"Vertical" Integration and Foreclosure of Complementary Products*

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Abstract

Using data from the 128 bit video game industry this paper evaluates the effect of vertical integration and the foreclosure of complementary software to rival hardware. Foreclosure occurs when a console hardware manufacturer produces software which is incompatible with rival hardware. Estimation of video game console demand deviates from previous research by incorporating video game heterogeneity and software competition into demand for consoles–consumers differentiate between games rather than assume video games are homogeneous. There are two important trade-offs to vertical integration. The first is a foreclosure effect which increases console market power and forces prices higher. The second, an efficiency effect, drives prices lower. Counterfactual exercises determine vertical integration with foreclosure is pro-competitive. It increases price competition as well as consumer welfare and console manufacturer profits, and is due to console makers subsidizing consumers in order to increase video games sales, in particular their own developed games, where the greatest proportion of industry profits are made.

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1 Introduction

There are many high tech industries in which consumers must associate with a platform in order to utilize its complements. For example, a consumer chooses between a HD-DVD or a Blu-ray machine or a PlayStation 3, Microsoft Xbox 360 or Nintendo Wii before he is able to watch high definition DVDs or play video games, respectively. Moreover, with a large portion of complements compatible with multiple platforms the additional differentiation they create is quite minimal. There are complements, however, that are exclusive to one platform–to purchase the Apple iPhone consumers must subscribe to AT&T Wireless or to watch a high definition Warner Brothers-produced DVD a consumer must purchase a Sony Blu-ray player.[1] Exclusive complements bring added differentiation to platforms and thus influence an industry's competitive landscape. However, exclusive complements like these can raise anti-competitive concerns through the foreclosure of rivals and deterrence of potential entrants.[2] Yet a video game platform, DVD standard or a cell phone provider can also replicate the added differentiation exclusive contracts yield through "vertical" integration and foreclosure or in the terms of Gilbert and Riordan (2007) vertical integration with a technological tie–foreclosure occurs when a hardware manufacturer produces software which is incompatible with rival hardware. For instance, Nintendo, the maker of the Wii video game console, can itself produce a video game and restrict the playability of its game to only the Wii. This subsequently increases Nintendo's market power in the console market because a decrease in a rival's video game variety reduces its value to potential consumers (Church and Gandal (2000)). This raises the question, is vertical integration with foreclosure anti-competitive? Does the practice of vertical integration with the foreclosure of complementary goods create market power or does it enhance efficiency and increase welfare?

Prior to the early 1980s, the Chicago School of thought regarding vertical integration and exclusive dealings was the dominant theory. This school of thought believed that the only incentive for such an act was due to efficiencies. Bowman (1957) and Bork (1978) both argue that the owner of an essential monopoly input that is used in fixed proportions with another competitively supplied complementary good has no incentive to bundle or tie

[1] These exclusive complements are exclusive due to a formal contract between producers of complementary goods.

[2] See i.e. Rasmusen, Ramseyer and Wiley (1991), Bernheim and Whinston (1998) or for an overview Whinston (2006) and Rey and Tirole (2007).

the essential good with the complementary product. Their argument rests on the fact that there exists a single monopoly profit and the owner of the essential input can capture this rent by simply offering the monopoly price. However, this thought quickly came under fire with the introduction of game theoretic models in the early to mid 1980s. For instance, the post-Chicago economic theory of Salop and Scheffman (1983) concludes that a vertically integrated firm can reduce competition through raising rivals' costs.[3]

Now although the above examples are not in a traditional sense vertical integration, the same economic principles can be extended to sellers of two complementary products where software can be thought of as the input or upstream supplier to the production of the downstream hardware (Salop (2005)). Take for example entry of a hardware manufacturer into the software market. Such an act can give rise to competitive concerns through the foreclosure of the integrated software (the input) to rival hardware makers. By creating a technological tie the integrated software is only compatible with hardware produced by the same company. This action degrades rival hardware demand while enhancing the integrated manufacturer's hardware demand because in order for a consumer to play the integrated software he has to first purchase the respective hardware. This exclusivity increases a hardware manufacturer's market power, leading to an increase in hardware price by raising the value of the hardware because its demand is a function of the compatible complementary software.[4] One can think of this example as a raising rivals' costs strategy associated with complementary product markets (Gilbert and Riordan (2007)). This, however, is not the entire story. As Salinger (1998) discusses, the theory of raising rivals' costs can coexist with the effect of eliminating the double marginalization associated with a merger between two firms with market power. If we assume that software as well as hardware are differentiated products then the entry of a hardware producer into the software market diminishes the successive markups of each product as a result of the integrated firm coordinating software and hardware pricing and internalizing the effects software and hardware prices have on each other. This consequently leads to a decrease in hardware and integrated software prices. Thus, the net competitive effect of vertical integration and foreclosure of software to rival

[3]See Williamson (1968), Ordover, Saloner and Salop (1990), Riordan and Salop (1995), for other papers which outline conditions under which a vertically integrated firm may profitably raise rival costs.

[4]See Church and Gandal (2000) for equilibrium model of complementary foreclosure or Choi and Yi (2000) for a more generalized version of Church and Gandal. See Gilbert and Riordan (2007) for impact of vertical integration via technological tying.

hardware is ambiguous and is an empirical question.

Using data from the 128-bit video game industry which consists of Nintendo GameCube, Sony PlayStation 2 and Microsoft Xbox, I empirically analyzes whether vertical integration with foreclosure of complementary software to rival hardware producers is anti-competitive. Or more specifically, does the act create market power or increase welfare? I answer these questions by studying the impact vertical integration and foreclosure have on video game console price competition, consumer welfare and firm profit. Moreover, I present a new structural methodology for console demand which captures the complementary relationship between hardware and software while accounting for video game heterogeneity and competition.

To understand how important software quality is in constructing console demand consider the following: assume two competing consoles with two games each are identical except that the first console's games are both of mediocre quality while the second console has one mediocre game and one of higher quality. Under a demand model which only accounts for the number of games compatible to a console, demand for each console would be identical. A more flexible model which accounts for software heterogeneity would provide greater demand for console two than for console one, resulting in a different equilibrium outcome from model one. It is therefore essential to model the demand for video games well given that console demand is derived from video game demand. The technique I implement deviates from prior research by allowing console demand to account for differentiated video games and competition among game titles rather than assume video games are homogeneous, which is a nice approximation when consumers only value product variety.[5] Accounting for video game heterogeneity is an important aspect of console demand; a 2002 study by Forrester Research concluded 96% of people surveyed believed the quality of video games was an important characteristic in choosing a game console.

In contrast to the large theoretical literature regarding vertical integration, there is a small but growing number of empirical studies which discuss the topic. Yet, the results of these studies differ across industries. Chipty (2001) studies the effects of integration between cable programming and its distribution in the cable television industry. Chipty discovers vertical integration does not harm consumers but results in the foreclosure of

[5] See i.e. Nair, Chintagunta and Dubé (2004); Clements and Ohashi (2004); Hu and Prieger (2008); Corts and Lederman (2007); Dubé , Hitsch and Chingtagunta (2007) and Lee (2009) for prior research.

rival programs on a competitor's cable lineup. Papers by Hastings (2004) and Hastings and Gilbert (2005) both investigate the impact of vertical integration in the retail gasoline market. Hastings (2004) finds evidence to support an increase in price when independently owned retail gasoline stations vertically integrate with a branded wholesale gasoline provider. Hastings and Gilbert (2005) also find support for the idea that "vertical integration may lead to an increase in wholesale prices as a consequence of the incentive to raise rivals' costs." Hortacsu and Syverson (2007) analyze vertical integration among the cement and ready-mixed concrete industries. They, however, find vertical integration is pro-competitive–it leads to a decrease in price, an increase in quantity, and constant entry rates.[6]

In my empirical research below I take a different approach than the majority of papers on vertical integration. Instead of employing a reduced form methodology similar to the above papers I estimate a structural model in the style of Asker (2004a, 2004b). I investigate the impact of vertical integration and foreclosure in two stages. I first run simple reduced form regressions in order to look at the relationship between console prices and vertical integration. I then create structural demand and supply models and jointly estimate them. After estimation I employ the estimated utility parameters from the demand model and associated marginal costs from the supply model to run counterfactual simulations. I investigate the impact of vertical integration with two simulations i) vertical integration is prohibited and is accompanied by a subsequent ban on exclusive contracting (all *first party* games are completely eliminated and are not produced) and ii) only vertical integration is prohibited (all integrated video games are produced but by an independent video game developer). I implement the latter simulation due to the fact that exclusive contracts and vertical integration are perfect substitutes–they both restrict the ability to play certain video games on rival consoles. Consequently, with these two simulations, I am able to determine whether a policy banning vertical integration should be accompanied by a ban on other exclusive dealing arrangements.

Vertical integration with foreclosure is pro-competitive: console price competition, new console owner welfare and console manufacturer profits all increase. With the implementation of the two above counterfactual scenarios I determine a policy maker should not ban vertical integration with foreclosure because a ban only on vertical integration will lead a

[6]See also Cuellar and Gertler (2006) and Ciliberto and Dranove (2006), Mullin and Mullin (1997) and Marin and Sicotte (2003) for additional empirical papers.

firm to adopt exclusive contracts which is even less attractive for all. Furthermore, a policy which also eliminates all forms of exclusive dealings is by far the least desirable because such a policy reduces competition in the software market which results in consoles being less attractive to consumers. In addition to my pro-competitive findings regarding vertical integration with foreclosure, I determine prices (profits) of consoles with a larger degree of concentration in vertically integrated games rise (fall) more than consoles with less concentration under all policies banning exclusive dealings. High quality vertically integrated games are thus a leading factor in explaining why vertical integration is pro-competitive. With the existence of high quality integrated games firms are willing to forego the incentive to raise console prices in order to increase the demand for consoles and their own integrated video games, where the largest proportion of industry profits are made.

The structure of this paper is as follows. First, an overview of the 128-bit video game industry and the data used in my analyses is provided. Section 3 briefly discusses the results of the reduced form analysis and sections 4, 5, and 6 present the structural empirical model, estimation technique and model results, respectively. Section 7 presents the counterfactual scenarios and the simulation results. Lastly, I review the innovations of my work and results of my analyses.

2 The Video Game Industry

Further motivation for this research is guided by the antitrust case of *Atari Games Corp. v Nintendo of America Inc.* regarding Nintendo's use of exclusive contracts with video game developers in the late 1980s. These exclusive contracts restricted the playability of games to Nintendo's console for the first two years of a game's release and the number of games developed by a firm to five per year (Shapiro 1999). Prior to this time the industry leader was Atari but after Nintendo's release of its console in 1985 it quickly overcame Atari as the market leader. During this time Nintendo did not permit independent game developers to create games for both consoles whereas Atari did not have this policy. Accordingly, a gamer who wished to play a particular Nintendo game was required to purchase a Nintendo console.

These exclusive contracts were one tool Nintendo used to overtake Atari as market leader.

A second tool was its vertical integration into the software market. By entering the video game market and foreclosing Atari from its games it was able to mimic the effect of exclusive contracts. In this respect vertical integration and exclusive contracts were perfect substitutes for Nintendo. Vertical integration in this situation and as will be defined throughout the remainder of the paper is a result of Nintendo (or in general any other console manufacturer) electing to design, produce and sell games themselves.[7] Yet when the Department of Justice raised concerns about Nintendo's exclusive contracts there was no worry over Nintendo's vertical integration.

