture, Power Relations and Embeddedness." *Journal of Economic Geography* 6:151–180.

Katz, Michael L. and Carl Shapiro (1985). "Network Externalities, Competition, and Compatibility." *The American Economic Review* 75(3):424-440.

Kiri, Kaze (2003). "Japanese Video Games: A Model for International Popular Medias?" Posted May 20 at http://www.j-fan.com/edit.cgi?selected=japanese_video_games1.

Kleibergen, Frank and Richard Paap (2006). "Generalized Reduced Rank Tests Using the Singular Value Decomposition." *Journal of Econometrics* 127(1): 97-126.

Koski, Heli and Tobias Kretschmer (2004). "Survey on Competing in Network Industries: Firm Strategies, Market Outcomes, and Policy Implications." *Journal of Industry, Competition and Trade*, 4(1):5-31.

Lee, Robin S. (2007). "Vertical Integration and Exclusivity in Platform and Two-Sided Markets." NET Institute Working Paper #07-39.

Mantena, Ravi, Ramesh Sankaranarayanan, and Siva Viswanathan (2007). "Exclusive Licensing in Complementary Network Industries." NET Institute Working Paper #07-04.

Nair, Harikesh, Pradeep Chintagunta, and Jean-Pierre Dubé (2004). "Empirical Analysis of Indirect Network Effects in the Market for Personal Digital Assistants," *Quantitative Marketing and Economics*, 2:23-58.

Oster, Sharon M. (1995). "Exclusive Licensing in a Sequence of Innovations." *International Journal of the Economics of Business*, 2(2):185-198.

Prieger, James E. and Wei-Min Hu (2006). "An Empirical Analysis of Indirect Network Effects in the Home Video Game Market." NET Institute Working Paper #06-25.

Prieger, James E. and Wei-Min Hu (2007). "Applications Barriers to Entry and Exclusive Vertical Contracts in Platform Markets." NET Institute Working Paper #07-46.

Régibeau, Pierre (2004). "Network Externalities and Competition Policy. Comments on Koski and Kretschmer." *Journal of Industry, Competition and Trade*, 4(1):33-39.

Rochet, Jean-Charles and Jean Tirole (2003). "Platform Competition in Two-Sided Markets." *Journal of the European Economic Association*, 1(4), 990–1029.

Schilling, Melissa A. (2003). "Technological Leapfrogging: Lessons from the U.S. Video Game Console Industry." *California Management Review*, 45(3):6-32.

Segal, Ilya R. and Michael D. Whinston (2000). "Exclusive Contracts and Protection of Investments." *The RAND Journal of Economics*, 31(4):603-633.

Shea, John (1997). "Instrument Relevance in Multivariate Linear Models: A Simple Measure." *Review of Economics & Statistics*, 79(2): 348–352.

Snyder, Christopher M. (1995). "Empirical Studies of Vertical Foreclosure." *1995 Industry Economics Conference Papers and Proceedings*. Bureau of Industry Economics Report 95/23, 98-125.

Table 1: Platform Characteristics

Platform	Introduced	Manufacturer	Hardware Characteristics GPU (MHz)	CPU (MHz)	RAM (GB)	Statistic	2002	2003	2004
Play-Station2	October 2000	Sony	150	300	32	**% Console Sold**	0.61	0.50	0.42
						Mean Console Price	233	187	160
						% Software variety	0.44	0.43	0.47
Xbox	October 2001	Microsoft	233	733	64	**% Console Sold**	0.23	0.25	0.37
						Mean Console Price	237	187	157
						% Software variety	0.30	0.33	0.34
GameCube	October 2001	Nintendo	162	485	24	**% Console Sold**	0.17	0.26	0.21
						Mean Console Price	171	133	100
						% Software variety	0.26	0.24	0.19
						Total Console Sales (Million Units)	14.1	12.9	10.9
						Total Software Variety	502	539	511

Notes: GPU is the speed of the graphics processing unit in megahertz. MHz is the CPU clock speed in megahertz, and RAM is the memory size in gigabytes.

