Matthew Kalahiki

William Haden Chomphosy

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Indirect Network Effects in the Video Game Console Industry

Introduction:

Since its birth in the early 70's, the video game console industry has undergone tremendous evolution, and in today's digitally dominated era, it is projected to continue experiencing substantial growth (Fortune Business Insights, 2020). Aside from its captivating interactive media and cultural significance, studies conducted in the wake of the enormously successful sixth generation of video game consoles indicate that an underlying catalyst for the proliferating popularity of the industry is the concept of indirect network effects.

Network effects occur when an increase in users enhances the value of a good or service. More particularly, indirect network effects rely on two or more groups of users in which the value of the product for a particular group depends on the users of the other groups and vice versa. Regarding the video game console industry, indirect network effects refer to console players benefiting from software availability and, on the other hand, software developers benefiting from a larger market to sell to.

Though there are many studies conducted around the sixth generation of video game consoles (Binken & Stremersch, 2009; Corts & Lederman, 2009; Landsman & Stremersch, 2011), the ninth generation of consoles is currently on the rise, and the industry has changed drastically. From commercialized game engines and a rise in the digital market encouraging new developers to advancements in technology leading to higher quality games, the current era of interactive entertainment differs significantly from its archaic predecessors, and thus, the factors affecting the market could have changed as well.

Therefore, this paper will explore the scope of indirect network effects in the newer generations of video game consoles and determine whether they still exist by replicating Corts and Lederman (2009). This model will analyze the correlation between hardware demand and software supply and the correlation between software supply and the number of console users. A positive correlation between both of the aforementioned relationships would indicate that hardware demand is positively (indirectly) correlated to software supply, thus indicating the presence of indirect network effects in the video game console industry.

In recent years, vertical integration in the video game industry has become increasingly popular with video game console companies producing video games and purchasing video game producers and developers. Most notably, there has recently been much controversy with Microsoft's, the producer of a major video game console, attempt to acquire Activision Blizzard, a major video game producer and developer. Therefore, understanding indirect network effects in the video game console industry will provide insight on the extent to which control of software supply could impact the market, and, in turn, highlight the lasting effects of vertical integration in the video game console industry.

Literature Review:

Network externalities have long been considered essential constituents to the success or failure of two-sided markets. Specifically, the focus has been on the potency of indirect network effects across the product cycle. Nair et al. (2004) provides insight on the significant indirect network effects present in the developing phase of the product cycle of the personal digital assistant industry. Like this study, Nair et al. (2004) estimates a hardware demand equation and a software supply equation as the basis for their empirical model to estimate the scope of indirect network effects. Clements & Ohashi (2005) takes the aforementioned study even further by evaluating indirect network effects in the perpetually evolving video game console industry. Unlike Nair et al. (2004), Clements & Ohashi (2005) considers the entire product cycle of the two-sided video game console industry and concludes that network effects are the most potent towards the end of a platform's life cycle.

Moreover, indirect network effects are present between users of specific platforms as well as between users of an entire generation of platforms. For example, while both the previously mentioned studies provide evidence of indirect network effects between users of given platform, Corts and Lederman (2009) illustrates generation-wide network effects, i.e., indirect network effects present between all users of a given generation of (still incompatible) video game consoles; however, even though these generation-wide network effects are significant, the study indicates that console exclusive software leads to a greater increase in console demand than software available to other video game consoles. Similarly, Landsman & Stremersch (2011) and Lee (2013) support the idea that console exclusivity is most beneficial to the hardware demand of smaller, underdeveloped platforms.

Furthermore, it is important to consider more than the sheer quantity of software available when analyzing network effects. Kim et al. (2014) conveys that considering the quality of software available leads to more accurate results, and Binken & Stremersch (2009) highlights that "superstar" software has a disproportionate effect on hardware demand.

Although the scope of indirect network effects has been studied thoroughly in the past, especially regarding the sixth generation of video game consoles, the industry has evolved drastically, and with the market growing, vertical integration becoming more prominent, costs of development increasing, etc., it is imperative that indirect network effects be analyzed for the more recent generations of video game consoles. Therefore, this study will investigate the scope indirect network effects for the seventh and eighth generation of video game consoles.

