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Mixed Bundling in Two-Sided Markets: Theory and Evidence*

Yong Chao† and Timothy Derdenger‡

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Abstract

We extend the traditional literature on bundling and the burgeoning literature on two-sided markets by presenting a theoretical monopoly model of mixed bundling in the context of the portable video game console market—a prototypical two-sided market. It is shown that the monopoly platform's dominant strategy is to offer a mixed bundle rather than pure bundle or no bundle. Deviating from both traditional bundling literature and standard two-sided markets literature, we find that, under mixed bundling, both the standalone console price on the consumer side and the royalty fee on the game developer side are lower than their counterparts under independent pricing equilibrium. In our setting, mixed bundling acts as a price discrimination tool segmenting the market more efficiently as well as functions as a coordination device helping solve "the chicken or the egg" problem in two-sided markets.

After theoretically evaluating the impact mixed bundling has on prices and welfare, we further test the model predictions with new data from the portable video game console market in the early to middle 2000s, during which Nintendo was a monopolist. We employ a reduced-form approach similar to Jin and Rysman (2009), and find empirical support for all theoretical predictions.

JEL Classification: L1, L4, L86

Keywords: mixed bundling, two-sided markets, price discrimination, handheld video game industry

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1 Introduction

The practice of mixed bundling consists of selling two or more separate products together with a discount, in addition to selling them individually. The most obvious explanation of bundling is efficiency—bundling can reduce costs and improve quality. However, antitrust authorities are often concerned that bundling may be strategically used by firms which have market power in one market and want to leverage that power to another. Starting with Stigler's (1963)[16] classical "Block-Booking" and followed by Adams and Yellen (1976)[1], strategic reasons of offering a bundle have been extensively studied to date. Although Chicago School's famous "single-monopoly-profit theorem" debunks leverage theory, the post-chicago literature refines leverage theory and identifies some circumstances under which bundling could be strategically profitable, taking into account Chicago School's intellectual argument. Nowadays, two leading explanations of bundling are price discrimination and entry deterrence. For price discrimination[1], it is the heterogeneity in consumer valuations which frustrates the seller in its ability to extract consumer surplus through one price. Thus, bundling which helps reduce the dispersion in valuations will increase a firm's profit. Whinston (1990)[17] studies the case when the firm is a monopoly in the primary market and a differentiated duopoly in the secondary market. He proposes another explanation for bundling—changing the market structure by exclusion and precommitment matters in his model. Nalebuff (2004)[11] advances the literature by showing that bundling can effectively deter entry even in the absence of precommitment. And furthermore, an entry deterrent effect is more important than the price discrimination effect in the face of competition.

We extend the literature on mixed bundling as well as two-sided markets by presenting a theoretical monopoly model of mixed bundling in the context of a two-sided (or multi-sided) market. A two-sided market differs from a 'traditional' one-sided market (such as those studied above) because it involves two or more end users which interact via an intermediary. Moreover, each end user's participation is determined by the participation of other types of end users. Examples of such markets are credit cards, media, yellow page phone directories, computer operating systems and video game consoles. In this paper our focus is directed towards the portable video game console market where a bundle consists of a game and console sold together for a single price. We elect to focus

[1] See Stigler (1963)[16], Adams and Yellen (1976)[1], Schmalensee (1984)[15], McAfee, McMillan and Whinston (1989)[10], and Bakos and Brynjolfsson(1999)[4].

our study on the video game industry because it is a prototypical two-sided market with consumers and game developers interacting with each other through the intermediary console. Furthermore, during a period from mid 2001 through late 2006 there existed only one portable video game console manufacturer, Nintendo. And, with access to a new data set which tracked sales and revenue of Nintendo's portable consoles, all available software and bundles, we are able determine whether our theoretical model predictions hold to data.

Now although mixed bundling has been widely studied, as is evident from the above literature, it has yet to be studied in the context of a two-sided (or multi-sided) market. This is because two-sided market theory is quite recent and sparse.[2] To the best of our knowledge, only three papers—Rochet and Tirole (2008)[**?**], Amelio and Jullien (2007)[2] and Choi (2009)[6]—have analyzed an extreme form of bundling—tying. Rochet and Tirole (2008)[**?**] study the payment card industry and illustrate tying can make the pricing structure more balanced and raise social welfare. Amelio and Jullien (2007)[2] explains tying as a coordination tool for a platform to increase participation on both sides yet the effect on competition is ambiguous. Choi (2009)[6] analyzes the effect of tying on two-sided market competition with multi-homing and shows that tying can be welfare enhancing.

Our interest in developing a new theoretical model of mixed bundling in a two sided market setting also stems from the fact that there are a few peculiar data trends which run contrary to the theory of mixed bundling in one-sided markets. For instance, Adams and Yellen (1976)[1] determine that component prices of the bundled goods should increase when a bundle is offered in order to make the bundle more attractive. The table below presents the predicted price-bundle correlations from Adams and Yellen's analysis next to correlations statistics from our data. Yet, simply looking at the correlation between the console component price and the presence of a bundle illustrates the opposite of Adams and Yellen (A&Y)'s analysis.

[2] See Caillaud and Jullien (2003)[5], Rochet and Tirole (2003)[12], Armstrong (2006)[3]

Table 1: Predicted and Observed Correlations Between Bundling and Component Prices

	A&Y	Data
Standalone Console Price	+	−0.6076
Standalone Video Game Price	+	0.0113
Video Game Royalty Rate	?	?

Consequently, we develop and present a new theoretical model of mixed bundling in a two-sided market setting which capture and explain this interesting trend.[3]

In the traditional bundling literature, the standalone price should go up under bundling in order to make the bundle more attractive. But in our data, the standalone console price goes down under bundling. This is due to the price discrimination effect in the two-sided markets context. In a two-sided markets setting, the offering of a bundle enables consumers to reveal their true type. Specifically, bundling generates two forms of price discrimination. The first segments new potential customers into distinct groups, like a traditional mixed bundling case, while the second is specific to the two-sided markets setting and technology industries. The second form capitalizes on the fact that by offering the bundle the firm can segment consumers into two additional independent groups, potential consumers and the installed base, and set segment specific prices–the effective game price for potential console consumers (the difference between the bundle price and the standalone console price) and the game price for the installed base. Unlike in a standard one-sided market, the standalone console price does not increase with the introduction of bundling. Instead, it decreases, which is due to the existence of cross-group externalities. Such cross-group externalities play a vital role in this finding. In particular, with the existence of a bundle, a larger number of marginal consumers are attracted to the console given that the bundle price is less than the sum of the component price. The increase in consumers consequently leads to more games being produced on the other side, and hence a further increase in the demand for the console (a consequence of the presence of cross-group externalities). Such two-way indirect network effects rein-

[3]Determining the correlation between royalty and bundling requires a two-sided markets model as well as assumptions given that data on royalty rates is unobserved. We develop the two-sided markets model and make such assumptions below in the econometric section of the paper in order to recover the relationship.

force each other, and give the platform more incentive to lower prices, but still increase its profits due to the increased participation on both sides.

Additionally, we find the royalty rate video game developers pay to the platform for the right to produce and sell a game declines too. This is also quite a surprising result and is counter to the standard price structure associated with two-sided markets. In standard two-sided markets literature, it is widely known that the optimal pricing involves cross subsidy from the inelastic side to the elastic side, which is in the same spirit as Ramsey pricing. And in the context of video game industry, the consumer side is usually considered as the elastic side, and the game developer side is acknowledged as the inelastic side. Under bundling, we have shown that prices on consumer side are lower due to price discrimination. So according to the cross-subsidization rule, we should expect an inflated price on game developer side. However, we see the opposite. The intuition behind this result is quite simple, nonetheless. With the introduction of a bundle, consumers become more inelastic with respect to their participation on the platform—from the fact that bundling can target the consumers more accurately. Such a shift changes the relative elasticity between consumers and game developers platform participation. With relatively more elastic game developers, with respect to participation, the platform is required to shift its relative attention away from consumers to game developers. The platform, consequently, lowers its royalty rate to game developers in order to attract them to its platform.

Furthermore, we find total surplus increases with mixed bundling. The introduction of a mixed bundle not only acts a price discrimination tool but also as a method to better coordinate the participation of consumers and game developers which aids in the solving of the "chicken or the egg" problem of which comes first.

As we mentioned above, Ameilo and Julien (2007)[2] find that a platform's sole incentive for offering a tie is to coordinate each side of the platform to join, which then enables the platform to skew prices even more heavily to the inelastic side of the market. We find in a more generalized form of bundling that this is not the entire story. A firm's incentive is now based upon price discrimination. The firm wants to lock-in as many consumers as possible and perfectly price discriminate with respect to those who buy the standalone game; and it does so with lower standalone console prices to consumers and lower royalty rates to game developers. Consequently, we show unambiguously that platform participation increases on each side of the market.

