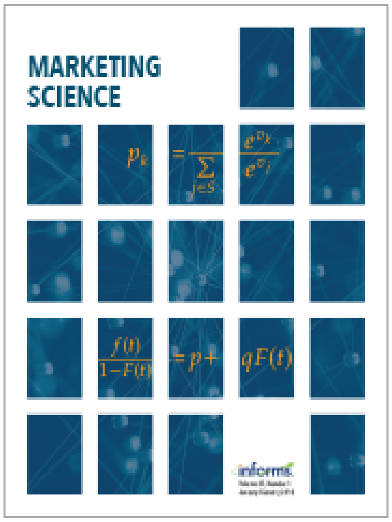

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Exclusive Channels and Revenue Sharing in a Complementary Goods Market

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This paper evaluates the joint impact of exclusive channels and revenue sharing on suppliers and retailers in a hybrid duopoly common retailer and exclusive channel model. The model bridges the gap in the literature on hybrid multichannel supply chains with bilateral complementary products and services with or without revenue sharing. The analysis indicates that, without revenue sharing, the suppliers are reluctant to form exclusive deals with the retailers; thus, no equilibrium results. With revenue sharing from the retailers to the suppliers, it can be an equilibrium strategy for the suppliers and retailers to form exclusive deals. Bargaining solutions are provided to determine the revenue sharing rates. Our additional results suggest forming exclusive deals becomes less desirable for the suppliers if revenue sharing is also in place under nonexclusivity. In our extended discussion, we also study the impact of channel asymmetry, an alternative model with fencing, composite package competition, and enhanced price-dependent revenue sharing.

Key words: exclusive channels; channel competition; revenue sharing; complementary goods
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1. Introduction

Exclusive channel strategies are practiced in a variety of complementary goods markets. For example, in the wireless market, the iPhone, the mobile phone product of Apple, was designed to be used only through the service provider AT&T when the iPhone was first launched in 2007 (Koman 2007, Yoffie and Slind 2007). Similarly, in 2008, Google launched its GPhone in conjunction with an exclusive deal with T-Mobile, and Research in Motion entered into an exclusive deal with Verizon with its smartphone, Storm (Reuters 2009). In the video game market, Capcom's *Monster Hunter 3* game is designed to be played only on the Nintendo video game console (Thomson Financial 2007). In the TV market, it is well known that some entertainment programs are aired through exclusive channels. In the e-book market, *UR* by Stephen King, for example, is sold exclusively in the format of Amazon's Kindle, rather than Barnes & Noble's Nook (Anand et al. 2009).

Intuitively, product suppliers, such as Apple, Capcom, and e-book publishers, may attain compensatory benefits, such as revenue sharing, from their complementary partners for sacrificing part of their potential market when committing to an exclusive deal. For example, the National Football League (NFL) required several forms of compensation, including rights fees and Sirius stock options, when selling the exclusive rights to air NFL game audio on satellite radio to Sirius from 2004 to 2010 (Elberse et al. 2010). In the wireless world, it has been widely reported that Apple, iPhone's affiliated company, receives a portion of revenue from AT&T for every iPhone service (Koman 2007, Yoffie and Slind 2007), although the detailed financial terms of the deal are not obtainable because of commercial confidentiality.

Although a number of studies have discussed exclusive channels (e.g., Marx and Shaffer 2007, O'Brien and Shaffer 1993) and revenue sharing (e.g., Cachon and Lariviere 2005, Foros et al. 2009), to the best of our knowledge, no existing literature has theoretically investigated the efficacy of a combination of exclusive channels and revenue sharing when competition exists in both categories of complementary goods. Without loss of generality, we refer to the sellers of some substitutable goods as suppliers (e.g., wireless phone manufacturers) who sell products (e.g., cell phones) and their complementary counterparts as retailers (e.g., service providers) who sell substitutable services (e.g., cell phone plans). The above industry practices motivate us to ask the following research question: *How does a combination of exclusive deals and revenue sharing impact suppliers and retailers in a competitive multichannel market, where the suppliers sell products and the retailers sell complementary goods/services simultaneously*?

To answer this question, we introduce a stylized model with two suppliers and two retailers. Each supplier sells a single product, and each retailer provides a single complementary service. Consumers can purchase a composite package of a product and a service from the four (2×2) potential combinations. However, not every potential package is available to the consumers, because a supplier–retailer pair may choose to form an exclusive deal such that the package of the exclusive supplier's product and the other (rival) retailer's service becomes unavailable. Because of the complementary features of the products and services, we extend the established model of nonexclusive composite goods in Economides and Salop (1992) to four different channel structures: one with no exclusive channel, two with one exclusive channel, and one with two exclusive channels. This unique combination is different from that found in the extant literature on channel distribution and competition and can be applied to a wide range of markets, including wireless communication, TV, e-books, and video games. It is also worth noting that, different from traditional revenue sharing contracts where a retailer shares revenue with its supplier for selling the supplier's product (e.g., Cachon and Lariviere 2005), in our model, the shared revenue comes from the retailer's own service simply because the supplier exclusively locks its product to the retailer's service. The model is then solved backward in a three-stage game. First, both suppliers propose a contract, either exclusive or not, to the retailers. If there is revenue sharing in an exclusive deal, then the corresponding supplier and retailer also negotiate on the revenue sharing rate. Second, the retailers decide whether to accept the contract. Finally, all players engage in a pricing Nash game where the suppliers and the retailers simultaneously determine their respective product prices and service rates to maximize their own profits.

Our study first shows that, without revenue sharing, forming exclusive deals cannot be an equilibrium. Intuitively, an exclusive deal without revenue sharing is always desired by a retailer, who benefits from a higher retail price as a result of the more monopolistic market caused by the exclusive deal. But the partnered supplier loses its edge in the exclusive deal without revenue sharing because of a lower product price and less demand and, hence, will be reluctant to form an exclusive deal with the retailer. Our analysis, however, indicates that forming exclusive deals can be Pareto-efficient for the entire supply chain only if package substitutability is high; otherwise, selling the product nonexclusively is a more efficient solution.

We then prove that, with a revenue sharing mechanism, forming exclusive deals can be an equilibrium for both suppliers and both retailers. When package substitutability is high, a reasonable amount of the revenue shared from the retailer compensates the supplier and makes an exclusive deal mutually beneficial for the partnered supplier and retailer. This, however, places their rivals without an exclusive and revenue sharing deal in a disadvantageous situation, which stimulates them to form another exclusive deal. As our analysis demonstrates, the equilibrium revenue sharing rate decreases with package substitutability, because less intense package competition allows the retailers to share more with the suppliers. We can then characterize the negotiated revenue sharing rate via bargaining solutions. In an extended model with revenue sharing under exclusivity and nonexclusivity, we further show that forming exclusive deals becomes less desirable for the suppliers as the revenue sharing rate under nonexclusivity increases. The intuition is that a supplier's relative benefit from entering an exclusive deal diminishes as the difference in the revenue sharing rates under exclusivity and nonexclusivity reduces.

Our analysis also indicates that product prices in exclusive deals tend to be lower than in nonexclusive deals when package substitutability is low. This trend occurs because the supplier attains a relative advantage against the other (rival) supplier when switching to an exclusive deal, especially with revenue sharing, which creates an additional pricing cushion. However, the overall package price becomes higher with an exclusive deal(s) with or without revenue sharing, as fewer available packages give rise to less intense competition.

Our model is related to the research on channel distribution and competition, which has been extensively studied in recent years. The related multichannel literature examines factors such as service competition (Tsay and Agrawal 2004a), channel distribution (Cai 2010, Rangan 1987), exclusion (Marx and Shaffer 2007, O'Brien and Shaffer 1993), and the impact of an Internet channel (Chiang et al. 2003, Liu et al. 2006). A comprehensive review of multichannel supply chains can be found in Cattani et al. (2004) and Tsay and Agrawal (2004b). Ingene and Parry (2004) also provide insightful discussions on channel distribution and coordination. Desai et al. (2001) analyze a design configuration with commonality on whether a component should be common or unique for the manufacturer. Although sharing some similarities with the above work, our model can be considered an extension of McGuire and Staelin (1983), Choi (1996), and Economides and Salop (1992). Based on a model with two exclusive channels without revenue sharing, McGuire and Staelin (1983) provide an explanation as to why a supplier would want to use an intermediary retailer in the context of two supply chains, each having one supplier. Choi (1996) considers a model with two manufacturers and two retailers, where each manufacturer sets the wholesale price and supplies the same product to both retailers. In this duopoly common retailer channel model, two differentiated common retailers compete in the same market. However, the extant literature does not compare dual exclusive channels with a duopoly common retailer or a mixed model of the two. Probably the most related study is Economides and Salop (1992), who consider four complementary products that can be combined into four composite goods. Their main model shares similar features with ours without exclusive channels. Nevertheless, the exclusive channels, revenue sharing, and bargaining in our model are distinct from theirs and the related extant literature.

Another closely related literature stream is on revenue sharing. Cachon and Lariviere (2005) perform a comprehensive analysis of the advantages and limitations of revenue sharing contracts. Tsay et al. (1999) document a variety of supply chain contracts including revenue sharing contracts. In practice, revenue sharing has been utilized by Blockbuster and its suppliers (Cachon and Lariviere 2005) and is commonly seen in a royalty format in franchising companies (Desai and Srinivasan 1996). Notably, price-dependent revenue sharing has also been successfully implemented in content messaging by wireless service companies and their content providers in Norway (Foros et al. 2009). The revenue sharing in our model is motivated by the exclusive deal between iPhone and AT&T and has not previously been discussed in the context of four different channel structures.