Methods:

Replicating Corts and Lederman (2009), we estimate indirect network effects in the video game console industry by estimating both a console demand equation in which demand is a function of software availability and a software supply equation in which supply is a function of the installed base of hardware (or number of console users). Finding a positive relationship between console demand and software availability and software supply and the number of console users of a given console would indicate a positive, indirect relationship between the demand and number of users for a particular console.

First, we assume that each consumer decides which console to buy (if any) by maximizing the utility of each option. The utility (*u)* that a consumer (*i)* gets from purchasing a particular console(*j)* in a given month (*t)* can be represented by the following independent variables: a vector of observed characteristics of console *j* in month *t* (x_j^t), the price of console *j* in month *t* (p_j^t), and the number of software available for console *j* in month *t* (SW_j^t). Therefore, the utility consumer *i* would receive from console *j* in month *t* can be written as,

$$u_{ij}^t = \beta_1 x_j^t + \beta_2 p_j^t + \beta_3 SW_j^t + \epsilon_j^t + v_{ij}^t.$$

where ϵ_j^t is a vector of characteristics for console *j* in month *t* unobserved to the econometrician.

Now, let $\delta_j^t = \beta_1 x_j^t + \beta_2 p_j^t + \beta_3 SW_j^t + \epsilon_j^t$ represent the mean valuation of console j across all consumers such that v_{ij}^t is the difference between consumer i's valuation of console j in month t and the mean valuation; thus, the distribution assumed for v_{ij}^t determines the choice probabilities and substitution patterns. Following Berry (1994) and setting the mean utility of the outside good to zero, we can derive the following one-level nested logit equation:

$$\ln\left(s_j^t\right) - \ln(s_0^t) = \beta_1 x_j^t - \beta_2 p_j^t + \beta_3 SW_j^t + \sigma \ln\left(s_{\frac{j}{g}}^t\right) + \epsilon_j^t$$

Where s_j^t is consoles j's market share (consoles sold as a percentage of the potential market), s_0^t is the outside product's market share (1 – the sum of the market shares of all consoles sold in month t), $s_{j/g}^t$ is console j's within group market share (percentage of all consoles sold in month t), and ϵ_j^t is the econometric error term. The potential market for a given console j in month t is the number of households in the United States in month t less the installed base of console j in month t. By excluding the installed base of a console from its potential market, we assume that someone who owns a given console will not purchase another one of those consoles. Additionally, grouping all inside goods together allows for correlation in v_{ij}^t, thus allowing the inside goods to be closer substitutes with each other in contrast to the outside good.

Furthermore, ϵ_j^t is divided into a time invariant component, estimated as a platform fixed effect, and a time variant component. Because we include platform fixed effects in our model, it is unnecessary to include time invariant hardware specifications such as CPU speed, RAM, storage space, etc. Although Corts and Lederman (2009) uses the sum a platform's measurable hardware characteristics, specifically CPU speed, RAM, and processor word length in bits, over that of other platforms in the market as measurement of competition faced by each platform, we find that in more recent generations, Nintendo products tend to rely on different specifications than its competitors, thus leading to inaccurate measurements; therefore, we omit these instruments.

Additionally, we include dummy variables for the calendar month to capture the change in the perceived quality of a platform during certain months (such as spikes in November and December due to the Christmas season), and in order to control perceived and actual quality changes of a console throughout its life cycle, we account for platform age. Corts and Lederman (2009) presents three methods for controlling platform age: age and age squared in months since release, age fixed effects for each year since release, and finally, the combination age and platform fixed effects to create platform-fixed effects. Because Corts and Lederman (2009) claims that the platform-age fixed effects method is the most flexible in that it accounts for the unobserved quality changes of each platform in each year of its life, we choose to adopt this method.

Regarding the software supply model, the independent variables used will be a vector of characteristics of console *j* in month t that may affect software producers' incentive to publish video games for the console y_j^t, the installed base of console *j* in month *t* IB_j^t, and the installed base of other consoles in the same technological generation as console *j* in month *t* IB_{-j}^t. The dependent variable will be the number of software available for console *j* in month *t* with a logarithmic transformation $ln(SW_j^t)$. This said, the following equation will be used to model software supply:

$$\ln(SW_j^t) = \gamma_0 + \gamma_1 y_j^t + \gamma_2 IB_j^t + \gamma_3 IB_{-j}^t + u_j^t$$

Where γ_0 represents a platform fixed effect and u_j^t is the econometric error term. We also control technological advancement during the period of study with time dummy variables, and we control for console age because developers may become more efficient making games for a particular console the longer it has existed. Because we use dummy variable for platform fixed effects and time effects, we can’t use age fixed effects without perfect multicollinearity amongst the independent variables; therefore, we use age squared.