After theoretically evaluating the impact mixed bundling has on prices and welfare,

we test the model predictions with data from the portable console market in the early to mid 2000s. We employ a reduced form approach similar to Jin and Rysman (2009)[**?**] to do so. With a reduced form methodology we look to see whether there are correlations in the data which are consistent with our theoretical results. We conclude that the proposed model is correct and all theoretical predictions are evident in our data—we find strong evidence of negative correlation between mixed bundling and two-sided market prices.

The structure of this paper is as follows. First, we provide an overview of the portable video game console industry. Next, we set up the model and describe the game. In Section 4, we present two theoretical models in a traditional one-sided market structure, the first does not allow for mixed bundling while the second does, to assist in the identification of the impact mixed bundling has in a standard one-sided market structure. In this section we also compare prices, profits and welfare between the two regimes. After introducing the one-sided market model, we present and discuss our two-sided market model of mixed bundling in Section 5. Moreover, due to the unobservability of the royalty fees on game developer side in our data, we perform the analyses with the royalty fee as both exogenously and endogenously determined. We, again, present the analysis and results of a model without bundling first and follow with a model which introduces mixed bundling. Section 6 discusses our data and presents industry statistics. We present the results of our reduced form tests of the theoretical model in Section 7. Lastly, we conclude.

2 Portable Video Game Console Industry

During the early 2000s through late 2006, Nintendo was a monopolist in the production of portable video game consoles. Specifically, it was a multi-product monopolist producing two versions of its very popular Gameboy Advance console as well as portfolio of games to be played on its console. Each version was internally identical and played the same games, but the second version dubbed the GBA SP was reoriented with the display lying horizontally rather than vertically. Moreover, the target market of these two devices was toward younger kids, rather than teenagers or young adults for a home video game console. The portable console market most drastically differs from the traditional home video game console market in that it is extremely portable with the size of the device no larger than an adult hand. It can easily travel with a consumer and be played in a car or airplane, while a home console is restricted to a location which has a television and

electricity.

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.[4] A portable 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 console, consumers, and game developers. A consumer purchases a console in order to play games. Moreover, a consumer pays a fixed fee for the console and a fixed price for a video game. However, in order for a consumer to play a video game, the developer of the game is required to pay the console a royalty rate 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.[5] Figure 1 presents an illustration of the discussed market structure.

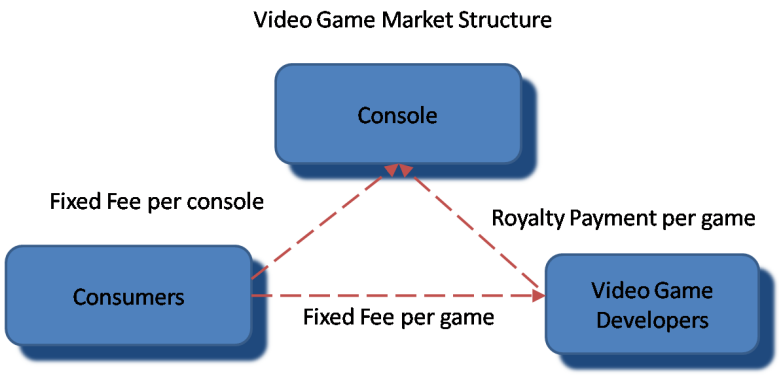

Figure 1: Video Game Market Structure

The above figure describes a generalized industry structure. A more tailored structure makes a distinction between two different types of video game developers. The first is what we and the industry note as first party games. These games are produced by the

[4] See Kaiser (2002)[8], Caillaud and Jullien (2003)[5], Rochet and Tirole (2006)[13], Rysman (2004)[14], Kaiser and Wright (2006)[9], Armstrong (2006)[3], Hagiu (2006)[7] and for general literature on two-sided platform markets

[5] Console manufacturers actually manufacture all video games themselves for quality control purposes and to track sales for royalty collection.

console's (Nintendo's) own in house design studio. The second type of game is produced by independent firms not associated with the producing console (Nintendo). We denoted these developers as third party.

In addition to Nintendo selling two portable devices as well as a large library of first party games, they also sold bundles. The contents of these bundles always included a portable console and one of its first party games—often the first party game was a hit game.

3 Model Settings

There are three classes of players in the model: two types of agents and a platform. In the context of the portable video game console industry, the agents are consumers (C) and video game developers (D) while the platform (P) is the portable console. We assume interactions among all three classes of players exist and are illustrated by Figure 1 above. In this section, I use lower-case letters to denote prices. And in the later part, lower-case letters are used specifically for independent pricing regime, while upper-case letters are used to denote the corresponding prices under bundling.

Console Platform:

There is a monopoly console platform which locates at the origin of a horizontal line and produces its own video games. For simplicity, we assume P has only one first party game, with marginal cost, c, while the marginal cost of producing its console is f. The platform, P, interacts with both agents by charging a fixed fee p_c to consumers for the purchase of the console hardware, a fixed fee p_g for the first party game, and levying a per unit royalty fee, r, to game developers for the right to produce and sell games compatible with the console hardware. Likewise, consumers and game developers interact with consumers purchasing video games from developers at their corresponding game prices.

Consumers:

We implement a modified hotelling model to analyze the consumers' decisions. Assume there are two groups of consumers ($i = 1, 2$) with total size normalized to one. Group 1, identified as the installed base (with fraction α), is a pre-existing group who already have purchased the hardware for platform P but have yet to purchase the first party game.[6] The gross utility a consumer from group 1 garners from purchasing the

[6] One interpretation of the assumption that the installed base has yet to purchase the first-party game is that the console manufacturer has innovated and created a video game after the release of its console.

first party game is $u_{installed} = \overline{v}_g$. And group 2, a continuum of new gamers with fraction $1 - \alpha$ population, are uniformly located on a horizontal line and have yet to purchase platform $P's$ hardware. The utility a group 2 consumer receives from purchasing a portable console is dependent upon the number of games (or game developers since we assume each developer only produces one game) x available for consumers to play, and a transportation cost equal to t. Specifically, the marginal utility of an additional game is β. The gross utility associated with a consumer situated at point d who elects to purchase only platform P's hardware is $(\overline{v}_c - td) \cdot 1\{x\} + \beta \cdot x$[7], while $\overline{v}_c + v_g + \beta \cdot x - td$ if he purchases both the hardware and the platform's software, where $1\{\cdot\}$ is the indicator function, $\overline{v}_c$ and v_g are the new gamers' intrinsic values for the console and first party game, respectively. For simplicity, we assume that $\overline{v}_c$, $\overline{v}_g$ are constant and known to all, and v_g is drawn from the uniform distribution $U(\cdot)$ on $[0, 1]$. Lastly, note new gamers are heterogeneous in two dimensions: in their location d; and in their valuation for the first party game v_g.

Game Developers:

We assume that the console is essential for consumers to enjoy a game. In the case of game developers, they also must join the console platform in order for their software to be compatible with the console. Moreover, we assume there is free entry into the market for video game software and that developers are heterogeneous. Each game developer's type can be summarized by θ, which is its fixed cost of developing a game for platform P. For simplicity, we assume θ is i.i.d. according to a uniform distribution $U(\cdot)$ on $[0, 1]$. The total number of potential game developers is therefore normalized to one. With the assumption of free entry into the game developer segment, developers do not set game prices. Instead, they decide whether to enter the market and join P. The profit each game developer can receive per consumer if it elects to produce a game is ϕ. Consequently, a type θ developer will create and produce a video game for platform P if and only if $\theta < (\phi - r)(q_c + q_{both} + \alpha)$, where q_c is the quantity of consoles sold individually, q_{both} is the number of consoles purchased with the first party game, and α is the aggregate number of consoles previously purchased or what we denote as the installed base. The number of video games available on console P is then

[7] When $x = 0$, the console only won't provide any utility to the consumer unless purchased with the first-party game.

$$
\begin{aligned}
x &= U((\phi - r)(q_c + q_{both} + \alpha)) \qquad (1) \\
&= (\phi - r)(q_c + q_{both} + \alpha).
\end{aligned}
$$

The above equation therefore implies that as more consumers join the platform more games will be produced and is denoted throughout the economic literature as an indirect network effect.

The timing of the game is as follows. First, the monopoly platform chooses either to bundle or not and then sets prices accordingly. Next, after observing the price offers from the platform, consumers and game developers make their purchase decisions and entry decisions, respectively. Rational expectations are assumed for the simultaneous equilibrium outcome.

