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Strategic Analysis of the Agency Model for Digital Goods

Yinliang (Ricky) Tan
A.B. Freeman School of Business, Tulane University, New Orleans, Louisiana 70118, USA, ytan2@tulane.edu

Janice E. Carrillo
Department of Information Systems and Operations Management, Warrington College of Business Administration, University of Florida, Gainesville, Florida 32611-7169, USA, janice.carrillo@warrington.ufl.edu

The introduction of digital goods in the media industry has gained a considerable amount of positive press due to superior features such as increased accessibility and portability. However, the distribution of these digital goods in conjunction with their physical analogs (i.e., printed books) has been operationally problematic for media supply chains. Specifically, the types of contracts utilized to distribute these goods such as agency models have come under fire in the press. A high profile case brought by the Department of Justice (DOJ) against Apple exemplifies this debate as the DOJ claims that the agency model utilized by Apple caused higher prices and decreased consumer surplus. We create and analyze a model of vertically differentiated goods to compare and contrast the agency model with the wholesale model. We ascertain that both (a) the revenue-sharing structure and (b) the upstream publisher's control over the price contribute to the benefits of the agency model. We consider a variation of this model which shows that if the retailer utilizes a "fixed price" model, then he suffers from a short-term loss in profit, possibly to garner additional market share. We also investigate an incentive alignment condition for the agency model which assures that the retailer and the publisher will together commit to selling digital goods alongside physical goods in the supply chain. Finally, we analyze an extension of the original model which incorporates horizontal differentiation in addition to vertical differentiation and shows that in most cases, the horizontal differentiation does not alter our original results that the agency model outperforms the wholesale model.

Key words: digital goods; channel coordination; e-book industry; agency pricing
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1. Introduction

In recent decades, the book industry has advanced following two alternate trends (Stone 2012). First, modern digital formats have changed the nature of the physical design of the books. Second, the power balance of supply chain relationships has evolved in a commensurate manner. As summarized by a statement in the *New York Times* (Miller and Bosman 2011), "Amazon sold 105 books for its Kindle e-reader for every 100 hardcover and paperback books, including books without Kindle versions and excluding free e-books." Moreover, in the same article Amazon's Chief Executive Jeff Bezos expressed his surprise with the growth in the digital book industry and states, "We had high hopes that this would happen eventually, but we never imagined it would happen this quickly." Explanations for this expansion in the e-book market include technological factors such as the decreasing costs of e-book readers (Los Angeles Times, May 2011) and the accessibility of e-books via alternate technological platforms including PCs, laptops, tablets, and smartphones.

Managers and policy makers in the digital goods/publishing industry also have been impacted by the introduction of the digital goods as a result of evolving contract and revenue negotiations between different members of the supply chain. For example, consider the recent lawsuit from the US Department of Justice (DOJ) against Apple, Inc[1] regarding newer pricing models for consumers and publishers purchasing digital books. At the heart of this lawsuit is the agency model used by the e-book publishing industry, where the publishers are directly involved in setting the retail price of the digital books. Prior to the introduction of the agency model, New York best-seller Kindle books were originally priced at $9.99 (this corresponds to the "fixed price" model in our study), whereas the prices of printed versions of the same book typically range from $20 to $40. Shortly thereafter, publishers demanded to have the rights to price the digital goods (i.e., the "agency model") in the marketplace due to cannibalization concerns. The agency model is a variation of a revenue-sharing model whereby the publisher decides the price of the e-book and the retailer who serves as an agent collects

a predetermined percentage of the revenue. The DOJ prosecutors blamed Apple for colluding with publishers by introducing the agency model in retaliation for Amazon's aggressive pricing strategy. The publishers eventually insisted that all retailers utilize the agency pricing model. Figure 1 illustrates an example of the agency model from Amazon. A federal judge ruled on July 10, 2013 (United States Department of Justice 2013) that Apple conspired with major publishers to raise e-book prices. All of the major publishers settled the case by reaching an agreement to suspend the agency model for two years, but Apple is still appealing the legal ruling.

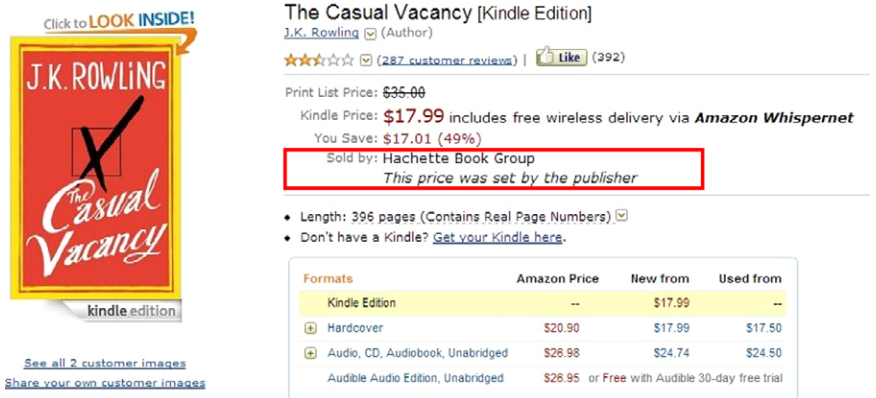
Some politicians have expressed concern about the decision. A noteworthy example recently appeared in the press when US Senator Charles E. Schumer wrote an opinion editorial article in the *Wall Street Journal* (Schumer 2012) arguing against the case made by the Department of Justice, in which he claimed that the average price for New York Times bestselling books decreased after Apple and publishers utilized the agency model. In addition, a recent study by Hao and Fan (2014) shows that consumer surplus is higher in the agency model compared with the wholesale model. Hence, several natural and intriguing questions arise from our discussion. In the e-book market, why would the publisher introduce the agency model? If the agency model benefits the publisher, how about the retailer? Which pricing model does the retailer prefer? What is the underlying mechanism of the agency model? Are consumer surplus measures commensurate under these pricing schemes?

In this study, we utilize game theory methodologies to analyze the benefits and drawbacks associated with alternate distribution models, thereby aiding retailers, publishers, and policy makers to successfully manage the "digital revolution" (Stone 2012). First we consider the "agency model" where the publishers set the retail price for e-books, which is a variation of the revenue-sharing contract commonly used in supply chains. The retailer keeps a predetermined percentage α of the digital book's sales revenue while the publisher collects the remainder, and this percentage α was purportedly set at 30% for the digital books industry (WSJ 2012). Recently, Amazon signed a new contract with HarperCollins and other major publishers which is again based on the agency model after its suspension (Streitfeld 2015, Trachtenberg 2015). We also investigate an alternate version of the agency model whereby the retailer sets the price of the digital books instead of the publisher. We refer to this model variation as the "retailer's agency model," which allows us to further investigate the mechanism of pricing control in the agency model. Next, we study the wholesale model which represents another contract type utilized to set prices between the publisher and retailer. Note that the wholesale model was conventionally utilized to establish wholesale and retail prices in the traditional printed book markets. In the two channel wholesale model, the publisher first offers both types of books (i.e., digital and printed) at two separate wholesale prices. The retailer then sets the different prices to offer the different versions of the books to consumers.

It's noteworthy to point out that Amazon initially priced most New York Times best-seller books at $9.99 regardless of their actual cost. We also investigate the "fixed price" model, where the price of the digital goods is treated as an exogenous variable. It's important to understand certain nuances associated with the fixed price model in contrast to the wholesale model. In the fixed price model, the retail price of the digital goods is fixed by the retailer, which may produce two conflicting effects. On one hand, the retailer is taking the "first-mover" advantage in the price setting game. On the other hand, it loses the flexibility to adjust the retail price based on different wholesale prices.

Our analysis of these alternate contract forms shows that contrary to the claims of the DOJ, there are

Figure 1 An Example of the Agency Model (Screenshot was taken on October 10, 2012)



many previously unrecognized benefits associated with the agency model. Although the price of the e-book increased from its original value of $9.99, this evidence seems insufficient to conclude that consumer welfare has been compromised by the implementation of the agency model. Indeed, we show that the consumer welfare is actually greater when utilizing the agency model as compared with the wholesale model. Instead by utilizing a "fixed price model," we believe that Amazon produced a "loss leader" by selling each Kindle book priced at $9.99 at a loss (Rich 2009). Our analysis reveals that the agency model is a very effective pricing model for the e-book supply chain, which sheds light on why new contracts between Amazon and major publishers are still based on the agency model after the 2-year suspension period (Gilbert 2015). In the early stages of the e-book market when many consumers still favored the printed book, both the publisher and retailers were better off under the agency model compared with the wholesale model. The intuition driving this result is that the agency model utilizes a revenue-sharing scheme with upstream publisher's control over the price for sales of the digital goods which mitigates the double marginalization effect. Further, when the market matures and technology advances, consumers may prefer the e-book to the traditional printed book. We find that the agency model can coordinate the supply chain under this situation. Finally, note that although the agency model has some similarities with traditional revenue-sharing contracts, there are key differences in terms of the mechanisms and implementation.