A positive γ_2 combined with a positive β_3 would indicate platform wide indirect network effects, while a positive γ_3 combined with a positive β_3 indicates generation wide indirect network effects. Moreover, we expect software availability to have a positive correlation to console demand and the installed base for a given console as well as the installed base of other consoles in its generation to have a positive correlation to software supply, thus our hypotheses are:

$$H_0: \beta_3 \leq 0, \gamma_2, \gamma_3 \leq 0$$

$$H_a: \beta_3 > 0, \gamma_2, \gamma_3 > 0$$

Additionally, aside from the sheer number of video games, the quality of a game also affects hardware demand, so we run the model four separate times, each time using one of the following collections of video game data: all video games available, all video games with at least a single MobyGames Review, all video games with more than 10 reviews and a Moby Score of at least 5.0, and finally, all software weighted by the product of its Moby Score and number of reviews divided by the difference of the platform release date and its oldest release date (to account for the perceived quality changes of the reviews that took place in a different technological generation).

MobyGames, where the software data is collected from, provides a score for each game (if it has any reviews) based on the combination of user reviews and critic reviews. We are assuming that MobyGames community is comprised of a large, diverse group of users that accurately represents the preferences of the gaming population as a whole, and thus, the reviews are accurate representations of a game's quality. This said, including only games with any reviews should weed out small games developed by underdeveloped indie game developers that probably don't affect hardware demand. Including games that include at least 10 reviews and a score of 5.0 represents "high-quality" games. Finally, weighting games allows higher quality games to have more effect on hardware demand than lower quality games, which is a more accurate representation of the video game industry.

Data:

Monthly hardware demand data was collected from VGChartz.com a website that tracks and estimates video game and video game console sales. Software data was collected from MobyGames.com, an extensive video game database and the same website used by Corts and Lederman (2009). Inflation data was collected form the Bureau of Labor Statistics, and the household data was collected from the FRED Economic Database.

Results:

The results of the models using all video game data and only games with reviews agree with the preliminary expectations and provide statistically significant evidence to reject the null hypothesis while the models using the review threshold and the weighted software deviate slightly.

Table 1

	Dependent variable:
	Log(MarketShare/OutsideMarketShare)

RealPrice	-0.003***
	(0.001)
SoftwareAvailable	0.0003**
	(0.0001)
Log(WithinGroupMarketShare)	0.853***
	(0.027)
Constant	-5.759***
	(0.389)
Observations	678
R^2	0.987
Adjusted R^2	0.986
Residual Std. Error	0.240 (df = 603)
F Statistic	639.093*** (df = 74; 603)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 1 shows the results of the hardware demand model using all video game data.

Table 2

	Dependent variable:
	Log(SoftwareAvailable)
InstalledBase	1.697e-08***
	(4.448e-09)
GenerationInstalledBase	1.320e-08***
	(1.880e-09)
Constant	0.594*
	(0.321)
Observations	678
R^2	0.931
Adjusted R^2	0.928
Residual Std. Error	0.326 (df = 652)
F Statistic	351.129*** (df = 25; 652)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 2 shows the results of the software supply model using all video game data.

Table 3

	Dependent variable:
	Log(MarketShare/OutsideMarketShare)
RealPrice	-0.002^{***}
	(0.001)
SoftwareAvailable	0.001^{***}
	(0.0004)
Log(WithinGroupMarketShare)	0.830^{***}
	(0.028)
Constant	-6.308^{***}
	(0.435)
Observations	678
R^2	0.988
Adjusted R^2	0.986
Residual Std. Error	0.239 (df = 603)
F Statistic	646.879^{***} (df = 74; 603)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 3 shows the results of the hardware demand model using only video games that have reviews.