4 One-Sided Benchmark Model: Without third party Games

Before we introduce a theoretical two-sided market model to analyze the impact of mixed bundling we first present a benchmark model in a one-sided market setting in order to assist in drawing comparison between the impact mixed bundling has in a traditional one-sided market and that of a two-sided market model. In our basic setting, if we eliminate all the third party games, that is, let $x = 0$, then the indirect network effect disappears since there is only one game available on the platform, which is a first party game. In this case, the market is reduced to a one-sided market with the console and the first party game as perfect complements. We begin by constructing a one-sided market model which omits the practice of mixed bundling and then modify the model to allow for its practice. After the introduction and description of the equilibrium of both models, we compare the two regimes to determine the effects of mixed bundling on prices and welfare. We then follow with the analysis of mixed bundling in a two-sided market setting.

4.1 Independent Pricing Model

The independent pricing (IP) equilibrium consists of the monopoly platform setting prices (p_c, p_g). The two groups of consumers' decisions are as follows. For the installed base they will purchase the first party game from P if and only if $u_{installed} = \overline{v}_g - p_g \geq 0$. Hence, each individual's demand for the first party game is

$$n_g = 1\{\overline{v}_g \geq p_g\}.$$

Aggregating across the installed base yields an aggregate demand of

$$\begin{aligned} q_g &= \alpha \cdot n_g \\ &= \alpha \cdot 1\{\overline{v}_g \geq p_g\}. \end{aligned}$$

If we assume $\overline{v}_g$ is large enough to represent the loyalty or lock-in effect of the installed base, it is without loss of generality to restrict our attention to $\overline{v}_g \geq p_g$ case. Thus, $q_g = \alpha$.

The equilibrium number of new gamers is a bit more complicated to derive given that consumers can purchase the console and the first party game in conjunction or elect to not purchase either the console or the game.[8] Note that, since there is no third party game ($x = 0$) the console will only provide utility to consumers who own or purchase the first party game. Therefore, no one only buys the console. The new gamers will buy both the console and the first party game if and only if $(\overline{v}_c - p_c) - td + (v_g - p_g) \geq 0$; and buy nothing otherwise. The new gamers' demand is in the figure below.

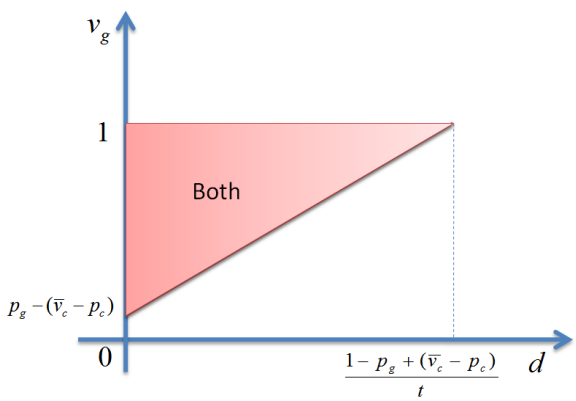

Figure 2: New Gamers' Demand under IP in One-Sided Market

[8] Recall that the console is essential, so the one game doesn't provide any utility to new gamers, whom have no console.

Denote $u \equiv \overline{v}_c - p_c$. Then the demand for only the console and the demand for both a console and a first party game are

$$\begin{aligned} q_c &= 0 \\ q_{both} &= \frac{(1 - p_g + u)^2}{2t}, \end{aligned}$$

respectively.

portable console $P's$ profit under IP is

$$\begin{aligned} \pi^{IP} &= (p_g - c) \cdot q_g + (p_c + p_g - f - c) \cdot q_{both} \\ &= (p_g - c) \cdot \alpha \cdot 1\{\overline{v}_g \geq p_g\} \\ &\quad +(p_c + p_g - f - c) \cdot \frac{(1 - p_g + \overline{v}_c - p_c)^2}{2t}. \end{aligned}$$

Notice that the second term is purely a function of $p_c + p_g$. And hence p_g could be freely set as long as $p_c + p_g$ is kept as a certain constant. Obviously, the first term will be maximized at $p_g = \overline{v}_g$.

Proposition 1 (One-Sided Market IP Equilibrium) *When there is no third party game, the IP equilibrium*[9] *is*

$$\begin{aligned} p_g &= \overline{v}_g \\ p_c &= \frac{2(f + c) + 1 + \overline{v}_c}{3} - \overline{v}_g. \end{aligned}$$

4.2 Bundling Equilibrium

The monopoly platform under a bundling model can set prices (P_c, P_g, P_B), where P_B is the bundle price. Hence, the new gamers now possess the option of purchasing the portable console and the first party game bundled together. However, in this one-sided case, only the bundle will be purchased since the console does not provide any utility unless it is combined with the purchase of the one available game. As a result, the prices that bind are P_g and P_B due to the fact that $P_c + P_g \geq P_B$. The monopoly platform's

[9] An implicit assumption for the existence and uniqueness of this equilibrium is $2(f + c) + 1 > 2\overline{v}_c$.

profit are essentially the same as π^{IP} in the IP equilibrium above with P_g substituting for p_g and P_B substituting for $p_c + p_g$.

Proposition 2 (One-Sided Market Bundling Equilibrium) *When there are no third party games, the bundling equilibrium is*

$$\begin{aligned} P_g &= \overline{v}_g \\ P_c &\geq \frac{2(f+c)+1+\overline{v}_c}{3} - \overline{v}_g \\ P_B &= \frac{2(f+c)+1+\overline{v}_c}{3}. \end{aligned}$$

An immediate conclusion from the comparison between these two regimes is that there is no need to bundle in such a one-sided market setting.

Proposition 3 (One-Sided Market Comparison) *When there are no third party games, the IP equilibrium and the bundling equilibrium yield exactly the same outcome.*

Such a redundancy of bundling comes from the fact that here the console and the first party game are perfect complements with fixed proportion. The Chicago School's "single-monopoly-profit theorem" applies for the new gamers since they will demand both the console and the first party game. In summary, a pure tie would suffice for the platform. Yet, due to the existence of the installed base, who only buy the first party game since they already own the console, the standalone price for the first party game has bite in both regimes and is necessary to further extract rents from these consumers.

As we will see next, once third party games are introduced, the market structure will switch to a two-sided market. Although the console and the first party game remain complements, they no longer are *perfect* complements with fixed proportion–new gamers could only buy the console without purchasing the first party game since third party games are available to be played with the console. Consequently, the availability of substitutes to the first party game dramatically changes the market structure and invalidates the "single-monopoly-profit theorem."

5 Two-Sided Model: With third party Games

We now allow for third party games to enter into our model. As indicated in Section 3, the number of third party games available is endogenously determined as $x = (\phi - r)(q_c +$

$q_{both} + \alpha$). The presence of these third party games has two implications: first, the first party game is no longer essential to new gamers, since they can now enjoy the console with other third party games; second, indirect network effects emerge in this setting, because the number of third party games depends on the number of total console owners $q_c + q_{both} + \alpha$ and vice versa. As a result, the market structure becomes two-sided.

5.1 Independent Pricing Equilibrium

Similarly to the one-sided market model, the demand for the first party game from the installed base is

$$q_g = \alpha \cdot 1\{\overline{v}_g \geq p_g\}.$$

The equilibrium number of new gamers is more challenging to derive given that consumers can either solely purchase the console, purchase the console and the first party game in conjunction or elect to not purchase either console or game. We thus classify consumers based among their different locations into two different types. The first, Type A, values the console enough on its own to purchase. That is, the consumer's utility from consumption of hardware is greater than zero, or $\overline{v}_c + \beta \cdot x - p_c - td \geq 0$. Hence, new gamers will buy both the hardware and first party game if $v_g \geq p_g$ and only the console if $v_g < p_g$. The second, Type B, consumer does not value the console enough on its own to purchase it. That is, $\overline{v}_c + \beta \cdot x - p_c - td < 0$. Thus, these consumers only purchase the console with the first party game. In this case the first party game is a complementary product which makes the console more attractive, although it is not essential as in our one-sided market model. They, therefore, will buy both the console and the first party game if $(\overline{v}_c + \beta \cdot x - p_c - td) + (v_g - p_g) \geq 0$; and buy nothing otherwise. The new gamers' demand is in the figure below.

