ABSTRACT

The agency model in the e-book industry has been highlighted in the press as a result of the U.S. Department of Justice’s (DOJ) lawsuit against Apple, Inc. We investigate the strategic impact of the agency model in comparison with the prevalent wholesale and fixed price models by formulating a dual channel model. Contrary to DOJ prosecutor’s argument, we find that the equilibrium price of e-book is lower in the agency model than in the conventional wholesale model. Furthermore, the agency model can increase firm’s profit as well as consumer surplus by mitigating the double marginalization effect.

KEYWORDS: Digital goods, Channel coordination, Agency pricing

INTRODUCTION

The book publishing industry is currently experiencing a "Digital Revolution" (Stone, 2012) impacting both demand and supply chain relations. While the sales of traditional books have been relatively flat for decades, the introduction of the e-book has started to “eclipse” the sales of traditional books. Specifically, the e-book has received widespread coverage in the business press due to increased demand. According to a recent report in the Los Angeles Times (May 2011), “Customers are now choosing Kindle books more often than print books, for every 100 print books sold on Amazon, 105 Kindle e-books have been sold.” Another report by the Association of American Publishers (AAP) also notes that the sales of e-books has reached $282.3 million in the first quarter 2012 while sales of hardcover books only amount to $229.6 million in the same time period. Explanations for this expansion in the e-book market include technological factors such as the decreasing costs of the e-book reader (Los Angeles Times, May 2011) and also the accessibility of e-books via alternate technological platforms. To illustrate, consumers can read their e-books on their PCs, laptops, tablets, and smartphones conveniently through the software application.

The digitalization of physical goods not only transforms consumers’ shopping habits, but also brings many challenges to business managers and policy makers for related industries. To illustrate, issues concerning consumer pricing and supplier negotiations are now more complex due to consumer perception of the digital goods and alternate revenue models with suppliers. Many new business models have evolved with the technology innovation, but not without concerns and suspicions. A case in point is the public attention brought by the U.S. Department of Justice’s (DOJ) lawsuit against Apple, Inc [The U.S. Department of justice accused Apple Inc.

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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](http://www.justice.gov/atr/cases/applebooks.html). The agency model utilized by the e-book publishing industry is central to this lawsuit. Before the introduction of the agency model, New York bestseller Kindle books were originally priced at $9.99 (i.e. 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 after that, publishers demanded to have the rights to price the digital goods (i.e. the “Agency Model”) in the marketplace due to cannibalization concerns. In the agency model, the publisher sets the price of the e-book and the retailer who serves as an agent retains a percentage of the revenue. The DOJ prosecutors stated that Apple colluded with publishers who were unhappy with Amazon’s aggressive pricing, and Apple proposed the controversial agency model to let the publishers set prices of e-books. Later the publishers required that all of the retailers including Amazon should adopt this new pricing model. Figure 1 illustrates an example of the agency model from Amazon. The prosecutors claim that as a result, the price of the digital version of New York Times bestselling books has increased from $9.99 to $12.99 and $14.99 after retailers adopted the agency model, and further the increased price impairs consumer’s benefits. A federal judge ruled on July 10th, 2013 (Ryan et al., 2013) that Apple conspired with major publishers to raise e-book prices, but Apple is still appealing the legal ruling.

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

In this paper, we analyze the consequential strategic distribution decisions facing retailers, publishers, and policy makers alike in the face of "Digital Revolution" (Stone, 2012). In particular, we utilize a game theory model to capture these alternate electronic publishing pricing schemes and discuss the impact of different pricing models. We compare several prevalent supply chain pricing schemes for the digital goods whereby the prices of the digital goods are set utilizing different mechanisms. First we consider the “Agency Model” where the publishers set the retail price for e-books. Under the agency model, the retailer retains a fixed proportion $\alpha$ of the digital book’s sales revenue. According to the media report (WSJ, 2012), the value of $\alpha$ was set at 30% in the book publishing industry, which denotes the situation where the retailer keeps 30% of the revenue associated with each digital book they sell and 70% of the revenue goes to the publisher. Next, we study the wholesale model which represents the current price setting game between the publisher and retailer. In the wholesale model, the publisher first offers both the digital book and traditional book at two separate wholesale prices. Then the retailer is free to offer the book to consumer at their preferred retail prices. The pricing
The mechanism for e-books has been switched from the controversial agency model to the wholesale model after major publishers settled with the Department of Justice around the beginning of 2013 (Tagholm, 2013). Initially, Amazon priced most of the New York Times best-seller books at $9.99 regardless of their actual cost. We also investigate the “Fixed Price” model which denotes the scenario where the price of the digital goods is treated as an exogenous variable, representing the early pricing model of the digital goods utilized by Amazon.