Table 4

	Dependent variable:
	Log(SoftwareAvailable)
InstalledBase	$9.078e\text{-}09^{**}$
	(4.204e-09)
GenerationInstalledBase	$1.344e\text{-}08^{***}$
	(1.777e-09)
Constant	0.203
	(0.304)

Observations	678
R^2	0.921
Adjusted R^2	0.918
Residual Std. Error	0.308 (df = 652)
F Statistic	305.072*** (df = 25; 652)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 4 shows the results of the software supply equation using only video games that have reviews.

Table 5

	Dependent variable:
	Log(MarketShare/OutsideMarketShare)
RealPrice	-0.002***
	(0.001)
SoftwareAvailable	0.003***
	(0.001)
Log(WithinGroupMarketShare)	0.821***
	(0.029)
Constant	-6.211***
	(0.416)
Observations	678
R^2	0.988
Adjusted R^2	0.986
Residual Std. Error	0.238 (df = 603)
F Statistic	647.060*** (df = 74; 603)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 5 shows the results of the hardware demand model using only video games that meet a threshold of 10 reviews and a Moby Score of at least 5.0.

Table 6

	Dependent variable:
	Log(SoftwareAvailable)

InstalledBase	-9.354e-10
	(4.532e-09)
GenerationInstalledBase	01.346e-08***
	(1.916e-09)
Constant	-0.705**
	(0.328)
Observations	678
R^2	0.904
Adjusted R^2	0.900
Residual Std. Error	0.332 (df = 652)
F Statistic	244.807*** (df = 25; 652)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 6 shows the results of the software supply model using only video games that meet the threshold of 10 reviews and a Moby Score of at least 5.0.

Table 7

	Dependent variable:
	Log(MarketShare/OutsideMarketShare)
RealPrice	-0.002***
	(0.001)
SoftwareAvailable	0.00002***
	(0.00001)
Log(WithinGroupMarketShare)	0.810***
	(0.028)
Constant	-6.538***
	(0.413)
Observations	678
R^2	0.988
Adjusted R^2	0.986
Residual Std. Error	0.236 (df = 603)
F Statistic	658.302*** (df = 74; 603)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 7 shows the results of the hardware demand model using video games weighted by the combination of the number of reviews and its Moby Score.

Table 8

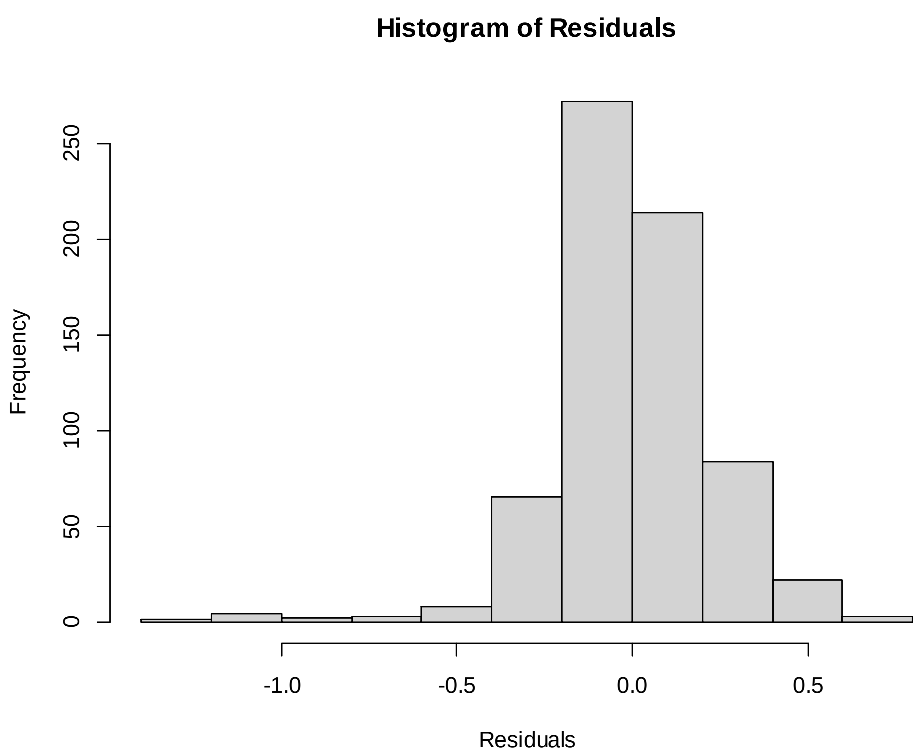
	Dependent variable:
	Log(SoftwareAvailable)
InstalledBase	2.580e-09
	(03.969e-09)
GenerationInstalledBase	1.063e-08***
	(1.677e-09)
Constant	5.119***
	(0.287)
Observations	678
R^2	0.936
Adjusted R^2	0.934
Residual Std. Error	0.291 (df = 652)
F Statistic	384.042*** (df = 25; 652)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 8 shows the results of the software supply model using video games weighted by the combination of the number of reviews and its Moby Score.