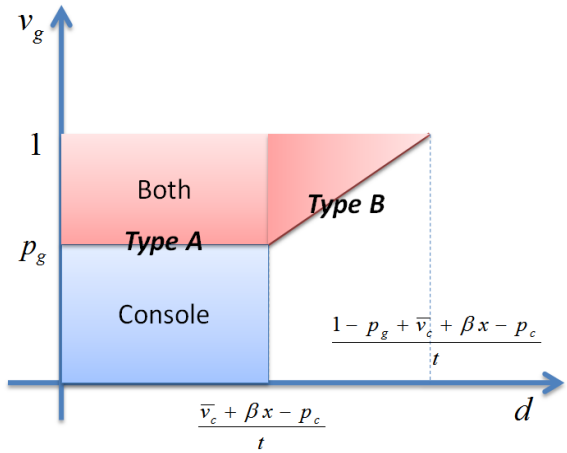

Figure 3: New Gamers' Demand Under IP

In order to determine the aggregate demand for consumers who purchase only a console and those who purchase both a console and first party game we must aggregate the demand from both types of new gamers. Again we can think of the consumers who purchase a console only as those who value the console separately without any game or value a third party game more than the game produced by the platform. Denote $u \equiv \overline{v}_c + \beta \cdot x - p_c$ then the number of Type A new gamers buying both products is

$$\int_0^{\frac{u}{t}} (1-p_g)ds = (1-p_g) \cdot \frac{u}{t};$$

while the demand for only the console from Type A consumers is

$$\int_0^{\frac{u}{t}} p_g ds = p_g \cdot \frac{u}{t}.$$

Likewise, the demand of Type B consumers who buy both a console and a first party game is

$$\int_{\frac{u}{t}}^{\frac{u}{t}+\frac{1-p_g}{t}} \{1-[p_g-(u-ts)]\}ds = \frac{(1-p_g)^2}{2t}.$$

The aggregate demand for the console as well as the demand for both a console and a first party game under the assumption that consumers form rational expectation as to

the number of available games is

$$\begin{aligned} q_c &= (1-\alpha)\cdot\frac{p_g}{t}\cdot u \\ q_{both} &= (1-\alpha)\cdot\frac{1-p_g}{t}\cdot(u+\frac{1-p_g}{2}), \end{aligned}$$

respectively.

Given the demands for each of these products, the equilibrium number of video games available on console P is

$$x = \frac{\phi - r}{\Omega}\{\alpha + (1-\alpha)[\frac{\overline{v}_c - p_c}{t} + \frac{(1-p_g)^2}{2t}]\},$$

where $\Omega = 1 - \frac{(1-\alpha)\beta(\phi-r)}{t}$.

With equilibrium demand for consoles and first party games as well as the number of third party game developers determined, in terms of hardware price p_c, software price p_g and royalty rate r, the portable manufacturer maximizes its profit with respect to these two strategic variables. The corresponding platform profit under independent pricing is

$$\begin{aligned} \pi^{IP}(p_c, p_g, r) &= r\cdot x\cdot(q_c + q_{both} + \alpha) + (p_g - c)\cdot q_g + (p_c - f)\cdot q_c + (p_c + p_g - f - c)\cdot q_{both} \\ &= r\cdot(\phi - r)\{\alpha + (1-\alpha)[\frac{u}{t} + \frac{(1-p_g)^2}{2t}]\}^2 + (p_g - c)\cdot\alpha \\ &\quad +(p_c - f)\cdot(1-\alpha)\cdot\frac{p_g}{t}\cdot u + (p_c + p_g - f - c)\cdot(1-\alpha)\cdot\frac{1-p_g}{t}\cdot(u + \frac{1-p_g}{2}) \end{aligned}$$

Since the royalty fees are unobservable in our data, we analyze two possible cases: i) when the royalty fee is exogenously determined and ii) when it is endogenously determined.

Lemma 1 (Two-Sided Market IP Equilibrium) *When there are third party games, the market structure is two-sided.*

- *When the royalty fee $\overline{r}$ is exogenously determined, the IP equilibrium is*

$$(p_c^{*\overline{r}}, p_g^{*\overline{r}}) = \arg\max_{x,y} \pi^{IP}(x, y, \overline{r});$$

- *when the royalty fee r is endogenously determined, the IP equilibrium is*

$$(p_c^*, p_g^*, r^*) = \arg\max_{x,y,z} \pi^{IP}(x, y, z).$$

5.2 Bundling Equilibrium

Our mixed bundling model differs slightly from the above independent pricing model in that new consumers now possess the option of purchasing the portable console and the first party game bundled together. Consumers still retain the option of purchasing the hardware and software separately. The monopoly platform therefore does not completely tie its first party game to its hardware device. Like the above IP model, the platform, P, interacts with both agents by charging a fixed fee P_c to consumers for the purchase of the hardware and levying a per unit royalty fee, R, to game developers for the right to produce and sell games compatible with the console hardware. Consumers and game developers still interact with consumers. Consumers purchase the first party video game separately for a fixed fee, P_g. Yet, in the bundling model platform P also sells its first party game and hardware device together at price P_B. Prices are thus $\{P_c, P_g, P_B, R\}$.

To begin our equilibrium analysis, first note that in order for the bundle to be effective, we must have $P_c + P_g > P_B$. By doing so, we ensure that new gamers will never solely purchase the first party game at P_g since this game provides zero utility without the ownership of the portable console. Moreover, if they elect to purchase the first party game they will do so via the bundle. P_g is thus specifically targeted to the installed base of users who have not purchased the console produced game. Hence, it is easy to see that the price of the first party game is set to $P_g = \overline{v}_g$, since P_g is directed to the installed base and its intrinsic valuation for first party game is known . The resulting demand for the first party game from the installed base is $Q_g = \alpha$.

Under bundling, new consumers determine their purchase decisions on two strategic variables, the price of the console and the effective price of the first party game $P_g^e \equiv P_B - P_c$. Our analysis regarding new gamer demand for the portable console and the purchase of both the console and first party game (the bundle) takes the same structure as the independent pricing equilibrium if we define the effective price of the first party game for new gamers as P_g^e and by replacing P_g with the effective game price. The standalone demand for the console is

$$Q_c = (1-\alpha) \cdot \frac{P_g^e}{t} \cdot U$$

where $U \equiv \overline{v}_c + \beta \cdot X - P_c$ while the bundle demand is

$$Q_B = (1-\alpha) \cdot \frac{1-P_g^e}{t} \cdot (U + \frac{1-P_g^e}{2}).$$

Consumers' decisions are shown below and are consequently quite similar to their decision under the independent pricing model.

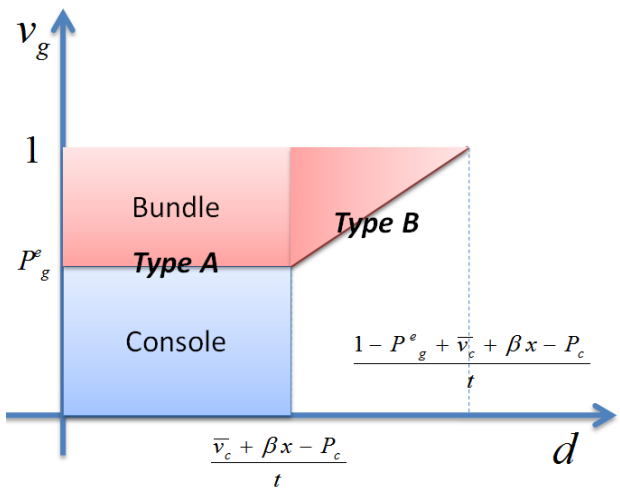

Figure 4: New Gamer's Demand Under Mixed Bundling

Likewise, assuming rational expectations, the number of gamer developers joining the platform is

$$\begin{aligned} X &= (\phi - R)(Q_c + Q_B + \alpha) \\ &= \frac{\phi - R}{\Omega}\{\alpha + (1-\alpha)[\frac{\overline{v}_c - P_c}{t} + \frac{(1-P_g^e)^2}{2t}]\}, \end{aligned}$$

where $\Omega = 1 - \frac{(1-\alpha)\beta(\phi-R)}{t}$.

Given the demand for the first party game from the installed base, the demand from new gamers for only the console and the demand for the bundle, the monopoly platform's

profit under bundling is

$$\begin{aligned}
\Pi^B(P_c, P_g^e, R) &= R \cdot X \cdot (Q_c + Q_B + \alpha) + (P_g - c) \cdot Q_g + (P_c - f) \cdot Q_c + (P_B - f - c) \cdot Q_B \\
&= R \cdot (\phi - R)\{\alpha + (1-\alpha)[\frac{U}{t} + \frac{(1-P_g^e)^2}{2t}]\}^2 + (P_g^e - c) \cdot \alpha \\
&\quad +(P_c - f) \cdot (1-\alpha) \cdot \frac{P_g^e}{t} \cdot U + (P_c + P_g^e - f - c) \cdot (1-\alpha) \cdot \frac{1-P_g^e}{t} \cdot (U + \frac{1-P_g^e}{2}) \\
&\quad +(\overline{v}_g - P_g^e) \cdot \alpha \\
&= \pi^{IP}(P_c, P_g^e, R) + (\overline{v}_g - P_g^e) \cdot \alpha
\end{aligned}$$

Notice that the structure of this profit function is identical to the independent pricing model. The platform receives profits from third party game developers via royalties, profit from selling its first party game and console separately and from consumers who purchase the bundle of console and game at the bundle price P_B.