The third related area of study is bargaining in distribution channels. Bilateral bargaining was first developed by Nash (1950, 1953) and has been applied to a wide range of channel structures. For example, Zusman and Etgar (1981) use Nash bargaining theory to analyze a simple three-level channel and examine the interrelations among individual dyadic contracts. Desai and Purohit (2004) consider two sellers whose decision is to offer fixed prices or to haggle over prices with customers (i.e., bargain prices with the customers). In the case of haggling by the seller, a detailed analysis of the disagreement point for customers is given. Shaffer (2002) characterizes negotiation using a model with multiple manufacturers and retailers. In a model with two manufacturers and two multiproduct retailers under bilateral channel bargaining, Dukes et al. (2006) show that the manufacturers can benefit from cost asymmetry between the two retailers, even though the low-cost retailer has a better bargaining position than its rival retailer. See Iyer and Villas-Boas (2003), Myerson (1997), and O'Brien and Shaffer (2005) for more discussion on bargaining.

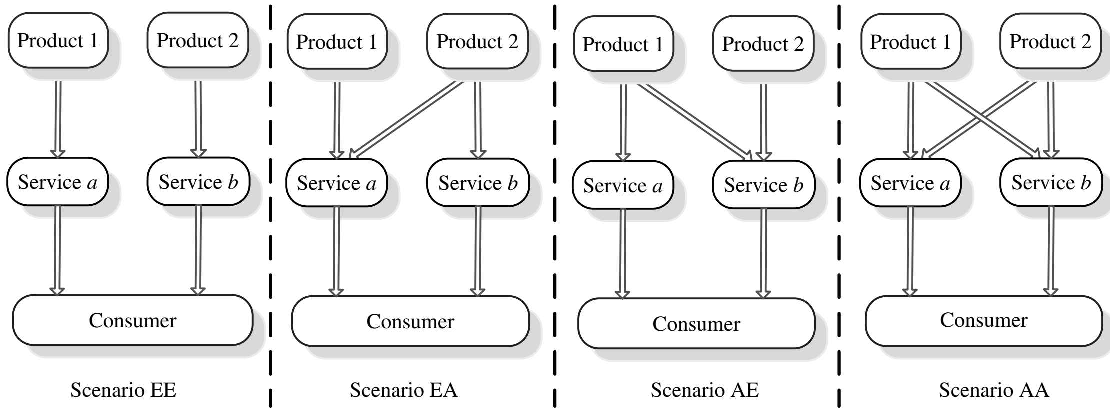
The remainder of this paper is organized as follows. We introduce the model in §2. In §3, we first discuss the impact of channel structures without revenue sharing and then demonstrate the efficacy of revenue sharing. We further provide bargaining solutions for the revenue sharing rate. Moreover, we extend our discussion to a different revenue sharing scheme where the retailers also share revenue with the suppliers in nonexclusive channels. We conclude in §4. Extensions to asymmetric suppliers/retailers, an alternative model with fencing, composite package competition, and a price-dependent revenue sharing contract are elaborated in the appendix. All proofs are relegated to the electronic companion, available as part of the online version that can be found at http://mktsci.journal.informs.org/.

2. The Model

To explore the efficacy of supply chain structures and revenue sharing, we consider a stylized model with two suppliers and two retailers. Each supplier manufactures a single product (i.e., supplier i produces product i, $i = 1, 2$), and each retailer provides a single service (i.e., retailer j provides service j, $j = a, b$). The services complement the products. Although no single model can fully capture the entire reality of complementary goods markets, our model is intended to investigate a one-period game where consumers can freely combine either product with either service, if the suppliers and retailers do not form exclusive deal(s). Therefore, there are a total of $2 \times 2 = 4$ possible composite goods. These composite goods are referred to as *packages*, and the total price for each package is given by $P_{ij} = p_i + p_j$, where p_i is the price of product i and p_j is the rate of service j, $i = 1, 2$, $j = a, b$. Throughout this paper, we use i, j, and ij as subscripts to denote the corresponding supplier, retailer, and package/channel, respectively. We also use $\bar{j}$ to represent the rival retailer to j; for example, if $j = a$, then $\bar{j} = b$.

We study four channel structures, as detailed below and illustrated in Figure 1. Without loss of generality, we assume that in the exclusive deal(s), supplier 1 will only pair with retailer a and/or supplier 2 will only pair with retailer b. This assumption also allows

Figure 1 **A Competitive Model with Two Suppliers and Two Retailers: Scenarios EE, EA, AE, and AA**



us to study the noncooperative and bilateral bargaining games analytically:

1. Scenario EE—Supplier 1 partners exclusively with retailer a, and supplier 2 partners exclusively with retailer b. Packages $1a$ and $2b$ are available.
2. Scenario EA—Supplier 1 partners exclusively with retailer a, and supplier 2 sells through both retailers. Packages $1a$, $2a$, and $2b$ are available.
3. Scenario AE—Supplier 1 sells through both retailers and supplier 2 partners exclusively with retailer b. Packages $1a$, $1b$, and $2b$ are available.
4. Scenario AA: Both suppliers 1 and 2 sell through both retailers. All packages are available.

Scenario EE is similar to the model in McGuire and Staelin (1983) in terms of channel structure, but it differs in that we consider two packages including four complementary products/services, and McGuire and Staelin focus on a model with only two products. Scenario AA shares the same features as the model in Economides and Salop (1992). To the best of our knowledge, Scenarios EA and AE are relatively new to the literature. Note that in Scenarios EA and AE, given that supplier i sells exclusively through retailer j, there is another similar "exclusive" channel in terms of service, as retailer $\bar{j}$ sells only supplier $(3-i)$'s product. Because of the focus of this paper, we only refer to the exclusive *product* channel as the exclusive channel, which is consistent with the iPhone case. We use the superscripts EE, EA, AE, and AA to denote the corresponding scenario throughout this paper.

We denote the demand for package ij as D_{ij}, $ij = 1a, 1b, 2a, 2b$. To obtain demand functions for the different channel structures, we adopt the framework established by Ingene and Parry (2007) and employ a utility function of a representative consumer from the perspective of aggregate demand as follows:

$$U \equiv \sum_{ij}(\alpha_{ij}D_{ij} - D_{ij}^2/2) - \tau \sum_{ij\neq mn} D_{ij}D_{mn}\Big/2 - \sum_{ij} P_{ij}D_{ij}, \qquad (1)$$

where τ $(0 \leq \tau < 1)$ denotes package substitutability. Note that $\tau < 1$ is required by the second-order condition to obtain a maximum (Ingene and Parry 2004). The above utility function reflects an income constraint where the marginal utility of income is 1. If $\tau = 0$, the packages are completely monopolistic; as τ approaches 1, the packages converge toward being completely substitutable. The term α_{ij} reflects the consumer's preference for package ij and can be considered as a measure of how much the representative consumer initially values package ij. It is also equivalent to the initial base demand when all prices equal 0 and package ij is the only available package. To obtain parsimony, we start with a symmetric setting by fixing $\alpha_{ij} = 1/4$ and study the impact of asymmetry in §A.1. The symmetric setting has been widely adopted in the literature (e.g., Choi 1996, Economides and Salop 1992, McGuire and Staelin 1983), especially for a complex model like ours. The main reason for choosing $\alpha_{ij} = 1/4$ is to make it reusable in our discussion of asymmetric cases in §A.1. All our qualitative results hold if we normalize α_{ij} to any other positive value. Note that α_{ij} is independent of the availability of the packages and package substitutability.

It is worth noting that a simpler form of this utility function was first introduced by Spence (1976), Dixit (1979), and Shubik and Levitan (1980) for models with two products. It has since been widely utilized in the economics, marketing, and operations management literature (see Ingene and Parry 2007, Lus and Muriel 2009, Singh and Vives 1984, Xiao et al. 2008). The term "representative consumer" is drawn from the economic notion of "a fictional individual" (Mas-Colell et al. 1995, Chapter 4) and can be considered as a "theoretically average consumer" (Ingene and Parry 2004, Chapter 11). The utility function implies that the value of using multiple substitutable packages is less than the sum of the separate values of using each package by itself (Samuelson 1974). The consumer utility decreases as products become more substitutable. The utility function also encompasses the classical economic features of diminishing marginal rates of substitution and diminishing marginal utility.