Through our comparison of three prevalent pricing schemes, we believe that the short-term observation (i.e. the price increase of e-book from $9.99 to a higher price) is not sufficient to conclude that consumers’ welfare has been compromised as claimed by the prosecutors. The initial low price of the bestselling books may be due to a consumer lock-in effect, building market awareness/share and other important factors (e.g. consumers may purchase other items when they purchase the discount e-book). Actually, Amazon is creating a “loss leader” by compensating consumer for each Kindle book they sell at $9.99 (Rich, 2009). In this study, we provide a more complete assessment of the long-term effect (i.e. equilibrium) of these prevalent pricing schemes and show that there are other benefits associated with agency model. Our results suggest that the regulators may have moved too quickly while ignoring the long-term positive impact of the agency model in their decision concerning the digital books market.

Others have expressed similar concerns about the regulators’ decision. US Senator Charles E. Schumer wrote an op-ed article in the Wall Street Journal (Schumer, 2012) urging the Department of Justice to drop the suit against Apple and several major publishers. The main focus of his article is to support the evolving agency model. The central argument for the senator’s proposal is the fact that the average price (including New York Times bestsellers and other books) for e-books fell to $7 from $9 after the introduction of the agency model. A recent study by Hao and Fan (2014) shows that the consumer surplus is higher in the agency model compared with the wholesale model. Hence, several natural and intriguing questions arise from our discussion above. How does the introduction of a digital goods channel affect the pricing strategies, the sales and the profits of a traditional goods channel? Under what scenario should the company focus on (a) only a digital goods channel, (b) only a traditional channel, or (c) both channels simultaneously? Which model, the agency model, the wholesale model, or the fixed price model is better for the e-book industry as a whole? Which pricing model do the retailers prefer? Are consumer surplus measures commensurate under these pricing schemes? We address these issues and provide valuable managerial insights to executives and policy makers alike by formalizing a game theoretic model.

Our results reveal that the agency model is a very effective pricing model for the e-book supply chain. At the early stage of the e-book market when consumers still favor the printed book, both publisher and retailers are better off under the agency model compared with the wholesale model. The intuition driving this result is that the agency model using a revenue sharing scheme for sales of the digital goods mitigates the double marginalization effect. While we validate that that consumers’ surplus does decrease after switching from the fixed price model to the agency model, our analysis highlights that high consumer surplus in the fixed price model is unsustainable. The forward-looking retailer is compensating the consumer for each digital book they sell to create “loss leader”. Eventually 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. Although the agency model has some similarities with the traditional revenue sharing contract, there are key differences in terms of the mechanism and implementation. Although our focus in this study is on the e-books industry, our results can resonate beyond e-books, with broader implications for providers of other digital goods.

Our analysis proceeds as follows. In the next section, we review the relevant literature and point out the contributions of the current study. In section 3, we introduce a consumer choice model
including channel pricing decisions when products are offered through a traditional goods channel as well as in digital goods channel. After analyzing the fixed price model, agency model, and wholesale model, respectively, in section 4, we compare both profit and consumer surplus measures under these pricing schemes in section 5. Section 6 presents several extensions of the basic model. The last section concludes this study by highlighting the implications and future research directions.

LITERATURE REVIEW

IS/Digital Goods Literature

Several papers in the Information Systems (IS) literature discuss the impact of digital goods on the value chain. Bockstedt et al. (2006) proposes a conceptual model to analyze the value chain of online digital music industry. Buxmann et al. (2007) utilize empirical methodologies to show that the value chain can reach Pareto-efficient solutions through the coordination of the stakeholders by offering a lower price to attract more demand. Jones and Mendelson (2011) conclude that the digital goods markets are dominated by a single firm because they lack the segmentation inherent in physical goods markets. Several additional papers specifically address issues facing the e-Book industry. The first one is by Jiang and Katsamakas (2010), who develop a game theory model to analyze the impact of the introduction of an e-book retailer under the situation where there is an online seller of physical books and another offline seller of physical books. Our research extends their previous work by considering the supply chain for the publishing industry involved in digital goods. In addition, we focus on a single dominant player which offers both traditional and digital goods simultaneously. Finally, we consider several decision scenarios whereby alternative members of the supply chain have control over various pricing options. Hu and Smith (2011) empirically analyze the impact of digital goods channels on traditional goods sales where the publisher makes the decision on whether or not to release the digital format. They find that delaying the release of the e-book relative to the corresponding traditional book causes a significant decrease in e-book sales. This result is consistent with our findings that the dual channel strategy is optimal when consumers start to accept digital goods as a substitute for traditional goods. Most recently, Hao and Fan (2014) develop an analytical model to study pricing mechanisms in the e-book publishing industry. They focus on the complementary consumption of e-readers and e-books as the driving force of the e-book price change between different pricing models. In this paper, we extend their study by endogenizing the physical book price and also considering a fixed price scenario. Similar to Hao and Fan (2014), we find that consumer surplus is higher in the agency model than in the wholesale model. However, in contrast to their results, we identify circumstances under which the social welfare and profit are also higher for the agency model as compared to the wholesale models.