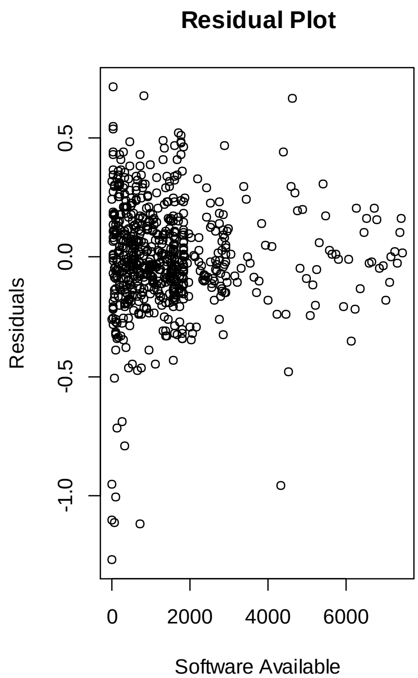
As expected in any demand model, Console Price has a negative, statistically significant co-efficient in all variations of the model. Furthermore, the log of within group market share has a positive, statistically significant co-efficient in each variation, supporting the idea that other consoles are closer substitutes than outside products. Finally, supporting the hypothesis, software available has a positive, statistically significant co-efficient in each variation.

Using all video game data and only video games with reviews, the installed base has a statistically significant, positive co-efficient which, in conjunction with the positive co-efficient of software available in the hardware demand model, indicates platform specific indirect network effects regarding games of any quality and games with a significant number of players; however, the models ran with games meeting the review threshold and weighted video games do not provide enough evidence to reject the null hypothesis meaning there is not enough evidence to affirm the presence of indirect network effects of "high-quality" video games in the video game console industry. On the other hand, for all variations of the supply model, the statistically significant, positive co-efficient of the generation installed base indicates the presence of generation wide indirect network effects.

Graph 1(Histogram of residual frequency for hardware demand model)

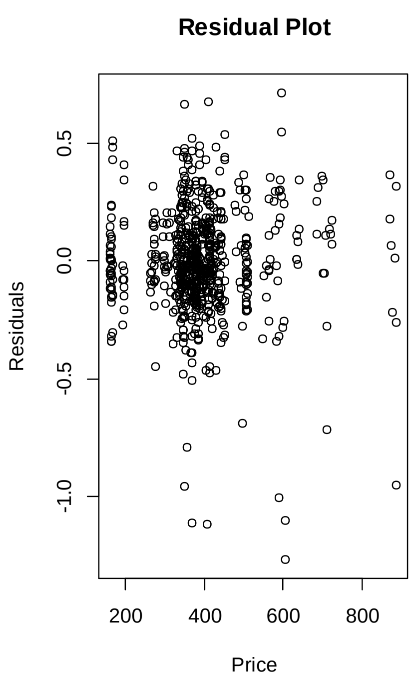


Plot 1



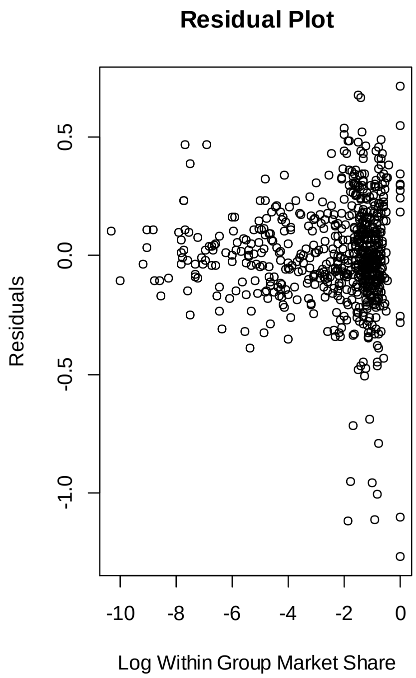
Residual Plot
Residuals
0.5
0.0
-0.5
-1.0
0
2000
4000
6000
Software Available