Was the government's lack of concern with Nintendo's vertical integration justified? As I discussed above, vertical integration can generate pro- as well as anti-competitive effects. Pro-competitive effects are in-line with efficiency theories whereas anti-competitive effects are due to theory in-line with raising rivals' costs. Within the video game industry anti-competitive effects are a direct result of the exclusive release of a game produced by a console manufacturer leading to an increase in the console manufacturer's market power and console price. I denote this effect throughout the remainder of the paper as the foreclosure effect. Under efficiency-based theory, integration increases price competition among consoles because vertically integrated firms coordinate on video game and console pricing and internalize the effects that video games and console prices have on each other.

The structure of the video game industry is a prototypical platform market where a video game console acts as a platform to two different end users, consumers and game developers.[8] A console permits two end users to interact via its platform creating externalities for each side of the market where the demand-side indirect network effects pertain to the effect that a game title has on a console's value to the consumer as well as the benefit a game developer receives when an additional consumer joins the console's owner base. Determining the size of these cross group externalities depends on how well the console performs in attracting the other side. Within the console market there are three classes of players: the consoles, consumers, and game developers. A consumer purchases a console in order to play games. Moreover, a consumer pays a fixed fee p_c for the console and a fixed price p_g for video game g. However, in order for a consumer to play a video game, the developer of the game is required

[7] Vertical integration could also occur via the purchase of an independent game studio but rarely does. One instance is Sony's recent purchase of Zipper Interactive

[8] See i.e. Kaiser (2002), Caillaud and Jullien (2003), Rochet and Tirole (2004), Rysman (2004), Kaiser and Wright (2005), Armstrong (2006), Hagiu (2006) and for general literature on two-sided platform markets

to pay the console a royalty rate r for the rights to the code which allows the developer to make his game compatible with the console. This royalty rate is not a fixed one-time fee. Rather, a developer pays a royalty fee for each copy of its game that is bought by a consumer.[9] Figure 1 presents an illustration of the discussed market structure.

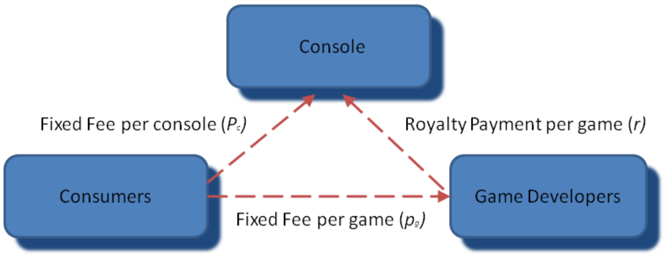

Figure 1: Video Game Market Structure

The above figure describes a very generalized industry structure. A more tailored structure makes a distinction between two different types of video games. The first is what the industry and I note as *first party* games. These games are produced by the console's in house design studio. The second type of video game is that games produced by independent firms not associated with the producing consoles. I denote these developers as *third party*. Typically, *third party* vendors make games accessible to all consoles as a result of the high fixed costs of production whereas *first party* games are exclusively released for the console maker. The average fixed cost for a game on Nintendo Gamecube, Sony Playstation 2 or Microsoft Xbox is roughly two and half to four million dollars (Pachter and Woo).

During the 128-bit video game console (2000-2006) life cycle the video game industry saw three of the most revolutionizing consoles come to market, the Sony PlayStation 2, Microsoft Xbox and Nintendo GameCube. These consoles brought larger computing power, more memory, enhanced graphics, better sound and the ability to play DVD movies. In addition, the producing firms each launched an expansive line of accessories to accompany their platform.

Sony enjoyed a yearlong first mover advantage with its launch of PlayStation 2 debuting in October 2000. Its success was attributed to moving first but more significant was its large catalog of games which were exclusively produced for its console by its development

[9] Console manufacturers actually manufacture all video games themselves to ensure control over the printing process and to track sales for royalty collection.

studio and by *third party* developers. Many of its biggest software hits were exclusive to PlayStation 2 but only one was Sony produced.

Microsoft Xbox launched in very late October 2001 and was by far the most technologically advanced console. It was technically superior to the dominant Sony PlayStation 2, possessing faster processing speed and more memory. Microsoft, however, struggled to gain market share as a result of its inability to attract developers to its platform to produce software titles exclusively for Xbox, in particular the many prominent Japanese developers (Pachter and Woo 2006). The inability to secure *third party* exclusive games forced Microsoft to design and produce video games internally.

Nintendo GameCube launched in November of 2001, within weeks of the Microsoft Xbox. The GameCube was the least technically advanced of the three consoles. Instead of competing in technology with Sony and Microsoft, Nintendo targeted its console to younger kids. "The GameCube's appeal as a kiddie device was made apparent given the fact that the device did not include a dvd player and its games tilt[ed] towards an E rating" (Pachter and Woo 2006). GameCube's limited success was a result of Nintendo leveraging its "internal development strength and target[ing] its loyal fan base, composed of twenty somethings who grew up playing Nintendo games and younger players who favored more family friendly games" (Pachter and Woo 2006).

2.1 Data

The data used in this study originates from three proprietary independent data sources and one public data source. They are NPD Funworld, TNS Media Intelligence, Forrester Research Inc. and the March 2005 United States Consumer Population Survey (CPS). Data from the marketing group NPD Funworld track sales and pricing for the video game industry and are collected using point-of-sale scanners linked to over 65% of the consumer electronics retail stores in the United States. NPD extrapolates the data to project sales for the entire country. Included in the data are quantity sold and total revenue for the three consoles of interest and all of their compatible video games, roughly 1200. The TNS Media Intelligence data tracks console advertising expenditures over 19 different media channels within the United States and are reported on a monthly basis. The remaining proprietary data set is from Forrester Research, which reports consumer level purchase/ownership of video game consoles. The North American Consumer Technology Adoption Study surveyed 10,400 US and Canadian households in September of 2005. But, since sales data from NPD only tracks US sales I restrict the survey sample to only US households. In addition to ownership information the survey also provides key household demographic data. The last data set originates from the 2005 March CPS and provides demographic information on the United States population.

Each of the first two data sets covers 35 months starting in January 2002 and continuing through November 2004. The remaining two data sets, Forrester Research and the CPS, are one time snapshots of consumers in 2005.

General statistics about the video game industry are provided in Table 1.

Table 1: Summary Statistics

	GameCube	Xbox	PlayStation 2
Release Date	Nov. 2001	Oct. 2001	Oct. 2000
Hardware			
Installed Base (Nov. 2004)	8,223,000	10,657,000	25,581,000
Price			
Average	\$133.18	\$190.54	\$240.10
Max	199.85	299.46	299.54
Min	92.37	146.92	180.66
Sales			
Average	200,420	264,140	522,860
Max	1,158,200	1,079,400	2,686,300
Min	58,712	77,456	188,670
Advertising Expenditures			
Average	65,731	252,030	295,260
Std. Dev.	252,130	565,000	915,740
Max	1,141,700	2,881,400	4,584,900
Min	0	0	0
DVD Playability	no	yes	yes
Max Number of Controllers	4	4	2
Average Consumer Characteristics			
Family size	3.6725	3.7206	3.59876

Below I briefly discuss two important facts regarding the industry. The first is that the video game industry exhibits a large degree of seasonality in both console and video game sales. Figures 2 and 3 illustrate the total number of consoles and video games sold in each month, both of which increase considerably in the months of November and December. It is, therefore, important to account for the large degree of seasonality in estimation.

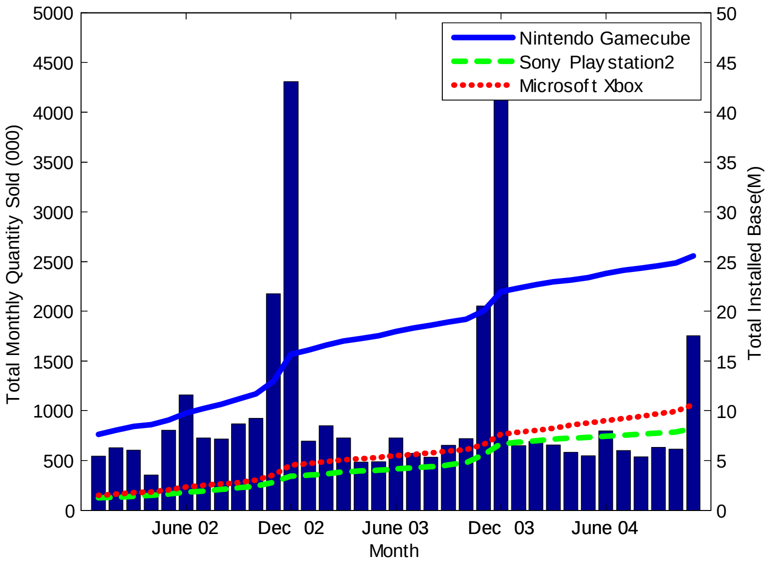

Figure 2: Console Sales and Installed Base

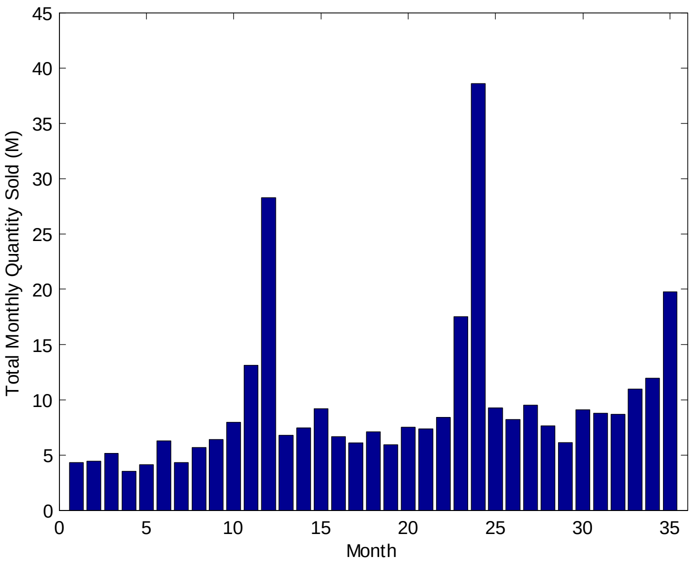

Figure 3: Software Sales per Month

The second fact is that video games are differentiated goods, which is quite evident by walking into the nearest consumer electronic store and looking at their video game shelves. There are over eleven genres of games which range from action to simulation. The largest is action games with 24% of the market, and simulation games are the smallest genre with only 1%. Video game sales for individual games also range in the number of units sold.

There are large "hits" such as *Grand Theft Auto: Vice City* which has cumulative sales of over six million on PlayStation 2 and "busts" like *F1 2002* which sold only 48,000 units on the same console. It is this differentiation that is the driving factor for the construction of a new console demand model.

Next, I present statistics regarding vertical integration in the video game market. Table 2 indicates the total units sold of *first party* games for each console in January of the reported years as well as the number of *first party* games and a "pseudo" HHI.[10] The HHI index measures the concentration of vertically integrated games for each console. A small index indicates *first party* games have little impact on video game sales while a large index signifies the opposite. The HHI is a more encompassing measure of *first party* game importance as compared to the number of games or the total units of *first party* games sold because these two measures do not measure the quality of available games whereas the latter also does not indicate the number of games available. Table 2 also brings light to the relative importance of vertically integrated games for Nintendo and Microsoft. In January 2002 both Nintendo's and Microsoft's HHIs are on the magnitude of 500 and 300 times the size of Sony's and by January 2004 the magnitude decreases to only five and three times Sony's, respectively.