2. Literature Review

2.1. IS/Digital Goods Literature

First, we summarize the literature in the Information Systems (IS) field which is relevant to our digital goods industry. Jones and Mendelson (2011) analyze a duopoly selling vertically differentiated goods to show that the markets for digital goods (termed *information goods* in their study) are typically dominated by a single firm. Buxmann et al. (2007) utilize data from the music download industry and find that while lowering prices can increase demand, all supply chain partners must act in cooperation in order for this to be a successful strategy. A number of additional papers focus solely on the e-book industry as an example of a digital good. Jiang and Katsamakas (2010) develop a stylized model to analyze the entry of an e-book retailer into an existing market for physical books and consider several variations of a price setting game between the retailers. Kwark et al. (2016) have also studied a setting with downstream competition between the retailers and identify circumstances under which the retailers benefit from external third party information concerning the quality of the product. Our work models the supply chain partners via a game between a single retailer and a single supplier. This allows us to more precisely analyze a variety of pricing mechanisms (including to two types of agency models). Hu and Smith (2013) utilize a natural experiment and discover that delaying the release of the digital books leads to both (a) a significant decrease in the total sales for the digital books, and (b) a modest (and insignificant) decrease in the sales for the traditional books. This result is captured in our model as we also consider a dual channel strategy and further characterize the circumstances under which such a strategy is optimal for both the retailer and the supplier. Most recently, Hao and Fan (2014) developed an analytical model to study pricing mechanisms in the e-book publishing industry. In their setting, they have considered a horizontally differentiated model with exogenously given printed book prices and a complementary e-book reader market. They find that the e-book retail price in the agency model is higher than that in the wholesale model. We extend their study by (a) endogenizing the printed book price and (b) considering vertical differentiation between the printed book and the e-book. In contrast to their results, we identify circumstances under which both the consumer surplus and profit are higher for the agency model as compared to the wholesale models. Essentially, this result is driven by the combination of vertical differentiation, endogenizing the printed book pricing, and abstracting away from the complementary market. Interested readers can also refer to Gilbert (2015) who reviewed the recent development and history of the e-book revolution.

2.2. OM/Channel Coordination Literature

Many authors in the operations management (OM) field address the repercussions of digital goods for operations managers. To illustrate, Hayes (2002) investigates more broadly the impact of new technologies on the "New IT-Based Economy" and outlines several challenges relevant to supply chain managers operating in an online setting. Geoffrion (2002) also offers a conceptual four-stage framework directly addressing the challenges highlighted by in the Hayes (2002) article.

Another line of research associated with OM literature analyzes interactions between sales via a traditional (i.e., bricks-and-mortar) store and direct channels (i.e., internet channels) incorporating alternate members of the supply chain. Chiang et al. (2003) formulate a groundbreaking model through which a manufacturer establishes an online channel selling directly to consumers in addition to selling their goods via an alternate retailer. These authors illustrate that the addition of a direct channel can

increase the profit of the supply chain by decreasing the degree of double marginalization. Arya et al. (2007) and Cattani et al. (2006) similarly develop results highlighting the benefits of the creation of a direct channel from a manufacturer to the customers in a supply chain. The intuition driving these results is that the manufacturer's encroachment will induce a reduction in the wholesale price and improve efficiency gains that can secure Pareto improvements. Recently, Abhishek et al. (2015) compared the agency selling and reselling format for online retailers, capturing the online and off-line channel interaction via spillover effects between the alternate channels. Their main conclusion is consistent with our work, where the agency model is more efficient than reselling and leads to a lower equilibrium price. Our research extends the aforementioned works by (a) including characteristics specific to the digital goods industry and (b) addressing alternate supply chain structures and pricing schemes. Moreover, we utilize a demand function which explicitly takes into account both vertical and horizontal differentiation via a consumer choice model. In most previous studies, the manufacturer can sidestep the retailer and sell to the customers directly. However, in our study, the publisher/supplier is obligated to use the platform provided by the retailer to sell digital goods in the marketplace.

Our study also intersects research in the marketing literature on penetration pricing strategies and channel coordination in the presence of a dominant retailer. The fixed price model in the publishing industry is an example of penetration pricing whereby the dominant retailer establishes a very low price so as to accelerate product adoption. Noble and Gruca (1999) point out that penetration pricing is an effective strategy in the early stages in the product life cycle when there are few direct competitors and competition comes primarily from substitutes. Raju and Zhang (2005) compare the quantity discounts and two-part tariff contracts in the presence of a dominant retailer. Recent studies also explore the impact of a dominant retailer on the manufacturer's wholesale price (Geylani et al. 2007). In contrast to the previous literature, we study a setting where the dominant retailer owns both digital goods and traditional goods distribution channels in the fixed price model.

2.3. Contribution to the Literature

This study makes both theoretical and practical contributions to the technology management literature. From a theoretical perspective, we explain how the agency model can mitigate the double marginalization effect in the digital goods supply chain. We have shown that the retail price under the agency model is lower than that under the wholesale model when we abstract from the complementary e-book reader market. More importantly, we identify and conceptualize the similarities as well as differences between the agency model and traditional revenue-sharing contracts. In contrast to the previous literature (Tan and Carrillo 2014), we find that when the publisher sets the price of the digital goods within the framework of the agency model, the resulting allocation is superior to other systems. From a practical point of view, we compare the profitability and consumer welfare for different pricing schemes (i.e., the agency model, wholesale model and fixed price model). Our results indicate that in the future, the agency model with prices determined by the supplier is a superior pricing model than the wholesale model for the digital goods market due to (a) decreasing the double marginalization and (b) increasing levels of consumer surplus. Recently, major publishers and retailers in this industry have been negotiating new e-book contracts, and our research provides valuable insights to business managers and policy makers involved in this important decision.

3. Notation and Model

We introduce notation appropriate to a consumer choice model including the possibility of distributing the products via a traditional channel (denoted by the subscript T) and also a digital channel (denoted by the subscript D). We also include nomenclature to indicate the corresponding supply chain position as a publisher/supplier (denoted by the subscript P) and also a retailer (denoted by the subscript R). Table 1 summarizes the complete notation utilized for this model.

Table 1 Model Variables

Variable	Description
V	Consumer valuation of traditional (physical) goods, $V \in [0, \overline{V}]$
P_T	Retail price of traditional goods (decision variable)
P_D	Retail price of digital goods (decision variable)
$\tilde{P}_D$	Fixed price of digital goods
C_T	Cost of printed book to the publisher including production and logistics costs
W_T	Wholesale price of traditional goods charged by the publisher (decision variable)
θ	Consumer acceptance level of digital goods
α	Proportion of the revenue that the retailer keeps from the sale of digital goods; $0 < \alpha < 1$
V_k^l	Valuation threshold for consumers buying from channel k ($k = D$ or T)
V^e	Valuation threshold where consumers are indifferent between both channels
Q_T	Demand for traditional goods
Q_D	Demand for digital goods
$\pi_{i,k}$	Net profit of player i ($i = P$ or R) on the supply chain associated with channel k ($k = D$ or T)
CS_k	Total consumer surplus associate with channel k ($k = D$ or T)
SW	Total social welfare

3.1. Single Channel Model

We first analyze a basic consumer choice model in which products are offered either only through a single traditional channel or a single digital channel. Note that the notation here is similar to Tan and Carrillo (2014). Let the variable V represent the heterogeneous consumers' willingness to pay for traditional goods and assume that (a) this variable is uniformly distributed i.e., $V \in [0, \overline{V}]$ and (b) the total market size is normalized to one. Also let the variable P_T represent the retail price of the traditional goods such that consumers will purchase these traditional goods only if the price is less than their individual valuation. We define the indifference point as V_T^I as the threshold for which consumers are indifferent between purchasing the traditional goods or not purchasing at all. The demand for traditional goods is:

$$Q_T = Pr(V - P_T \geq 0) = (\overline{V} - P_T)\frac{1}{\overline{V}}. \quad (1)$$

Utilizing a customary wholesale model, we assume that the publisher offers the goods to the retailer at a wholesale price of W_T, and the publisher incurs a cost of C_T. The publisher's profit for the single traditional channel is given as:

$$\pi_{P,T} = (W_T - C_T)Q_T = (W_T - C_T)(\overline{V} - P_T)\frac{1}{\overline{V}}. \quad (2)$$

The retailer's profit is given as:

$$\pi_{R,T} = (P_T - W_T)Q_T = (P_T - W_T)(\overline{V} - P_T)\frac{1}{\overline{V}}. \quad (3)$$

To facilitate the demand model for the digital goods, we assume that the digital goods are vertically differentiated with respect to the traditional goods and we introduce a variable θ which reflects the consumers' differential preference. Specifically, let θ be defined as the consumer acceptance level. If the consumers prefer the digital goods relative to the traditional goods then $\theta > 1$, whereas if the consumers prefer traditional goods over digital goods then $\theta < 1$. While recent empirical evidence from a study in 2011 shows that consumers have a consumer acceptance level of <1 (PWC, 2011), we also consider the possibility of a consumer acceptance level of >1 (Stone 2012). Given the retail sales price for the digital goods P_D and a consumers' valuation of θV, then the consumer will purchase the digital good only if the consumer surplus $\theta V - P_D$ is strictly >0. Similarly, we define the indifference point as V_D^I as the threshold for which consumers are indifferent between purchasing the digital goods or not purchasing at all. The demand for digital goods is:

$$Q_D = Pr(\theta V - P_D \geq 0) = \left(\overline{V} - \frac{P_D}{\theta}\right)\frac{1}{\overline{V}}. \quad (4)$$

To model the profit-sharing mechanism within the agency model, we assume that for each digital book the retailer sells, he retains a certain percentage of the revenue denoted by the variable α. Similar to Sundararajan (2004), we assume that the marginal production cost for the digital goods is zero. Therefore, the retailer earns a profit of αP_D for each digital book sold, and the publisher receives a payment of $(1 - \alpha)P_D$.