Moreover, compared with the platform's profit under IP, the only extra term is the surplus gains extracted from the installed base, that is, $(\overline{v}_g - P_g^e) \cdot \alpha$, if we substitute p_g in π^{IP} with P_g^e. Consequently, we determine that bundling is a dominant strategy for the monopoly platform since offering P_B and P_g simultaneously is equivalent to offer P_g^e and P_g to new gamers and the installed base separately. Offering a bundle, therefore, provides the monopoly platform an additional instrument to extract consumer surplus.

Lemma 2 (Mixed Bundling is Profitable) *Whenever bundling is possible, mixed bundling is a dominant strategy over no bundling or pure bundling.*

Proof. *Any independent pricing menu (p_c, p_g) can be perfectly mimicked by (P_c, P_g, P_B) with $P_c = p_c$, $P_g = p_g$ and $P_B = p_c + p_g$. Due to the presence of installed base, offering mixed bundling gives the platform more freedom in extracting surplus. Thus, mixed bundling is strictly better than independent pricing.*

Under pure bundling, neither the installed base nor the new gamers with low value on first party game would be served. Hence, pure bundling will be strictly dominated, too.

■

The above lemma is consistent with the existing literature on mixed bundling in that mixed bundling is the optimal strategy for the monopolist. Parallel to the IP case, we perform the analyses for both cases in which the royalty fee is exogenously or endogenously determined.

Lemma 3 (Two-Sided Markets Bundling Equilibrium) *In the two-sided markets context with third party games,*

$$P_g^{*(\overline{R})} = \overline{v}_g.$$

- *When the royalty fee $\overline{R}$ is exogenously determined, the bundling equilibrium is*

$$(P_c^{*\overline{R}}, P_g^{*\overline{R}}) = \arg\max_{x,y} \Pi^B(x, y, \overline{R});$$

- *when the royalty fee R is endogenously determined, the bundling equilibrium is*

$$(P_c^*, P_g^{e*}, R^*) = \arg\max_{x,y,z} \Pi^B(x, y, z).$$

5.3 Prices, Profits and Welfare Comparison

In this subsection, we compare the equilibria of the two regimes–IP vs Bundling. Interestingly, we find the price and welfare effects of bundling when the royalty fee is exogenously given to differ from those when the royalty fee is endogenously determined.

5.3.1 When Royalty Fee $\overline{R}$ is Exogenously Determined

Proposition 4 *When royalty fee $\overline{R}$ is exogenously determined, under mixed bundling, the standalone console price and the standalone price for the first party game are higher than those under IP, while the effective first party game is lower under bundling. In addition, the bundle price is lower than the sum of console and first party game under IP. Specifically,*

$$\begin{aligned} P_c^{*\overline{R}} &> p_c^{*\overline{r}} \\ P_g^{e*\overline{R}} &= P_B^{*\overline{R}} - P_c^{*\overline{R}} < p_g^{*\overline{r}} < \overline{v}_g = P_g^{*\overline{R}} \\ P_B^{*\overline{R}} &= P_c^{*\overline{R}} + P_g^{e*\overline{R}} < p_c^{*\overline{r}} + p_g^{*\overline{r}}. \end{aligned}$$

We determine from the above proposition that by offering the bundled option it allows the monopolist to increase the standalone price of the video game and console. The above price structure allows consumers to sort into distinct groups and consequently reveal their true preferences. The mixed bundle option thus acts a price discrimination tool and allows the monopolist to raise standalone prices in search of more efficient and complete extraction of consumer surplus.

Lastly, we determine the impact on total surplus depends on whether the total number of game developers increases or decreases–under numerical simulations the effect of total surplus is not ambivalent but clearly shows that total surplus increases.

Proposition 5 (Total Surplus) *When royalty fee $\overline{R}$ is exogenously determined, total surplus under bundling is higher than IP if and only if there are more participation on both sides in equilibrium.*

Proof. Given the standalone price of the bundled video game increases under a mixed bundling regime the installed base is worse off. Yet, this decrease in surplus is a direct transfer to the console resulting in total surplus to remain unchanged. Consequently, total surplus is dependent upon the change in surplus of new gamers. The impact of new gamer surplus is ambiguous. First there are consumers who only purchase the console. These consumers are worse off since the standalone console price increased, holding the number of games constant, while gamers who purchase the bundle are better off since they purchased at the bundled price. However, a new gamer's utility is not only a function of price but also the number of games on the platform. The change in consumer surplus caused by a change in price could very well be offset or dominated by the change in surplus from the indirect network effect. Moreover, the equilibrium number of game developers is also ambiguous given that the number of game developers is decreasing in P_g^e and P_c and $P_c > p_c$, $P_g^e < p_g$.

$$\frac{\partial X}{\partial P_g^e} < 0, \ \frac{\partial X}{\partial P_c} < 0 \text{ and } P_c > p_c, \ P_g^e < p_g.$$

■

5.3.2 When Royalty Fee R is Endogenously Determined

Proposition 6 *When royalty fee R is endogenously determined, under mixed bundling, all prices except the standalone price of the first party game are lower than those under*

IP. Specifically,

$$\begin{aligned} R^* &< r^* \\ P_c^* &< p_c^* \\ P_g^{e*} &= P_B^* - P_c^* < p_g^* < \overline{v}_g = P_g^* \\ P_B^* &= P_c^* + P_g^{e*} < p_c^* + p_g^*. \end{aligned}$$

This is quite a surprising result! Both the standalone console price and the royalty rate are lower under the mixed bundling equilibrium than their respective counterparts in the independent pricing equilibrium. It is widely know that in two-sided markets the optimal pricing scheme is to subsidize the more elastic side of the market and extract rents form the other, more inelastic, side. Or more generally, the optimal price structure is to adjust prices downward by the external benefit a console receives from attracting an additional side i user. When the console maker uses mixed bundling they are in affect offering a "subsidy" to consumers which increases demand for its console by attracting a greater number of marginal consumers. It is typically thought that by further subsidizing consumers, via mixed bundling in our case, the console maker is increasing the game developers' willingness to pay and thus the ability to raise the royalty rate in which it levies. Yet, this is not what we encounter. We find that the royalty rate is in fact lower under the mixed bundling equilibrium. By offering the mixed bundle the console maker becomes more effective in extracting consumer surplus, compared to the independent pricing case. Consequently, by offering the mixed bundle the consumer side becomes less elastic to platform pricing since the console can more efficiently extract consumer surplus without deterring consumer participation. The game developer therefore becomes relatively more elastic which creates an incentive for the console platform to lower R under mixed bundling.

There also is an additional argument for the lowering of the royalty rate. We know that the console platform would like to increase participation on the side it can more efficiently extract surplus from since doing so will increase profits. Given that non-linear pricing is only available to the consumer side the console consequently is able to more effectively extract rents from consumers. Given this, the console platform has an incentive to increase demand for its console. How does the console accomplish this? It does so by reducing the game developers' royalty rate R. A reduction in royalty rate will lead to an increase in game development and thus attract more consumers through

the indirect network which will consequently lead to more entry of games through the indirect network effect resulting in each of these network effects to reinforce the other.

In addition to a decrease in royalty rate we also find the standalone console price is less under a mixed bundling regime. This smaller standalone console price is a consequence of the mixed bundle segmenting the market into new gamers and the installed base. Under a mixed bundle regime the standalone first party game price is specifically targeted to the installed base as oppose to a uniform price under the independent pricing equilibrium. Since, the installed base's value of the first party is known to all, the console maker is able to perfectly price discriminate and set price equal to $\overline{v}_g$, which is greater than p_g. As a result, the additional profit the console receives from selling its first party game and the payment of royalty fees from third party developers is larger under a mixed bundling equilibrium leading to a larger discount of the standalone console price and hence a smaller price.

Unlike the one-sided case above, we can determine the impact mixed bundling has on the equilibrium number of game developers. We show that the number of developers increase under a regime which includes mixed bundling. We, therefore, conclude the strategic decision to offer a mixed bundle also solves the coordination problem of which comes first the chicken or egg since both consumer and game developer participation increases.

Proposition 7 *When royalty fee R is endogenously determined, under mixed bundling, the number of third party game developers is higher than under IP.*

Proof. $X = \frac{\phi - R}{\Omega}\{\alpha + (1-\alpha)[\frac{\overline{v}_c - P_c}{t} + \frac{(1-P_g^e)^2}{2t}]\}$

$\frac{\partial x}{\partial R} < 0$; $\frac{\partial x}{\partial P_g^e} < 0$; $\frac{\partial x}{\partial P_c} < 0$

Since (R, P_c, P_g^e) is uniformly lower than (r, p_c, p_g) we find that the number of game developers under a mixed bundling equilibrium is larger than under the independent pricing model. ■

With determining that all prices are lower, with the exception of the standalone first party game price, in addition to the number of third party developers being greater under a mixed bundling equilibrium we find new gamers are strictly better off. Yet, the installed base of consumers is strictly worse off, which is a consequence of the installed base being locked-in to the console and the ability of console manufacturer to segment the market and target the installed base with a segment specific software price which extracts all surplus from them under mixed bundling. This extraction, however, does

not cause total surplus to change since it is a transfer from consumers to the platform. Moreover, from Lemma 2 we know that the platform's profits are strictly higher under mixed bundling. We, thus, have the following proposition regarding the comparison of total surplus between regimes.