Table 2: Software Provision

Platform	Statistic	Stock at start of 2002	Introduced in 2002	Introduced in 2003	Introduced in 2004	Stock at end of 2004
PlayStation2	Game Titles	202	250	249	257	958
	% exclusive to the platform	80	50	48	49	55
	% provided by manufacturer	11	8.8	10	7.8	9.3
Xbox	Game Titles	34	162	201	184	581
	% exclusive to the platform	50	31	33	34	34
	% provided by manufacturer	21	8.6	10.5	7.1	9.5
GameCube	Game Titles	18	149	138	103	408
	% exclusive to the platform	39	27	31	29	29
	% provided by manufacturer	22	5.4	7.3	12	8.3

Table 3: Summary of Console Related Variables

Platform	Statistic	Market Share (%)	Within Group Share	Price	Game Titles (recent)	Game Titles (old)	Game Titles (recent exclusive)	Game Titles (recent non-exclusive)
PlayStation2	**Mean**	0.74	0.52	175	83	501	41	43
	Max	3.37	0.64	289	148	812	72	82
	Min	0.22	0.32	135	41	187	20	19
	s.d.	0.69	0.09	35	32	202	13	21
Xbox	**Mean**	0.42	0.28	176	60	240	22	38
	Max	1.83	0.51	289	113	475	38	77
	Min	0.08	0.19	135	25	25	9	16
	s.d.	0.42	0.08	37	26	150	8	19
GameCube	**Mean**	0.32	0.20	123	44	184	16	28
	Max	1.71	0.36	193	100	349	32	68
	Min	0.09	0.12	90	18	13	7	11
	s.d.	0.38	0.05	33	21	116	6	17
Overall	**Mean**	0.49	0.33	158	62	309	26	36
	Max	3.37	0.64	289	148	812	72	82
	Min	0.08	0.12	90	18	13	7	11
	s.d.	0.54	0.16	43	31	211	14	20

Notes: prices are in real figures (deflated with the CPI series for "all urban consumers, all items"). Figures may not add up due to rounding.

Table 4: Nested Logit Demand Estimations for Sixth Generation Game Consoles

	Estimation 1 (GMM)			Estimation 2 (OLS)	
	Coefficient	**s.e**	**Partial R^2**	**Coefficient**	**s.e**
Constant	-0.306	1.637	--	-1.157	1.884
Price (log)	-1.070**	0.220	0.672	-0.869**	0.258
Game Titles (recent, log)	0.317**	0.108	0.847	0.239*	0.121
Game Titles (1 + old/recent, log)	-0.189	0.126	0.795	-0.060	0.140
Within Group Share	0.614**	0.152	0.444	0.836**	0.134
R^2	0.928			0.936	
Kleibergen-Paap *rk* Wald statistic	*p*-value = 0.0000			--	
Hansen *J* statistic	*p*-value = 0.7350			--	
Anderson-Rubin *F* statistic	*p*-value = 0.0000			--	
Elasticities					
Price	-2.198**			-3.810	
Game Titles (recent)	0.947**			1.250	
Game Titles (old)	-0.296			-0.202	

* = significant at 5% level. ** = significant at 1% level.

Notes: $N = 102$. For dependent variable, see equation (1). Data are by month and console. All specifications include console and year effects (and their interactions), and seasonal effects. Standard errors are robust to heteroskedasticity and autocorrelation. *Game Titles (recent)* is the software variety accumulated during the current month and the three previous months. Partial R^2 (Shea, 1997) is a measure of the explanatory power of the instruments, accounting for correlation among the endogenous variables and among the instruments. *Kleibergen-Paap rk Wald statistic* tests for underidentification. *Hansen J statistic* tests the overidentifying restrictions, for instrument exogeneity. *Anderson-Rubin F statistic* tests for the joint significance of the endogenous variables. See text for details.