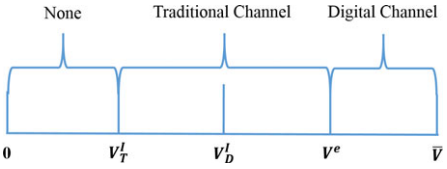
3.2. Dual Channel Model

Now we extend the consumers' choice model previously shown for a single channel assuming that the retailer has control over both a digital and traditional goods channel simultaneously. To illustrate, consider the dual channel distribution configurations of both Amazon and Barnes & Noble. Similar to other dual channel models, we assume that the consumer will only purchase from a specific channel if the consumer's valuation exceeds the consumer valuation threshold (V_T^I and V_D^I) for that channel. If (a) two channels are available simultaneously and (b) the consumer's valuation exceeds both thresholds, then the consumer will choose the item from the channel with higher consumer surplus (similar to Chiang et al. 2003 and Hao and Fan 2014). The consumer surplus from purchasing the traditional goods is $V - P_T$ while the consumer surplus from the digital goods is $\theta V - P_D$. We characterize another threshold $V^e = \frac{P_T - P_D}{1-\theta}$ as the level where consumers are indifferent regarding buying from either channel and we derive the dual channel demand function under these alternate cases. We assume $C_T \leq \overline{V}(1-\theta)$ to eliminate situations where demand of traditional goods is <0.

Case 1 $\theta \geq 1$: When $P_T < \frac{P_D}{\theta}$, we find that $V_T^I < V_D^I < V^e$. In this situation, consumers can be divided into three parts based on their valuation: (a) Consumers in the first region $[0, V_T^I]$ will not purchase any goods, (b) consumers in the second region $[V_T^I, V^e]$ will buy traditional goods and (c) consumers in the third region $[V^e, \overline{V}]$ will buy the digital goods, as shown in Figure 2.

For the case when $V_T^I \geq V_D^I$ (i.e., $P_T \geq \frac{P_D}{\theta}$), then $V^e < V_D^I < V_T^I$. It follows that consumers whose valuation is low $[0, V_D^I]$ will not buy from either channel, and consumers with higher valuation $[V_D^I, \overline{V}]$ will choose to purchase from the digital goods channel. Essentially, the intuition driving this result is that if consumers prefer digital over traditional goods and the price of the digital good is relatively low, it is optimal for consumers is to purchase the digital goods.

Figure 2 Consumers Purchasing Choice under $V_T^I < V_D^I$ when $\theta \geq 1$



The demand function when $\theta \geq 1$ follows:

$$Q_T = \begin{cases} \left(\frac{P_T - P_D}{1-\theta} - P_T\right)\frac{1}{\overline{V}} & P_T < \frac{P_D}{\theta} \\ 0 & P_T \geq \frac{P_D}{\theta} \end{cases}$$

$$Q_D = \begin{cases} \left(\overline{V} - \frac{P_T - P_D}{1-\theta}\right)\frac{1}{\overline{V}} & P_T < \frac{P_D}{\theta} \\ \left(\overline{V} - \frac{P_D}{\theta}\right)\frac{1}{\overline{V}} & P_T \geq \frac{P_D}{\theta}. \end{cases} \quad (5)$$

Case 2 $\theta < 1$: Similarly, when $\theta < 1$ which occurs when consumers prefer the traditional goods to their digital counterparts, we demand function is as follows:

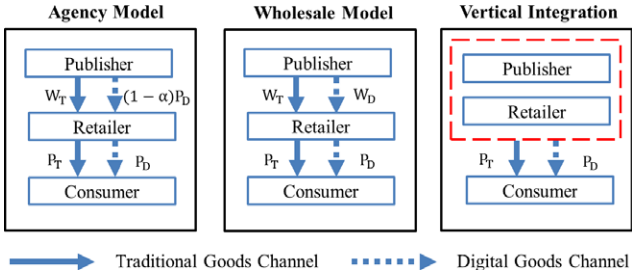
$$Q_T = \begin{cases} \left(\overline{V} - P_T\right)\frac{1}{\overline{V}} & P_T < \frac{P_D}{\theta} \\ \left(\overline{V} - \frac{P_T - P_D}{1-\theta}\right)\frac{1}{\overline{V}} & P_T \geq \frac{P_D}{\theta} \end{cases}$$

$$Q_D = \begin{cases} 0 & P_T < \frac{P_D}{\theta} \\ \left(\frac{P_T - P_D}{1-\theta} - \frac{P_D}{\theta}\right)\frac{1}{\overline{V}} & P_T \geq \frac{P_D}{\theta}. \end{cases} \quad (6)$$

4. Analysis

In this section, we analyze the prevalent contract types associated with the e-book industry. Since the central focus of our study is on agency and wholesale model forms, we do not address the possibility of e-book rentals in this model. More specifically, we utilize a Stackelberg game to capture the interplay between the publisher and the retailer and analyze the following scenarios[2] including the agency and wholesale models. We assume that the publisher makes the first move in the game as it has access to original content from the authors. The retailer responds to the publisher's choices in the second stage of the game. We assume that both players have access to full information concerning consumer demand and costs. The major difference between the agency model and the wholesale model is that the former allows the publisher to control the sales price of the digital goods. We also analyze the vertically integrated supply chain as the benchmark for later analysis and provide details in the online Appendix. We illustrate the details of these pricing models in Figure 3. For the remainder of the study, we use the pronoun "he" to represent the publisher and "she" to represent the retailer.

Figure 3 Decision Sequence for the Publishing Industry



To solve this problem, we assume that there are three alternate strategies that the players can follow: a single channel strategy, a dual channel strategy, and an equivalent price strategy. The single channel and dual channel strategies are similar to those delineated in sections 3.1 and 3.2. Similar to Chiang et al. (2003), we also consider the possibility that the retailer can follow an equivalent price strategy, whereby the retailer sets the price such that $P_T = \frac{P_D}{\theta}$. The net effect of this equivalent price strategy is that while both channels are opened for sales, positive demand only occurs in one channel. Moreover, we assume that as the leader, the publisher chooses a particular strategy (i.e., dual channel, single channel or equivalent price), and the retailer must follow that strategy. In the case where the resulting profits from both dual channel and equivalent price strategies are equal, then we assume that the publisher will choose an appropriate strategy based on other qualitative information (such as customer loyalty, alternate marketing initiatives, etc.) Later, we relax this assumption that the publisher chooses the optimal strategy and consider the possibility that the retailer may prefer an alternate strategy to the one that the publisher chooses. We solve the problem by utilizing a standard backward induction technique. In this section, we mainly present the analysis for $0 < \theta < 1$. We solve for the case when $\theta \geq 1$ by following a similar set of steps.

In addition to comparing the price of the goods under alternate agency and wholesale models, we utilize a more complete measure of consumer welfare to illustrate the differences between the alternate contract forms. Consumer surplus is an economic measure which reflects the total difference between the maximum price a consumer is willing to pay and the actual price. We calculate the consumer surplus for the dual channel strategy as the summation $CS = CS_T + CS_D = \int_{V^e}^{\overline{V}} (v - P_T)\frac{1}{\overline{V}}dv + \int_{V_D^I}^{V^e} (\theta v - P_D)\frac{1}{\overline{V}}dv = \frac{1}{2}\left(\overline{V} + V^e - 2P_T\right)Q_T + \frac{1}{2}[\theta(V^e + V_D^I) - 2P_D]Q_D$ when $\theta < 1$. For the single (traditional) channel strategy or the equivalent price strategy, we then consider only the consumer surplus from the single traditional channel, $CS = CS_T = \int_{V_T^I}^{\overline{V}} (v - P_T)\frac{1}{\overline{V}}dv = \frac{(\overline{V} - P_T)^2}{2\overline{V}}$.

Correspondingly, we analyze other measures such as profit, prices, and consumer surplus when $\theta \geq 1$.

4.1. Agency Model

Recall that in the agency model, the retailer acts as an agent for the wholesaler and consequently receives a portion of the revenue α which is usually associated with an industry standard. Consequently, we initially assume that this revenue-sharing proportion α is exogenous, and relax the assumption later in the paper. The following sequence of events dictates the agency pricing model: (1) The publisher determines the wholesale price for the traditional goods W_T and the retail price for the digital goods P_D, (2) the retailer then sets the price for the traditional goods P_T. Applying the backwards induction technique to the retailer's problem first, we find,

$$\max_{P_T} \pi_R = \pi_{R,D} + \pi_{R,T} = \alpha P_D Q_D + (P_T - W_T)Q_T. \quad (7)$$

First, we characterize the optimal value for the price of the traditional goods, which is a function of the wholesale price W_T and digital goods price P_D such that $P_T = \text{argmax}\ \pi_R(W_T, P_D)$. We then substitute this value for P_T back into the publisher's problem and determine the optimal wholesale price W_T and digital goods price P_D as follows:

$$\max_{W_T, P_D} \pi_P = \pi_{P,D} + \pi_{P,T} = (1-\alpha)P_D Q_D + (W_T - C_T)Q_T. \quad (8)$$

In the following analysis, we consider the situation where consumers prefer traditional goods such that $\theta < 1$. Specifically, we find the optimal solution for P_T^* given W_T and P_D. We divide the problem into three alternate parts corresponding to the dual channel solution ($P_T > \frac{P_D}{\theta}$), the equivalent solution ($P_T = \frac{P_D}{\theta}$), and the single traditional channel solution ($P_T < \frac{P_D}{\theta}$). The first-order conditions (FOCs) of optimality are necessary and sufficient to identify the following solution:

$$P_T^*(W_T, P_D) = \begin{cases} \frac{[P_D + \alpha P_D + \overline{V} - \theta\overline{V} + W_T]}{2} & \text{If } P_D < \frac{\theta[W_T + \overline{V} - \theta\overline{V}]}{2 - \theta - \alpha\theta} \\ & (\textit{Dual Channel}) \\ \frac{\overline{V} + W_T}{2} & \text{If } P_D > \frac{\theta}{2}\left[\overline{V} + W_T\right] \\ & (\textit{Single Traditional}) \\ \frac{P_D}{\theta} & \text{Otherwise} \\ & (\textit{Equivalent Price}). \end{cases} \quad (9)$$

In the basic model, we do not consider the incentive alignment issue[3] between the publisher and retailer. Essentially, we assume the publisher as the game leader determines the choice of which strategy to implement based on his own profits. This choice enhances our focus on the strategic implications of the agency model. Later in the extension, we show that relaxing this mild assumption[4] does not change our qualitative insights.