Proposition 8 *When royalty fee R is endogenously determined, total surplus is higher under bundling than under IP:*

$$TS^B > TS^{IP}.$$

From our theoretical analyses we show the effects of mixed bundling on prices, surplus and demand for the console (both consumer and game developer demand) to differ substantially under two different market structures. While, the motivations behind the act of offering a bundle are consistent across structures (price discrimination), mixed bundling under a two-sided market structure leads to a very different and unique outcome. We determine, unlike the single-sided case, total surplus in a two-sided market structure is definitively larger than welfare under an independent pricing regime even though all prices with the exception of the standalone video game price are lower. When a console producer is able to optimally set its royalty rate and offer a mix bundle the firm's response is not increase console price like the case of the one-side market but it is to lower both the royalty rate and console price. The decrease in marginal revenues from the decline in console price and game developer royalty rate are more than overcome by the increase in consumer and game developer demand to join the platform.

6 Hypotheses and Data

In this section we test the above theoretical prediction for the two-sided market model via reduced form regressions with data from the portable console market. Our model above generates three distinct price correlations between a regime which includes mixed bundling and one that does not. They are:

$$\begin{aligned} 1 &: \; P_c^* < p_c^* \\ 2 &: \; P_g^* > p_g^* \\ 3 &: \; R^* < r^* \end{aligned}$$

In order for the theoretical model to hold to the data all three correlations need to be present.

The data used in this study originates from NPD Funworld. Data from the marketing group NPD Funworld tracks sales and pricing for the video game industry and is 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 two consoles and three bundles and all of their compatible video games, roughly 700. The data sets cover 45 months starting in June 2001 and continue through February 2005.

In June of 2001, Nintendo launched a new generation of portable console devices dubbed the Gameboy Advance. This generation of portable improved on the previous generation by increasing the CPU speed, RAM, screen size and screen resolution. Nonetheless, there were flaws with the device, mostly due to its size and shape. In early 2003, a new Game Boy Advance device called the GBA SP was launched to rectify these issues. This new device augmented the shape and size of the GBA but the internal workings of the GBA remained. The GBA SP looks like a mini laptop computer and was close to half the size of the original GBA. Moreover, it is usually the case with the introduction of a new device new games are released which are not backwards compatible. Yet, with the introduction of the SP this was not the case since the internal parts of both devices were identical. Consequently, both devices shared the same set of games. And, at the end of the data set there were over 600 unique video games produced.

General statistics of the portable video game industry are provided in the tables below.

Table 2: Handheld Console Market Statistics

	Release Date	Units	Months on Console Market
Nintendo			
Gameboy Advance (GBA)	June 2001	12,821,233	45
Gameboy Advance SP	March 2003	13,070,720	24
GBA w/ Mario Kart	November 2001	215,394	29
GBA w/ Mario Advance 2	November 2002	199,225	17
GBA SP w/ Mario Advance 4	November 2003	149,065	4

Table 3: Handheld Console and Bundle Prices

	Average Price	Max Price	Min Price	Independent Games Sold
Nintendo				
Gameboy Advance (GBA)	$72.00	$94.46	$52.37	
Gameboy Advance SP	$93.73	$100.30	$70.60	
GBA w/ Mario Kart	$86.17	$150.54	$61.50	2,027,636
GBA w/ Mario Advance 2	$67.33	$71.73	$56.60	2,438,732
GBA SP w/ Mario Advance 4	$97.62	$99.85	$94.92	1,673,304

In the above tables we present statistics regarding the release date, total units sold and the number of months on the console market, average (min and max) prices and total standalone units sold of the bundle games for two standalone consoles and four bundles. An interesting fact which is clearly evident from the table is that Nintendo elected to release its bundles at the height of the holiday time period–the first being a Gameboy Advance device bundled with the hit game Mario Kart in November 2001. Moreover, the bundled games were high quality hit video games each selling over one and half million standalone units.

Below we present Figure 4 which illustrates the sales of consoles and bundles over time. The video game industry exhibits a large degree of seasonality in console sales with significant increases in the months of November and December. It, therefore, is important to account for the large degree of seasonality in our empirical tests.

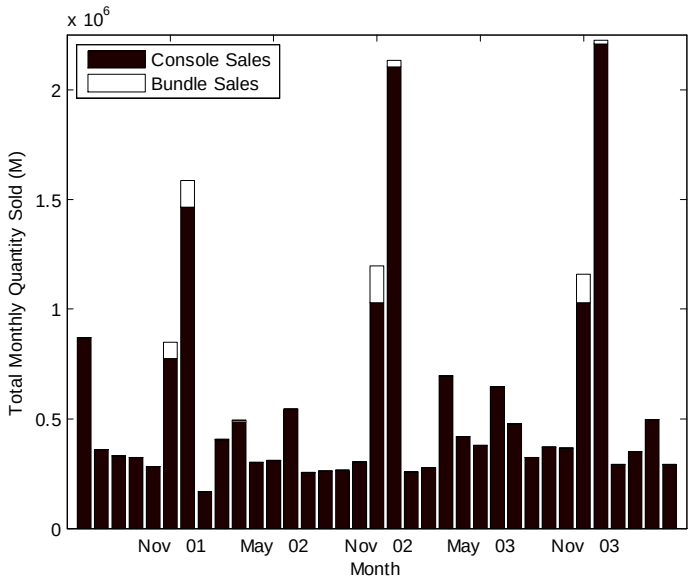

Figure 4: Console and Bundle Sales

7 Reduce Form Tests

The first theoretical prediction we test is whether the standalone console price decreases when a mixed bundle is offered. Accordingly, if our theoretical model is correct, there should exist a negative correlation between console price and the presence of bundles in the data. In order to properly determine whether a negative correlation is present we must address econometric issues such as whether unobserved heterogeneity and omitted variable bias is an issue, proper specification and model selection. We first tackle the issue of model selection given that we have two variables which capture the presence of a bundle. They are i) an indicator taking value equal to one if a bundle is offered in period t and zero otherwise and ii) the count of the number of bundles offered in time t. However, given that we are uncertain about model specification we run three encompassing tests for three different model specification, linear, log-linear and log-log. These results are presented in the appendix below and from them we determine the model which employs the count of bundles encompasses all the features of a model employing the indictor variable. We thus use the count of the number of bundles as the variable which captures the presence of a bundle. With the model selection complete we turn our attention to model specification. We implement a Box-Cox regression model to determine the proper specification. In this regression we allow nonlinearity to enter both the dependent as

well as (a few) independent variables–we thus are testing between a linear and non-linear model. Again, these results are presented in the appendix below but from them we conclude that the best specification is a double log model. Moreover, the residuals of the preferred model are normally distributed, unlike a linear or log-linear model. Lastly, we perform two Hausman tests. The first, tests for the endogeneity of the log number of software titles since our theoretical model illustrates that the number of software developers is endogenously determined. The purpose of this test is due to the fact that a simple OLS model yields inconsistent estimates of the $\beta's$ when correlation between ϵ_{ct} and $\ln(\#\ of\ Software_{ct})$ is present. Consistent estimates of the model parameters can, nonetheless, be obtained using an instrument that is correlated with $\ln(\#\ of\ Software_{ct})$, but uncorrelated with ϵ_{ct}–we use the log of $t-1's$ installed base as an instrument since we illustrate above that the installed base will influence the number of video game developers ($\alpha = IB_{t-1}$). Likewise, in the presence of panel data the correlation can be eliminated with the use of console fixed effects resulting in $E[\epsilon_{ct}|X_c, c_c] = 0$ and thus providing an unbiased estimate of β. The use of console fixed effects also corrects for any unobserved heterogeneity or omitted variable bias. We consequently implement a second test which determines whether a pooled regression model is more efficent than a fixed effects model. The results of each of these models in addition to the Hausman test statistic are presented below. From these results we find the use of a pooled regression is more efficient than the fixed effects model and the number of software titles is not endogenous.

We analyze the impact of mixed bundles on standalone console prices by restricting the data to consist only of the two standalone consoles, the Gameboy Advance and the Gameboy Advance SP. In addition to a variable which measures the entry of a bundle we include month fixed effects to account for large seasonal spikes during these periods, console age, the number of compatible video games and the total number of consoles present in market t as covariates. The model we take to the data is a double log model (Model 1 below):

$$\ln(P_{ct}) = \beta_0 + \beta_1 Age_{ct} + \beta_2 \ln(\#\ of\ Software_{ct}) + \beta_3 \ln(1 + \#\ of\ Additional\ Consoles_{ct}) + \beta_4 \ln(1 + \#\ of\ Bundles_{ct}) + \sum_{m=1}^{m=11} \beta_{4+m} Month_m + \epsilon_{ct}.$$

Below we present the results of three models. Models 1 and 2 implement a model without fixed effects while model 3 includes fixed effects.