Table 2: First Party Game Statistics

Platform	Units Sold of *First Party* Games		
	2002	2003	2004
GameCube	179,011	193,347	427,153
PlayStation 2	267,545	925,290	546,351
Xbox	382,599	234,258	414,333
	Number of *First Party* Games		
GameCube	5	12	21
PlayStation 2	24	45	66
Xbox	10	20	38
	Pseudo HHI of *First Party* Games		
GameCube	535.94	59.49	54.44
PlayStation 2	10.28	55.29	8.02
Xbox	305.02	17.39	29.09

Note: Statistics calculated for January of the corresponding year.

[10] The HHI measure is calculated by summing the squared market shares of each integrated game.

3 Reduced Form Analysis

Before I discuss and estimate a structural model, I present results from several regression models which analyze the relationship between vertical integration and console price competition. If vertical integration is to increase a console maker's market power by foreclosing rival consoles from its games, foreclosure theory states that there should be a positive relationship between vertical integration and price. Or more simply, console price should rise.

In order to determine whether the foreclosure effect is important I regress console price on console fixed effects, quarter dummy variables, the log of one plus console advertising expenditures, the number of *first party* titles, the number of independent games, and console specific trends. Two subsequent specifications include identical covariates with the exception of the number of *first* and *third party* titles. Regression two substitutes the number of corresponding types of games with the aggregated number of units sold and regression three incorporates the pseudo HHI index discussed in the data section.

Table 3: Price Regression Results

	Model 1		Model 2		Model 3	
Dependent Variable: Log Price	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Vertically Integrated Games	1.102	1.341	2.881e-06	6.087e-06	0.0025795	0.008746
Independent Games	0.558	0.216	4.651e-07	1.4149e-06	0.0210	0.01146
log (1+Advertising expenditures)	-0.236	0.511	0.1068	0.5178	0.1020	0.50160
R^2	0.9010		0.8943		0.8972	

Notes: ** significant at 95%; * significant at 90%; console fixed effects, console specific trends and quarter dummies not reported

As Table 3 indicates, there is no statistically significant relationship between console prices and the three corresponding measures of vertical integration. Yet, the coefficients corresponding to measures of vertical integration are all positive. While this preliminary analysis does not suggest the foreclosure effect is a significant factor affecting console price competition it does provide a starting point for further structured analysis.

4 The Empirical Model

In this section I discuss the structural model which captures the complementary relationship between console hardware and video game software, and accounts for differentiation and competition among video games.

Although there are numerous theoretical studies which analyze exclusionary strategies and vertical integration, a limited number of empirical studies exist related to markets similar to the video game industry. A few related papers are Hu and Prieger (2008), and Lee (2009), both of which analyze the impact of exclusive titles in the video game market and determine whether exclusive titles are anti-competitive. Hu and Prieger employ a structural model to estimate the demand for video game consoles–similar to that of Nair et. al (2004). This method is quite restrictive as it does not allow for differentiated video games. Nonetheless, Hu and Prieger move forward and run a "counterfactual experiment" which concludes exclusive games do not alter the demand for video game consoles, nor are they anti-competitive or create significant barriers to entry.[11]

In the attempt to ease this restriction Lee (2009) implements a methodology which simultaneously estimates dynamic demands for software and hardware and therefore allows consumers to differentiate between video games, but in doing so he makes a strong assumption regarding the nature of competition in the software market.[12] He assumes software titles are neither substitutes nor complements to each other; he effectively places each title into a market of its own and does not allow substitution to occur among video games. Lee also abstracts away from any pricing decisions. He does not attempt to model the price setting behavior for software or hardware firms. In his counterfactual exercises he presumes all prices follow the same price path as is observed in the data. The counterfactuals are thus partial counterfactuals; they do not find new equilibrium prices. Consequently, Lee's model is unable to take into account the important efficiency effect associated with vertical integration as well as capture the entire foreclosure effect. In practice, only a proportion of the foreclosure effect is captured–the effect on demand.

In this study I construct an empirical model which relaxes the simplifications made in the prior research by introducing software heterogeneity and competition into the software market. I also jointly estimate the consumer demand and console pricing models simultaneously to recover more precise parameter estimates as well as to capture the entire foreclosure and efficiency effects in the counterfactual exercises.

[11] They do not officially run a counterfactual experiment which finds a new equilibrium price vector. Instead they take the approach of re-estimating the demand model without exclusive video games.

[12] He makes such an assumption for computational purposes.

4.1 Model Formulation

I first discuss the consumer's decision process and follow with the console manufacturer's pricing model. In each period a potential consumer purchases or chooses not to purchase a video game console. After consuming a console a consumer decides which game to purchase, if any, from a set of available games. Once a consumer has purchased a video game console he exits the market for consoles but continues to purchase video games in future periods.

A consumer derives utility when he purchases a given video game. This utility must be accounted for in the utility he receives when consuming a specific console. Moreover, at the stage in which a consumer decides to purchase a console he is uncertain about the utility he receives from video games. The consumer only realizes the utility after the purchase of a video game console. It is therefore important to link the realized video game demand with the expected utility from video games in console demand.

Given the sequential nature of the model and the model assumptions, a nested logit structure is employed for console demand. The use of the nested logit structure provides a natural extension for the inclusive value to link video game demand to console demand in addition to it being consistent with the model assumptions. The formation of the inclusive value is generated from the assumption that video game demand is a discrete choice in each month and is of logit form. Employing the methodology of Berry (1994) I am able to construct the inclusive value (software index) without parameterizing the demand for video games–all that is required is data on video game sales and the potential market size.

I would like to note that the sequential interpretation of my model is just that: an interpretation. The same model also supports a multinomial logit model where buyers simultaneously choose consoles and games. In this case the choice probabilities for consoles have inclusive values and are interpreted in the same manner.

4.1.1 The Demand Side

The consumer decision process is as follows. In time t, each consumer makes a discrete choice from the set of $\mathcal{J}$ available consoles. If a consumers elects to purchase console $j \in (0, ..., J)$ where 0 is the outside option of not purchasing, he then purchases complementary video games which are compatible to console j. In choosing a console, a consumer only considers the expected maximum utility generated from the set of available video games in period t as a result of the consumer's uncertainty of the utility each video game generates at the stage in which he elects to purchase a console. The timing is as follows:

Stage 1: Consumers choose which console to purchase $j \in \mathcal{J}$

Stage 2a: Consumers realize the utility video games generate

Stage 2b: Consumers purchase video games which are compatible to console j.

Consumers are indexed by i, consoles by j and time by t. A consumer's indirect utility for console j is characterized by console price P_{jt}, a set of observed physical characteristics X_{jt}, the video game index Γ_{jt}, unobserved product characteristics ξ_{jt} (the econometric error term) and an individual taste parameter ε_{ijt}, distributed i.i.d. type-1 extreme value across i, j and t. A consumer's indirect utility for console j in market t is

$$\begin{aligned} u_{ijt} &= \alpha_i^{hw} P_{jt} + X_{jt}\beta_i^{hw} + \phi\Gamma_{jt} + \xi_{jt} + \varepsilon_{ijt} \qquad (1) \\ \begin{pmatrix} \alpha_i^{hw} \\ \beta_i^{hw} \end{pmatrix} &= \begin{pmatrix} \overline{\alpha}^{hw} \\ \overline{\beta}^{hw} \end{pmatrix} + \Sigma v_i + \Pi D_i \qquad v_i \backsim N(0, I_{k+1}) \end{aligned}$$

where α_i^{hw} and β_i^{hw} are $K+1$ individual specific parameters, K is the dimension of the observed characteristics vector, D_i is a $d \times 1$ vector of demographic variables, Π is a $(K+1) \times d$ matrix of parameters that measure how consumer taste characteristics vary with demographics and Σ is a vector of scaling parameters. The model parameters are $\theta^{hw} = (\theta_1^{hw}, \theta_2^{hw})$. θ_1^{hw} contains the linear parameters of the model $(\alpha^{hw}, \beta^{hw}, \phi)$ and $\theta_2^{hw} = (\Sigma, \Pi)$ the nonlinear parameter.[13]

Examples of physical characteristics are processing speed, graphics quality, volume of the console, CPU bits, number of controllers and the log of one plus advertising expenditures. Unobserved characteristics include other technical characteristics and market specific effects of merchandising. I control for these unobserved product characteristics as well as observed characteristics which do not vary over time with the inclusion of console specific fixed effects. In the attempt to capture some dynamic aspects of the consumer's valuation for consoles over time, I allow the console fixed effects to be year specific. I also control for the large seasonal spikes during holiday months with quarterly dummy variables. By employing fixed effects the econometric error term transforms from ξ_{jt} to a console–year month specific deviation, $\Delta\xi_{jyt}$, because I characterize the unobserved product characteristics as $\xi_{jt} = \xi_{jy} + \Delta\xi_{jyt}$ where ξ_{jy}

[13] Software utility enters linearly into the utility function for consoles so the expected utility of software is a sufficient statistic for calculating utility for hardware.

is captured by year specific console fixed effects. Lastly, I assume consumers observe all console characteristics and take them into account when making a console purchase decision.

From the above utility function a consumer will purchase console j if and only if the utility from console j is greater then the utility of all other consoles and the outside option

$$u_{ijt}(\varepsilon_{ijt}, X_{jt,}\xi_{jt}, \Gamma_{jt}(\cdot); \theta^{hw}) \geq u_{irt}(\varepsilon_{ijt}, X_{jt,}\xi_{jt}, \Gamma_{jt}(\cdot); \theta^{hw}) \ \forall r \ 0, 1, .., J.$$

Let

$$A_{jt} = \{(D_i, v_i, \varepsilon_{.t}) | u_{ijt} \geq u_{irt} \ \forall r \ 0, 1, .., J)\}$$

denote the set of values of ε_{ijt} which induce consumers to purchase console j in market t and assume $dP^*(\cdot)$ denotes population distribution functions. Then the predicted probability that a consumer purchases console j in market t is given by

$$s_{jt}(X_{jt}, \xi_{jt}, \Gamma_{jt};\theta^{hw}) = \int_{A_{jt}} dP^*_{\varepsilon}(\varepsilon) dP^*_v(v) dP^*(D). \quad (2)$$

In order to predict console market shares and determine a consumer's indirect utility from a console purchase I must examine the utility he receives from purchasing software in order to define $\Gamma_j(\cdot)$, the software index. Consider a consumer who purchases console j in period t. The indirect utility consumer i receives when purchasing software k_j compatible with console j is

$$u_{ik_jt} = \alpha^{sw,j} p_{k_jt} + x'_{k_jt}\beta^{sw,j} + \psi_{k_jt} + \eta_{ik_jt} \equiv \delta_{k_jt} + \eta_{ik_jt} \quad (3)$$

where p_{k_jt} is software k's price, x_{k_jt} is vector of game characteristics, ψ_{k_jt} is the unobserved software characteristics and η_{ik_jt} is a type-1 extreme value distributed random variable which is independently and identically distributed across individuals, software, console and time. Parameters vary by console to allow for the possibility that consumer preferences differ across consoles. Unlike a model where software titles are neither substitutes nor complements,[14] a consumer makes his decision based upon the notion that titles are substitutes for each other.