We solve the publisher's problem under different strategies and characterize the optimal solutions. When $\theta < 1$, we find that both the dual channel strategy and the single channel strategy are viable. We summarize the results in Table 2.

When $\theta < 1$, we find that, in equilibrium, the publisher will choose to implement the dual channel strategy when

$$\Delta = \pi_P{}^{Dual} - \pi_P{}^{Single} = \frac{[1-2\alpha]\theta\overline{V}^2 + \frac{C_T{}^2\theta}{1-\theta}}{8\overline{V}} \geq 0.$$

Generally speaking, when the publisher retains a larger portion of the revenue (i.e., a small value of α) then the publisher prefers to sell via a dual channel strategy. However, when the consumer acceptance level θ approaches 1, the publisher prefers the dual channel strategy even when the division of digital goods sales is in favor of the retailer. This is because the equilibrium price of the digital goods $P_D = \frac{\theta\overline{V}}{2}$ is linearly increasing in θ and the demand of the digital

Table 2 Equilibrium Results of the Agency Model when $\theta < 1$

	Dual channel strategy	Single traditional channel strategy
Price		
Digital goods price, P_D	$\frac{\theta\overline{V}}{2}$	*n/a*
Traditional goods price, P_T	$\frac{1}{4}[C_T - (\theta - 3)\overline{V}]$	$\frac{1}{4}[C_T + 3\overline{V}]$
Wholesale price W_T	$\frac{1}{2}[C_T + \overline{V} - \alpha\theta\overline{V}]$	$\frac{C_T + \overline{V}}{2}$
Quantities		
Digital goods, Q_D	$\frac{1}{4}\left[1 + \frac{C_T}{\overline{V} - \theta\overline{V}}\right]$	0
Traditional goods, Q_T	$\frac{1}{4}\left[1 + \frac{C_T}{\theta\overline{V} - \overline{V}}\right]$	$\frac{[\overline{V} - C_T]}{4\overline{V}}$
Profits		
Publisher's profit, π_P	$\frac{1}{8}\left[(1 + \theta - 2\alpha\theta)\overline{V} + C_T\left(\frac{C_T}{\overline{V} - \theta\overline{V}} - 2\right)\right]$	$\frac{\left[\overline{V} - C_T\right]^2}{8\overline{V}}$
Retailer's profit, π_R	$\frac{1}{16}\left[\overline{V} - \theta\overline{V} + 4\alpha\theta\overline{V} + \frac{C_T{}^2}{\overline{V} - \theta\overline{V}} - 2C_T\right]$	$\frac{\left[\overline{V} - C_T\right]^2}{16\overline{V}}$
Supply chain, $\pi_R + \pi_P$	$\frac{1}{16}\left[(3 + \theta)\overline{V} + 3C_T\left(\frac{C_T}{\overline{V} - \theta\overline{V}} - 2\right)\right]$	$\frac{3\left[\overline{V} - C_T\right]^2}{16\overline{V}}$
Consumer surplus, *CS*	$\frac{1}{32}\left((1 + 3\theta)\overline{V} + C_T\left(\frac{C_T}{\overline{V} - \theta\overline{V}} - 2\right)\right)$	$\frac{(\overline{V} - C_T)^2}{32\overline{V}}$

goods is also increasing in θ. Furthermore, the traditional goods price $P_T = \frac{1}{4}[3\overline{V} + C_T - \theta\overline{V}]$ is linearly decreasing in the consumer acceptance level θ. Hence, the publisher's profit is mainly attributed to digital goods sales when θ approaches 1, and the publisher is better off with the dual channel strategy even when the revenue-sharing proportion is favorable to the retailer.

4.2. Wholesale Model

The following sequence of events dictates the wholesale pricing model: (1) The publisher determines the wholesale price for both the traditional goods W_T and the digital goods W_D (2) the retailer then sets the price for the traditional goods P_T and the digital goods P_D. The results shown in Lemma 1 and online Appendix A confirm that the dual channel strategy is optimal when $\theta < 1$.

LEMMA 1 *The optimal solution for the wholesale model when $\theta < 1$ is:*

a) Pricing: $W_T = \frac{C_T+\overline{V}}{2}$, $W_D = \frac{\theta\overline{V}}{2}$, $P_D = \frac{3\theta\overline{V}}{4}$, $P_T = \frac{1}{2}[\overline{V} + \frac{C_T+\overline{V}}{2}]$

b) Quantities: $Q_D = \frac{C_T}{4\overline{V}[1-\theta]}$, $Q_T = \frac{1}{4}[1 + \frac{C_T}{\theta\overline{V}-\overline{V}}]$

c) Profits and Consumer Surplus:
$\pi_P = \frac{1}{8}[\overline{V} + C_T(\frac{C_T}{\overline{V}-\theta\overline{V}} - 2)]$,
$\pi_R = \frac{1}{16}[\overline{V} + C_T(\frac{C_T}{\overline{V}-\theta\overline{V}} - 2)]$,
$\pi_{SC} = \frac{3}{16}[\overline{V} + C_T(\frac{C_T}{\overline{V}-\theta\overline{V}} - 2)]$,
$CS = \frac{1}{32}(\overline{V} + C_T(\frac{C_T}{\overline{V}-\theta\overline{V}} - 2))$

Note that both the wholesale price and sales price of digital goods W_D and P_D increase with the consumer acceptance level θ. Consequently, the profits for both the publisher and retailer increase corresponding to higher levels of θ. The implication from this result is that there exists a strong incentive for both the publisher and retailer to improve the consumer's acceptance of the digital platform when adopting the wholesale model. Specifically, the publishers can offer a greater variety of books in a digital format and provide multimedia content such as videos and audio books. Likewise, the retailers can increase consumers' experience when utilizing digital books by pursuing activities such as introducing new technology in digital book readers and offering a better online preview system.

5. Implications for Digital Goods Management

In this section, we discuss results that show the advantages and disadvantages of the agency model relative to the wholesale model. We also analyze a vertically integrated supply chain and show the results in the online Appendix. These values serve as a point of reference with which to compare the results for the disintegrated supply chain. In fact, Amazon is allegedly moving aggressively toward cutting out the publishing middleman by soliciting some books directly from the authors (Stone 2012, Streitfield 2011). It is interesting to explore the impact of such vertical integration on the optimal pricing and consumer surplus measures. To further explore the mechanisms of the agency model, we also analyzed a variation of the agency model where the retailer can set the price of digital goods. We summarize all of the feasible channel strategies under alternate contract types below in Table 3.

Suppose that consumers favor digital goods as opposed to traditional goods (i.e., $\theta \geq 1$). In this case, we notice that only single channel and equivalent price strategies are possible choices. We summarize the equilibrium results for all scenarios in Table 4.

Next, we highlight several important implications from the results shown in the previous tables. First,

Table 3 Possible Channel Strategies of Dual Channel Supply Chain in Digital Goods

Supply chain structure	$\theta < 1$	$\theta \geq 1$
Agency model	Single traditional channel Dual channel	Single digital/equivalent channel
Wholesale model	Dual channel	Single digital/equivalent channel
Integrated supply chain	Dual channel	Single digital/equivalent channel

Table 4 Comparison of Different Models when $\theta \geq 1$

	Agency model/integrated supply chain	Wholesale model
Price		
Digital goods price, P_D	$\frac{\theta\overline{V}}{2}$	$\frac{3\theta\overline{V}}{4}$
Wholesale price W_D	*n/a*	$\frac{\theta\overline{V}}{2}$
Quantities		
Digital goods, Q_D	$\frac{1}{2}$	$\frac{1}{4}$
Traditional goods, Q_T	0	0
Profits		
Publisher's profit, π_P	$\frac{1}{4}[1-\alpha]\theta\overline{V}$	$\frac{\theta\overline{V}}{8}$
Retailer's profit, π_R	$\frac{1}{4}\alpha\theta\overline{V}$	$\frac{\theta\overline{V}}{16}$
Supply chain, $\pi_R + \pi_P$	$\frac{\theta\overline{V}}{4}$	$\frac{3\theta\overline{V}}{16}$
Consumer surplus, *CS*	$\frac{\overline{V}}{8}$	$\frac{\overline{V}}{32}$

the demand is equal to zero for the traditional goods channel. In this situation, the profit for the equivalent price and single digital channel strategies is the same. Note that it may be appropriate for the publisher to choose a strategy (i.e., equivalent price vs. single digital channel) based on other qualitative information such as customer loyalty, alternate marketing initiatives, etc. To illustrate, the publisher and retailer may choose to keep the traditional channel open when consumers favor digital goods over traditional goods (i.e., $\theta > 1$), to act as a virtual showroom or to appease loyal customers who prefer printed books.