Table 4: Standalone Console Price Regression

ln(Price)	Model 1-OLS	Model 2-IV	Model 3-FE no IV
ln(1+ # of Bundles)	-0.0587^{**}	-0.0578^{**}	0.0278
	(0.0249)	(.0252)	(0.0488)
ln(1+ # of Additional Consoles)	0.2340^{**}	0.2255^{**}	0.1336^{*}
	(0.0504)	(.0526)	(0.0695)
ln(# of Software Titles)	-0.0029	0.0038	-0.0807^{*}
	(0.0223)	(.0256)	(0.0439)
Age	-0.0137^{**}	-0.0138^{**}	0.0078^{**}
	(0.0012)	(.0012)	(0.0031)
Console FE's	No	No	Yes
Number of Obs.	69	69	69
Hausman Endogeneity Test		0.71(0.4029)	
Hausman Test Model 3 vs. Model 1		4.16 (0.9986)	

All models include Month fixed effects and Model 1 an unreported constant. **significant at 95% *significant at 90%

From the table above the coefficient corresponding to the presence of a bundle for model one, our preferred model, is negative. A negative and significant correlation between console price and the presence of a bundle thus illustrates that our first theoretical prediction holds to data. Other predictions from economic theory also hold. For instance, the coefficient corresponding to the total number of consoles in the market is positive and significantly different from zero. This positive sign is consistent with economic theory of a multiproduct monopolist, which internalizes the effect of its prices on its other substitute products creating a positive price externality. Likewise, note the negative sign with regard to the log of one pluse the number of software titles. This negative sign indicates price decreases as the number of titles increase, but it is insignificantly different from zero. Although console price should increase when games are added since doing so increases the demand for the console there is also a subsequent effect which creates an incentive to decrease console price, thus the insignificance of the sign does not worry us. When an additional game is added the console acquires either more royalties or the price of the game depending whether the game is a third or first party game. This additional revenue creates an incentive to decrease console price through the externality associated with multiproduct pricing of complementary products. Our results illustrate

that these two effects offset each other and cause prices to remain unchanged with the introduction of an additional software title. Most importantly, though we do present evidence that our first theoretical prediction holds to the data. Yet, in order for us to claim that our theoretical model is correct we need to further test the remaining two theoretical predictions.

Next, we test prediction two–whether the standalone bundled software price increases when the bundle is introduced. Following a similar methodology to the above analysis, we first implement a Box and Cox regression to test model specification and follow with Hausman tests to determine whether the number of software titles is endogenous and whether a fixed effect or pooled regression is more efficient. We first test to determine whether the number of software titles is endogenous. We do so with a Hausman test; first running an OLS regression and following with an instrument variable estimator. We concluded that the number of software titles is endogenous and thus requires the use of instruments or fixed effects. It is therefore no surprise that a Hausman test concludes that a fixed effects model is more efficient than a pooled model.

We test the second theoretical prediction by restricting the data set to include only software which was bundled with a console and regressing its price on month fixed effects, software age, the number of software titles present as a measure of competition and an indicator variable which takes the value one if the software was also bundled with a console in a given period and zero otherwise. If our theoretical model is correct we expect the sign on the indicator variable to be positive, signifying a positive correlation between software price and bundling. From our model selection analysis and Hausman tests we determine that the proper model to estimate is a linear instrumental variable model with fixed effects.

$$P_{g_b t} = \alpha_{g_b} + \beta_1 I[Bundle]_t + \beta_2 Software\ Titles_t + \beta_3 Age_{g_b t} + \sum_{m=1}^{m=11} \beta_{3+m} Month_m + \epsilon_{g_b t}.$$

The results of the model we take to the data are below, model one is a pooled model, model two includes instrumental variables for number of software titles while model three includes software fixed effects. What is evident from these results is that there is clear evidence of a positive correlation between standalone software price and whether the game was bundled with a console in period t. We also would like to note the sign corresponding to the number of software titles for model two and three is negative and suggests that bundled games face competition from other software titles. We conclude

that our second prediction from the theoretical model also holds to the data.

Table 5: Standalone Bundled Software Price Regression

Price	Model 1-OLS	Model 2-IV	Model 3-FE no IV
I(Bundle)	0.1708	0.3109*	0.5084**
	(0.1501)	(0.1695)	(0.1616)
# of Software Titles	0.0006	−0.0022*	−0.0032
	(0.0007)	(0.0013)	(0.0022)
Age	0.0206	0.0692**	0.0860**
	(0.0147)	(0.0237)	(0.0330)
Software FE's	No	No	Yes
Number of Obs.	97	97	97
Hausman Endogeneity Test		9.74(0.0025)	
Hausman Test Model 3 vs. Model 1		26.87 (0.0298)	

All models include Month fixed effects and Model 1 an unreported constant. **significant at 95% *significant at 90%

The last prediction we test is whether the royalty rate levied by Nintendo decreases when mixed bundling is offered. Unfortunately, royalty rates are unobserved so we are unable to directly regress royalty rates on a set of covariates. However, we are able to determine if royalty rates decrease indirectly with a simple assumption regarding the marginal cost of third party games. We assume that marginal cost is constant, with the exception to the impact royalty rate have, over a software's life cycle (certainly not unrealistic). With this assumption and covariates which account for varying degrees of competition, we can infer that the royalty rate decreases if software prices decrease with the presence of a bundle. Also note that software competition does not increase as a result of the entry of a bundle since the bundled game has already been on the market prior to the bundling. We implement this test by restricting the set of video games to only third party games and employing a regression with identical covariates as the above test with the exception of the indicator variable for whether the software was bundled in period t. Instead we use an indicator variable which takes the value one if a bundle was offered in period t and zero otherwise. Like the above two tests, a Box and Cox regression is first performed to determine the correct model specification and is then followed by Hausman tests.

For our third prediction as well as the entire theoretical model to hold to the data

there must be evidence of a negative correlation between third party software price and the corresponding bundle measure. The last regression we estimate is a nonlinear model with fixed effects

$$P_{gt}^{0.5} = \alpha_g + \beta_1 I[Bundle]_t + \beta_2 Software\ Titles_t^{0.5} + \beta_3 Age_{gt} + \sum_{m=1}^{m=11} \beta_{3+m} Month_m + \epsilon_{gt}.$$

Table 6: Independent Software Price Regression

Price	Model 1-OLS	Model 2-IV	Model 3-FE no IV
I(Bundle)	-0.2353^{**}	-0.2265^{**}	-0.0469^{**}
	(0.0159)	(0.0159)	(0.0161)
# of Software Titles	-0.0929^{**}	-0.0910^{**}	-0.1492^{**}
	(0.0020)	(0.0020)	(0.0063)
Age	-0.0265^{**}	-0.0267^{**}	0.0018
	(0.0006)	(0.0006)	(0.0028)
Software FE's	No	No	Yes
Number of Obs.	14,445	14,445	14,445
Hausman Endogeneity Test		65.49(0.0000)	
Hausman Test Model 3 vs. Model 1		35.80(0.0011)	

All models include Month fixed effects and Model 1 an unreported constant. **significant at 95% *significant at 90%

The presence of a negative correlation, with regard to the impact a mixed bundle has on independent software price, is clearly evident from Table 6 above. In each of these models the sign of the coefficient corresponding to whether a bundle was offered is negative with point estimates significantly different from zero. Likewise, the measure of competition is negative and significantly different from zero. Consequently, as more games enter the software market the price of video games decrease. With this result in addition to the two tests run above we show our theoretical monopoly model of mixed bundling in a two-sided market setting holds to real world data.

8 Conclusion

We further extend the literature on two-sided markets by presenting a theoretical monopoly model of mixed bundling. We find the monopoly platform's dominant strategy is to of-

fer a mixed bundle rather than a pure bundle or independent pricing. Moreover, the equilibrium prices a platform levies to each side of the market for access to the platform are lower under a mixed bundling regime where as the standalone bundled software price is higher. In our setting mixed bundling acts as a price discrimination tool which allows the platform to segment the market into new game players and the installed base. As a result, the platform maker offers a more balanced pricing structure to consumers and developers for access to the platform. We find that all predictions under mixed bundling are consistent with our estimates from the portable video game market.