[14] Which is in the spirit of a static version of Lee's (2009) paper.

Consequently, a consumer purchases software k_j if and only if

$$u_{ik_jt}(\eta_{ik_jt}, x_{k_jt}, \psi_{k_jt}; \theta^{sw,j}) \geq u_{ig_jt}(\eta_{ig_jt}, x_{g_jt}, \psi_{g_jt}; \theta^{sw,j}) \ \forall g \ 0, 1, .., K.$$

Similar to the above console model, denote the set of values of η_{k_jt} which induce consumption of software k_j in market t to be defined as

$$L_{k_jt} = \{\eta_{k_jt} | u_{ik_jt} \geq u_{ig_jt} \ \ \forall g_j \ 0, 1, .., K_j\}.$$

With software titles being substitutes for one another and consumers knowing which games are available on a console but not the utility a game provides at the console selection stage, the consumer forms an expectation as to the utility he would receive from video games. The expectation of software utility forms the indirect network effect and equals the expected maximum utility from choosing from a set of available and compatible video games for console j in market t

$$\Gamma_{jt} = E(\max_{k \in \mathcal{K}} u_{k_jt}). \tag{4}$$

I complete the console demand model with the specification of the outside good or the option of not purchasing a console. The indirect utility from not purchasing is

$$u_{i0t} = \xi_0 + \sigma_0 v_{i0} + \pi_0 D_i + \varepsilon_{i0t}.$$

It is normalized to zero by setting (ξ_0, σ_0, π_0) to zero.

4.1.2 The Supply Side

The profit function of a console manufacturer differs from that of a standard single product firm. Console firms face three streams of profits (selling consoles, selling video games and licensing the right to produce a game to game developers) and take each into consideration when setting console price. Assume that each console producer sets price in order to maximize profits and that they act myopically. Furthermore, assume console producers face a marginal cost of \$2 when interacting with game developers (this cost is associated with the production and packaging of video games).[15] Additionally, a developer's marginal

[15] Game developers do not actually create the physical disk which is sold to consumers. Instead, the console manufacturer stamps all video games for quality control purposes.

cost for a game equals the royalty rate charged by a console and is set at \$10 per game. I thus treat a console's royalty rate as exogenous and therefore it is not a strategic variable for consoles.

Assumption 1: Console producers and game developers all act myopically

Assumption 2: Console firms face a marginal cost of two dollars when interacting with game developers

Assumption 3: Developer's marginal cost equals the royalty rates charged by console manufacturer and is set at ten dollars per game.[16]

Console maker $j's$ profit function in time t is

$$\Pi_{jt} = (P_{jt} - mc_{jt}) M_t S_{jt}(P, X, \Gamma; \theta^{hw}) + \sum_d (\underbrace{IB_{jt-1} + M_t S_{jt}(P, X, \Gamma; \theta^{hw})}_{\text{Potential Market for game d=IB}_{jt}}) S_{dt}(\delta)(p_{dt} - c) + \sum_k (\underbrace{IB_{jt-1} + M_t S_{jt}(P, X, \Gamma; \theta^{hw})}_{\text{Potential Market for game k=IB}_{jt}}) S_{kt}(\delta)(r - c)$$

where P_{jt} is the console price, mc_{jt} the console marginal cost, M_t the potential market for consoles, S_{jt} is the average probability consumers purchase console j, IB_{jt-1} is the number of j consoles sold up to and including period $t-1$, S_{dt} is the probability game d, which is produced by the console manufacturer, is purchased by consumers and S_{kt} is the probability consumers purchase game k, a *third party* game. Lastly, IB_{jt} is the installed base of console j and the potential market size for a video game.

The above profit function differs from a standard single product profit function in that there are two additional profit streams. The first term is the usual single product profit. The second and third terms are profits the console maker receives from interacting with game developers and selling its own games. Specifically, the second term is the profit a console maker garners from creating and selling its own games and the third term is the profit it receives from *third party* developers. The resulting first order conditions, in matrix

[16] Assumptions two and three are made from an industry expert's inside knowledge.

notation, assuming firms compete in a Bertrand-Nash fashion, is

$$S(P) - (P - mc + \Omega)\Delta = 0 \tag{5}$$

$$\Delta = diag\left[-\frac{\partial S_{jt}(\,\cdot\,)}{\partial P_{jt}}\right]$$

$$\Omega_{jt} = \sum_{d} S_{dt}(\delta)(p_{dt} - c) + \sum_{k} S_{kt}(\delta)(r - c)$$

where Ω is the marginal profit a console producer receives from *third party* developers and selling *first party* games when one additional console is sold. The above first order conditions can be inverted to solve for console price-cost markups:

$$P - mc = \Delta^{-1} S(P) - \Omega. \tag{6}$$

Because prices and video game market shares are observed and markups are determined using $\Delta^{-1}S(P)$, console marginal costs can be estimated. Assume marginal cost takes the form

$$\ln(mc) = W\tau + \varpi \tag{7}$$

where W is a $J\times\ H$ matrix of console observed cost side characteristics and ϖ is an unobserved component of marginal cost. Cost side observables are console dummy variables, a console specific time trend and quarter dummy variables.

5 Estimation

The estimation procedure I use to recover the structural model parameters is quite similar to that of Petrin (2002)–I supplement typical Berry, Levinsohn and Pakes (1995), henceforth BLP, moments with a new set of micro moments obtained from the North America Consumer Technology Adoption Study survey data. Assuming that the observed data are equilibrium outcomes I estimate the parameters $\theta^{hw} = (\theta_1^{hw}, \theta_2^{hw})$ with simulated method of moments. There are three sets of moments I employ in estimation. But before I describe these moment conditions, I first discuss the estimation of video game demand and the formation of the software index.

5.1 Video Game Demand

The demand for video games follows a multinomial logit structure. I allow consumers to repurchase an already owned title. This assumption is not as extreme as one might think. Consumers are likely to repurchase a game after it has been lost or damaged. With these assumptions the software index is analytic and can be determined without the parameterization of the demand model. Only monthly quantity and potential market size data are needed.

The implementation of the standard logit utility function as opposed to a more complex random coefficient function, such as the one employed for the console demand model, allows for the analytical construction of the software index without parameterizing the demand model as long as the indirect utility function for software is of a linear form. The ease of this technique has its drawbacks. It does not allow for the determination of how game prices change as a result of a merger among video game developers or the elimination of any games.[17] To analyze these questions, I would be required to recover the model parameters.

I proceed by following the methodology of Berry (1994) to construct the software index.

Let S_{k_jt} be the observed probability that game k on console j is purchased in period t and s_{k_jt} be the model's predicted probability then the following equation will hold for population values of δ :

$$S_{k_jt} = s_{k_jt}(\delta) \qquad \forall\ k = 0...K.$$

where 0 is the outside option of not purchasing a game. Given the logit distribution for unobserved consumer taste the above system of equations can be inverted analytically. The mean utility (in vector form) is

$$\delta = s^{-1}(S).$$

and is determined uniquely by the observed probabilities along with a normalization of the utility from not purchasing a game to zero

$$\ln \frac{S_{k_jt}}{S_{ot}} = \delta_{k_jt}.$$

[17] I futher discuss and test the sensitivity of this assumption below.

The software index for console j in time t is

$$\Gamma_{jt} = E(\max_{k_j \in \mathcal{K}_j} u_{k_j t}) = \ln\left(\sum_{k_j=0}^{K_j} \exp[\delta_{k_j t}]\right) + \varphi$$

where φ is Euler's constant. The software index is of the familiar logit inclusive value form and holds the same interpretation. Again, note that the software index is determined only with potential market size and sales data. No parameterization is needed.

5.2 The Moments

There are three sets of moments that I employ in estimation. The first two are typical macro BLP type moments. From the demand side I match predicted market shares to observed shares or

$$s_j(\delta(\theta^{hw}), \theta^{hw}) - s_j = 0 \quad j = 0, 1, ...J.$$

In construction I solve for $\delta_{jt}(\theta^{hw}) = \overline{\alpha}^{hw} P_{jt} + X_{jt}\overline{\beta}^{hw} + \phi\Gamma_{jt} + \xi_{jt}$ which matches the predicted model shares to the observed shares. After the recovery of $\delta(\theta^{hw})$, via simulation, I find the first moment unobservable $\Delta\xi$ from

$$\Delta\xi = \delta(\theta^{hw}) - \overline{\alpha}^{hw} P - X\overline{\beta}^{hw} + \phi\Gamma.$$

The second BLP type moment originates from the pricing model. I construct the second set of moment conditions by expressing an orthogonality between the cost side unobservables and corresponding instruments and using the demand side estimates in order to recover marginal costs as shown above in equation (7). The corresponding moment unobservables are:

$$\varpi = \ln(P - \Delta^{-1} S(P) + \Omega) - W\tau.$$

The main estimating assumption for $(\Delta\xi(\theta^{hw}),\ \varpi(\theta^{hw}))$ assumes that the unobserved demand and supply unobservables are uncorrelated with the observed demand and cost side variables (with the exception of console price) in a given period t. Similarly, the unobservables are mean independent of a set of exogenous instruments, Z

$$E[\Delta\xi_j(\theta_0^{hw})|Z^d] = E[\varpi_j(\theta_0^{hw})|Z^s] = 0.$$

As price is not exogenous I use instrumental variables to correct for the associated bias. For instance, if price is positively correlated with quality then the price coefficient will be biased upward. I resolve this correlation through the use of console dummy variables. Even with the use of year specific console fixed effects the proportion of the unobservable which is not accounted for may still be correlated with price as a result of consumers and producers correctly observing and accounting for the deviation.[18] Under this assumption, market specific markups will be influenced by the deviation and will bias the estimate of console price sensitivity. Berry (1994) and BLP both show that proper instruments for price are variables which shift markups. I use standard BLP type estimates but also draw from the above first order conditions for additional instruments. The first two instruments are derived from the software index and the log of one plus the advertising expenditure. They are equal to the sum of a console's competitors' software indices or log of one plus the advertising expenditure.[19] The next set of instruments also takes the same functional form in addition to a console's own value. As discussed above, the console's price is a function of the expected profit it receives from *first* and *third party* games, in the form of *first party* game price or levied royalty. The number of *first* and *third party* games in addition to the sum of a console's competitors *first* and *third party* games aid in determining console price and are suitable instruments. Lastly, I also include console specific market time trends as instruments.[20]

One might also suppose the software index in addition to console price is endogenous. In order to properly identify the software index I assume the residuals of the structural error terms, $\boldsymbol{\Delta\xi}_{jyt}$, are independent of each other. This assumption negates any impact an aggregate demand shock in period $t-1$ has on the software index in period t and therefore eliminates the need for instrumental variables. And, the assumption is quite reasonable given that video game developers commit to the release date for a game well in advance. Moreover, the time it takes a game to come to fruition, from concept to production, is a substantive period ranging from twelve to eighteen months. I, therefore, treat the software index as an exogenous product characteristic which implicitly implies the number of *first* and *third* party games is also exogenous.

[18] See Nevo 2001 for futher explanation.

[19] See below for why software index is assumed exogenous.

[20] The first stage Adjusted R^2 value for the regression of the endogenous variable, price, on the instruments is 0.9054.