Second, when consumers favor digital goods over traditional goods (i.e., $\theta > 1$), the supply chain profit for the agency model exactly matches that of the integrated supply chain case. Therefore, the agency model coordinates the supply chain when the consumers favor digital goods. Since the sales volume drops to zero for the traditional goods, the agency model essentially mimics a simple revenue-sharing scheme whereby the retailer shares a pre-determined proportion α of her revenue with the publisher. As established in previous literature (Cachon and Lariviere 2005), the supply chain will reach its coordination under this pricing scheme. We also notice that the supply chain performance of the wholesale models are suboptimal due to the double marginalization effect.

From Table 4, we also find that there exists a region for the revenue-sharing proportion $\alpha \in [0.25, 0.5]$ such that both the publisher and the retailer strictly prefer the agency model to the wholesale model. This Pareto improving region of α provides practical guidance for managers operating in the e-book industry. This is also a very interesting result from a theory perspective, because common wisdom suggests that one party can secure higher revenue by having more decision rights. However, we find that the retailer can earn a higher profit by (a) abandoning its pricing right and (b) relying solely upon the publisher's pricing decision. In summary, we find that when the consumer acceptance level of digital goods is >1, the agency model is a very efficient contract form that improves the supply chain performance while also benefiting the retailer and publisher individually. Next we focus on the strategic channel design when the consumer acceptance level of digital goods is <1.

PROPOSITION 1. *Consider the situation where the consumer acceptance level of the digital goods θ is <1. Comparing the agency model with the wholesale model, we find*

a) If the revenue-sharing proportion $\alpha \in [0, 0.25]$, then the publisher prefers the agency model while the retailer prefers the wholesale model.

b) If the revenue-sharing proportion $\alpha \in [0.25, 0.5]$, then both the publisher and the retailer prefer the agency model to the wholesale model.

c) If the revenue-sharing proportion $\alpha \in [0.5, 1.0]$, then (i) when the dual channel strategy is employed in the agency model, both the publisher and the retailer prefer the agency model to the wholesale model. (ii) If the single channel strategy is adopted in the agency model, then both the publisher and the retailer prefer the wholesale model.

The proof is provided in the online Appendix. Common wisdom suggests that the publisher and the retailer may have different preferences concerning the agency and the wholesale models, in the sense that the publisher prefers the agency model when the value of the revenue-sharing proportion α is low, while the retailer prefers the agency model when the value of α is high. In general, we find our results are in line with this expectation. However, we find that when α belongs to an intermediate range (i.e., $\alpha \in [0.25, 0.5]$), both the publisher and the retailer enjoy a higher profit under the agency model as compared with the wholesale model. This is due to the fact that under the agency model, the supply chain profit is improved compared with the wholesale model and both publisher and retailer are satisfied when the division of the digital goods profits is appropriate.

Now we conceptualize the similarities and differences between the agency model and a traditional revenue-sharing contract. The core idea of a traditional revenue-sharing contract is sharing the risk along the supply chain where the retailer shares her revenue with the supplier in exchange for a reduction in the wholesale price (Cachon and Lariviere 2005). The agency model works in a similar manner; the publisher takes the entire risk in the digital goods channel, in the sense that the publisher sets the wholesale price of the digital goods to zero (i.e., $W_D = 0$) and only collects the revenue of the digital goods shared from the retailer. We also observe that the wholesale price of traditional goods W_T drops along with the reduction of the wholesale price of digital goods. Although the agency model and revenue-sharing contract are similar, they are not identical. First, in the presence of the traditional goods with $\theta < 1$, the revenue-sharing contract can achieve supply chain coordination but the agency model cannot. The agency model is a "partial revenue sharing" contract in the sense that it alleviates the double marginalization effect of the digital goods but not the traditional goods, where the traditional goods channel is governed by the wholesale model. Second, as opposed to a revenue-sharing contract, the sales price is determined by the upstream supplier/publisher

instead of the retailer in the agency model. Third, the implementation and administration of the agency model is simpler than the traditional revenue-sharing contract in physical goods. Publishers/suppliers can validate information concerning the sales of digital goods through a 3rd party information and measurement company.[5] One of the most significant limitations of a traditional revenue-sharing contract as highlighted by Cachon and Lariviere (2005) is the administrative burden imposed on the firms.

Multiple reports (e.g., Rich and Stone 2010, WSJ Staff 2012) indicate that the value of α was set at 30% in the book publishing industry, which lies within the range whereby both parties earn more profit by utilizing the agency model. As a consequence, we focus our comparison of the agency model and other pricing models within this range. To further assess the pricing and consumer welfare issues between these two pricing models, we have the following proposition.

PROPOSITION 2. *When the consumer acceptance level of digital goods θ is <1 and $\alpha \in [0.25, 0.5]$, we analyze the relative values of several metrics under the agency model with those derived for the wholesale model utilizing the dual channel strategy as follows:*

a) $P_D{}^{Agency} < P_D{}^{Wholesale}$, $P_T{}^{Agency} < P_T{}^{Wholesale}$, $W_T{}^{Agency} < W_T{}^{Wholesale}$

b) $Q_D{}^{Agency} > Q_D{}^{Wholesale}$, $Q_T{}^{Agency} = Q_T{}^{Wholesale}$

c) $\pi_P{}^{Agency} - \pi_P{}^{Wholesale} = \frac{[1-2\alpha]}{8}\theta\overline{V} > 0$,
$\pi_R{}^{Agency} - \pi_R{}^{Wholesale} = \frac{[4\alpha-1]}{4}\theta\overline{V} > 0$,
$\pi_{SC}{}^{Agency} - \pi_{SC}{}^{Wholesale} = \frac{\theta\overline{V}}{16} > 0$,
$CS^{Agency} - CS^{Wholesale} = \frac{3\theta\overline{V}}{32} > 0$

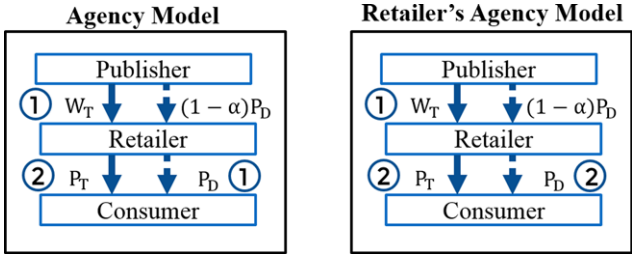
These results show that when utilizing a dual channel strategy with a moderate revenue-sharing proportion, the supply chain profit under the agency model outperforms those associated with the wholesale model by $\frac{\theta\overline{V}}{16}$. This difference stems from the fact that the digital goods demand in the agency model is strictly higher than the demand in the wholesale model, $Q_D{}^{Agency} > Q_D{}^{Wholesale}$, while the demand for the traditional goods is kept the same under these two pricing schemes, $Q_T{}^{Agency} = Q_T{}^{Wholesale}$. Essentially, the agency model alleviates the double marginalization effect by utilizing a "partial revenue sharing" scheme. Compared with the wholesale model, the agency model not only reduces the wholesale price of traditional goods W_T but also leads to a decrease in consumer prices, P_D and P_T. Specifically, the publisher charges a price of $P_D{}^{Agency} = \frac{\theta\overline{V}}{2}$ for the digital goods under the agency model, and the publisher also charges the same wholesale price $W_D{}^{Wholesale} = \frac{\theta\overline{V}}{2}$ under the wholesale model. However, the retailer will add an additional markup under the wholesale model for the digital goods. In equilibrium, the price for the digital goods is $P_D{}^{Wholesale} = \frac{3\theta\overline{V}}{4}$, which is 50% higher than the digital goods price under the agency model. Because of the lower prices and higher demands, the consumer surplus in the agency model is also higher than the wholesale model, $CS^{Agency} - CS^{Wholesale} > 0$.

There are two main features that distinguish the agency model with other traditional pricing contract forms, which are (a) the upstream publisher's control over the price and (b) the revenue-sharing mechanism. The revenue-sharing mechanism has been explored in the previous literature (Cachon and Lariviere 2005) and has been shown to be an effective contract form to achieve coordination. Here we investigate whether the publisher's control over the price also contributes to the Pareto improving feature of the agency model. To further identify the precise factors driving the benefits of the agency model, we examine a revised version of the agency model to compare with our original version (i.e., retailer's agency model). Under the retailer's agency model, the downstream retailer (instead of the publisher) determines the retail price of the e-book. The publisher first declares the wholesale price W_T, then the retailer responds to the publisher's decision by setting both the price for the digital goods P_D and for the traditional goods P_T. Similar to the agency model, we assume that the revenue-sharing proportion α is exogenous. The key difference between the agency model and the retailer's agency model concerns which party (i.e., publisher or retailer) takes control of e-book pricing, which is illustrated in the following Figure 4.

PROPOSITION 3. *Comparing the agency model with the retailer's agency model, we find that:*

(i) When the consumer acceptance level of digital goods θ is >1, the agency model and the retailer's agency model lead to the same result.