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Appendix

Proof of Proposition 2. F.O.C.s for IP:

$$\begin{aligned}\frac{\partial}{\partial p_c}\Pi_P^{IP}(p_c,p_g) &= 0\\ \frac{\partial}{\partial p_g}\Pi_P^{IP}(p_c,p_g) &= 0\end{aligned}$$

F.O.C.s for bundling:

$$\begin{aligned}\frac{\partial}{\partial P_c}\Pi_P^{B}(P_c,P_g^e) &= 0 \Longleftrightarrow \frac{\partial}{\partial P_c}\Pi_P^{IP}(P_c,P_g^e)=0\\ \frac{\partial}{\partial P_g^e}\Pi_P^{B}(P_c,P_g^e) &= 0 \Longleftrightarrow \frac{\partial}{\partial P_g^e}\Pi_P^{IP}(P_c,P_g^e)=\alpha\end{aligned}$$

Consequently, we can focus on the properties of $\Pi_P^{IP}(p_c,p_g)$ for the comparative statics. Denote its Hessian matrix as

$$H = D_iD_j[\Pi_P^{IP}(p_c,p_g)] = [h_{ij}] = \begin{bmatrix} h_{11} & h_{12}\\ h_{21} & h_{22}\end{bmatrix}.$$

Standard comparative statics gives that

$$\begin{aligned}\frac{\partial p_c}{\partial \alpha} &= \frac{\begin{vmatrix} 0 & h_{12}\\ 1 & h_{22}\end{vmatrix}}{|H|} = \frac{-h_{12}}{|H|} > 0\\ &(\ \because\ h_{12}<0 \text{ since console and game are complement products,}\\ &\quad\text{their prices should be strategic substitutes.})\\ \frac{\partial p_g}{\partial \alpha} &= \frac{\begin{vmatrix} h_{11} & 0\\ h_{21} & 1\end{vmatrix}}{|H|} = \frac{h_{11}}{|H|} < 0\\ &(\ \because\ h_{11}<0).\end{aligned}$$

And

$$\begin{aligned}\frac{\partial(p_c+p_g)}{\partial\alpha} &= \frac{\partial p_c}{\partial\alpha}+\frac{\partial p_g}{\partial\alpha}\\ &= \frac{h_{11}-h_{12}}{|H|}<0.\end{aligned}$$

■

Proof of Proposition 6. F.O.C.s for IP:

$$\begin{aligned}\frac{\partial}{\partial r}\Pi_P^{IP}(r,p_c,p_g) &= 0\\ \frac{\partial}{\partial p_c}\Pi_P^{IP}(r,p_c,p_g) &= 0\\ \frac{\partial}{\partial p_g}\Pi_P^{IP}(r,p_c,p_g) &= 0\end{aligned}$$

F.O.C.s for bundling:

$$\begin{aligned}\frac{\partial}{\partial R}\Pi_P^{B}(R,P_c,P_g^e) &= 0 \Longleftrightarrow \frac{\partial}{\partial R}\Pi_P^{IP}(R,P_c,P_g^e)=0\\ \frac{\partial}{\partial P_c}\Pi_P^{B}(R,P_c,P_g^e) &= 0 \Longleftrightarrow \frac{\partial}{\partial P_c}\Pi_P^{IP}(R,P_c,P_g^e)=0\\ \frac{\partial}{\partial P_g^e}\Pi_P^{B}(R,P_c,P_g^e) &= 0 \Longleftrightarrow \frac{\partial}{\partial P_g^e}\Pi_P^{IP}(R,P_c,P_g^e)=\alpha\end{aligned}$$

Consequently, we can focus on the properties of $\Pi_P^{IP}(r,p_c,p_g)$ for the comparative statics. Denote its Hessian matrix as

$$H = D_iD_j[\Pi_P^{IP}(r,p_c,p_g)] = [h_{ij}].$$

Standard comparative statics gives that

$$\frac{\partial r}{\partial \alpha} = \frac{\begin{vmatrix} h_{11} & h_{12} & 0 \\ h_{21} & h_{22} & 0 \\ h_{31} & h_{32} & 1 \end{vmatrix}}{|H|} = \frac{\begin{vmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{vmatrix}}{|H|} < 0$$

$$\frac{\partial p_c}{\partial \alpha} = \frac{\begin{vmatrix} h_{11} & 0 & h_{13} \\ h_{21} & 0 & h_{23} \\ h_{31} & 1 & h_{33} \end{vmatrix}}{|H|} = \frac{-\begin{vmatrix} h_{11} & h_{13} \\ h_{21} & h_{23} \end{vmatrix}}{|H|} < 0$$

$$\frac{\partial p_g}{\partial \alpha} = \frac{\begin{vmatrix} 0 & h_{12} & h_{13} \\ 0 & h_{22} & h_{23} \\ 1 & h_{32} & h_{33} \end{vmatrix}}{|H|} = \frac{\begin{vmatrix} h_{12} & h_{13} \\ h_{22} & h_{23} \end{vmatrix}}{|H|} < 0.$$

[10] ■

[10] The determination of the sign for these terms is followed from direct calculation.

8.1 Empirical Appendix

Regression Model Tests for Theoretical Prediction 1

Table 7: Non-Nested Model Selection Test–An Encompassing Test

	Linear		Log-Linear		Log-Log	
ln(1+ # of Bundles Present)					−0.0730*	(0.0436)
# of Bundles Present	−2.5259*	(1.3992)	−0.0220	(0.0173)		
I(Bundle)	0.4747	(3.1190)	−0.0044	(0.0385)	0.0200	(0.0498)
ln(# of Consoles Present)					0.2443**	(0.0568)
# of Consoles Present	13.7172**	(4.0344)	0.1481**	(0.0498)		
ln(# of Software Titles)					−0.0046	(0.0229)
# of Software Titles	0.0017	(0.0140)	0.0001	(0.0002)		
Age	−1.1167**	(0.1453)	−0.0145**	(0.0018)	−0.0138**	(0.0012)
Console FE's	No		No		No	

All models include Month fixed effects and an unreported constant. **significant at 95% *significant at 90%

Box-Cox Model Specification Test

$$P_{ct}^{(\lambda)} = \beta_0 + \beta_1 Age_{ct} + \beta_2 (Number\ of\ Software_{ct})^{(\lambda)} + \beta_3 (1 + \#\ of\ Other\ Consoles_{ct})^{(\lambda)} + \beta_4 (1 + \#\ of\ Bundles_{ct})^{(\lambda)} + \sum_{m=1}^{m=11} \beta_{4+m} Month_m + \epsilon_{ct}.$$

Table 8: Box-Cox Model (Non) Linear Specification Test

	Coef.	Std. Err.
Lambda	−.2501	(0.5340)

Test H_0	Chi2	Prob>Chi2
Lambda=0	0.21	0.643
Lambda=1	4.82	0.028

Table 9: Log-Log Model Residual Normality Test

H_0	Chi2(2)	Prob>Chi2
$\epsilon_{ct} \backsim N$	5.29	0.0710

Regression Model Tests for Theoretical Prediction 2

Box-Cox Model Specification Test

$$P_{g_b t}^{(\lambda)} = \beta_0 + \beta_1 Age_{g_b t} + \beta_2 (Number\ of\ Software_{g_b t})^{(\lambda)} + \beta_4 I(Bundles_{g_b t}) + \sum_{m=1}^{m=11} \beta_{4+m} Month_m + \epsilon_{g_b t}$$

Table 10: Box-Cox Model (Non) Linear Specification Test

	Coef.	Std. Err.
Lambda	1.863	(0.697)

Test H_0	Chi2	Prob>Chi2
Lambda=0	3.14	0.076
Lambda=1	1.54	0.214

Table 11: Linear Model Residual Normality Test

H_0	Chi2(2)	Prob>Chi2
$\epsilon_{ct} \backsim N$	4.11	0.1281

Regression Model Tests for Theoretical Prediction 3

Box-Cox Model Specification Test

$$P_{gt}^{(\lambda)} = \beta_0 + \beta_1 Age_{gt} + \beta_2 (Number\ of\ Software_{gt})^{(\lambda)} + \beta_4 I(Bundles_{gt}) + \sum_{m=1}^{m=11} \beta_{4+m} Month_m + \epsilon_{gt}$$

Table 12: Box-Cox Model (Non) Linear Specification Test

	Coef.	Std. Err.
Lambda	0.556181**	(0.0167)

Test H_0	Chi2	Prob>Chi2
Lambda=0	1229.36	0.000
Lambda=1	656.02	0.000

Table 13: Non-Linear Model Residual Normality Test

H_0	Chi2(2)	Prob>Chi2
$\epsilon_{ct} \backsim N$	1.98	0.3724

In this specification test we reject both hypotheses. We, thus, interpret these test results as indicating that both the linear and log-log models are inappropriate. However, given that lambda in the Box and Cox regression is very near 0.5, a model which employs a square-root transformation of variables, we proceed and assume this specification is correct. Like the above two tests, we test to determine whether the residuals of such a model are normally distributed.