There is also a need for supply side instruments. I suspect ϖ to be correlated with $\boldsymbol{\Delta\xi}_{jyt}$ because a console with a high unobserved quality might be more expensive to produce. Instruments include cost shifters, W, and the above demand side instruments which shift a console's margin.

The last and third set of moments supplements the BLP moments with micro level survey data. This set of moments matches predicted average family size conditional on ownership of a given video game console to the observed data. Let B_j for $j = 1, 2, 3$ be the residual associated with the matching of predicted and realized average family size conditional on ownership of a given console j, b_j for $j = 1, 2, 3$ be the realized average family size associated with the ownership of console j and $E[fs_i \mid \{i \text{ owning console } j\}]$ be the predicted average. These moments are then given by

$$B_j = b_j - E[fs_i \mid \{i \text{ owning console } j\}] \text{ for } j = 1, 2, 3.$$

With the observed data capturing a snapshot of ownership in 2005, the predicted average family size conditional on console j ownership must account for this distinction. I form the predicted average by aggregating over all time periods and employing Bayes' Rule at the terminal date in the data.

5.3 The Estimator

A simulated method of moments procedure is used to recover model parameters. The estimation procedure is as follows.

For a given value of parameters Θ and the software index Γ

1. Simulate 1,000 (consumer) purchases of video games consoles and compute console market shares. Solve for the vector of mean console utility which matches observed shares to predicted shares.

2. Calculate (β, ϕ) and compute the demand unobservables, $\Delta\xi$. Calculate τ and compute the cost side unobservables ϖ

3. Calculate the micro residual

4. Search for the parameter values that minimize the objective function $\Lambda' Z A^{-1} Z' \Lambda$.

The objective function which is minimized is $\Lambda' Z A^{-1} Z' \Lambda$, where A^{-1} is the weighting matrix that is a consistent estimate of the inverse of the asymptotic variance-covariance matrix of the moments, $[Z'\Lambda\Lambda' Z]$ and Z are instruments orthogonal to the model error term, Λ. Let Z^d, Z^s, Z^{micro} be instruments for the BLP and micro moment residuals, respectively. The sample moments are

$$Z'\Lambda = \begin{bmatrix} \frac{1}{G}\sum_{g=1}^{G} \mathbf{Z}_g^d \boldsymbol{\Delta\xi}_g \\ \frac{1}{G}\sum_{g=1}^{G} \mathbf{Z}_g^s \boldsymbol{\omega}_g \\ \frac{1}{J}\sum_{j=1}^{J} \mathbf{Z}_j^{micro} B_j \end{bmatrix}.$$

With joint estimation I am able to find more efficient parameter estimates as a result of accounting for any cross equation restrictions on parameters that affect both supply and demand.[21] However, this does come with a computational cost.

5.4 Identification

The following is a short discussion on how variation in the data aids the identification of model parameters.

With every console there is a mean utility found to match the observed and predicted purchase probabilities. If we assume consumers are identical then all variation in sales would be a result of variation in product characteristics. Thus, monthly variation in product characteristics with monthly variation in shares aids in the identification of the mean utility parameters such as the log of one plus console advertising expenditure and the software index.

Identification of (Σ, Π) pertains to how price sensitive households are and how they substitute. If the price of one product changes and substitution occurs to other products with

[21] As in BLP (1995), standard errors are corrected for simulation. I assume the population sampling error is negligible given the large sample size of over 78 million households. Simulation error, however, cannot be ignored as a result of the need to simulate the integral which defines console market share S_{jt}. Geweke (1998) shows antithetic acceleration reduces the loss in precision from simulation by an order of 1/N (where N is the number of observation) and thus requires no adjustment to the asmpototic covariance matrix.

a similar price then there are signs of consumer heterogeneity. Likewise, if consumers substitute equally to all other goods then consumers are homogenous. Changes in product characteristics therefore aid the identification of the nonlinear parameters. For instance, assume console A and B are very similar in characteristics, think of A and B as PlayStation 2 and Xbox whereas console B and C (Xbox and GameCube) have the same purchase probabilities. Suppose we have sales and price information for two periods and that the only change to occur is a reduction in the price of console A. A logit model predicts purchase probability for B and C to fall by equivalent amounts whereas a random coefficient logit model predicts console B, the console most similar in characteristics to console A, to fall by more than that of console C. Therefore, by observing the actual relative changes in purchase probability of consoles B and C and variation in console characteristics I can determine whether consumers are heterogeneous or homogenous in taste. Additionally, the degree of change allows the parameter that determines the distribution of the random coefficient to be identified.[22] Furthermore, I augment the console sales data with micro survey ownership data. This additional information allows variation in ownership to mirror variation in taste for console characteristics. Correlation between $X_{jt}D_i$ and choices identifies the demographic taste parameters, Π. And to conclude, identification of the impact observable cost characteristics have on marginal cost is due to variation in console prices and shares.

6 Structural Estimation Results

There is significant variation in taste across consumers toward numerous product characteristics. I present the model results in Table 4.[23] Column two gives the mean parameter $\theta_1^{hw} = \{\alpha, \beta, \phi, \tau\}$ and the remaining columns provides estimates of unobserved and observed consumer heterogeneity about these means $\theta_2^{hw} = \{\Sigma, \Pi\}$. Let me first describe the random demand parameters results and follow with the non random demand coefficient results. I estimate the means and standard deviations for console price (Price) and the log of advertising expenditures (Ad) whereas only the standard deviation of consumer taste toward the maximum number of controllers a console is able to be played with. Additionally, I inter-

[22]This example is a modified version of the example provided in Nevo (2000).

[23]I present alternative models in the appendix. These models consist of i) only estimating demand and ii) estimating demand and supply without year specific year fixed effects.

act console price and console advertising expenditures with the number of family members within the same household. The mean price parameter is negative and significant at the 95% confidence interval, (-0.0184). Consumers, therefore, have significant marginal disutility to console price, as would be expected. Furthermore, the associated standard deviation in which consumer taste toward price is distributed is positive and significant whereas the interaction term of console price and the number of family members is significantly negative. This latter parameter indicates that larger households, most notably because of an increase in children, are more price sensitive (-0.0053), while the former indicates that household price sensitivity can be further explained by unobserved heterogeneity, (0.0066). Unlike a consumer's taste toward price, consumer heterogeneity toward console advertising is fully captured by household size (0.0023), resulting in an insignificant estimate of the standard deviation (0.0039). I find that larger households gain more utility as a result of an increase in console advertising expenditure. Lastly, the standard deviation which explains the distribution of unobserved consumer heterogeneity for the maximum number of controllers a console is able to be played with is insignificantly different from zero (0.1262).

Below the random coefficient results in Table 4 are the non-random demand and marginal cost parameters. The coefficient on the software index is the expected sign and is significant at the standard 95% level (0.8892). The positive sign indicates video games and consoles are complements. Although the marginal utility with respect to advertising expenditures (Ad) is negative, counter to intuition, it is insignificant. As a result, advertising has zero impact on the mean consumer. Its greatest impact is on large families. To conclude, the cost side estimates are below the demand estimates. A large number of the parameters hold the proper sign and are significantly different from zero.

Table 4: Model Results

Variable	Coefficient	Std. Error	Std. Dev.	Std. Error	Household Size	Std. Error
Utility Parameters						
Price	-0.0184**	0.0088	0.0066*	0.0035	-0.0053**	0.0012
Ad	-0.0046	0.0089	0.0039	0.2668	0.0023**	0.0009
Controllers			0.1262	0.2948		
Software Index	0.8892**	0.0830				
Q1	0.0379	0.1336				
Q2	-0.3294**	0.1426				
Q3	-0.3082**	0.1366				
Cost Side Parameter						
Nintendo GameCube	5.1513**	0.0413				
Sony PlayStation2	5.6465**	0.0425				
Microsoft Xbox	5.2708**	0.0500				
Nintendo GameCube*trend	-0.0306**	0.0016				
Sony PlayStation2*trend	-0.0222**	0.0015				
Microsoft Xbox*trend	-0.0160**	0.0018				
Q1	-0.0248	0.0286				
Q2	-0.1086**	0.0263				
Q3	-0.0587**	0.0268				
GMM Objective Function	28.7845					

Notes: ** indicates significant at 95%; * indicates significant at 90%; Year specific console fixed effects not reported

Table 5 reports the North American Consumer Technology Adoption Survey (NACTAS) moments. The table also lists these moments at the estimated parameter values. It is clearly evident that the described model is flexible enough to match the moments–average family size given the purchase of a specific console matches almost perfectly. Furthermore, a test of differences is unable to reject the hypothesis that the moments are the same.[24]

[24] The test statistic is distributed chi-squared with 3 degrees of freedom with a realized test statistic of 0.000022853 and a critical value at a 99% confidence level of 11.37

Table 5: Micro Moments from North American Consumer Technology Adoption Study and Equivalent Predictions from Model

	NACTAS (StdErr)[1]	Model(θ)
Average Family Size, Given Purchase of:		
GameCube	3.6725 (0.2532)	3.6722
PlayStation2	3.5987 (0.1631)	3.5967
Xbox	3.7206 (0.2460)	3.7291

[1] Standard error on NACTAS reflects sampling variance associated with moments and is accounted for in estimation

6.1 Substitution, Marginal Cost, and Markups

The estimation of a structural model supplies necessary and sufficient information to find consumer substitution patterns, which in part helps determine console markups. Table 6 provides own and cross price elasticities estimates for January of 2002.[25] As the table indicates, all the diagonal elements are negative and greater than one. The estimates are consistent with oligopolistic behavior in which firms price on the elastic portion of the demand curve. Moreover, the off-diagonal elements are positive and the estimated cross-price elasticity measures are consistent with the beliefs of an industry insider regarding the relative competition among video game consoles. For instance, Nintendo GameCube is most sensitive to price changes from Microsoft's Xbox while Microsoft is most sensitive to price changes from Sony's PlayStation 2. The closest competitor to the Sony PlayStation 2 is the Microsoft Xbox. Consumers, therefore, substitute to products closer in characteristics.

Table 6: A Sample of Console Elasticities from January 2002

	GameCube	PlayStation 2	Xbox
GameCube	-3.8571	0.1691	0.0631
PlayStation2	0.0185	-4.4554	0.1014
Xbox	0.0195	0.2857	-4.6392

Note: Cell entry i, j, where i indexes row and j column, gives the percent change in market share of brand i with a one percent change in the price of j.

[25] Elasticities are computed by multiplying the numerical derivative of estimated demand by price and dividing by actual market share.

In order to gain further insight into the firm pricing and markups I estimate console marginal cost. Figure 4 depicts estimated console marginal costs and Figure 5 illustrates console markups over time.[26] It is evident that marginal cost decreases with time. Yet, in Figure 5 markups increase–as is the case in most technological markets marginal cost is falling faster than price, leading to increasing markups over time.