The utility function specified in Equation (1) provides the "logically consistent" demand curves when the number of distributors/channels changes (see Ingene and Parry 2007). If there is no exclusive channel (Scenario AA), we have $ij = 1a, 1b, 2a, 2b$. If supplier 1 forms an exclusive deal with retailer a while supplier 2 and retailer b do not (Scenario EA), we have $ij = 1a, 2a, 2b$, and set $D_{1b} = 0$ in Equation (1), as package $1b$ is not available owing to the exclusive deal. If supplier 2 forms an exclusive deal with retailer b while supplier 1 and retailer a do not (Scenario AE), we have $ij = 1a, 1b, 2b$, and $D_{2a} = 0$. If both $1a$ and $2b$ are exclusive (Scenario EE), we have $ij = 1a, 2b$, and $D_{1b} = D_{2a} = 0$.[1] In all these scenarios, maximizing Equation (1) yields the demand for the available packages as follows:

$$D_{ij} = A_{ij} - \beta P_{ij} + \theta \sum_{mn \neq ij} P_{mn}, \tag{2}$$

where

$$A_{ij} = \frac{(1+(N-2)\tau)\alpha_{ij} - \tau \sum_{mn\neq ij} \alpha_{mn}}{(1-\tau)(1+(N-1)\tau)},$$

$$\beta = \frac{1+(N-2)\tau}{(1-\tau)(1+(N-1)\tau)},$$

$$\theta = \frac{\tau}{(1-\tau)(1+(N-1)\tau)},$$

where N is the number of available packages. Everything else being equal, the demand for each package decreases with N. Obviously, price coefficient (β) and cross-price coefficient (θ) are affected by the package substitutability (τ) and the number of available packages (N). The demand intercept (A_{ij}) represents the "attractiveness" of package ij, which depends on the initial base demand (α_{ij}), the total number of available packages (N), and the package substitutability (τ) (Ingene and Parry 2004, Chapter 1). Desirably, the aggregate demand decreases in τ. This feature echoes the benefits of product differentiation, because more differentiated products/packages reach a larger customer base and consumers are less price sensitive when purchasing a more unique item (Lus and Muriel 2009; Talluri and van Ryzin 2005, Chapter 8).

If there is a revenue sharing contract in the exclusive deal, the retailer needs to share a proportion of its corresponding service revenue with the supplier, because the customer who purchases the product has to buy the retailer's service. Let r_{ij} denote the revenue sharing rate that supplier i will obtain from its partner retailer j if a customer purchases product i, and we have

$$r_{ij} = \begin{cases} r & \text{if revenue sharing occurs between } i \text{ and } j \\ & \quad \text{in an exclusive deal,} \\ 0 & \text{otherwise.} \end{cases}$$

We discuss a different revenue sharing scheme where revenue sharing is also in place for nonexclusive channels in §3.4 and extend our discussion to price-dependent revenue sharing in §A.4.

The operational and production costs for the two suppliers and the two retailers are normalized to zero for brevity, which has been adopted in the literature (McGuire and Staelin 1983, Raju and Zhang 2005). Consequently, supplier i's and retailer j's respective profit functions are

$$\begin{aligned} \Pi_i &= \sum_{j=a,\,b} (p_i + r_{ij}) D_{ij}, \quad i = 1, 2, \\ \Pi_j &= \sum_{i=1,\,2} (p_j - r_{ij}) D_{ij}, \quad j = a, b. \end{aligned} \tag{3}$$

We further denote $\Pi_{ij} = \Pi_i + \Pi_j$ and Π_{All} for the overall profit of the entire supply chain.

We configure this multichannel game into three stages. In the first stage, the channel structure is suggested by the suppliers via a contract (exclusive or not) with the retailers. If the exclusive deal(s) comes with a revenue sharing clause, the corresponding supplier and retailer will negotiate on the revenue sharing rate at the same time. In the second stage, the retailers decide whether to accept the contract. More specifically, in each channel, if the supplier proposes an exclusive contract and the retailer accepts it, then an exclusive deal is formed. However, if the retailer refuses or their negotiation on the revenue sharing rate fails, the supplier will sell through both retailers by default. If the supplier proposes a nonexclusive contract, then the retailer will have no choice but to follow a nonexclusive deal. It is straightforward that an exclusive deal will be formed only if both the supplier and the retailer benefit from such a deal. In the third stage, the retailers and the suppliers simultaneously determine their service rates and product prices, respectively, in each subgame (Scenarios EE, EA, AE, and AA). Note that in each scenario, each player maximizes its own profit in a Nash game, a game setting referred to as *independent ownership* (*IO*) *competition*. This game setting is widely employed in the extant marketing literature (see Economides and Salop 1992, Ingene and Parry 2004).[2] The solution to the three-stage game is a subgame-perfect equilibrium and is solved by backward induction.

[1] In §A.2, we discuss an alternative model where consumers can still purchase an "excluded" package by incurring a switching cost.

[2] In §A.3, we study a benchmark game setting, composite package competition, where the ownership of the goods is transferred to each package such that each package optimizes its package profit (see Economides and Salop 1992).

3. Channel Structures, Revenue Sharing, and Bargaining Solutions

To investigate the pure impact of channel structures on the players and the overall supply chain, we first explore the three-stage game without revenue sharing in §3.1. Motivated by the exclusive and revenue sharing deal between iPhone and AT&T, in §3.2, we employ revenue sharing to attain cooperation between suppliers and retailers in the exclusive deals. This allows us to investigate the potential equilibrium domain of exclusive deals under a given revenue sharing rate. We then provide bargaining solutions to determine the revenue sharing rate. We further extend our discussion to a different revenue sharing scheme where the retailers also share revenue with the suppliers in nonexclusive channels.

3.1. Effects of Channel Structures Without Revenue Sharing

To single out the effects of channel structures, in this subsection we assume away revenue sharing ($r=0$) and restore the feature from the next subsection. We first characterize each subgame/scenario in a Nash game and then study channel structure selection by the retailers and then by the suppliers. The unique equilibrium for each scenario, as illustrated in Table 1 in the electronic companion, is solved from the four first-order conditions for both suppliers and both retailers. The entire game is solved backward. Because of the symmetry, for brevity much of our discussion focuses on supplier 1 and retailer a, although supplier 2 and retailer b are also taken into consideration throughout the paper. Note that the equilibrium solutions of supplier 2 and retailer b in Scenarios EE and AA are the same as those of supplier 1 and retailer a, respectively, and the equilibrium solutions of supplier 2 and retailer b in Scenario EA are the same as those of supplier 1 and retailer a, respectively, in Scenario AE. We first compare the equilibrium prices of different scenarios in the following lemma.

Lemma 1. *If* $0 \le \tau < 1/2$, *then*

$$p_1^{*\mathrm{EA}} \le p_1^{*\mathrm{AA}} \le p_1^{*\mathrm{EE}} \le p_1^{*\mathrm{AE}} \quad \text{and}$$
$$p_a^{*\mathrm{AE}} \le p_a^{*\mathrm{AA}} \le p_a^{*\mathrm{EE}} \le p_a^{*\mathrm{EA}};$$

otherwise,

$$p_1^{*\mathrm{AA}} \le p_1^{*\mathrm{EA}} \le p_1^{*\mathrm{AE}} \le p_1^{*\mathrm{EE}} \quad \text{and}$$
$$p_a^{*\mathrm{AA}} \le p_a^{*\mathrm{AE}} \le p_a^{*\mathrm{EA}} \le p_a^{*\mathrm{EE}}.$$

Lemma 1 indicates that product prices and service rates depend on package substitutability. If the packages are relatively more monopolistic than substitutable ($0 \le \tau < 1/2$), the supplier charges a lower product price when entering an exclusive deal (i.e., $p_1^{*\mathrm{EA}} \le p_1^{*\mathrm{AA}}$ and $p_1^{*\mathrm{EE}} \le p_1^{*\mathrm{AE}}$). Otherwise, the reverse is true because of the more intense competition caused by stronger package substitutability, along with more available packages. On the other hand, the service rate is higher (i.e., $p_a^{*\mathrm{AE}} \le p_a^{*\mathrm{EE}}$ and $p_a^{*\mathrm{AA}} \le p_a^{*\mathrm{EA}}$ for any τ) when the retailer enters an exclusive deal, since the retailer becomes relatively more monopolistic and yields a greater demand because of the exclusive deal. This observation is supported by the fact that AT&T issued an expensive service plan for the iPhone, with a minimum monthly service rate of \$59.99, \$20 more than AT&T's standard wireless package (Yoffie and Slind 2007).

Considering the package prices, we find that consumers have to pay higher package prices as a result of the exclusive deals between suppliers and retailers.

Theorem 1. *The package prices increase with the number of exclusive channels (i.e.,* $P_{1a}^{*\mathrm{AA}} \le P_{1a}^{*\mathrm{EA}} = P_{1a}^{*\mathrm{AE}} \le P_{1a}^{*\mathrm{EE}}$*).*

The intuition behind Lemma 1 is clear, because fewer available packages lead to a more monopolistic market, which in turn pushes up the package prices. Nevertheless, as we will show in §A.4 under price-dependent revenue sharing, the package prices can be lower with exclusive deals when package substitutability is low.

We now turn our attention to the channel structure selection by the suppliers and retailers. Comparing the profits of both suppliers and both retailers in different scenarios yields the following result.

Theorem 2. *Forming exclusive deals without revenue sharing is a weakly dominant strategy for both retailers; however, it is a dominated strategy for both suppliers. Thus, forming exclusive deals without revenue sharing cannot be an equilibrium.*

Theorem 2 suggests that a retailer will prefer an exclusive channel, regardless of whether the other supplier–retailer pair adopts an exclusive deal, provided that there is no revenue sharing. This result is supported by Lemma 1, in that the retailers can benefit from the more monopolistic market resulting from the exclusive deal(s) by charging higher service rates. In contrast, the suppliers will lose profits because of lower demand as a result of selling through an exclusive retailer. Therefore, no exclusive deal will be formed in this case, as it is not mutually beneficial for the suppliers or the retailers. This may explain why iPhone required a significant revenue sharing rate when promoting its exclusive deal (Yoffie and Slind 2007). In a similar case, in 2005, Sprint agreed to pay approximately \$50 million annually to be the NFL's exclusive wireless partner (Elberse et al. 2010).