OM/Dual Channel Literature

Several conceptual papers discuss the implications of the digital economy on operations management. Specifically, Hayes (2002) gives an overview of the challenges faced by the traditional operations management theories in the digital economy. Geoffrion (2002) poses a four-stage framework to solve these challenges. Karmarkar and Apte (2007) highlight the difference between a material-based economy and an information-based economy. Although they find that traditional Operations Management (OM) toolkits and concepts are applicable and
useful to a great extent in the information economy, their conclusion is mixed. They also identify circumstances under which there are differences when analyzing some of the most basic OM issues related to productivity, cost, value and transformation due to the fundamental difference between these two economies.

Another stream of research associated with OM literature focuses on interactions between traditional and direct channels (i.e. internet channels). Chiang et al. (2003) formulate a model whereby a manufacturer adds a direct channel as a substitute for shopping at an alternate traditional retail store. In their seminal work on dual channel distribution, they show that the addition of a direct channel increases overall profitability of the supply chain by reducing the degree of double marginalization between the manufacturer and retailer. Arya et al. (2007) similarly conclude that the introduction of a direct channel may not always be detrimental to the traditional retailer. 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. Cattani et al. (2006) also find that under an equal-pricing framework, the traditional retailer does not need to view the addition of a direct channel as harmful competition but rather a mechanism for segmenting the market to benefit both the manufacturer and the retailer. Our research extends the above works not only by incorporating digital goods but also considering alternate supply chain structures and different pricing schemes. In previous studies, the manufacturer can cut through the retailer and reach the customers directly. However, in our study, the publisher/supplier has to use the platform provided by the retailer to sell digital goods in the marketplace.

A substantial number of research papers focus on the dual channel problem in physical goods only. Interested readers in this topic should refer to Cattani et al. (2004) and Tsay and Agrawal (2004) who review recent research related to the coordination and competitive models of dual channel management.

**Contribution to the Literature**

This study makes both theoretical and practical contributions to the technology management literature. From a theoretical perspective, our model closes the gap between two streams of research by linking the information system literature in digital goods with dual channel models in operation management. We explain how the agency model can mitigate the double marginalization effect in the digital goods supply chain. More importantly, we identify and conceptualize the similarity as well as difference between the agency model and traditional revenue sharing contract. From a practical point of view, we compare the profitability and consumers’ welfare for different pricing schemes (i.e. agency model, wholesale model and fixed price model). Our results indicate that in the long-run, the agency model may be a better pricing model for the digital goods market by alleviating the double marginalization effect as well as passing the benefits to the consumers.

**NOTATION AND MODEL**

In this section, we introduce a consumer choice model including channel pricing decisions when products are offered through a traditional channel as well as in digital channel. Throughout this study, we use the subscript $T$ to denote the traditional retail channel, and the subscript $D$ to denote the digital retail channel. Also, we use the subscript $P$ to denote the publisher, and $R$ to denote the retailer, respectively. The notation for the model is summarized in Table 1.

**Table 1: Summary of Model Variables**
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>Consumer valuation on traditional (physical) goods</td>
</tr>
<tr>
<td>( \hat{V} )</td>
<td>Consumer reservation value, highest price the consumer is willing to pay</td>
</tr>
<tr>
<td>( P_T )</td>
<td>Retail price of traditional goods</td>
</tr>
<tr>
<td>( P_D )</td>
<td>Retail price of digital goods</td>
</tr>
<tr>
<td>( \bar{P}_D )</td>
<td>Fixed Price of digital goods</td>
</tr>
<tr>
<td>( C_T )</td>
<td>Wholesale price of traditional goods charged by the publisher</td>
</tr>
<tr>
<td>( W_T )</td>
<td>Retail price of digital goods</td>
</tr>
<tr>
<td>( \theta )</td>
<td>Consumer acceptance level of digital goods; ( \theta &gt; 0 )</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>Proportion of the revenue that the retailer keeps from the sale of digital goods; ( 0 &lt; \alpha &lt; 1 )</td>
</tr>
<tr>
<td>( V_{k}^I )</td>
<td>Valuation threshold for consumers buying from channel ( k ) (( k=\text{D or T} ))</td>
</tr>
<tr>
<td>( V^e )</td>
<td>Valuation threshold for consumers are indifferent from both channel</td>
</tr>
<tr>
<td>( Q_T )</td>
<td>Demand for traditional goods</td>
</tr>
<tr>
<td>( Q_D )</td>
<td>Demand for digital goods</td>
</tr>
<tr>
<td>( \pi_{i,k} )</td>
<td>Net profit of player ( i ) (( i=\text{P or R} )) on the supply chain associated with channel ( k ) (( k=\text{D or T} ))</td>
</tr>
<tr>
<td>( CS_K )</td>
<td>Total consumer surplus associate with channel ( k ) (( k=\text{D or T} ))</td>
</tr>
<tr>
<td>( SW )</td>
<td>Total Social Welfare</td>
</tr>
</tbody>
</table>