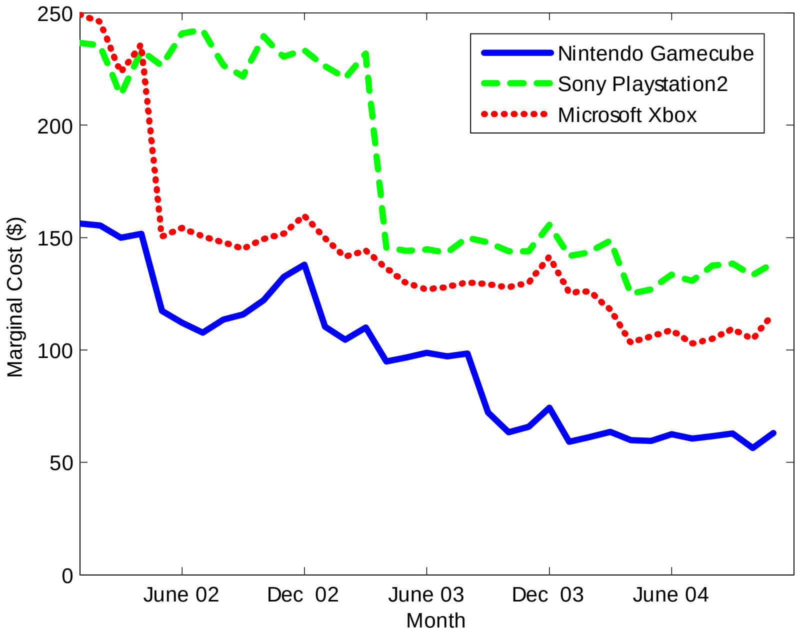

Figure 4: Console Marginal Cost

These results are consistent with my ex ante belief and industry insider knowledge–markups for consoles are small and perhaps negative at the launch of a console.

[26]Figure 5 has accounted for an assumed twenty percent margin by retailers.

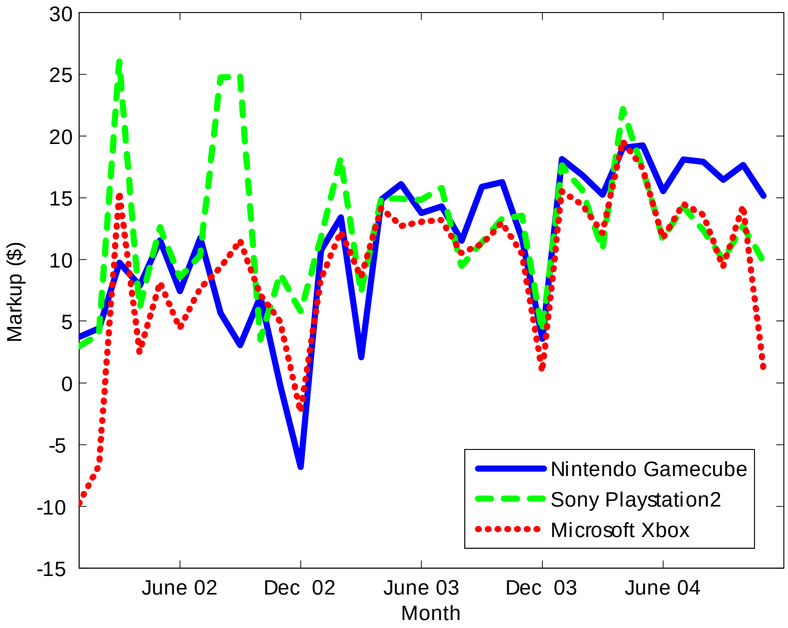

Figure 5: Console Markup

7 Counterfactual Simulation

Should the government have been concerned not only with Nintendo's exclusive contracts but also its vertical integration in the late 1980s? Does the foreclosure of integrated games to rival consoles create market power or enhance welfare? I answer this question through studying console price competition, consumer welfare and firm profits with two counterfactual simulations. I investigate the impact of vertical integration with two simulations: i) vertical integration is prohibited and is accompanied with a subsequent ban on exclusive contracting (all *first party* games are completely eliminated and are not produced)[27] and ii) only vertical integration is prohibited (all integrated video games are produced but by an independent video game developer).[28,29] I implement the latter simulation due to the fact that exclusive contracts and vertical integration are perfect substitutes–they both restrict the ability to

[27] I do not eliminate all exclusive contracts in this scenario. I assume the banning of exclusive contracts relates to only *first party* titles as I am unable to identify which *third party* games have entered into exclusive contracts with console makers or are exclusive due to high porting costs.

[28] This counterfactual is an appropriate simulation to run given that vertical integration in the video game industry occurs through the initiation of a console's own in house design studio rather than a merger with an established software firm. Consequently, any policy banning vertical integration and exclusive contracting would eliminate production of first party games whereas it would be appropriate to assume integration via merger would not eliminate any video games.

[29] See appendix for additional simulations via a calibrated model in which games compatible with Nintendo's console are the only available games and are also assumed to be compatible with the two remaining consoles.

play certain video games on rival consoles. Consequently with these two simulations, I am able to determine whether a policy banning vertical integration should be accompanied by a ban on other exclusive dealing arrangements.

Before implementing any counterfactual experiment I make an important assumption regarding the pricing of video games. Video game prices are assumed to not adjust to changes in competitive environments. Thus, my analysis does not capture the "full" efficiency gains from coordinating the pricing decisions of video games and consoles. I make this assumption on the basis that holding video game prices constant allows for an analytic solution of the software index and therefore does not require the parameterization of the software utility function. Moreover, the difference between the average price of *first party* and *third party* games is only a negative sixty-five cents or -2%. Additionally, this assumption generates a lower bound to the impact on console prices, and an upper bound for consumer welfare and firm profits in the first counterfactual. Although eliminating a large number of console produced games diminishes video game competition resulting in an increase in video game prices and an incentive to lower hardware prices the effect that higher game prices have on the additional profit console makers receive from game developers when one additional console is sold out weights the incentive to decrease console price. With higher game prices the additional profit from developers decreases as consumers are less likely to purchase a game. Video game hardware prices thus increase. In the following section I test the sensitivity of this assumption by rerunning each of the counterfactual simulations assuming the associated mean utility of all games decrease by 5% and 10% in counterfactual one and that any *first party* game's mean utility in counterfactual two declines by 2%.[30]

A priori the effect of vertical integration on console price competition is unclear. There are two important trade-offs to vertical integration. The first is a foreclosure effect. Because a *first party* game is always exclusive to the producing console maker it forecloses rival consoles from this game. In order for a consumer to play a *first party* title he has to first purchase the respective console. The exclusivity of the game increases the console manufacturer's market power which generates an incentive to raise console price. One can also think of the foreclosure effect as increasing differentiation among consoles. The production of a *first party* game and its release exclusively for the producing console has an

[30] By decreasing mean utility by these amounts I am in effect increasing price of software by more than these percentages if the price coefficient is less than one.

apparent benefit because it increases the value of the console relative to others through the software index. The added differentiation consequently forces prices higher.

There is also an efficiency effect. Under efficiency-based theory, integration increases price competition among consoles. When a console manufacturer elects to design video games as well as produce consoles its price structure adjusts to reflect its decision. Without vertical integration console prices are discounted by the profit console manufacturers receive from their interactions with developers when an additional consumer purchases a console. A third profit stream is created with vertical integration. Price is further discounted by the profit the console producer receives from designing, producing and selling its own video games when one more console is sold. Vertical integration, therefore, levies added pressure on price or generates an incentive for console manufacturers to lower console price because lower prices lead to an increase in the demand for consoles which consequently generates greater demand for video games, in particular their own video games.

Banning Vertical Integration and Exclusive Contracts:

The results of counterfactual simulation one are presented in Table 7 and the results from counterfactual two are in Table 10.[31] Likewise, price graphs for each counterfactual illustrating the predicted change in price are below in Figures 6 and 7. The results of counterfactual one indicate the efficiency effect dominates the foreclosure effect leading to an increase in console price competition when vertical integration and exclusive contracts are permitted. Moreover, *first party* games benefit Microsoft and Nintendo more than Sony. The first counterfactual predicts Nintendo's price for its GameCube to increase an average of 5.24 percent while Microsoft's Xbox price rises an average of 2.14 percent and Sony's price by 0.87 percent when both vertical integration and exclusive contracts are prohibited. The increase in the price of Xbox and GameCube decrease their respective shares by an average of three and three-quarter percentage points leading to an increase in industry concentration. One explanation as to why prices increase more for Microsoft and Nintendo than for Sony is a result of these two console makers producing "hit" *first party* games. This is a consequence of the fact that the model accounts for fewer "hit" *first party* games for Sony than Microsoft and Nintendo. To illustrate this fact Table 8 shows the ten leading titles on each platform for the given time period, nine of which are *first party* titles for Nintendo and four for Microsoft.

[31] All results are calulated as a weighted average. The weight is the proportion of sales in each month relative to aggregate sales.

Table 7: Counterfactual Results

		Data (w/ VI)	Counterfactual I
Mean Price	GameCube	$131.66	$138.52
	PlayStation 2	$244.44	$246.61
	Xbox	$187.36	$191.36
Mean Price Effect	GameCube		5.24%
	PlayStation 2		0.87%
	Xbox		2.14%
Mean % Market Share	GameCube	20.30%	17.28%
	PlayStation 2	52.95%	56.70%
	Xbox	26.75%	26.02%
Mean Number of Consoles Sold	GameCube	378,660	262,750
	PlayStation 2	958,260	908,920
	Xbox	461,540	395,420
Total Number of Consoles Sold (M)		34.55942	31.484
Mean Variable Profit (M)	GameCube	$64.09	$24.45
	PlayStation 2	$179.27	$126.15
	Xbox	$73.94	$39.26
Mean Variable Profit From Games (M)	GameCube	$48.080	$14.428
	PlayStation 2	$101.360	$69.773
	Xbox	$47.210	$21.485
% change in Mean Consumer Surplus			-12.84%

When these top selling games in addition to all other *first party* titles are eliminated a console maker's market power deceases because the remaining games are available on multiple consoles.[32] Moreover, the attractiveness of the console decreases because the demand side indirect network effect is smaller. This drives price lower. Yet the elimination of all *first party* games also creates an incentive to increase console prices though the reduction of additional profit console makers receive from developers when one more console is sold. Consequently,the firm's profit function is now only a function of its interactions with *third party* developers. I find the efficiency effect is a significantly more important driver of price than the foreclosure effect. Thus, prices rise and rise more for Nintendo and Microsoft when vertical integration and foreclosure are prohibited.

[32] There will remain some exclusive *third party* games available on each console resulting in the retention of some console market power through foreclosure.