An immediate question is whether the entire supply chain can benefit from an exclusive deal. Theoretically, an exclusive channel can be a mutually beneficial choice for both a supplier and a retailer only if the entire channel with the exclusive channel(s) is more Pareto-efficient. Otherwise, there is no merit in forming an exclusive deal. The following theorem regarding overall supply chain efficiency provides a guideline for potential cooperation via revenue sharing.

Theorem 3. *For the entire supply chain, there exist two threshold values* $\hat{\tau}_1$ *and* $\hat{\tau}_2$*, such that*

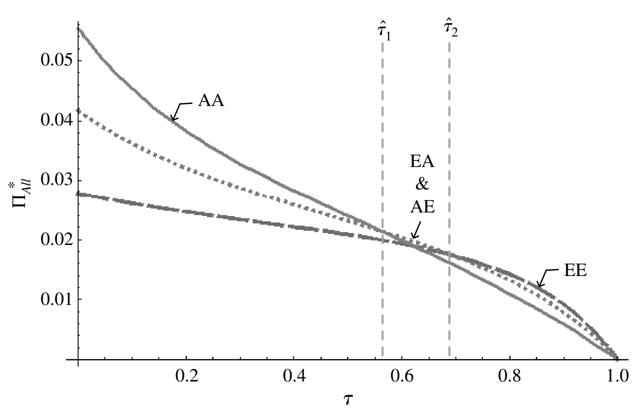
$$\begin{cases} \text{AA dominates EA, AE, and EE if } 0 \le \tau < \hat{\tau}_1, \\ \text{EA and AE dominate EE and AA if } \hat{\tau}_1 \le \tau < \hat{\tau}_2, \\ \text{EE dominates EA, AE, and AA if } \hat{\tau}_2 \le \tau < 1. \end{cases}$$

Theorem 3 suggests that the entire supply chain can benefit from exclusive deals when package substitutability is high (i.e., $\tau \ge \hat{\tau}_2$ as illustrated in Figure 2). However, as shown in Theorem 2, the designated suppliers in the exclusive deals cannot benefit from the deal because of the noncooperative nature of the game, and the suppliers lose significant market share as they unilaterally stop selling through the other retailer. Ideally, if the additional supply chain profit from the exclusive deals can be redistributed among suppliers and retailers to generate sufficient incentives for suppliers and retailers to partner exclusively, then forming exclusive deals can be an equilibrium strategy for all players. However, the equilibrium will not occur without an additional contracting mechanism, such as revenue sharing. We next demonstrate that revenue sharing can indeed lead to such a mutually beneficial result from exclusive deals.

3.2. Impact of Revenue Sharing

Under revenue sharing, each retailer transfers a fixed payment of r to the exclusively partnered supplier for each package sold. Because of the complementary nature of our model, the revenue sharing works differently from the traditional models, for example, the famous Blockbuster revenue sharing deal, where Blockbuster shares partial revenue with its suppliers (i.e., movie studios) when the suppliers reduce the wholesale prices of their videos. In contrast, in the motivating example of the exclusive deal between iPhone and AT&T, the product and the service are complementary goods and the wholesaling is not mandatory, given that the supplier and the retailer determine their product price and service rate separately. AT&T shares revenue with iPhone because it can be used only with AT&T. The profit functions are specified in Equation (3). Following the game structure specified previously, we first characterize some properties of the equilibrium prices.

Figure 2 **Entire Supply Chain Profits in Scenarios EE, EA, AE, and AA**



Lemma 2. *With revenue sharing, product prices decrease and service rates increase with the revenue sharing rate in Scenarios EE, EA, and AE. The package prices decrease in EA and AE but remain constant in EE as the revenue sharing rate grows.*

Lemma 2 shows that the product price can be lower in an exclusive deal after revenue sharing is employed, whereas the service rate is pushed up, as the retailer has to share revenue with the supplier. We, however, observe package prices decreasing with the revenue sharing rate in Scenarios EA and AE. This is because a higher revenue sharing rate renders additional advantages for the partnered supplier, which leads to a lower package price. Consequently, the price of their rival package reduces because of horizontal competition. On the contrary, in Scenario EE, the retailers increase their service rates by the amount of the shared revenue; thus package prices are restored to the level without exclusive deals. Therefore, consumers cannot benefit from revenue sharing in a dual-exclusive case (Scenario EE).

From the proof of Lemma 2, we can also infer that in Scenarios EE and AA, all players' profits are independent of the revenue sharing rate. With only one exclusive deal, such as in Scenario EA, the supplier's profit increases and the retailer's profit decreases as the revenue sharing rate grows. Intuitively, revenue sharing yields benefits to the supplier whereas it costs the retailer in the exclusive deal. The players not in the exclusive deal will be affected by revenue sharing too. For example, in Scenario AE, supplier 1 is pressured to reduce the product price because of supplier 2 doing so. Thus, supplier 1's profit decreases and retailer a's increases owing to the revenue sharing in the exclusive deal between supplier 2 and retailer b.

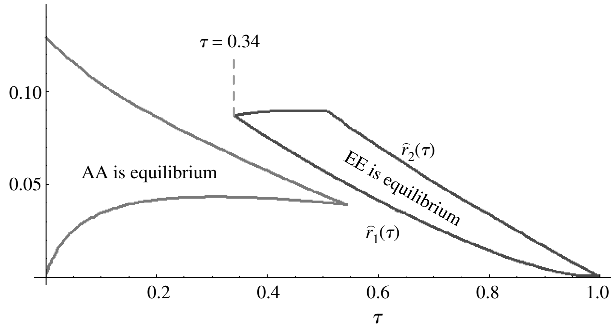
The major concern is whether the impact of revenue sharing in exclusive deals can lead to an equilibrium outcome where all players form exclusive deals. The following result affirms the answer.

Theorem 4. *For any given* $\tau \in [0.34, 1)$*, there exist* $\hat{r}_1(\tau)$ *and* $\hat{r}_2(\tau)$ *such that forming exclusive deals is a subgame-perfect equilibrium for all players (i.e., both suppliers and both retailers) as long as* $\hat{r}_1(\tau) \le r \le \hat{r}_2(\tau)$.

Theorem 4 demonstrates that forming exclusive deals with revenue sharing can be an equilibrium for all players. Without revenue sharing, as shown in Theorem 2, a supplier has no incentive to form an exclusive deal because, in doing so, the total demand for the supplier's product significantly decreases because of there being fewer available packages that contain the supplier's product. This relative disadvantage of less demand as a result of an exclusive deal, however, can be compensated and even surpassed by a reasonable amount of revenue being transferred from the retailer, such that both the supplier and the retailer are better off for forming an exclusive deal. Compared with Scenario AA, the first exclusive deal with revenue sharing yields additional profits to the corresponding supplier and retailer. However, this result comes at the expense of the other supplier–retailer pair when package substitutability is sufficiently high and consequently pressures them to forge another exclusive deal, which thus results in Scenario EE. The range of $\hat{r}_1(\tau) \leq r \leq \hat{r}_2(\tau)$ provides a guideline for such an equilibrium revenue sharing rate, if all players are determined to form exclusive deals. In general, the more substitutable the packages, the lower the revenue sharing rate required to sustain the equilibrium, because the retailers' profits decrease as package substitutability grows.

However, reaching equilibrium does not necessarily warrant maximal efficiency for the entire supply chain. We depict Theorem 4 in Figure 3 and compare it with Figure 2. We find the equilibrium area of Scenario EE goes beyond the Pareto-efficient area of Scenario EE as illustrated in Figure 2. With revenue sharing, the players are more inclined to form exclusive deals because of the relative disadvantage of not doing so, when the other supplier–retailer pair forms an exclusive deal (i.e., in Scenarios EA and AE). From Figure 3, we also observe that Scenario AA can be an equilibrium when channel substitutability is low, which is reasonable because the players prefer more available packages when those packages are sufficiently monopolistic. Note that we do not observe any equilibrium result for Scenarios EA and AE, because

Figure 3 The Equilibrium Area of Scenarios EE with Revenue Sharing



the disadvantaged players have incentives to unilaterally deviate to other scenarios. Nevertheless, it could be mutually beneficial for a supplier and a retailer to form an exclusive and revenue sharing deal on their own, although a single exclusive deal might not be stable in this symmetric competitive market.