Table 5: Elasticity of Demand Share with Respect to Software Variety

Platform	2002	2003	2004	Average
PlayStation2	0.749**	0.834**	0.912**	0.837**
	(0.184)	(0.214)	(0.253)	(0.219)
Xbox	0.941**	1.017**	0.960**	0.974**
	(0.353)	(0.340)	(0.286)	(0.323)
GameCube	0.938**	1.033**	1.106**	1.031**
	(0.372)	(0.348)	(0.367)	(0.359)
Average	0.876**	0.961**	0.993**	0.947**
	(0.302)	(0.300)	(0.302)	(0.300)

** = significant at 1% level.

Notes: Game variety elasticity is for recent games only. Elasticities and asymptotic standard errors calculated based on Estimation 1. Standard errors (in parentheses) are calculated via the delta method. Elasticities are calculated for each console-month and then averaged.

Table 6: Nested Logit Demand Estimation for Game Consoles: Exclusive vs. Non-Exclusive Software

	Estimation 3 (GMM)			Estimation 4 (OLS)		Estimation 5 (GMM)		
	Coefficient	**s.e**	**Partial R^2**	**Coefficient**	**s.e**	**Coefficient**	**s.e**	**Partial R^2**
Constant	-2.469	1.365	--	-1.505	1.903	-0.439	2.155	--
Price (log)	-0.610**	0 .219	0.598	-0.796*	0.281	-0.805**	0.295	0.551
Recent Game Titles (non-exclusive, log)	0.327**	0.042	0.678	0.270**	0.040	0.348**	0.045	0.669
Recent Game Titles (1 + exclusive/non-exclusive, log)	0.010	0.120	0.583	0.179	0.145	0.150	0.174	0.542
Older Game Titles	-0.047	0.071	0.762	-0.034	0.101	-0.089	0.127	0.679
Recent Game Titles available to console (fraction, < 0.75)						-0.267	0.618	0.658
Recent Game Titles available to console (fraction, > 0.75)						4.815**	1.789	0.680
Within Group Share	0.779**	0.115	0.513	0.840**	0.134	0.717**	0.138	0.487
R^2	0.938			0.937		0.938		
Kleibergen-Paap rk Wald statistic	*p-value* = 0.0000			--		*p-value* = 0.0000		
Hansen *J* statistic	*p-value* = 0.8156			--		*p-value* = 0.5805		
Anderson-Rubin *F* stat.	*p-value* = 0.0000			--		*p-value* = 0.0000		
Elasticities								
Price	-2.027*			-3.585		-2.147**		
Game Titles (recent, non-exclusive)	1.073*			0.905		0.772**		
Game Title (recent, exclusive)	0.013			0.309		0.009		
Game Titles (old)	-0.156			-0.153		-0.229		

* = significant at 5% level. ** = significant at 1% level.

Notes: See notes to Table 4. *Recent Game Titles available to console* is the fraction of all titles available (weighted by game revenue) for any console in the current and three previous months that are available for console *j*; it is splined with a knot at 0.75 (the coefficients are the slope in the relevant region). Standard errors are robust to heteroskedasticity and autocorrelation.

Table 7: Top Software Titles

Revenue Rank	Game Title	Publisher	Platforms	Revenue ($Millions)
1	Grand Theft Auto:Vice*	Rockstar Games†	PS2 & Xbox‡	334.9
2	Grand Theft Auto 3*	Rockstar Games†	PS2 & Xbox§	319.9
3	Grand Theft Auto: San Andreas	Rockstar Games†	PS2	276.5
4	Halo 2 and Halo 2 Limited Ed.	Microsoft	Xbox	234.2
5	Madden NFL 2004	Electronic Arts	All consoles	221.4
6	Madden NFL 2005	Electronic Arts	All consoles	207.0
7	Madden NFL 2003	Electronic Arts	All consoles	165.6
8	Halo	Microsoft	Xbox	161.1
9	Need for Speed: Underground	Electronic Arts	All consoles	159.8
10	Need for Speed: Underground 2	Electronic Arts	All consoles	142.4
11	Madden NFL 2002	Electronic Arts	All consoles	132.2
12	Medal of Honor: Frontline	Electronic Arts	All consoles¶	129.1
13	Spider-Man: The Movie	Activision	All consoles	124.9

Notes:

* Revenue includes half of revenue from sales of the Grand Theft Auto dual pack (Vice and 3).