Table 8: Top 10 Video Game Titles

Console	Title	Publisher	Quantity
GameCube	MARIO KART: DOUBLE	NINTENDO	1,731,903
	SUPER SMASH BROTHER MELEE	NINTENDO	1,028,343
	ANIMAL CROSSING	NINTENDO	799,842
	MARIO PARTY 5	NINTENDO	774,623
	SOUL CALIBUR II	NAMCO	718,395
	LUIGI'S MANSION	NINTENDO	702,401
	POKEMON COLOSSEUM	NINTENDO	698,449
	SUPER MARIO SUNSHINE	NINTENDO	600,091
	ZELDA: THE WIND WAKER	NINTENDO	547,067
	METROID PRIME	NINTENDO	499,929
PlayStation 2	GRAND THEFT AUTO:VICE CITY	TAKE 2 INTERACTIVE	6,315,099
	GRAND THEFT AUTO 3	TAKE 2 INTERACTIVE	5,194,262
	GRAND THEFT: ANDREAS	TAKE 2 INTERACTIVE	3,590,284
	MADDEN NFL 2004	ELECTRONIC ARTS	3,419,157
	GRAN TURISMO 3:A-SPEC	SONY	2,781,235
	MADDEN NFL 2003	ELECTRONIC ARTS	2,727,112
	FINAL FANTASY X	SQUARE ENIX USA	2,192,461
	MEDAL HONOR FRONTLINE	ELECTRONIC ARTS	2,185,916
	KINGDOM HEARTS	SQUARE ENIX USA	2,120,314
	NEED FOR SPEED: UNDERGROUND	ELECTRONIC ARTS	2,111,249
Xbox	HALO	MICROSOFT	3,789,232
	HALO 2	MICROSOFT	1,777,697
	HALO 2 LIMITED ED	MICROSOFT	1,489,406
	T.CLANCY'S SPLINTER	UBISOFT	1,483,843
	GRAND THEFT AUTO PACK	TAKE 2 INTERACTIVE	1,200,618
	PROJECT GOTHAM RACING	MICROSOFT	1,188,976
	T.CLANCYS GHOST RECON	UBISOFT	965,620
	ESPN NFL 2K5	TAKE 2 INTERACTIVE	938,203
	DEAD OR ALIVE 3	TECMO	885,781
	STAR WARS: KNIGHTS	LUCASARTS	881,740

In addition to illustrating that Nintendo and Microsoft are quite reliable on their production of "hit" *first party* games through a list of top ten video games, I also show the benefit each game brings to its respective console. In Table 9 I provide console elasticities from losing the console's top selling *first party* video game. The elasticities show the change in console share in the first month in which the "hit" game was released. I also show how consoles benefit when a competing console loses a "hit" title. The table depicts the sizable impact such a loss has on GameCube's and Xbox's console shares.

Table 9: Console-Game Elasticities: Losing the Top First Party Game

	GameCube	PlayStation 2	Xbox
GameCube	-6.2853	0.0389	0.1395
PlayStation2	0.2957	-0.7444	0.1891
Xbox	0.3451	0.0732	-5.4401

Note: Cell entry i, j, where i indexes row and j column, provides the percent change in market share of brand i upon losing the top first party selling game in the first month of its release. Titles are Nintendo's Super Smash Brother, Sony's Gran Turismo 3 and Microsoft's Halo

After establishing that the efficiency effect dominates the foreclosure effect I analyze console manufacturer profits. I find that profits decrease. Intuitively, although console prices rise when vertical integration is prohibited, the percentage reduction in the number of consoles sold is larger than the increase in price. Furthermore, the reduction in the number of consoles sold consequently decreases the demand for software and thus reduces the profit manufacturers receive from video games. When vertical integration with foreclosure is permitted it drives console prices lower which in turn raises console sales and thus increases video game demand. Console makers therefore use vertical integration in order to drive sales of video games, in particular their own *first party* games, where the greatest proportion of industry profits are made.

In summary, the efficiency effect dominates the foreclosure effect for all consoles. Prices of consoles with a larger degree of concentration in vertically integrated games rise more than consoles with less when vertical integration is prohibited. As a result, consumer welfare decreases an average of 12.84% per month. Likewise, profits decrease.

Banning Vertical Integration but Permitting Exclusive Contracts:

The second counterfactual differs from the one above in that vertical integration with foreclosure is still prohibited but I allow console makers to remain able to contract exclusively with video game developers. Instead of eliminating all *first party* games I allow these games to become *third party* exclusive video games. In doing so, the associated foreclosure effect is equivalent to the effect under a policy permitting vertical integration with foreclosure– there is no difference as a result of exclusive contracts being perfect substitutes with vertical integration with foreclosure. Consequently, video game console prices will rise when *first party* games are banned relative to what is seen in the data. This increase is a direct result of the price effect which causes Ω to diminish under such a scenario relative to the circumstance in which all console manufactured games are produced. Put differently, the console maker has a substantially smaller incentive to decrease console price which leads to a greater demand for consoles and aggregate demand for video games because all of its "prior" first party games now only recover a small royalty fee rather than the sizable game price p_d. Consequently, I find console price competition decreases. Console prices rise on average 4.71, 0.68, and 1.85 percent for Nintendo, Sony, and Microsoft, respectively.

Similar to the first counterfactual scenario, the increase in the price of Xbox and GameCube decrease their respective shares which leads to an increase in industry concentration. The explanation as to why prices increase more for Microsoft and Nintendo than for Sony in the first exercise also holds. Note, however, under the second counterfactual scenario there is no substitution to *third party* games when *first party* games are eliminated which would partially offset the impact of the efficiency effect. Instead, the additional profit a console maker receives from *first party* games is the identical royalty payment it levies on *third party* titles. Table 8 above shows the ten leading titles on each platform for the given time period, nine of which were *first party* titles for Nintendo, four for Microsoft and one for Sony. The switching of these top selling games in addition to all other *first party* titles to *third party* games eliminates the substantial premium console developers receive from selling their own games. Thus, console manufacturer profits are smaller than when vertical integration is permitted. Likewise, consumer surplus is smaller.

Table 10: Counterfactual Two Results

		Data (w/ VI)	Counterfactual II
Mean Price	GameCube	$131.66	$137.83
	PlayStation 2	$244.44	$246.12
	Xbox	$187.36	$190.83
Mean Price Effect	GameCube		4.71%
	PlayStation 2		0.68%
	Xbox		1.85%
Mean % Market Share	GameCube	20.30%	18.76%
	PlayStation 2	52.95%	54.77%
	Xbox	26.75%	26.47%
Mean Number of Consoles Sold per Month	GameCube	378,660	319,010
	PlayStation 2	958,260	943,210
	Xbox	461,540	433,050
Total Number of Consoles Sold (M)		34.55942	33.239
Mean Variable Profit per Month (M)	GameCube	$64.09	$30.49
	PlayStation 2	$179.27	$132.61
	Xbox	$73.94	$44.52
Mean Variable Profit From Games per Month (M)	GameCube	$48.080	$18.578
	PlayStation 2	$101.360	$74.533
	Xbox	$47.210	$25.297
% Change in Mean Consumer Surplus			-4.93%

With the use of two counterfactual scenarios I determine that vertical integration with foreclosure is pro-competitive and therefore does not require any government intervention to restrict console market power. Additionally, a policy maker should not ban vertical integration nor accompany it by any bans on other types of exclusive dealings. Under the situation in which console makers are prohibited from vertically integrating and foreclosing rivals from their games and are subsequently not allowed to enter into exclusive deals with video game developers, prices rise relative to a policy permitting vertical integration with foreclosure. When vertical integration only is prohibited (consoles are thus allowed to enter into exclusive contracts with video game developers) console price competition remains depressed, relative to a policy permitting vertical integration with foreclosure, but by a lesser amount. I also conclude that profits (prices) of consoles with a larger degree of concentration in vertically integrated games fall (rise) more than consoles with less concentration under all policies banning foreclosure. High quality vertically integrated games are thus a leading factor as to why vertical integration is pro-competitive. With the existence of high quality first party games, firms are willing to forego the incentive to raise console prices in order to increase the demand for consoles and their own *first party* video games, where the greatest proportion of industry profits are made.

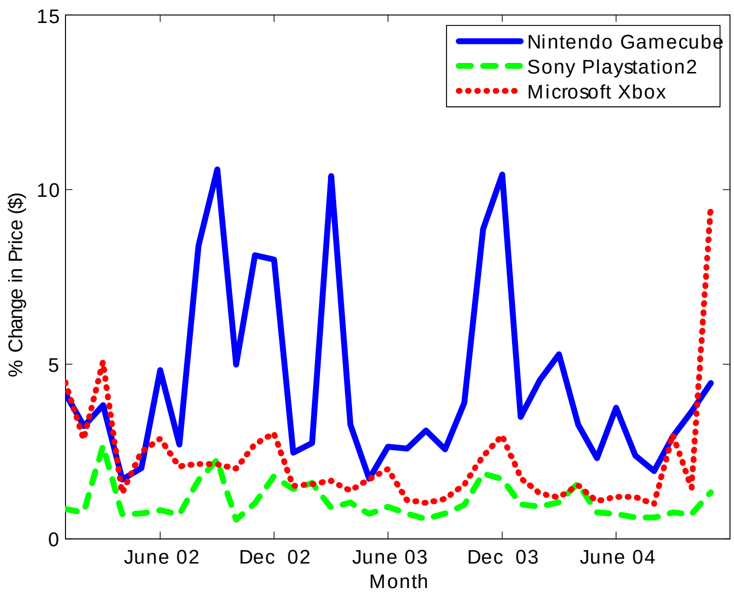

Figure 6: Counterfactual One Predicted Console Price Changes

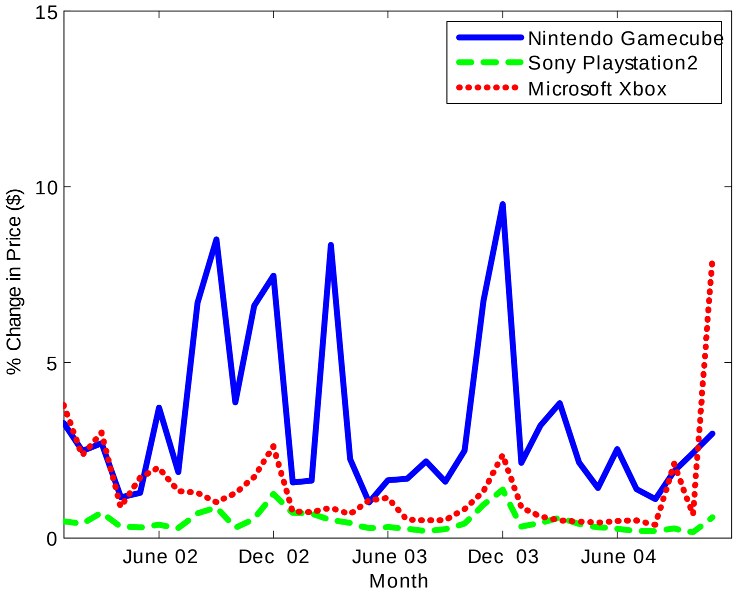

Figure 7: Counterfactual Two Predicted Console Price Changes

7.1 Sensitivity Analysis

A key assumption in the implementation of the counterfactual exercises is that video game prices are assumed to not adjust to changes in competitive environments. Table 11 assesses the sensitivity of the counterfactual results to this assumption with the last three columns reporting the results. Columns four and five assume that the associated mean utility for all remaining games decreases by 5% and 10% in counterfactual one, respectively. The last column assumes that in counterfactual two all *first party* game mean utilities declines by 2%. Interestingly, this assumption generates a lower bound to the impact on console prices, and an upper bound for consumer welfare and firm profits in the first counterfactual. Although eliminating a large number of console produced games diminishes video game competition leading to an increase in video game prices and an incentive to lower hardware prices, the effect that the higher game prices have on the additional profit console makers receive from game developers when one additional console is sold outweights the incentive to decrease console prices. With higher game prices the additional profit from developers decreases because consumers are less likely to purchase a game. Video game hardware prices thus increase more than the original counterfactual.

The last column of Table 11 presents the sensitivity of the key assumption for counterfactual 2. The results show that when the "prices" of *first party* games adjust to reflect the full efficiency effect from the coordination of both video game and console prices the results are trivially different from the above counterfactual. I thus conclude the key assumption regarding video game pricing is not of significant importance in determining the overall impact of vertical integration with foreclosure on console price competition, consumer welfare and firm profits.