Figure 4 Illustration of Agency Model and Retailer's Agency Model



(ii) When the consumer acceptance level of digital goods θ is <1, the agency model outperforms the retailer's agency model in terms of the publisher's, retailer's and supply chain's profit. Specifically, the wholesale price and the retail price for both traditional goods and digital goods are lower in the agency model compared with those in the retailer's agency model.

The proof is provided in online Appendix D. The first part of Proposition 3 is expected. When $\theta > 1$, sales of the traditional goods channel will drop to zero in both the agency and the retailer's agency models because consumers prefer digital goods to traditional goods. Consequently, alternating the decision right of pricing the digital goods does not affect the result and both the agency and retailer's agency models lead to supply chain coordination in this situation.

When $\theta < 1$, we focus on the dual channel strategy because the results of single channel and equivalent price strategy are the same between the agency and the retailer's agency models. For ease of notation, we use the superscript R and A to represent the retailer's agency model and the agency model, respectively. In the retailer's agency model, we find that the profits for both the publisher and the retailer are lower as compared with those associated with the agency model. The intuition of this result is as follows: In the retailer's agency model, the pricing of the digital goods is controlled by the downstream retailer. In this situation, the publisher tends to charge a higher wholesale price for the traditional goods ${W_T}^R$ in response to the loss of the pricing decision. As a result, we observe that in the equilibrium ${W_T}^R > {W_T}^A$. Next, the retail prices of the traditional goods and digital goods also increase (i.e., ${P_T}^R > {P_T}^A$ and ${P_D}^R > {P_D}^A$) due to the higher wholesale price, which results in reduced market demand and creates supply chain inefficiency. Chiefly, the shift in pricing rights for the digital goods will intensify the double marginalization effect. In the agency model, only the traditional goods suffer from inefficient markups, while in the retailer's agency model, both the traditional goods and digital goods suffer from double marginalization. The mark-up of the digital goods is implicit in the sense that the publisher does not charge a price on the digital goods to the retailer directly, but instead influences the price of the digital goods through setting the wholesale price of the traditional goods. In summary, we now establish a deeper understanding of the mechanism of the agency model. Both the revenue-sharing mechanism and the upstream publisher's control over the price contribute to the benefits of the agency model.

Note that the marketing literature on pricing delegation finds that sales delegation is appropriate and effective when the salesforce possesses asymmetric information (Lal 1986). In our study, the sales entity (i.e., the retailer) does not possess unique (asymmetric) information. Consequently, the results from our pricing model show that in most cases, pricing delegation (via a retailer) is not profitable in the digital goods industry. Future work may address the possibility of information asymmetry for this industry.

6. Extensions

6.1. Incentive Alignment

To focus on the strategic implication of the different pricing models, we do not incorporate the incentive alignment issue in the basic model. Instead, we assume that the publisher as the game leader determines which strategy to implement based on his own interest. Now we relax this assumption and show that our main qualitative insights still hold. Note that technically speaking, the key difference induced by the incentive alignment constraint is whether the retailer will respond based on her own profit. By considering the incentive alignment issue in the Stackelberg game, the retailer will not necessarily follow the publisher's strategy; instead, the retailer may choose an alternate strategy based on her profit. Through analysis, we find that the conflict of interest between the publisher and retailer only occurs in the agency model with $\theta < 1$ and the condition for the dual channel strategy to be viable is characterized as follows.

LEMMA 2. *In order for the dual channel strategy to be optimal strategy for both the publisher and the retailer in the agency model, the parameters should satisfy the following two conditions,*

$$\textit{(i)}\ \ \tfrac{1}{4}\theta^2[{C_T}^2 - 2\alpha C_T(\theta-1)\overline{V} - (1-\theta)(1 + \alpha(\alpha\theta - 2))\overline{V}^2] \geq 0;$$

$$\textit{(ii)}\ \ (1-2\alpha)\overline{V}^2 + \tfrac{{C_T}^2}{1-\theta} \geq 0$$

The first condition guarantees that the retailer will follow the publisher's decision if the dual channel strategy is adopted and the second condition assures that it is in the publisher's best interest to adopt the dual channel strategy over the single channel strategy. The details of the analysis are shown in the online Appendix. The key insight from this analysis is that incorporating incentive compatibility between the publisher and retailer will reduce the firms' incentive to implement the dual channel strategy. However, there always exists a feasible range where both the retailer and the publisher optimally choose the dual channel strategy and all the results in the previous section are still relevant. It may appear that the dual channel strategy with incentive alignment

concern is somewhat limited as a result of the conflict of interest between the retailer and the publisher. Both parties would like to share a higher proportion of the revenue, but can only find an agreeable solution when the revenue-sharing proportion lies in a middle range. There are several reasons that we believe our major result is robust to this concern. First, we have shown that there always exists a feasible parameter range that reconciles the profit conflict between the players. As a result, managers can adopt different values for the revenue-sharing proportion α based on the different product characteristics such as: valuation, production and logistics costs, and consumer perception of digital goods. More importantly, the retailer is forward-looking. Recall that in the fixed price model, the retailer is willing to sacrifice short-term profit to lock in consumers and build market awareness. Likewise, the retailer in the agency model would like to introduce the digital goods by utilizing a dual channel strategy even when the single traditional channel strategy leads to a temporarily higher profit. Thirdly, the retailer and publisher can make an agreement on the revenue-sharing proportion based on negotiations, which we discuss in the next section. Notice that unlike the agency model, the conflict incentive issue does not exist in the wholesale or fixed price models when imposing the incentive alignment consideration.

6.2. Endogenous Revenue-Sharing Proportion

In the preceding analysis, we assumed that in the agency model, the revenue-sharing proportion α is exogenously fixed. A natural extension of this assumption is to study what factors may impact this revenue-sharing proportion. In this section, we consider α to be an endogenous variable that is determined through negotiations between the publisher and retailer. Note that we only consider the case where the dual channel strategy is optimal for the agency model, as negotiations for the revenue-sharing proportion are only significant in this case.

To reflect each party's influence on the revenue-sharing proportion, we employ the standard Nash bargaining solution (Myerson 1991), generalized to allow asymmetric bargaining power. We adopt this axiomatic approach because it allows for a tractable characterization of equilibrium without necessitating an explicit representation of the precise bargaining process. Specifically, let $\beta \in [0, 1]$ reflect the relative bargaining power of the retailer and $1 - \beta$ represent the bargaining influence of the publisher. The relative bargaining power might depend on the popularity and exclusivity of the digital goods provided by the publisher. As a result, the negotiated revenue-sharing proportion, α_N, is the solution of the following Nash bargaining formulation:

$$\alpha_N = \arg\max_{\alpha}[\pi_P(W_T, P_D, P_T, \alpha)]^{1-\beta}[\pi_R(W_T, P_D, P_T, \alpha)]^{\beta}. \quad (10)$$

The details of the analysis are shown in the online Appendix, and the results are summarized here. When $\theta \geq 1$, it is readily shown that $\alpha_N = \beta$, which is the relative negotiation power of retailer. This occurs because only the digital goods will be distributed (where the demand of the traditional goods drops to zero) when consumers prefer digital to traditional goods. Thus, the revenue-sharing proportion that the retailer retains, α_N, precisely reflects the bargaining power of the retailer in the negotiation. We summarize the results and insights from the comparative statics when $\theta < 1$ in the next proposition.

Proposition 4. *When the revenue-sharing proportion, α_N, is determined through Nash bargaining:*

(i) for $0 \leq \beta \leq 1$, $\frac{\partial \alpha_N}{\partial \beta} \geq 0$;

(ii) for $0 \leq \beta \leq 1/3$, $\frac{\partial \alpha_N}{\partial \theta} \geq 0$; for $\frac{1}{3} < \beta \leq 1$, $\frac{\partial \alpha_N}{\partial \theta} < 0$

The result of part (i) is expected, as the retailer with a stronger bargaining position demands a higher revenue-sharing proportion during the transaction with the publisher. For the second part of the proposition, we distinguish the results depending on the relative bargaining position for each player. Specifically, when $\beta \in [0, 1/3]$, the publisher's bargaining power is relatively high, and when $\beta \in [1/3, 1]$, the retailer's bargaining position is relatively high. One interpretation of the second part of this proposition is that when the relative bargaining power of one of the parties is stronger, that party is willing to sacrifice a proportion of the total revenue in response to an increase in the consumer acceptance level of the digital goods (cost of the traditional goods). To illustrate, as discussed in section 5, an increase in the consumer acceptance level θ will alleviate the supply chain double marginalization effect and increase profits for both parties. When the publisher is in the stronger negotiating position, we know the value of α_N is relatively small; as a result, the publisher is willing to give a slightly higher revenue-sharing proportion to the retailer to avoid the breakdown of the negotiation with the increase of the consumer acceptance level. Similar reasoning applies when the retailer has a relative bargaining advantage.