**Single Channel Model**

Initially, we introduce the basic model of consumer choice and the channel pricing decision when products are only offered through a single channel. Let \( V \) denote the heterogeneous consumers’ willingness to pay for traditional goods. We assume \( V \) is uniformly distributed between zero and the reservation value, i.e., \( V \in [0, \hat{V}] \). Note that a uniform demand distribution not only allows us to capture the consumers’ heterogeneity in valuation but also preserves the tractability of the model. Also, let \( P_T \) denote the retail price of traditional goods. Similar to other consumer choice models, all consumers whose valuation is greater than \( P_T \) will purchase the product while all consumers with valuations strictly less than \( P_T \) will not purchase the product. Consumers whose valuation is exactly \( P_T \) are indifferent to buying or not. We denote the valuation threshold for traditional goods that consumers are indifferent buying (or not) as \( V^I_T \). The total market size is normalized to one, thus the demand for the traditional goods is:

\[
Q_T = Pr(\hat{V} - P_T \geq 0) = (\hat{V} - P_T) \frac{1}{\hat{V}} \tag{1}
\]

The publishing company supplies an exclusive retailer at a wholesale price, \( W_T \) with a cost \( C_T \), which includes the cost of production and logistics. In the single traditional goods channel, the publisher’s profit is characterized by:

\[
\pi_{\text{P,T}} = (W_T - C_T) Q_T = (W_T - C_T) (\hat{V} - P_T) \frac{1}{\hat{V}} \tag{2}
\]

The retailer’s profit is determined by

\[
\pi_{\text{R,T}} = (P_T - W_T) Q_T = (P_T - W_T) (\hat{V} - P_T) \frac{1}{\hat{V}} \tag{3}
\]

Similar to many models based on Mussa and Rosen (1978), we introduce a variable to
represent the non-negative consumer acceptance level \( \theta \), to capture the consumers’ perception of digital goods [Our demand model can be easily extended to incorporate the heterogeneous consumers’ perception of digital goods by introducing the discrete distribution over \( \theta \) (e.g. there exist \( \lambda \) consumer with \( \theta_1 \) and 1- \( \lambda \) with \( \theta_2 \)). However, this complication does not add new insights since our focus of this paper is to study the strategic implication of different pricing models. Without loss of main qualitative insights, we keep our model as parsimonious as possible.]. From a practical perspective, if \( \theta \) is greater than one, it denotes the situation where consumers prefer digital goods to traditional goods and vice versa. The variable \( \theta \) is influenced by retailer or publisher through the means of introduction of new technology, lowering the price of digital book readers, marketing promotions and etc. According to a consulting company survey conducted from 1000 target customers in May 2010, most readers are willing to pay 20\%-70\% (i.e. \( \theta \in [0.2,0.7] \)) of the traditional book price for the same digital version of the book (PWC, 2011)[In this study, we do not restrict the value of \( \theta \) to be less than one which is supported by current empirical evidence. Instead we believe this value will increase along the time due to on-going technology innovations.]. If a digital goods channel exists with the retailer pricing at \( P_D \) and the consumers’ valuation is \( \theta V \), then the resulting consumer surplus is \( \theta V - P_D \). If this value is strictly larger than zero, consumers will purchase the digital goods. If the surplus is less than zero, consumers will not purchase the digital goods and if the surplus is equal to zero, consumers are indifferent between buying or not. We characterize the indifferent valuation of purchasing from digital goods channel as \( V_D^{I} \). When there is only a single channel of digital goods, then the consumer demand for the digital goods is as follows:

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

There are two common cost structures (Chellappa and Shivendu, 2007) for digital goods retailers, which are fixed-fee licensing (FFP) and per-copy licensing (PCP). We use a per-copy licensing scheme in our study, which is the common practice of e-book publishing industry. Essentially, the retailer reimburses a constant wholesale price \( W_D \) or shares a portion of her revenue with the publisher for the sales of each book. The former one is refereed as the wholesale model and the later one is called agency model in publishing industry. Capturing a key feature of the digital goods (Sundararajan, 2004), we set the marginal production cost for the digital goods to zero. As a result, for each digital product sold under the agency model, the retailer earns \( \alpha P_D \) as profit, where \( \alpha \) denotes the proportion of sales that retailer keeps and \( 1-\alpha \) denotes the proportion of sales that the upstream publisher retains.