Plot 2



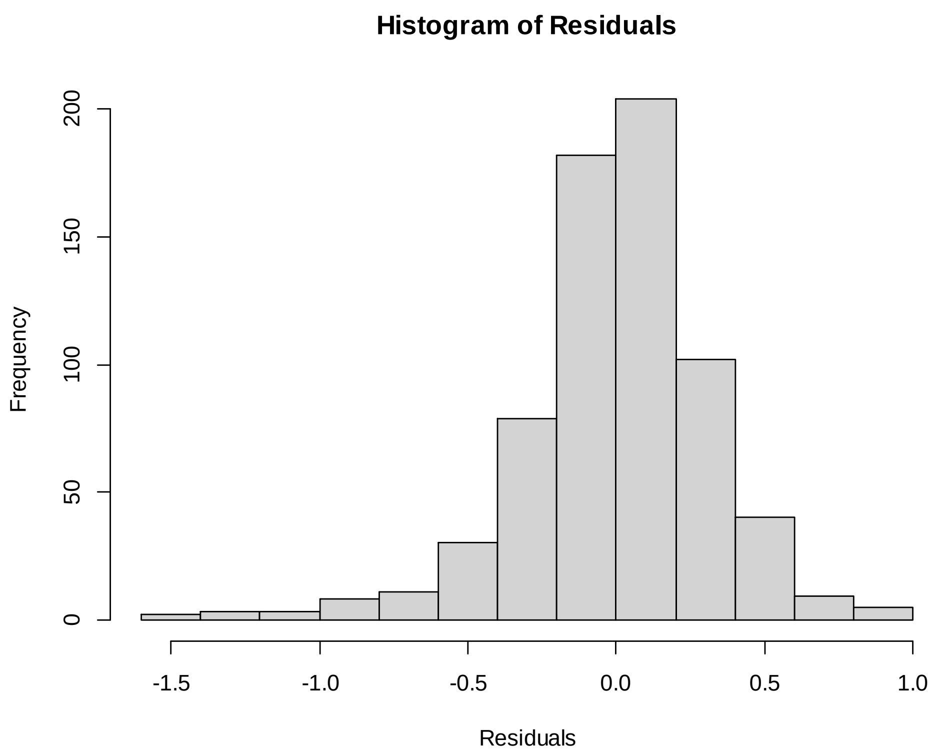
Residual Plot
Residuals
0.5
0.0
-0.5
-1.0
200
400
600
800
Price

Plot 3

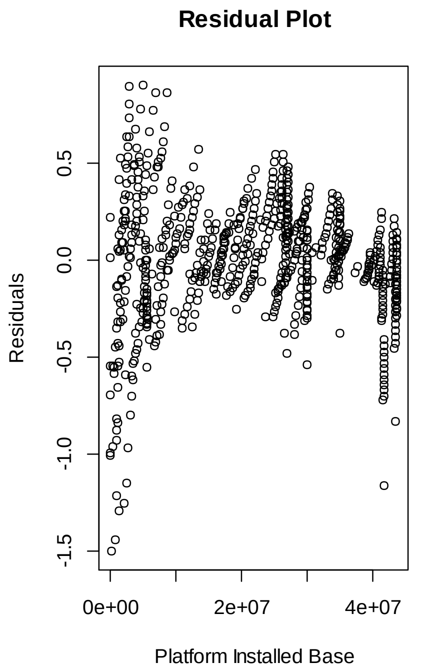


Graph 2 (Histogram of u hat frequencies in the software supply model):

Graph 2 (Histogram of residual frequency for software supply model)