Table 11: Counterfactual (CF) Sensitivity Results

		Data (w/ VI)	CF #1: 5% decrease in δ_k	CF #1: 10% decrease in δ_k	CF #2: 2% decrease in δ_d
Mean Price	GameCube	$131.66	$139.52	$139.32	$138.28
	PlayStation 2	$244.44	$248.40	$247.58	$246.73
	Xbox	$187.36	$192.57	$192.33	$191.38
Mean Price Effect	GameCube		5.5810%	5.8758%	4.74%
	PlayStation 2		1.0823%	1.2688%	0.69%
	Xbox		2.4102%	2.6526%	1.87%
Mean % Market Share	GameCube	20.30%	17.27%	17.25%	18.75%
	PlayStation 2	52.95%	56.85%	57.02%	54.77%
	Xbox	26.75%	25.88%	25.74%	26.47%
Mean Number of Consoles Sold per Month	GameCube	378,660	246,630	232,440	318,880
	Playstation 2	958,260	867,260	830,990	943,120
	Xbox	461,540	372,580	352,440	432,940
Total Number of Consoles Sold (M)		34.55942	30.026	28.829	33.229
Mean Variable Profit per Month (M)	GameCube	$64.09	$22.22	$20.36	$30.35
	Playstation 2	$179.27	$116.14	$107.81	$132.29
	Xbox	$73.94	$35.66	$32.62	$44.37
Mean Variable Profit From Games per Month (M)	GameCube	$48.08	$12.705	$11.293	$18.434
	PlayStation 2	$101.36	$61.898	$55.410	$74.205
	Xbox	$47.21	$18.746	$16.482	$25.149
% Change in Mean Consumer Surplus			-18.15%	-22.57%	-4.96%

8 Conclusion

In order to understand how vertical integration impacts console price competition, the above analysis extends the empirical industrial organization literature by constructing a new methodology which allows consumer demand for video game consoles to depend upon the set of available video games rather than only the number of games. The estimation technique differs from prior research by incorporating video game heterogeneity and software competition into the demand for consoles. Consequently, further research will continue to analyze the importance of heterogeneity and indirect network effects. In particular, comparing the model fit between three different console demand models: i) linking video game and console demand using only the number of compatible software titles, ii) introducing video game heterogeneity, and iii) the model above which includes video game heterogeneity and competition. Moreover, future research will illustrate how important heterogeneity and competition is in forming indirect network effects and the role they play in forming correct public policy.

This paper analyzes the impact of vertical integration with foreclosure on console price competition, consumer welfare and firm profits. I conclude vertical integration with foreclosure in the video game industry is pro-competitive. It increases price competition as well as consumer welfare and console manufacturer profits. Although I cannot generalize these results to other similar type industries, such as the DVD/DVD player market, because the question is empirical, my paper does provide a structural framework for a public policy maker to employ in order to study whether vertical integration and foreclosure of complementary products is anti-competitive.

In determining whether vertical integration with foreclosure is anti-competitive my structural model predicts markups in line with insider knowledge and economic theory–console markups are small. Consoles subsidize consumers to increase demand for consoles in order to drive sales of video games. More specifically, with the existence of high quality *first party* games, firms are willing to forego the incentive to raise console prices, due to the foreclosure effect, in order to increase the demand for consoles and consequently their own *first party* video games, where the largest proportion of industry profits are made.

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Appendix A-Alternative Models

Below are results from an IV logit and OLS logit models without the joint estimation of a supply model or the matching of micro moments.

Table 12: Alternative Models

Variable	IV Logit		OLS Logit	
	Coefficient	Std. Error	Coefficient	Std. Error
Utility Parameters				
Price	-0.0085**	0.0036	-0.0044**	0.0017
Ad	0.0009	0.0082	0.0018	0.0082
Software Index	0.6915**	0.0778	0.6898**	0.0781
Q1	-0.4079**	0.1756	-0.5698**	0.1238
Q2	-0.5853**	0.1143	-0.6366**	0.1077
Q3	-0.5540**	0.1075	-0.5748**	0.1067
Micro Moments	No		No	

Notes: **indicates significant at 95%; *indicates significant at 90%;

Year specific console fixed effects not reported

In Table 12 below I present results of an alternative model which does not incorporate year specific console fixed effects but only standard console fixed effects. These results illustrate the importance of including year specific console dummies into the utility function to account for some dynamic aspect of consumer demand.

Table 13: Alternative Model Results–No Year Specific Console Fixed Effects

Variable	Random Coefficients		IV Logit		OLS Logit	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Utility Parameters						
Price	-0.0080**	0.0008	-0.0068**	0.0010	-0.0061**	0.0009
Ad	-0.0013	0.0074	0.0068	0.0077	0.0071	0.0088
Software Index	0.8662**	0.0780	0.6886**	0.0932	0.6649**	0.0865
Q1	-0.2963**	0.1371	-0.4570**	0.1438	-0.4951**	0.1262
Q2	-0.5436**	0.1423	-0.6050**	0.1457	-0.6261**	0.1209
Q3	-0.4602**	0.1400	-0.5513**	0.1446	-0.5667**	0.1203
Non-Linear Parameters						
Price Std. Dev	0.0057**	0.0002				
Ad Std. Dev.	0.0277	0.0846				
Controllers Std. Dev.	0.1662	0.1869				
Price*Household Size	-0.0052**	0.0006				
Ad*Household Size	0.0022**	0.0006				
Cost Side Parameter						
Nintendo GameCube	4.8931**	0.0552				
Sony PlayStation2	5.1483**	0.0919				
Microsoft Xbox	4.9617**	0.0723				
Nintendo GameCube*trend	-0.0380**	0.0022				
Sony PlayStation2*trend	-0.0177**	0.0032				
Microsoft Xbox*trend	-0.0177**	0.0027				
Q1	-0.0922**	0.0436				
Q2	-0.1633**	0.0423				
Q3	-0.1011**	0.0396				
Micro Moments	Yes		NO		NO	
GMM Objective Function	29.2277					

Notes: **indicates significant at 95%; *indicates significant at 90%; console fixed effects not reported

Table 14: A Sample of Console Elasticities from January 2002 for Alternative Model

	GameCube	PlayStation 2	Xbox
GameCube	-2.0779	0.0447	0.0171
PlayStation2	0.0049	-2.0951	0.0206
Xbox	0.0053	0.0581	-2.2612

Note: Cell entry i, j, where i indexes row and j column, gives the percent change in market share of brand i with a one percent change in the price of j.

9 Appendix B-A Calibrated Model

In this appendix I present results from alternative calibrated models. Using the estimated demand and marginal cost parameters from the model above in addition to assumptions regarding the availability, compatibility and vertical integration of games I am able to determine, in a simpler setting, the associated effects of vertical integration and foreclosure of complementary video games to rival consoles. I simplify the model by restricting the set of games to only consist of games available on Nintendo's console. In the first simulation I allow for all independent video games to be available on consoles, whereas games produced by Nintendo remain produced by and exclusive to Nintendo.[33] This simulation, therefore, corresponds to the data. By restricting the model to only include these games and allowing only Nintendo to vertically integrate and foreclose rather than all consoles I am able to more precisely identify the effects of vertical integration for Nintendo and its competitors. I use these results as the baseline to two additional counterfactual simulations. These simulations are identical to the above counterfactuals where I transfer ownership of vertically integrated games to an independent developer that executes exclusive contracts with Nintendo whereas the other assumes all Nintendo integrated games are not produced. As I stated above, this counterfactual is an appropriate simulation to run given that vertical integration in the video game industry occurs through the initiation of a console's own in house design studio rather than a merger with an established software firm. Consequently, any policy banning vertical integration and exclusive contracting would eliminate production of *first party* games whereas integration via a merger would not.

Table 15: Calibrated Counterfactuals

		w/ VI & Foreclosure	Exclusive Contracts Permitted	Nintendo Games Not Produced
Mean Price	GameCube	$131.71	$138.22	$138.78
	PlayStation 2	$246.57	$246.62	$246.76
	Xbox	$192.08	$192.10	$192.16
Mean Price Effect	GameCube		4.98%	5.41%
	PlayStation 2		0.0179%	0.0707%
	Xbox		0.0123%	0.0419%
Mean % Market Share	GameCube	23.06%	20.54%	17.97%
	PlayStation 2	51.19%	52.85%	54.54%
	Xbox	25.75%	26.61%	27.48%
Mean Number of Consoles Sold per Month	GameCube	404,680	333,210	268,580
	PlayStation 2	780,230	789,480	798,350
	Xbox	428,930	434,370	439,750
Total Number of Consoles Sold (M)		31.871	31.178	30.511
Mean Variable Profit per Month (M)	GameCube	$63.17	$31.60	$24.92
	PlayStation 2	$108.44	$109.21	$101.006
	Xbox	$39.70	$40.07	$40.46
Mean Variable Profit From Games per Month (M)	GameCube	$51.487	$18.999	$14.600
	PlayStation 2	$61.911	$62.119	$62.316
	Xbox	$20.114	$20.226	$20.336
% Change in Mean Consumer Surplus			-2.57%	-5.32%

With the restriction of the set of games to be identical across both Sony and Microsoft and

[33] In these counterfactuals I assume prices are what are observed in the data and that preferences toward video games do not differ across consoles.

by allowing Nintendo to vary its strategies, (ie: electing to vertical integration and foreclosure rival consoles from its games, not produce integrated games but enter into exclusive contracts with a third party developer or not produce integrated games) I can single out the effects from such strategies more clearly than a model which allows multiple consoles producers to do so. As a consequence, the efficiency effect clearly dominates the foreclosure effect. From the above table it is evident console prices are strategic complements–an increase in the price of a GameCube results in an increase in the price of both competing consoles. Although prices are strategic complements, they are quite weak. A change in strategy by Nintendo has little impact on its competitors' prices where as a such a change has a sizeable impact on Nintendo's. Furthermore, a strategy of vertical integration and foreclosure or partaking in exclusive contracts certainly affects market share and the mean number of consoles sold per month more than that of a strategy of not vertically integrating or entering into exclusive agreements–roughly a five percent increase in mean market share and 136 thousand unit increase in mean number of consoles sold per month. As a result, Microsoft's and Sony's market share and quantity decrease. Lastly and perhaps most importantly though, consumer welfare is larger under vertical integration with the foreclosure of rival consoles from integrated games.

Appendix C-Console Market Size

For consoles, I let the data determine the potential market size. I use an approach from Bass (1969) that illustrates how to infer the initial potential market size of a product from its sales data. "An approximation to the discrete-time version of the model implies an estimation equation in which current sales are related linearly to cumulative sales and (cumulative sales)^2" (Nair 2004). Let k_t and K_t denote the aggregate sales of all consoles in month t and cumulative sales up to and including month t respectively. Let the below equation be the regression I estimate:

$$k_t = a + bK_t + cK_t^2 + \upsilon_t.$$

Given the estimates, the Bass model implies the initial potential market size for all consoles is $\bar{M} = \frac{a}{f}$, where f is the positive root of the equation $f^2 + fb + ac = 0$ and a is from the regression above. The predicted initial market size is 78,354,700 households. The potential market in period t is $M_t = \bar{M} - \textit{cumulative console sales till month } t$[34].

[34] The construction of the potential market size reflects the idea that a consumer is a first time buyer and does not re-enter the market to purchase additional goods. Consequently, I do not account for multihoming consumers.