3.3. Bargaining Solutions

In the above-mentioned revenue sharing mechanism, the retailers in exclusive deals are required to transfer a fixed amount of revenue to the suppliers. Typically, the revenue sharing rate(s) is negotiated before being signed into the contract (in the first stage of the game). We first consider the case where only supplier 1 and retailer a negotiate for the exclusive deal. If their negotiation leads to an agreement, the destination scenario of the negotiation is EA; otherwise, they end up with Scenario AA. Thus, the negotiated revenue sharing rate can be solved by the classic Nash bargaining solution as follows:

$$\max_{r_{1a}} [\Pi_1^{\mathrm{EA}}(r_{1a}) - \Pi_1^{\mathrm{AA}}(r_{1a})][\Pi_a^{\mathrm{EA}}(r_{1a}) - \Pi_a^{\mathrm{AA}}(r_{1a})].$$

Substituting the third-stage solutions derived in the proof of Lemma 2 into the objective function above, we can obtain the Nash bargaining solution $r_{1a}^{*\mathrm{EA}}$. Although the expression of $r_{1a}^{*\mathrm{EA}}$ is extremely lengthy, we can numerically observe that the revenue sharing rate, $r_{1a}^{*\mathrm{EA}}$, decreases from 0.08 to 0 as τ increases from 0 to 1. To obtain tractability, we also explore the egalitarian bargaining solution to obtain the revenue sharing rate as follows:

$$\Pi_1^{\mathrm{EA}}(r_{1a}) - \Pi_1^{AA}(r_{1a}) = \Pi_a^{EA}(r_{1a}) - \Pi_a^{AA}(r_{1a}).$$

The egalitarian bargaining solution, introduced by Kalai and Smorodinsky (1975) and Kalai (1977), drops the scale invariance condition while including both the axiom of independence of irrelevant alternatives and the axiom of monotonicity (see Myerson 1997, p. 381). The egalitarian bargaining solution attempts to grant equal gain to both parties (see Dukes et al. 2006; Myerson 1997, p. 381). After substituting the third-stage solutions derived in the proof of Lemma 2 into the above egalitarian bargaining solution function, we obtain

$$r_{1a}^{*\mathrm{EA}} = \frac{\sqrt{G_1} + G_2}{G_3},$$

where

$$\begin{aligned} G_1 &= (45 + 61\tau - 73\tau^2 - 77\tau^3 + 32\tau^4 + 12\tau^5)^2 \\ &\quad \cdot (432 + 1{,}908\tau + 3{,}001\tau^2 + 1{,}998\tau^3 + 541\tau^4 \\ &\qquad + 68\tau^5 + 4\tau^6), \\ G_2 &= -450 - 1{,}755\tau - 1{,}666\tau^2 + 1{,}294\tau^3 + 2{,}714\tau^4 \\ &\quad + 761\tau^5 - 550\tau^6 - 308\tau^7 - 40\tau^8, \end{aligned}$$

$$G_3 = 8(747+3{,}231\tau+4{,}119\tau^2-75\tau^3-3{,}266\tau^4 -1{,}268\tau^5+544\tau^6+288\tau^7+32\tau^8).$$

We can further observe that the revenue sharing rate, $r_{1a}^{*\mathrm{EA}}$, decreases from 0.081 to 0 as τ increases from 0 to 1, which is very close to the Nash bargaining solution.

We now consider the second case where channels $1a$ and $2b$ are simultaneously involved in the negotiation of exclusive deals. As a result, in the negotiation stage neither supplier–retailer pair knows the other pair's negotiation outcome. Therefore, the members of each channel negotiate based on their perception of the negotiation outcome of the rival channel. We assume that a supplier–retailer pair negotiates on the revenue sharing rate conceiving that the other pair will reach an agreement. This assumption is in line with Dukes et al. (2006), O'Brien and Shaffer (1992, 2005), and Horn and Wolinsky (1988). It is also consistent with Theorem 4, in that EE will be an equilibrium as long as $\hat{r}_1(\tau) \le r \le \hat{r}_2(\tau)$, given $\tau \in [0.34, 1)$, and is supported by the following bargaining solution. Thus, the negotiated revenue sharing rates are given by the egalitarian bargaining solution of the following problems for channels $1a$ and $2b$, respectively,

$$\Pi_1^{\mathrm{EE}}(r_{1a}, r_{2b}) - \Pi_1^{\mathrm{AE}}(r_{1a}, r_{2b}) = \Pi_a^{\mathrm{EE}}(r_{1a}, r_{2b}) - \Pi_a^{\mathrm{AE}}(r_{1a}, r_{2b}),$$
$$\Pi_2^{\mathrm{EE}}(r_{1a}, r_{2b}) - \Pi_2^{\mathrm{EA}}(r_{1a}, r_{2b}) = \Pi_b^{\mathrm{EE}}(r_{1a}, r_{2b}) - \Pi_b^{\mathrm{EA}}(r_{1a}, r_{2b}).$$

Based on the symmetry assumption, we obtain

$$r_{1a}^{*\mathrm{EE}} \equiv r_{1a}^* = r_{2b}^* = \frac{T_1 - T_2\sqrt{2(1+\tau)}}{T_3},$$

where

$$T_1 = 225+855\tau+690\tau^2-808\tau^3-1{,}197\tau^4-131\tau^5 +266\tau^6+92\tau^7+8\tau^8,$$
$$T_2 = 135+453\tau+237\tau^2-547\tau^3-512\tau^4+74\tau^5 +136\tau^6+24\tau^7,$$
$$T_3 = 252+1{,}188\tau+1{,}704\tau^2+456\tau^3-460\tau^4-12\tau^5 +56\tau^6-80\tau^7-32\tau^8.$$

We observe that the unique revenue sharing rate, $r_{1a}^{*\mathrm{EE}}$, decreases from 0.13 to 0 as τ increases from 0 to 1. Comparing $r_{1a}^{*\mathrm{EA}}$ with $r_{1a}^{*\mathrm{EE}}$, we find that $r_{1a}^{*\mathrm{EE}} > r_{1a}^{*\mathrm{EA}}$ $\forall \tau \in [0, 1)$. The difference between $r_{1a}^{*\mathrm{EE}}$ and $r_{1a}^{*\mathrm{EA}}$ decreases with τ and converges to 0 as τ approaches 1. The above inequality suggests that the perception that the other supplier–retailer pair will reach an exclusive deal agreement poses a threat to the retailer. As a result, this retailer is willing to share more revenue with the partnered supplier.

It is worth noting that the above results come from bilateral negotiation; thus an agreement on $r_{1a}^{*\mathrm{EA}}$ or $r_{1a}^{*\mathrm{EE}}$ does not warrant an equilibrium outcome for the dual-exclusive channels (Scenario EE). Nevertheless, we find that $\hat{r}_1(\tau) \le r_{1a}^{*\mathrm{EE}} \le \hat{r}_2(\tau)$ as long as $\tau \in [0.34, 1]$, which is located in the domain specified by Theorem 4. Therefore, the egalitarian bargaining solution for revenue sharing can lead to an equilibrium outcome.

3.4. Impact of Revenue Sharing Under Nonexclusivity

So far, we have studied the case where revenue sharing comes only with exclusive deals. Theoretically, one may wonder whether the players still have incentives to form exclusive deals if revenue sharing is also in place under nonexclusivity. To explore this situation, in this subsection, we assume both retailers share revenue with their suppliers regardless of whether or not there are exclusive deals. The new revenue sharing rate, r_{ij}, that supplier i will obtain from its partner retailer j is given by

$$r_{ij} = \begin{cases} r & \text{if supplier } i \text{ and retailer } j \text{ form an exclusive deal,} \\ \rho r & \text{otherwise, } 0 \le \rho \le 1, \end{cases}$$

where ρ represents the relative level of revenue sharing under nonexclusivity compared with that under exclusivity. We impose an additional constraint that $0 \le \rho \le 1$, which reflects the conventional wisdom that a supplier would demand a (weakly) higher revenue sharing rate under exclusivity than under nonexclusivity. To focus on the impact of revenue sharing under nonexclusivity and make our following discussion more interesting and comparable with our main model, we further assume that the given revenue sharing rate r satisfies $\hat{r}_1(\tau) \le r \le \hat{r}_2(\tau)$, as discussed in Theorem 4. It is easy to infer that our previously discussed revenue sharing scheme is a special case of this new revenue sharing scheme when $\rho = 0$.

Comparing the players' profits among scenarios in this new revenue sharing scheme results in the following observation.

Theorem 5. *For any given r satisfying $\hat{r}_1(\tau) \le r \le \hat{r}_2(\tau)$ given $\tau \in [0.34, 1)$, forming exclusive deals becomes less likely to be a subgame-perfect equilibrium as the relative level (ρ) of revenue sharing under nonexclusivity increases.*

Theorem 5 indicates that the players' willingness to form exclusive deals is negatively affected by the relative revenue sharing level ρ in those nonexclusive channels. As suggested by Theorem 4, when $\rho = 0$, forming exclusive deals is a subgame-perfect equilibrium for a given r satisfying $\hat{r}_1(\tau) \le r \le \hat{r}_2(\tau)$ for

$\tau \in [0.34, 1)$. In contrast, when $\rho = 1$ (i.e., the revenue sharing rate is the same under exclusivity and nonexclusivity), all players' profits are independent of the revenue sharing rate. This somewhat surprising finding is caused by the symmetric channel structure of the complementary goods market. When the revenue sharing rate is the same in all channels, a supplier gains no advantage from entering an exclusive deal. In particular, the package prices are independent of the revenue sharing rate, because the increase in service rates offsets the decrease in product prices. Thus, the demand and profits are equivalent to the case without revenue sharing. Recall that in Theorem 2 (without revenue sharing), forming exclusive deals is a dominated strategy for the suppliers. In the proof of Theorem 5, we show that supplier 1's profit difference between Scenarios EE and AE decreases with ρ and changes from positive to negative. This property posits that a supplier's relative benefit from entering an exclusive deal diminishes as ρ increases and becomes negative as ρ crosses a threshold value. As a result, it becomes more likely that a supplier would unilaterally deviate from Scenario EE as ρ increases.