6.3. Heterogeneous Consumers' Perception of Digital Goods

In this section, we assume that each consumer segment may have a distinct perception towards digital goods, which reflects the horizontal differentiation in

the digital goods market. To keep the model analytically tractable and parsimonious, we assume that there are two types of consumers in the market, which are θ_1 (high type) and θ_2 (low type). Without loss of generality, we assume there exist δ (i.e., $\delta \in (0, 1)$) percentage of consumers with perception of θ_1 and $1 - \delta$ with θ_2 and $\theta_2 < \theta_1$. Essentially, the θ_1 type captures the tech-savvy consumers who are more enthusiastic toward digital goods while θ_2 represents the consumer group who prefers the traditional reading experience associated with physical books. Thus we have a two-dimensional model $[0, \overline{V}] \times \{\theta_1, \theta_2\}$ to capture the consumer preference, where the first dimension denotes the consumers' valuation heterogeneity, and the second dimension captures the consumers' differing views toward the digital goods. This modeling technique captures both vertical and horizontal differentiation on consumers' view of digital goods. We consider the following two settings: $\theta_2 < \theta_1 < 1$ and $\theta_2 < 1 < \theta_1$, where the first case indicates that most consumers still prefer the printed book to the e-book, but their preference strength is different, and the second case represents that a certain portion of consumers prefer the e-book to printed books while other consumers prefer the printed book to the e-book. To test the robustness of our main finding in the preceding section, we focus on the comparison between the agency model and the wholesale model. The derivation and proofs are provided in the online Appendix. Although we derive closed-form solutions, the comparison between the two models is quite complicated. Therefore, we conduct extensive numerical experiments to explore the effect of the proportion of θ_1 type consumers (i.e., δ) on our optimal solutions and we find that the results are quite robust in a wide range of different parameters. For the sake of conciseness, we provide two representative examples in Figures 5 and 6 below.

In general, we find that the presence of horizontal differentiation of consumers' perception of digital goods does not affect the main qualitative insight obtained from the base model, where the agency model outperforms the wholesale model. As the proportion of high-type consumers (δ) increases, more consumers have a favorable preference for digital goods. Roughly speaking, this is equivalent to the situation where consumers' perception of digital goods (θ) increases in our base model. Further, we find that it is always optimal for firms to offer both traditional and digital goods to extract the surplus from the consumers when heterogeneity exists among consumers' perception of digital goods.

When $\theta_2 < \theta_1 < 1$, as illustrated in Figure 5, in the agency model, we find that when δ is relatively low, it is lucrative to serve both market segments (i.e., θ_1 and θ_2) with both traditional goods and digital goods. When δ becomes higher, it is more profitable for the publisher to serve the high-type consumer with both goods and the low-type with traditional goods only. This is also the dominant strategy in the wholesale model. The intuition driving this result is that it becomes costly to serve the low-type consumers when there are significant amounts of high-type consumers in the market. Essentially, the retailer has to charge a very low price for the e-book in order to retain the low-type consumers interested in the digital goods. When $\theta_2 < 1 < \theta_1$, as illustrated in Figure 6, we find that the high-type consumer will only purchase the digital goods irrespective of the value of δ in both the wholesale and agency models. Low-type consumers will purchase both traditional goods and digital goods when δ is relatively low but only purchase the traditional goods when the value of δ becomes larger. The intuition is similar to the previous case.

6.4. Fixed Price Model

When Amazon first introduced the Kindle reader and digital books, they sold their newly released best sellers for a fixed price of \$9.99 (Stone 2012).

Figure 5 **Comparison of Publisher, Retailer and Supply Chain's Profit under Agency Model and Wholesale Model with Heterogeneous Consumers' Perception of Digital Goods ($\theta_2 < \theta_1 < 1$). For illustration purpose, we set the parameters as follows: {$\theta_1 = 0.8$, $\theta_2 = 0.5$, $\alpha = 0.3$, $\overline{V} = 30$, $C_T = 3$}**

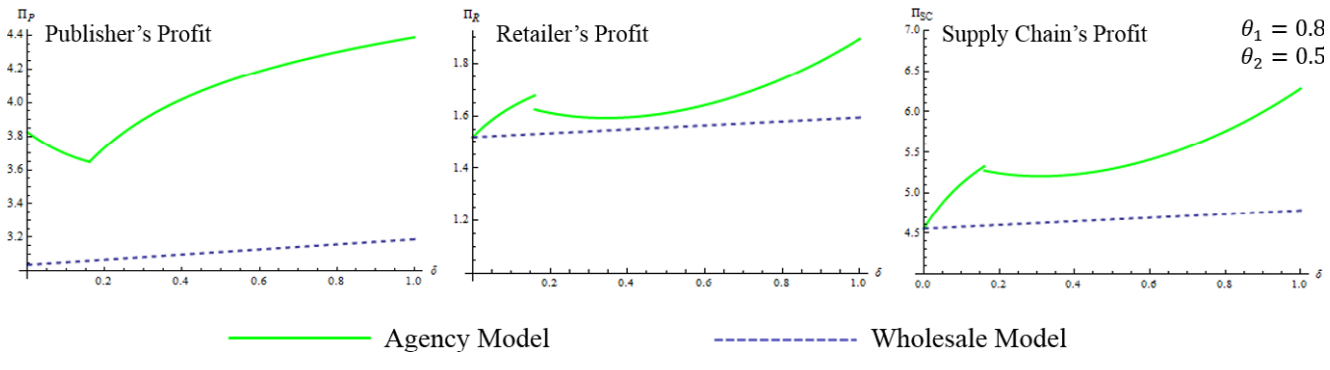
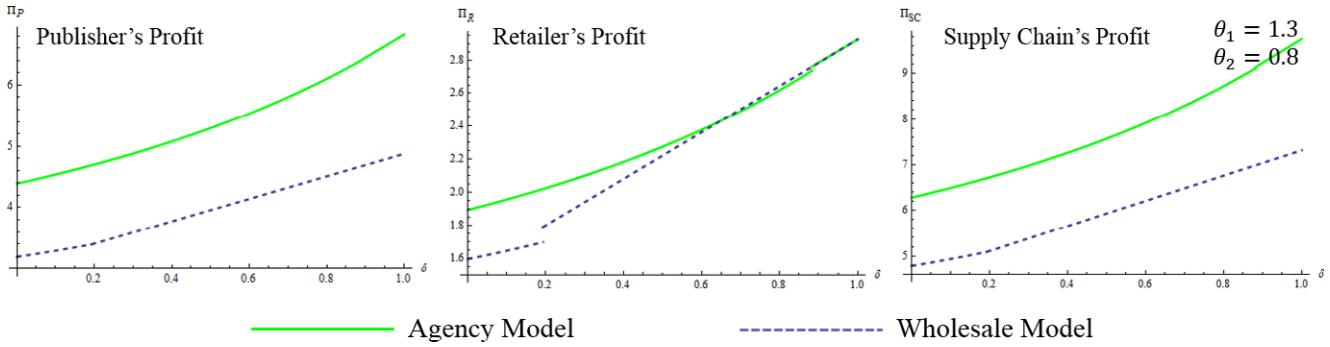


Figure 6 Comparison of Publisher, Retailer and Supply Chain's Profit under Agency Model and Wholesale Model with Heterogeneous Consumers' Perception of Digital Goods ($\theta_2 < 1 < \theta_1$). For illustration purpose, we set the parameters as follows: {$\theta_1 = 1.3$, $\theta_2 = 0.8$, $\alpha = 0.3, \overline{V} = 30$, $C_T = 3$}



This fixed price scenario denotes the situation where the price of the digital goods P_D is treated as an exogenous variable, reflecting the situation where Amazon fixed the price of all best seller e-books to the same level regardless of their cost and customer utility characteristics. We assume that the players utilize a wholesale pricing framework and that the wholesale price for both the traditional and digital goods is equivalent ($W_T = W_D = W$) as supported by media reports (Rich and Stone 2010). In the first stage of the game, the publisher declares the wholesale price W and in the second stage, the retailer responds to the publisher's decision by setting the corresponding retail price of traditional goods P_T.

In the fixed price model, the retailer retains the price of the digital goods at P_D regardless of the product characteristics. We find that conceding control of the price may result in an unfavorable short-term outcome in terms of the retailer's profit. Specifically, the retailer in this case will actually earn a negative profit for the dual channel strategy, and zero profit for the equivalent price strategy. This result is due to the retailer's inflexibility to adjust the retail price of digital goods. In both the dual channel and equivalent price strategy, the publisher captures the supply chain's entire profit by setting the wholesale price equal to the retail price of traditional goods. In most supply chains, the negative profit would be unacceptable to the retailer. However, empirical and anecdotal evidence indicates that indeed, this was the situation for Amazon. In fact, an article in the *New York Times* says: "Amazon is effectively subsidizing the $9.99 price tag for new book titles in digital form by paying publishers the same $13 it pays them for a new hardcover title with a list price of $26" (Rich 2009). These results suggest that in fact Amazon is willing to lose profit in order to establish itself in the digital goods market. On the other hand, this fixed price strategy has some long-term benefits which are not captured by the short-term profit measurement. For instance, from a marketing perspective, this strategy may help to build market share/awareness and lock in early consumers.

Next we compare the consumer surplus between the agency model and the fixed price model since this is one of the center issues of the lawsuit. We focus on the dual channel strategy in both the agency and fixed price models.