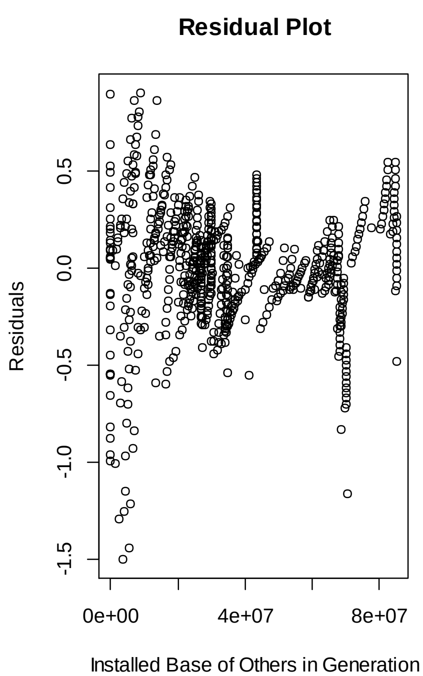


Plot 4



Residual Plot
Residuals
0.5
0.0
-0.5
-1.0
-1.5
0e+00
2e+07
4e+07
Platform Installed Base

Plot 5



Residual Plot
Residuals
0.5
0.0
-0.5
-1.0
-1.5
0e+00
4e+07
8e+07
Installed Base of Others in Generation

Graphs 1 and 2 depict the residual frequency distributions for the hardware demand and software supply models respectively. Although both distributions are slightly skewed left, they are both unimodal at 0. Furthermore, the residual plots tend to vary more as log of within group market share increases and as platform and generational installed bases decrease. Potential omitted variables for both models could be related to the presence of non-console substitutes such as gaming personal computers and virtual reality gaming headsets. These variables would effect both installed base of video game consoles as well as within group market share since availability of substitutes for a platform would effect the how many people purchase a platform as well as increase the "group" contained in the log of within group market share.

Conclusion:

With our results and assuming that the seventh and eight generations of video game consoles are fairly accurate representations of the current (ninth) generation of video game consoles, there are a few conclusions that can be drawn from this study. First, even after vast technological advancement and substantial variation in the quality of video games produced by small indie developers to multi-billion-dollar corporations, indirect network effects involving the sheer quantity of software are still present in the video game console industry. This isn't to say that the quality of a video game doesn't affect its sales or its platform's sales because as our results indicate, it does, but it is important to note that all games, most likely because there is a wide variety of prices, complexity, creativity, etc. that meet the unique preferences of each consumer, have a significant impact on the video game console industry.

Secondly, regarding high-quality video games, even though there is not enough evidence to indicate the presence of platform specific indirect network effects, we are still able to conclude the presence of generation wide network effects. This means that the installed base of other consoles in a platform's generation have a positive impact on the supply of high-quality software available for said platform, but the installed base of the platform does not necessarily impact the supply of high-quality games for itself. This is most likely because when the installed base of a platform's competitors begins to increase, the platform produces more quality games in an attempt to "catch up" so to speak. Whatever the reason, these generation wide network effects indicate that the recent increase in vertical integration in the video game console industry is not necessarily anti-competitive, but rather, the increase in high-quality (as well as all quality) video games available for a particular console will ultimately have a positive effect on other consoles in its generation, as opposed to a "lock-in" effect that establishes one console's dominance in the market.

The primary limitation of this study is data access. Most notably, there are multiple models available for most of the consoles in this study. Ideally, each model would be observed as a unique console, but the console sales data set used in this study clumps all models of a particular console together, so there is no way to know console demand or installed base of each model; therefore, we use the price of the most popular model at the time and assume that the idiosyncrasies of each model are controlled by platform-age fixed effects. Additionally, access to more software specifications such as cost, number of players, average time played by players, whether or not there are microtransactions, and even a more well-establish review system, such as IGN, in order to more accurately capture the quality of software.

Aside from obtaining the previously mentioned data, research regarding the effect of platform subscription services on the scope of indirect network effects would provide significant further insight on the intricacies of the video game console industry. Over the years, platform-specific subscription services have become increasingly relevant in the video game console industry, and in the recent generations, these subscription services are required to play video games online (which is required for a significant portion of recent games); however, the benefits to these services are increasing as well, including large catalogs of free games, new and games from previous generations, as well as access to video game streaming services, thus it will be interesting to study the impact of this dynamic on the current generation of consoles.

Also, as previously mentioned, there is a rise in substitutes for video game consoles that most likely affect network externalities as well as other dynamics in the video game console industry. For example, PC gaming has become prevalent in recent years, and virtual and augmented reality gaming is continuing to be pioneered. Thus, it is important to understand the effects these industries have over the video game console industry as it is currently the most relevant medium for interactive entertainment.

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