**Dual Channel Model**

In this section, we introduce a consumers’ choice model when the retailer owns both the traditional goods and digital goods channels (similar to Amazon or Barnes & Noble who both own the distribution channel of printed books and also digital books). As we have shown earlier, \( V_T^{I} \) and \( V_D^{I} \) are the consumer valuation threshold that consumers will choose to purchase from the traditional or the digital goods channel, respectively. If consumers’ valuation is greater than both thresholds, then consumers will compare the surplus derived from both channel and choose to purchase from the channel with higher consumer surplus (Chiang et.al, 2003; Chiang et.al, 2005; Dumrong Sirisiri, et.al, 2008). The surplus from buying the traditional goods and the digital goods are \( V - P_T \) and \( \theta V - P_D \), respectively. We characterize \( V^c = \frac{P_T - P_D}{1-\theta} \) as
the level where consumers are indifferent buying from either channel and thus we have the following result.

If the consumer’s acceptance level \( \theta \) is greater than 1, which denotes the situation where consumers prefer the digital goods to the traditional goods, then with \( V < V^e \), consumers will choose to purchase from traditional goods channel and if \( V > V^e \), consumers will purchase the digital goods instead. Similarly if the consumer’s acceptance level \( \theta \) is less than 1, consumers will purchase from traditional goods channel if \( V > V^e \) and from the digital goods channel if \( V < V^e \). Next, we derive the dual channel demand function under these two cases. We assume \( C_T \leq \hat{V}(1-\theta) \) to eliminate uninteresting cases where demand of traditional goods is less than zero.

**Case1** \( \theta \geq 1 \): When \( V_T < V_D^I \) (i.e. \( P_T < \frac{P_D}{\theta} \)), we can show that \( V_T < V_D^I < V^e \) by some algebraic steps. All consumers whose valuation is in the interval \([0, V_D^I]\) will not purchase from either channel, consumers with valuation in the interval \([V_D^I, V^e]\) will choose to purchase from the traditional goods channel and consumers whose valuation is in the interval \([V^e, \hat{V}]\) will purchase the digital goods, which illustrated in the Figure 2.

**Figure 2**: Consumers purchasing choice under \( V_T < V_D^I \) when \( \theta \geq 1 \)

<table>
<thead>
<tr>
<th>None</th>
<th>Traditional Channel</th>
<th>Digital Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>( V_D^I )</td>
<td>( V^e )</td>
</tr>
</tbody>
</table>

For the case when \( V_T^I \geq V_D^I \) (i.e. \( P_T \geq \frac{P_D}{\theta} \)), then \( V^e < V_D^I < V_T^I \). Therefore consumers whose valuation is in the interval \([0, V_T^I]\) will not purchase from either channel, consumers with valuation in the interval \([V_D^I, \hat{V}]\) will choose to purchase from the digital goods channel.

The intuition behind this result is straightforward. If the consumers prefer the digital goods to the traditional goods and the price of traditional goods is higher than the relative price of digital goods, then the best choice for consumers is to purchase from the digital goods channel.

Based on the above analysis, we derive the demand function when \( \theta \geq 1 \) as:

\[
Q_T \begin{cases} 
\frac{P_T - P_D}{1-\theta} \left( \frac{1}{V} \right) \frac{P_D}{\theta} & \text{if } P_T < \frac{P_D}{\theta} \\
0 & \text{if } P_T \geq \frac{P_D}{\theta}
\end{cases} \quad Q_D = \begin{cases} 
\left( \frac{\hat{V} - P_T - P_D}{\hat{V}} \right) \frac{1}{P_T} \frac{P_D}{\theta} & \text{if } P_T < \frac{P_D}{\theta} \\
0 & \text{if } P_T \geq \frac{P_D}{\theta}
\end{cases}
\]

**Case2** \( \theta < 1 \): Analogously, we can derive the demand function when \( \theta < 1 \), which denotes
the situation where consumers prefer the traditional goods to digital goods:

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

\[ Q_D = \begin{cases} 
0 & P_T < \frac{P_D}{\theta} \\
\frac{P_T - P_D}{1 - \theta} & P_T \geq \frac{P_D}{\theta}
\end{cases} \] (6)

ANALYSIS

In this section, we analyze three prevalent contract forms in the e-book publishing industry. The motivation stems from the current practice of an e-book price setting game between the publisher and the retailer. As quoted by the Senior Vice President of Apple Eddy Cue during the Department of Justice lawsuit (Ryan, et al., 2013), “Clearly, the biggest issue is in new release pricing......” Consequently, we abstract our analysis away from the e-book rental program, free e-book publications and other business initiatives but focus on the distribution and pricing decision of the purchase of newly released books.

We model the interaction between the publisher and the retailer by using a Stackelberg game and consider the three different scenarios including the Agency, Wholesale and Fixed Price Models. The publisher has access to original content from the authors and serves as the game leader by moving first in all of the models. The retailer as the follower will observe the publisher’s decision and then make her best response accordingly. The major difference between the agency model and the other two pricing schemes lies in the fact that the publisher can control the sales price of the digital goods in the agency model. The wholesale model is the traditional contract form which is widely used in the physical goods market, while the fixed price model is a special case of the wholesale model where the retailer fixes the digital goods price at a pre-determined value \( \hat{P}_D \). We have illustrated the details of these pricing models in Figure 3. We also assume that in both stages of the game, both the publisher and the retailer have the same information about consumer demand and the costs (complete and perfect information). For the remainder of the paper, we use the pronoun “he” to represent the publisher and “she” to represent the retailer.
Due to the piecewise demand functions, we separate our solution space into three different strategies, which we call dual channel strategy, single channel strategy and equivalent price strategy (similar to (Chiang, 2003)). In the dual channel strategy, demand will be positive in both distribution channels. In the single channel strategy, the retailer will only open either a single digital goods channel or traditional goods channel. In the equivalent price strategy, the retailer sets the price \( P_T = \frac{P_D}{\theta} \) (i.e. the traditional goods price equals the relative price of the digital goods) such that effective sales will only occur in one channel although both channels are open. If both the single channel and equivalent price strategies lead to the same profit, the publisher will make a channel distribution decision based on marketing initiatives and customer service support (e.g. there are some loyal customers who insist on printed books, and so the retailer may open the traditional goods channel to satisfy their requirements). The problem is solved by utilizing the backward induction technique. In this section, we mainly present the analysis for \( \theta < 1 \) and we solve for the case when \( \theta \geq 1 \) by following a similar set of steps. We analyze the results when \( \theta \geq 1 \) in the next section, where the single digital channel strategy and equivalent price strategy are the optimal channel strategy choices across all different pricing models.

One of the key arguments in the Department of Justice case is that the "Agency Model" scenario will hurt the consumers' interest by increasing prices for digital books. Instead of just simply comparing the price under different scenarios, we utilize a more holistic measure of social welfare to capture the impact of different decision sequences on society. Similar to Fishman and Rob (2000), we define social welfare as a sum of the supply chain profit and consumer surplus. Consumer surplus is the total difference between the maximum price a consumer is willing to pay and the actual price. We calculate the consumer surplus as

\[
CS = CS_T + CS_D = \frac{1}{2}(\hat{V} - V^c)Q_T + \frac{1}{2}(V^e - V^d)Q_D \quad \text{when} \quad \theta < 1
\]

and if the dual channel strategy has been chosen. If the single (traditional) channel strategy or equivalent price strategy has been selected, then

\[
CS = CS_T + CS_D = \frac{1}{2}(\hat{V} - V^c)Q_T
\]

And correspondingly, we analyze profit, consumer surplus and social welfare measures when \( \theta \geq 1 \).

**Agency Model**

Under an agency model, the publisher takes control of retail pricing. In the first stage, the publisher will declare the wholesale price \( W_T \) and digital goods retail price \( P_D \) simultaneously, then the retailer will respond to the publisher's decision by setting the corresponding retailer price \( P_T \) in the second stage. Similar to current practice in the e-book industry, we assume that the revenue sharing proportion \( \alpha \) is industry specific and exogenous. Later in the extension to the basic model, we relax this assumption. Essentially, the retailer simply becomes a sales agent from which consumers can purchase the e-book. The retailer is not allowed to charge a different price from the publisher’s decision for the digital goods. In the optimization problem utilizing backwards induction, we first solve the retailer’s problem,

\[
\max_{p_T} \pi_R = \pi_{R,D} + \pi_{R,T} = \alpha P_D Q_D + (P_T - W_T)Q_T
\]