It is worth noting, however, that the retailers prefer exclusive deals for any $\rho \in [0, 1]$ given $\hat{r}_1(\tau) \leq r \leq \hat{r}_2(\tau)$, as shown in the proof of Theorem 5. In addition, their desire for exclusive deals is strengthened as ρ increases. This is intuitive because, without an exclusive deal with its partner supplier, a retailer's profit decreases with a higher revenue sharing rate under nonexclusivity. As a result, this (nonexclusive) retailer can benefit more from exclusively selling a supplier's product when ρ is higher. However, the relative advantage that this retailer gains by forming an exclusive deal is at the cost of its partnered supplier. As shown previously, when ρ is larger than a threshold value, exclusive deals are no longer attractive to the suppliers, and hence, EE is not a subgame-perfect equilibrium.

4. Conclusion and Discussion

This paper develops a hybrid model with duopoly common retailers and exclusive channels to evaluate the impact of exclusive channels and revenue sharing on suppliers and retailers in a competitive multichannel market with complementary goods. The products are complementary to the services; therefore, there are four potential substitutable packages. We compare four different channel structures with or without revenue sharing. Our analysis establishes a theoretical framework to analyze similar multichannel competition in a complementary goods market.

This paper characterizes the game behavior in noncooperative and cooperative environments to explore the players' profit-maximization behavior and achieve optimal Pareto efficiency for the entire supply chain. We first demonstrate that without revenue sharing, forming exclusive deals is a dominated strategy for both suppliers. However, if the retailers share a portion of their revenues with the suppliers, forming exclusive channels can be an equilibrium strategy for both suppliers and both retailers. We also provide bargaining solutions to determine the revenue sharing rate through negotiation. In an extended model with revenue sharing under both exclusivity and nonexclusivity, we further show that forming exclusive deals becomes less likely to be an equilibrium as the relative revenue sharing level under nonexclusivity increases.

Our extended discussion, as presented in the appendix, indicates that, if a supplier/retailer is much stronger than its rival in the market, the supplier/retailer will be reluctant to form an exclusive and revenue sharing deal. We also analyze an alternative model with fencing and demonstrate that a price-out strategy is equivalent to an exclusive deal in our main model.

We further consider composite package competition, where both players in the same package maximize the overall profit of the package. Our results demonstrate that, compared with the main model, overall supply chain efficiency is lower under composite package competition when package substitutability is sufficiently high. This occurs because the horizontal competition intensifies as the externalities between package partners are internalized under composite package competition.

Moreover, our analysis suggests that a revenue sharing rate that is associated with the product price and the service rate can yield more profits for the suppliers and the retailers. Indeed, enhanced by price-dependent revenue sharing, the entire supply chain becomes more efficient such that it outperforms the one with integrated channels in the entire feasible domain. This result occurs because price-dependent revenue sharing provides a cushion to lessen the horizontal competition among packages.

However, because no single model can capture every relevant aspect of an actual scenario, we hope that our paper provides a stylized, yet flexible, framework that opens up numerous possibilities for generalization on this topic. Because of the complexity of the model, to capture some important managerial insights, parsimony has been kept in mind when constructing the model, though undoubtedly some interesting and important marketing mixes had to be deliberately left out.

4.1. Demand Function and Channel Structure

Although the underlying utility function in our model has been widely adopted in the existing literature, as Ingene and Parry (2004) point out, other factors, such as uncertainty, can affect game behavior. In addition, other nonlinear utility functions would allow us to examine more aspects of the model. As Ingene and Parry (2004) suggest, dual channels may be sufficient to capture many important features of market competition. However, a multisupplier/multiretailer model may better describe most complementary goods markets. Although it may be very difficult to gain any analytical insights from such a model, some simulation or empirical analysis could provide additional managerial insights. Furthermore, it may be useful to consider more than one product/service owned by each supplier/retailer.

4.2. Subsidies and Other Promotions

Competition in the wireless market is so intense that companies continuously provide rebates, coupons, and online discounts to promote their products/services both with and without exclusive channels. As a result, consumers may get free phones or even payback for cheaper models. In a preliminary analysis based on our model, by assuming both retailers provide uniform subsidies to the consumers, we find that the players' profits and the overall supply chain efficiency are the same as those in a model without subsidies. This result is intuitive because the subsidy providers simply increase the product prices/service rates on the same scale as the subsidies to compensate for the revenue loss. However, we can easily conjecture that if the retailers/suppliers discriminate against consumers by providing different subsidies to different groups, the entire supply chain's profits can increase. This is consistent with the conventional wisdom that price discrimination enhances revenue. Some marketing tools, such as noninstant rebates, can be used for that purpose, and we believe that our main managerial insights would hold under subsidies and other promotions.

4.3. Dynamic Settings

Although, for tractability, one-period models have been widely adopted in the marketing literature, in reality, the market status of the players, including their bargaining power, is changing over time. It is also arguable that the change of channel structure may have delayed effects on future demand. Accordingly, related research questions might include the following: How does the diffusion speed and/or the life span of certain products affect exclusive deals? How does one incorporate customers' awareness of a product into the dynamics of the demand function? Is product innovation significantly affected by exclusive deals? To understand these issues, a more dynamic and complicated model needs to be studied and the analysis will be much more challenging.

4.4. Contract Formats

This paper shows that revenue sharing can be utilized to further enhance supply chain efficiency. However, revenue sharing is not the only contract that can fulfill the task. We believe that other contract formats, such as two-part tariffs (Ingene and Parry 2004, Raju and Zhang 2005) and quantity discount schedules (Jeuland and Shugan 1983), can also improve the performance of similar supply chains, although they are not well documented in a model with complementary goods.

Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mktsci.journal.informs.org/.

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Appendix

In this appendix, we extend our discussion to asymmetric suppliers/retailers, an alternative model with fencing, composite package competition, and an enhanced price-dependent revenue sharing mechanism.

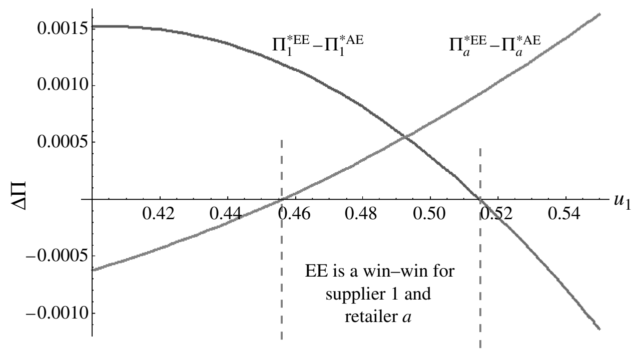
A.1. Asymmetric Suppliers/Retailers

In the foregoing analysis, the symmetry assumption has been imposed for the purpose of tractability. In reality, consumer preference for one supplier's product might be higher than that for the other one, which would positively affect the consumption of the particular service. In this subsection, we investigate the impact of asymmetries of suppliers and retailers in the presence of revenue sharing, as shown in §3.2. We define u_i as the percentage of consumers preferring product i to $3-i$, and v_j denotes the percentage of consumers preferring service j to $\bar{j}$. We have $u_i + u_{3-i} = 1$ and $v_j + v_{\bar{j}} = 1$. Thus, in line with Dukes and Liu (2010), the relative base demand for package ij can be rewritten as

$$\alpha_{ij} = u_i \times v_j.$$

We incorporate this new base demand into the utility function of Equation (1) and follow the same analysis procedures as in §3.2. Because of the computational complexity, we only illustrate the impact of asymmetry on supplier 1 and retailer a through Figures A.1 and A.2. To examine whether Scenario EE is a mutually beneficial choice for both

Figure A.1 **Profit Comparison with Asymmetric Suppliers (u), Where $\tau = 0.6$ and $r = 0.05$**



supplier 1 and retailer a, we compare their corresponding profits between Scenarios EE and AE as u_1 and v_a vary, respectively. Thus, we first fix $v_a = 1/2$ and let u_1 float in Figure A.1, and then we fix $u_1 = 1/2$ and let v_a float in Figure A.2.

Figures A.1 and A.2 demonstrate that forming exclusive deals can still be an equilibrium for all players, which is consistent with Theorem 4. On the one hand, the result further indicates that the retailer can benefit from partnering with a more powerful supplier in the exclusive deal, although this supplier cannot benefit from such an exclusive deal when it becomes sufficiently more powerful than the rival supplier, as illustrated in Figure A.1. On the other hand, as depicted in Figure A.2, the supplier benefits from partnering with a more powerful retailer in the exclusive deal, although the retailer will be reluctant to form such an exclusive deal as it becomes sufficiently more powerful than the rival retailer. This is supported by the fact that iPhone was eager to form an exclusive deal with the biggest service carrier in a country when it was first launched, as its market share was relatively small. However, not every retailer is willing to form such an alliance. For example, China Mobile, whose market share is 70% in China, declined an exclusive deal with iPhone in 2007 (Chan 2008).