† Rockstar Games is a division (developer) of Take 2 Interactive.

‡ Released for Xbox one year after available for PlayStation2.

§ Released for Xbox two years after available for PlayStation2.

¶ Released for Xbox and GameCube 6 months after available for PlayStation2

Table 8: Software Characteristics by Console

	Software Titles			Two-Sample Tests (*p*-val)		Three-Sample Tests (*p*-val)	
	Non-Exclusive	Exclusive, Self-provided	Exclusive, Independent Publisher	Non-Exclusive vs. Exclusive	Self-Provided vs. Independent Exclusive	ANOVA (means) or χ^2 Test (medians)	Regression-Based *F* Test
PlayStation2	457	95	466				
Total Revenue ($M)	6,174.1	1,159.3	2,888.5				
mean ($M)	15.5	12.2	6.1	0.000	0.010	0.000	0.000
median ($M)	4.8	4.3	2.2	0.000	0.003	0.000	0.000
% Revenue gained in first 4 months							
mean	62.5%	56.0%	57.0%	0.000	0.641	0.108	0.000
median	70.5%	62.7%	64.1%	0.000	0.820	0.000	0.001
Xbox	416	54	155				
Total Revenue ($M)	2,344.3	802.8	599.8				
mean ($M)	5.8	12.0	4.3	0.634	0.056	0.000	0.034
median ($M)	2.5	5.6	1.6	0.973	0.006	0.022	0.000
% Revenue gained in first 4 months							
mean	62.4%	61.9%	60.7%	0.423	0.683	0.101	0.697
median	70.8%	67.7%	72.0%	0.973	0.358	0.973	0.848
GameCube	305	37	91				
Total Revenue ($M)	1,152.4	974.2	392.7				
mean ($M)	4.0	32.5	4.4	0.000	0.000	0.000	0.000
median ($M)	1.9	17.7	1.3	0.718	0.000	0.000	0.000
% Revenue gained in first 4 months							
mean	54.0%	65.4%	52.5%	0.405	0.000	0.048	0.000
median	61.4%	75.5%	57.0%	0.718	0.009	0.718	0.013

Notes:
Revenue calculated from data covering Oct. 2000 to Mach. 2005 for game titles on the market for at least 12 months. Two-sample mean tests are two-sided *t* tests for equal means among the categories, and do not assume equal variances. Median tests are two-side Pearson chi-squared tests for equal medians among the categories. Three-sample mean tests are from ANOVA *F*-statistics, and assume equal variances. The regression-based *F* tests for the mean are robust tests that the regression coefficients on categorical dummy variables are zero from a regression of the row variable on categorical dummy variables. The regression-based *F* tests for the median are similar to those for the mean, but are based on a quantile regression for the median (least absolute deviations).

Table 9: Software Characteristics by Publisher

Publisher	Number of Titles	% Non-Exclusive Titles	Total Revenue ($M)	% of Industry Revenue	Revenue per Title ($M)	Rank of Revenue per Title	Average Quality Score
Electronic Arts	258	87%	4,033.7	24.5%	16.9	4	7.9
Take 2	110	82%	1,487.7	9.0%	13.4	5	6.7
Sony	95	0%	1,159.3	7.0%	12.2	6	7.4
Activision	102	81%	1,154.4	7.0%	11.2	8	7.1
Nintendo of America	37	0%	974.2	5.9%	32.5	2	8.0
Microsoft	55	2%	805.4	4.9%	11.8	7	7.7
THQ	110	77%	754.1	4.6%	7.0	13	6.7
Other independent publishers	1,309	53%	6,119.2	37.1%	5.2		6.4

Notes: Sample includes all game titles for GameCube, PlayStation2, and Xbox from Oct. 2000 to March 2005, except for revenue per title, which does not include titles available for fewer than 12 months in the data. Data are from NPD Fun Group and gamerankings.com

Figure 1: US Market Sales of Video Game Consoles