PROPOSITION 5. *When the consumer acceptance level of digital goods θ is <1, we find that the consumer surplus under the fixed price scenario is higher than the consumer surplus under the agency model.*

The proof of this proposition is provided in the online Appendix. Prosecutors from the US Justice Department claimed that Apple used publishers' dissatisfaction with Amazon's aggressive e-book discounting to shoehorn itself into the digital book market in 2010. Many retailers including Amazon switched their pricing model from the fixed price to the agency model. Consequently, consumers' welfare was compromised due to the increase in e-book prices. On the surface, our proposition seems to support the prosecutors' argument in the sense that consumer surplus measurements do decrease by introducing the agency model. However, as discussed before, the fixed price model is not a viable pricing model in the long term. We believe the original very low fixed price ($9.99 for New York Times bestselling books) is merely a strategic move to lock in consumers and build market share and awareness for the digital platform. Further, we have shown that the agency model performs better than the wholesale model from the previous proposition. As a result, our research indicates that the agency model may be a better pricing model for the digital goods market in

the future. Our results also reveal that the fixed price strategy is not a realistic pricing model for the retailer when consumers prefer digital goods to traditional goods (i.e., $\theta \geq 1$). The publisher can always set the digital goods price P_D at the fixed digital goods price P_D and extract the entire surplus. This result is consistent with our observation that Amazon's fixed price policy is only a short term marketing strategy to create a "loss leader."

7. Implications and Future Research

The advent of technological innovation for digital goods has created opportunities for suppliers and retailers in media-related industries to facilitate the distribution of their goods. However, the sales mechanisms utilized for these digital goods alongside traditional goods have become problematic in the digital goods supply chains. In this paper, we consider a single retailer which has the capability to sell both physical and digital goods simultaneously via a dual channel model. A classic wholesale contract is used to determine the prices for physical goods whereby the supplier offers the goods to the retailer at a pre-specified wholesale price, and the retailer is free to set the sales price for the traditional goods in the marketplace. We consider four diverse scenarios for pricing the digital goods, each capturing an alternate mechanism. For one scenario, the publisher decides the price for the digital goods in the marketplace while the profit is shared via an agency model with a pre-specified revenue-sharing percentage. We also analyze an alternate version of this agency model termed the "Retailer's Agency Model" where the price for the digital goods is determined by the retailer instead of the publisher. In the third scenario, the publisher determines the wholesale prices of both types of goods, and then the retailer determines the price of both types of goods in the marketplace. The fourth scenario is a fixed price scenario where the price of the digital goods is considered fixed, and the supply chain members negotiate over wholesale and retail prices for the traditional goods.

We highlight observations from Amazon.com and their digital books marketplace utilizing evidence published in the popular press to motivate and elucidate these scenarios. When Amazon first brought digital books to the marketplace, they priced most of them at $9.99 reflecting a fixed price policy. As publicized via a well-known case (Stone 2012), several publishers then colluded with Apple to mandate the utilization of agency pricing contracts with Amazon. One of the key features of these agency pricing contracts was that the publishers could then set the prices for the digital books, as shown in Figure 1. Amazon then responded by implementing the publisher controlled agency model and consequently, the publisher determined prices for the digital books under this model were higher than that associated with the fixed price policy. Because of the dramatic increase in price for the digital goods, the US Department of Justice claimed that the agency model adversely affected consumers.

Our analysis shows that the agency model for distributing digital goods is superior to other models under a wide variety of circumstances. In comparing the agency model directly to the wholesale model, we find that (a) the optimal prices for the digital goods are lower and also (b) the consumer surplus is higher (from Proposition 2). Because this result seems to run counter to the claims of the US Department of Justice, we also investigate an alternate form of the agency model (i.e., the retailer's agency model) and the fixed price model. Our analysis (from Proposition 3) shows that when the retailer is allowed to set the price for the digital goods, but revenue is still shared according to a pre-specified percentage, that the prices for both the digital and traditional goods are higher than if the publisher sets the price for the digital goods. Moreover, all members of the supply chain earn more profit when the publisher is allowed to set the price for the digital goods. This result illustrates that the key benefit of the agency model is driven by the publisher's ability to control the price of the digital goods and not simply the revenue-sharing mechanism. We also investigate a fixed price model, whereby the retailer simply sets the price of the digital goods (e.g. $9.99) for all books regardless of the demand and consumer valuation characteristics. In Proposition 5, we find that conceding control of the price decreases the retailer's profit, particularly when they are selling via both digital and traditional channels. As a consequence of the lower prices, the consumer surplus for the fixed price model is indeed higher than that associated with the agency model, but to the detriment of the retailer.

Further analysis of the agency model yields interesting insights with regard to the revenue-sharing proportion (i.e., α). Recall that in the agency model, α represents the portion of the digital book's sales revenue that the retailer retains, and this percentage α was purportedly set at 30% for the digital books industry (WSJ Staff 2012). In our initial model, we assume that this revenue-sharing proportion is exogenously given and we show that for intermediate values of this region (i.e., $\alpha \in [0.25, 0.5]$) both the publisher and the retailer prefer the agency model to the wholesale model. Therefore, the current industry standard (i.e., $\alpha = 0.3$) lies within the Pareto efficient region. In section 6.2, we also consider the more

generalized possibility that the supply chain members utilize their relative bargaining power to determine the revenue-sharing proportion endogenously. Confirming our intuition, we find that the optimal value of the revenue-sharing proportion increases proportionately with the player's bargaining power. More interestingly, we also show that if the bargaining power of the retailer is relatively high, the optimal revenue-sharing proportion decreases as the consumer acceptance level of digital goods increases. This result indicates that when the relative bargaining power of the retailer is stronger, the retailer is willing to sacrifice a proportion of the total revenue in response to an increase in the consumer acceptance level of the digital goods.

We also analyze the impact of the consumer acceptance of digital goods (i.e., θ) on the optimal channel configuration. While the results discussed in the previous paragraphs address the current situation where the consumer acceptance of digital goods is relatively low (i.e., $\theta < 1$), we also develop results for the possibility that the consumer acceptance level of digital goods is greater than that of traditional goods. Recently, Stone (2012) emphasized that Amazon favored digital goods over traditional goods by stating that "Amazon wants to burn the book business." We essentially show that when consumers favor digital goods over traditional goods (i.e., $\theta \geq 1$), it is no longer profitable for the retailer and the publisher to provide traditional goods alongside digital goods, thus lending credibility to Stone's prophetic statement. While our main model focuses on vertically differentiated goods, we also consider the possibility of horizontal differentiation with two segments of customers, the high-type of customer has a higher consumer acceptance of digital goods, and the low-type of customer has a lower consumer acceptance of digital goods. Our results show that it is still optimal for the retailer to provide a dual channel strategy under these circumstances, although the supply chain may target each type of consumer with an alternate channel option depending on the relative proportion of each type of consumer. For example, under certain circumstances it is optimal to offer a single channel to each type of consumer (i.e., the traditional channel for the low-type consumer, and the digital channel for the high-type consumer), or to offer a dual channel to one type of consumer and a single channel to another type of consumer (i.e., the dual channel for the low-type consumer and the single digital channel for the high-type consumer).

We briefly note some limitations of this paper and provide promising directions for future research. First, we have considered a monopoly market with only one publisher and a single retailer. This setting is in line with the practice that Amazon controls the majority market share of the e-book market as well as the theory that a single firm will dominate the digital goods market (Jones and Mendelson 2011). However, it may be interesting to incorporate the competition between multiple retailers and publishers. Tan et al. (2016) and Kwark et al. (2016) have studied a setting with downstream competition between the retailers. Second, there may exist a two-sided network effect (Parker and Van Alstyne 2005) in the e-book industry where future research can investigate its influence on the platform investment (Anderson et al. 2014). Moreover, future research can also incorporate other unique features of the digital goods; for example, consumers can easily resell their used traditional goods, while this is impossible for their digital counterparts.

Notwithstanding these limitations, the current study presents a first step in understanding how the agency model impacts the performance of the supply chain as well as the consumer's welfare in the digital goods market. We believe that the rising popularity of digital goods presents an exciting area of research in technology management.

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Notes

[1]The US Department of justice accused Apple Inc. and five of the nation's largest publishers of conspiring to raise e-book prices on April 11, 2012. Details can be found at http://www.justice.gov/atr/cases/applebooks.html.

[2]We have also studied the fixed price model and the results are presented in the extension section. In the fixed price model, the retailer fixes the digital goods price at a predetermined value $\bar{P}_D$.

[3]An incentive alignment issue may occur if the publisher and retailer prefer different strategies due to a conflict of interest. For example, when $\theta < 1$, the publisher may prefer the dual channel strategy and distribute both traditional and digital goods to the retailer, but the retailer may respond by only distributing the physical goods and limiting the availability of the digital goods.

[4]We believe it is a mild assumption because this issue only occurs when the publisher prefers the dual channel strategy and the retailer prefers the single channel strategy

under the agency model. For the case $\theta < 1$, reflecting a situation where the digital goods market is still growing, the retailer has a strong incentive (e.g., building market awareness and loyalty) to sell through both channels, even though switching to a single traditional channel strategy may lead to a higher profit in a short term. This issue does not occur for the case where $\theta \geq 1$.

[5]Nielsen BookScan operates the continuous retail sales monitoring service for books, with purchase information representing sales through a majority of the major retailers each week.

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Supporting Information

Additional supporting information may be found online in the supporting information tab for this article:

Appendix A: Wholesale Model Scenario Proof, $\theta \geq 1$ and $\theta < 1$.

Appendix B: Vertically Integrated Supply Chain Proof.

Appendix C: Proof of Proposition 1.

Appendix D: Proof of Retailer's Agency Model.

Appendix E: Details of Analysis for Incentive Alignment Extension.

Appendix F: Details of Analysis for Endogenous Revenue Sharing Extension.

Appendix G: Proof of Heterogeneous Consumers' Perception of Digital Goods.

Appendix H: Fixed Price Model Scenario Proof, $\theta \geq 1$ and $\theta < 1$.

Appendix I: Proof of Proposition 5.