A.2. An Alternative Model with Fencing

Our previous discussion was based on a stylized model with exclusive channels, where consumers cannot utilize the exclusive product with another service outside the exclusive deal. This is a reasonable assumption, especially in the wireless market of the United States and other countries, because it is illegal to hack an exclusive product to make it usable with a nonexclusive service.[3] However, the exclusivity might be mitigated by different versions in other countries. For example, Deutsche Telekom AG's T-Mobile was picked to exclusively sell iPhone at US$557 to its customers in Germany. Nevertheless, T-Mobile also sold an unlocked iPhone for US$1,478, which can be used with other service carriers (Pearce 2007). In this sense, iPhone is no longer purely exclusive but becomes a phone with fencing against its undesired market segment. For consumers wanting to cross the fence, a switching cost will be incurred. In the above T-Mobile example, a switching cost of $921 can be considered prohibitively high and our original model sustains for this situation. Nevertheless, this paper is positioned for a wider application beyond the wireless market; for example, using a bankcard in a nonnetwork ATM normally triggers a transaction cost. In another related example, an e-book reader who only has Nook and wishes to read an exclusive Kindle e-book must incur extra costs to transform the Kindle e-book format to be compatible with Nook. Hereby, we elaborate an alternative model with fencing.

In this alternative model with fencing, consumers have access to all four packages. The "exclusive" channel is the one with fencing, and the switching cost is equivalent to the disutility (e.g., penalty or transaction cost) incurred by the switchers. If there is no exclusive channel, consumers can freely select any package. However, if product i is sold exclusively through its partnered retailer, consumers incur a switching cost if a different retailer is chosen. We denote the switching cost as s_{ij}, which can be written as

$$s_{ij} = \begin{cases} k & \text{if } i \text{ is exclusively sold through } \bar{j}, \\ 0 & \text{otherwise.} \end{cases}$$

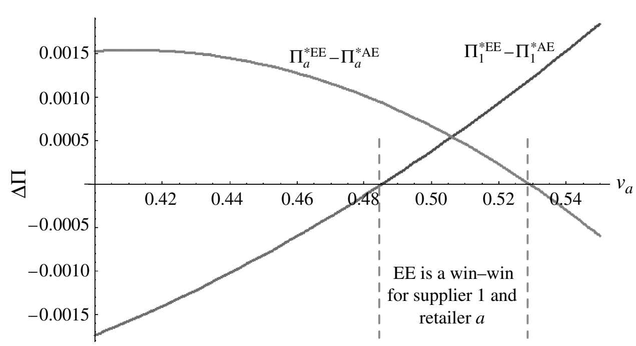
For tractability, we assume the same switching cost k for all packages in the exclusive deals, which is typical in the finance market, as in the example of ATMs and bankcards. Note that this assumption does not change our results qualitatively. Thus, the original utility function of Equation (1) is changed to

$$U \equiv \sum_{ij}(\alpha_{ij} D_{ij} - D_{ij}^2/2) - \tau \sum_{ij \neq mn} D_{ij} D_{mn} \Big/ 2 - \sum_{ij}(P_{ij} + s_{ij}) D_{ij}. \tag{4}$$

Maximization of Equation (4) yields the demand for each channel as follows:

$$D_{ij} = A_{ij} - \beta(P_{ij} + s_{ij}) + \theta \sum_{mn \neq ij} (P_{mn} + s_{mn}), \tag{5}$$

Figure A.2 **Profit Comparison with Asymmetric Retailers (v), Where $\tau = 0.6$ and $r = 0.05$**



[3] If hacking is possible, the hacking cost can be considered as the switching cost in this alternative model.

where

$$A_{ij} = \frac{(1+2\tau)\alpha_{ij} - \tau\sum_{mn\neq ij}\alpha_{mn}}{(1-\tau)(1+3\tau)},$$
$$\beta = \frac{1+2\tau}{(1-\tau)(1+3\tau)},$$
$$\theta = \frac{\tau}{(1-\tau)(1+3\tau)}.$$

Without loss of generality, we assume the revenue from the switching costs goes to the suppliers.[4] The profit functions are given by

$$\Pi_i = \sum_{a,b}(p_i + r_{ij} + s_{ij})D_{ij},$$
$$\Pi_j = \sum_{i=1,2}(p_j - r_{ij})D_{ij}. \tag{6}$$

As revenue sharing does not alter our qualitative results, we let $r_{ij} = 0$.

We now introduce a *price-out strategy* to study the corner solution where, as the switching cost grows, demand for package $1b$ and/or package $2a$ in Scenarios EE, EA, and AE approaches zero, respectively. For example, the retailer or the supplier, such as T-Mobile Germany or Apple, can set a switching cost high enough to *price out* the demand for package $1b$ in Scenario EA. The same technique was originally introduced by O'Brien and Shaffer (1993) for a scenario with two suppliers and a common retailer. In the following, we first compare Scenarios EE, EA, AE, and AA assuming that the switching cost is sufficiently low, and then we utilize a price-out strategy in Scenarios EE, EA, and AE.

Theorem 6. *In Scenarios EE, EA, AE, and AA with fencing, consider the entire supply chain.*

1. *For any switching cost lower than that of the price-out strategy, the overall supply chain efficiency is higher with more nonexclusive packages (i.e.,* $\Pi_{\text{All}}^{*\text{EE}} \leq \Pi_{\text{All}}^{*\text{EA}} = \Pi_{\text{All}}^{*\text{AE}} \leq \Pi_{\text{All}}^{*\text{AA}}$*).*
2. *Using the price-out strategy, this alternative model with fencing converges to our main model with exclusive channel(s).*

Intuitively, if the switching cost equals zero, all scenarios perform the same as Scenario AA. As the switching cost grows, the entire supply chain profit in Scenario EE decreases (more significantly than in Scenarios EA and AE); thus Scenarios AA, AE, and EA outperform Scenario EE. The inferiority of Scenario EE to Scenarios EA and AE is attributed to lower demand in the entire supply chain because of higher switching costs.

In the corner solution using the price-out strategy, we observe that all the equilibrium solutions of this alternative model are the same as those in Lemma 1. That is to say, *the price-out strategy restores all the features of our main model with exclusive channel(s)* specified in §2. In fact, both models have zero demand for the unavailable packages, because the price-out switching cost completely blocks demand for those undesired packages. Therefore, all previous analyses with exclusive channel(s) hold for the case with fencing, as long as the switching cost is set sufficiently high to block switching demand.

[4] We can prove that all qualitative results hold even if the revenue from the switching cost goes to either the retailers or a third party.

It is worth noting that this alternative model with fencing provides a more flexible extension of our main model. Recall the results in Figure 2, which are equivalent to the outcomes of the price-out strategy with fencing in this alternative model. If $\tau \geq 0.6901$, the players may employ the price-out strategy in both exclusive channels; if $0.5633 \leq \tau < 0.6901$, the price-out strategy is implemented in only one channel and zero switching cost is utilized in other channels; and if $\tau < 0.5633$, the players remove the fencing from all packages. As a result, the entire supply chain obtains Pareto efficiency in the entire domain (i.e., $\tau \in [0, 1)$).

A.3. Composite Package Competition

So far throughout the paper, our main focus has been on the *IO competition* where each player maximizes its own profit. To provide a useful benchmark for "understanding the basic economic forces" (Economides and Salop 1992, p. 107), we explore composite package (CP) competition, where each composite package is assumed to be produced by a different firm ij, $ij = 1a, 1b, 2a, 2b$. In this sense, the product and service are integrated in the same package. Extending from Economides and Salop's (1992) focus on a case similar to Scenario AA of this paper, we explore all four scenarios, EE, EA, AE, and AA. Because of the centralization feature of each package, no revenue sharing ensues under CP competition. We hence compare the four scenarios under IO competition and CP competition without revenue sharing. The comparison provides an insight into why firms would maximize their own profits noncooperatively rather than their joint channel profits cooperatively in a complementary goods market.

Again, we start from equilibrium prices.

Lemma 3. *In CP competition, the package prices increase with the number of exclusive channels (i.e.,* $P_{1a}^{*\text{AA}} \leq P_{1a}^{*\text{EA}} = P_{1a}^{*\text{AE}} \leq P_{1a}^{*\text{EE}}$*). The package prices are always lower than those in IO competition for all scenarios EE, EA, AE, and AA.*

The first part of this lemma is similar to Theorem 1, because the fewer the available packages resulting from greater numbers of exclusive channels, the more monopolistic the market. In fact, CP competition is similar to competition among integrated channels in terms of packages. The comparison of the package prices under CP competition with those under IO competition suggests package competition becomes more intense horizontally without vertical externalities, which leads to lower package prices in CP competition.

Similar to Theorem 3, we compare the overall supply chain efficiency of different scenarios in CP competition.