After characterizing the optimal value of \( P_T = \arg\max \pi_{R}(W_T, P_D) \), we substitute back into
the publisher's problem to decide the optimal wholesale price \( W_T \) and digital goods price \( P_D \).

\[
\max_{W_T, P_D} \pi_p = \pi_{p,D} + \pi_{p,T} = (1-\alpha)P_DQ_D + (W_T - C_T)Q_T
\]

We next provide the details of the analysis and focus primarily on the case where \( \theta < 1 \), which represents the situation where consumers prefer traditional goods to digital goods. Because of the piecewise demand function, the retailer needs to solve two separate optimization problems with different constraints: \( P_T \geq \frac{P_D}{\theta} \) (i.e. corresponding to the dual channel and equivalent price strategies) and \( P_T < \frac{P_D}{\theta} \) (i.e. corresponding to the single traditional channel strategy). The first order conditions (FOCs for brevity) are necessary and sufficient to determine the optimal solution of \( P_T \) given \( W_T \) and \( P_D \). Correspondingly, we have the following results:

\[
P^*_T(W_T, P_D) = \begin{cases} 
\frac{1}{2} \left[ P_D + \alpha P_D + \dot{V} - \theta \dot{V} + W_T \right] & \text{if } P_T > \frac{P_D}{\theta} \text{ (Dual Channel)} \\
\frac{P_D}{\theta} & \text{if } P_T = \frac{P_D}{\theta} \text{ (Equivalent Price)} \\
\frac{\dot{V} + W_T}{2} & \text{if } P_T < \frac{P_D}{\theta} \text{ (Single Traditional)} 
\end{cases}
\] (9)

In the basic model, we do not consider the incentive alignment issue [An incentive alignment issue may occur if the publisher and retailer prefer different strategies. 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 digital goods.] 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 helps us to concentrate on the strategic implications of the agency model. Later in the extension, we show that relaxing this mild assumption [We believe it's a mild assumption because this issue only occurs when the publisher prefers the dual channel strategy and the retailer prefers the single channel strategy. 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 although switching to a single traditional channel strategy may lead to a higher profit in a short-term. Further, this issue does not occur for the case \( \theta \geq 1 \) 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 dual channel strategy and single channel strategy are viable. We summarize the results in the following lemma.

**Lemma 1.** Under the agency model and when \( \theta < 1 \), the equilibrium entails:

**Pricing:**  

- **Dual Channel Strategy**  
  \( W_T = \frac{1}{2} [C_T + \dot{V} - \alpha \theta \dot{V}] \),  
  \( P_D = \frac{\theta \dot{V}}{2} \),  
  \( P_T = \frac{1}{4} [C_T - (\theta - 3) \dot{V}] \)

- **Single Traditional Channel Strategy**  
  \( W_T = \frac{C_T + \dot{V}}{2} \),  
  \( P_T = \frac{1}{4} [C_T + 3 \dot{V}] \)
Quantities: 

**Dual Channel Strategy** \[ Q_D = \frac{1}{4} \left[ 1 + \frac{C_T}{V - \theta V} \right], \quad Q_T = \frac{1}{4} \left[ 1 + \frac{C_T}{V - \theta V} \right] \]

**Single Traditional Channel Strategy** \[ Q_D = 0, \quad Q_T = \frac{[\dot{V} - C_T]}{4 V} \]

Profits and Consumer Surplus: 

**Dual Channel Strategy**

\[
\pi_P = \frac{1}{8} \left[ (1 + \theta - 2\alpha) \dot{V} + C_T \left( \frac{C_T}{V - \theta V} - 2 \right) \right], \quad \pi_R = \frac{1}{16} \left[ \dot{V} - \theta \dot{V} + 4\alpha \theta \dot{V} + \frac{C_T^2}{V - \theta V} - 2 C_T \right], \quad CS = \dot{\theta} \\
C_T^2 + \dot{V}^2 \dot{\theta}
\]

**Single Channel Strategy**

\[
\pi_P = \frac{[C_T - \dot{V}]^2}{8 V}, \quad \pi_R = \frac{[C_T - \dot{V}]^2}{16 V}, \quad CS = \frac{[\dot{V} - C_T]^2}{32 V}
\]

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

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

We have illustrated this constraint with respect to the revenue sharing proportion \( \alpha \) and consumer acceptance level \( \theta \) in Figure 4. Region 1 represents the situation when publisher prefers the dual channel strategy to single traditional channel strategy, and Region 2 denotes the parameter setting where the publisher favors the single traditional channel strategy.