Lemma 4. *For the entire supply chain in CP competition, there exist two threshold values* $\hat{\tau}_3$ *and* $\hat{\tau}_4$*, such that*

$$\begin{cases} \textit{AA dominates EA, AE, and EE if } 0 \leq \tau < \hat{\tau}_3, \\ \textit{EA and AE dominate EE and AA if } \hat{\tau}_3 \leq \tau < \hat{\tau}_4, \\ \textit{EE dominates EA, AE, and AA if } \hat{\tau}_4 \leq \tau < 1. \end{cases}$$

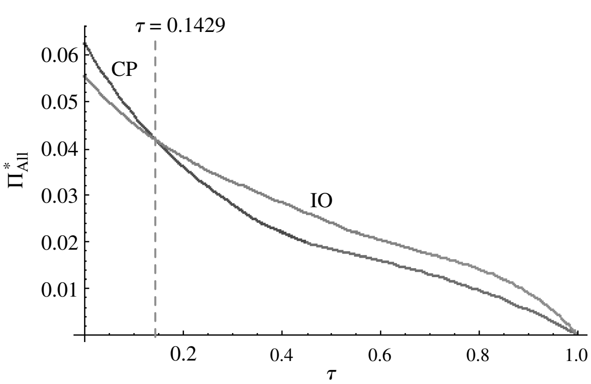
Comparing this result with Theorem 3, we notice that it is more likely for Scenario EE to outperform other scenarios in CP than in IO competition, because $\hat{\tau}_4 = 0.4468 < \hat{\tau}_2 = 0.6901$. This is because the horizontal competition among packages is more intense in CP competition because of the lack of an intermediary vertical cushion, which becomes more apparent as package substitutability grows. Therefore, when package substitutability is high, reducing the number of competing packages in CP competition is more efficient in improving overall supply chain efficiency than that in IO competition. Nevertheless, when package substitutability is sufficiently low, the benefit of package price reduction outweighs that of intensified horizontal package competition. As a result, Scenario AA becomes more efficient in CP than in IO competition. To show this, we compare the best performance among all scenarios of CP competition with the best performance among all scenarios of IO competition in the following.

Theorem 7. *Among all scenarios, EE, EA, AE, and AA, for the entire supply chain, the best CP case outperforms the best IO case if and only if package substitutability is sufficiently low.*

Although we might have expected better performance from an integrated package channel structure, Theorem 7 is somewhat counterintuitive. The explanation is that although the externalities between package partners are internalized, the more intense horizontal competition reduces the players' profits. This observation is supported by Lemma 3, where the package prices become lower in CP competition than in IO competition. The horizontal competition effect is particularly apparent when the packages are relatively more substitutable. As the packages become more monopolistic, the entire supply chain benefits from fewer externalities in CP competition and, thus, outperforms the one in IO competition. We more vividly illustrate Theorem 7 in Figure A.3, which shows that the IO case outperforms the CP case as long as $\tau > 0.1429$; otherwise, the reverse is true.

As ownership in CP competition is vague, we cannot induce the individual optimal selection of the channel structure without knowing the revenue redistribution structure among the players. Nevertheless, with an appropriately defined payment transfer mechanism, whether forming exclusive deals is a better choice can be determined accordingly. From Theorem 3 and Lemma 4, we can infer that the entire supply chain with exclusive channels can outperform the one without. If we allow the players to select the best case in any situation under IO and CP competition, Theorems 3 and 7 suggest the players would choose to form exclusive deals under IO competition rather than CP competition.

Figure A.3 Comparison of the Best Performance of Entire Supply Chain Among All Scenarios Between CP and IO Competition



A.4. Enhanced Revenue Sharing and Supply Chain Efficiency

Motivated by the revenue sharing employed by Blockbuster (Cachon and Lariviere 2005) and wireless content messaging (Foros et al. 2009), we hereby propose a price-dependent revenue sharing scheme. The following discussion is provided to shed some light on the possibility of enhancing supply chain efficiency and to attract more comprehensive analyses on similar areas in the future.

To showcase the efficacy of enhanced revenue sharing, we focus on Scenario EE.[5] We compare three cases: Case IO, Case CP, and Case O. Case IO is in IO competition. Case CP is in CP competition, which resembles an integrated version of McGuire and Staelin (1983), where the supplier and the retailer are vertically integrated in each exclusive channel. Case O is an *optimized* case where our enhanced revenue sharing mechanism is implemented. We use superscripts IO, CP, and O to denote Cases IO, CP, and O, respectively. We assume the shared revenue is associated with the unit revenue difference between the service and the product, as the product and the service are *complementary*.[6] We have

$$r_{ij} = r_0 + \eta(p_j - p_i), \quad ij = \{1a, 2b\}, \tag{7}$$

where η is a price coefficient. A base revenue sharing rate r_0 is similar to the revenue sharing discussed in §3.2. It is reasonable to argue that the retailer will share more revenue with the supplier if its service rate is higher or if the supplier is willing to reduce its product price to boost demand, or vice versa. We apply the above price-dependent revenue sharing to Scenario EE and find a value of η that optimizes the profit of each individual channel.

Lemma 5. *In Case O, each channel of EE is optimized when*

$$\eta^* = \frac{1-2\tau}{2-2\tau}.$$

The optimal profits are given by

$$\Pi_1^{*\text{EE}} = \Pi_a^{*\text{EE}} = \frac{1}{128+128\tau}.$$

Note that this revenue sharing mechanism optimizes each exclusive channel, as well as the entire supply chain. Given the symmetric setting, the revenue sharing rate does not appear in the players' profits, because these equally powerful players in the same channel claim their profit shares by

[5] It is worth noting that enhanced revenue sharing becomes computationally intractable in Scenarios EA and AE. Moreover, ownership for the exclusive channel coordination is ambiguous in asymmetric channel structures.

[6] This revenue sharing mechanism is not the only one that can optimize the entire supply chain of Scenario EE. For example, an alternative revenue sharing mechanism can be $r_{ij} = r_0 - \eta p_i$ or $r_{ij} = r_0 + \eta p_j$. However, these alternative mechanisms do not equally distribute the additional revenue among the players, a feature that resembles the symmetric Nash bargaining result.

adjusting their own prices/rates symmetrically, conditional on the revenue sharing contract.

Comparing Case O with Cases IO and CP, we obtain the following result.

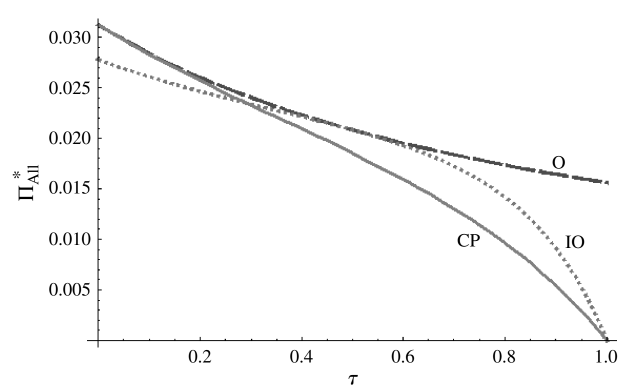
Theorem 8. *For the entire supply chain in Scenario EE, Case O outperforms Cases IO and CP.*

The result of comparing Case O with Case IO is relatively straightforward. This is because enhanced revenue sharing provides a price-dependent interactive cushion between the supplier and the retailer in each exclusive deal. If the packages are more substitutable (i.e., $\tau > 1/2$), the suppliers will be willing to reduce the revenue sharing rate to lessen the retailers' pressure on revenue sharing; if the packages are more monopolistic (i.e., $\tau < 1/2$), the retailers will share more of the revenue resulting from the relatively higher service rates with the suppliers.

The better performance of Case O over Case CP in the entire domain is worth emphasizing. As we previously argued, Case CP is an integrated version of Scenario EE. An integrated channel is normally considered the ultimate result of any coordination, which is true for single-channel supply chains. However, this conventional picture is altered under channel competition. As Theorem 8 demonstrates, Case O always dominates Case CP. This result occurs because, after erasing the internal externalities, the integrated channels compete more intensely horizontally. As illustrated in Figure A.4, Case IO outperforms Case CP when the packages are sufficiently substitutable, which is consistent with McGuire and Staelin (1983) although in a different setting. Enhanced revenue sharing provides a price-dependent cushion against fierce horizontal competition and, thus, enables each exclusive channel, as well as the entire supply chain, to eventually dominate the integrated dual-channel Case CP in the entire domain.

Figure A.4 delivers additional messages. First, Case O is equivalent to Case CP if the packages are purely monopolistic, as the horizontal competition disappears. Second, Case O is equivalent to Case IO when $\tau = 1/2$. This is because the price-dependent cushion of enhanced revenue sharing is suppressed at this middle point. Otherwise, Case O has more advantages over Case IO as the packages become either more monopolistic or more substitutable. The effectiveness of enhanced revenue sharing becomes more significant as the packages converge to pure substitutes. This result suggests that enhanced revenue sharing can significantly buffer horizontal competition as package substitutability grows.

Figure A.4 Entire Supply Chain Profit Comparison in Scenario EE Under O, IO, and CP



Consider the package prices. As previously demonstrated in Lemmas 1 and 3, package prices in Scenario EE are strictly higher than those in Scenario AA in both IO and CP competition. However, as we show next, if enhanced revenue sharing is employed, higher package price concerns in exclusive deals can be alleviated, if package substitutability is relatively low.

Corollary 1. *In Case O, $P_{1a}^{*\text{EE}} < P_{1a}^{*\text{AA}}$, if and only if $\tau < 1/3$.*

Corollary 1 implies that whether the package prices in exclusive deals are higher than those without exclusive deals depends on the package substitutability. If the package substitutability is high, the concern of higher package prices as a result of exclusive deals is substantially supported in Case O. However, if package substitutability is low, forming exclusive deals is therefore encouraged in terms of consumer welfare. Nevertheless, exclusive deals reduce the number of consumer choices and are not Pareto-efficient in terms of overall supply chain efficiency when the packages are sufficiently monopolistic.

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