Figure 4: Illustrations of Optimal Regions of Dual Channel Strategy in Agency Model (\( \theta < 1 \))

(Note: The above figure is an illustration of the special case where \( \dot{V} = 30 \) and \( C_T = 3 \), but further numerical experimentation shows that the configuration is robust to the different values of parameters)
Recall that the value of $\alpha$ is the proportion of the revenue that the retailer keeps from the sale of digital goods, while the publisher keeps the remaining $1 - \alpha$. Consistent with our intuition, generally speaking, the publisher prefers the dual channel strategy to the single traditional channel strategy when she retains a larger portion of the revenue (i.e., a small value of $\alpha$) from the digital goods sales and vice versa. However, when the consumer acceptance level $\theta$ approaches to one, the publisher prefers the dual channel strategy even when the division of the digital goods sales is in favor of the retailer. This is because the equilibrium price of the digital goods $P_D = \frac{\theta V}{2}$ is linearly increasing in $\theta$ and the demand of the digital goods is also increasing in $\theta$. Furthermore, the traditional goods price 

$$P_T = \frac{1}{4} \left[ 3\dot{V} + C_T - \theta V \right]$$

is linearly decreasing in the consumer acceptance level $\theta$. Hence, the publisher’s profit is mainly attributed to the digital goods sales when $\theta$ approaches to one and the publisher is better off with the dual channel strategy even the revenue sharing proportion is favorable to the retailer.

**Wholesale Model**

In the wholesale model, the retailer is free to set the digital goods price at her preferred level. In the beginning of the game, the publisher declares his preferred wholesale price for the traditional goods $W_T$ and digital goods $W_D$, respectively. After observing the wholesale prices, the retailer responds by setting the price for both traditional goods and digital goods simultaneously. In contrast to the agency model, analysis of the wholesale model yields a solution whereby the dual channel strategy dominates both the single channel and equivalent price strategy for both the retailer and the publisher when $\theta < 1$. We summarize the results of the wholesale model in Lemma 2 and proofs are provided in Appendix A.

**Lemma 2.** Under wholesale model and when $\theta < 1$, the equilibrium entails:

Pricing: Dual Channel Strategy

$$W_T = \frac{C_T + \dot{V}}{2}, \quad W_D = \frac{\theta \dot{V}}{2}, \quad P_T = \frac{3\dot{V}}{4}$$

$$P_T = \frac{1}{2} \left[ \dot{V} + \frac{C_T + \dot{V}}{2} \right]$$
Profits and Consumer Surplus:  

Quantities:  

\[ Q_D = \frac{C_T}{4V(1-\theta)}, Q_T = \frac{1}{4}[1 + \frac{C_T}{\theta V - V}] \]

Pricing:  

Dual Channel Strategy  

\[ W_D = W_T = W \]

Dual Channel Strategy  

\[ P_D = P_T = \frac{\theta V}{2} \]

Dual Channel Strategy  

\[ Q_D = \frac{1}{2} \frac{\theta V}{\theta V}, \quad Q_T = \frac{1}{2} \]

Dual Channel Strategy  

\[ \pi_p = \frac{1}{8} \left[ V + C_T \left( \frac{C_T}{V - \theta V} - 2 \right) \right], \quad \pi_r = \frac{1}{16} \left[ V + C_T \left( \frac{C_T}{V - \theta V} - 2 \right) \right], \quad CS = \frac{1}{32} \left[ V - 2C_T[1-\theta]V + 2C_T^2 \right] \]

Note that both the wholesale price and sales price of digital goods \( W_D \) and \( P_D \) increase with the consumer acceptance level \( \theta \). Consequently, the publisher and retailer profit both increase corresponding to higher levels of \( \theta \). The implication from this result is that, there exists a strong incentive for both 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 audiobooks. Likewise, the retailers can increase consumers’ experience when utilizing digital books by pursuing activities such as introducing new technology on the digital book reader and offering a better online preview system.

Fixed Price Model

When Amazon first introduced the Kindle reader and digital books, they sold their newly released bestsellers for a fixed price at $9.99 (Stone, 2012). 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 bestseller 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 numerous media reports (Rich & Stone, 2010; Bransford, 2012). 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 \( P_T \). Therefore, the fixed price model is a special case of the wholesale price model where (a) the price of the digital goods is given or fixed, and (b) the wholesale price for the digital goods is equivalent to the wholesale price for the traditional goods. We summarize the results of the fixed price model in Lemma 3 and proofs are provided in Appendix B.

Lemma 3. Under the fixed price model and when \( \theta < 1 \), the equilibrium entails:

(a) When \( P_D < P_{D\text{Dual}} = \frac{\theta V}{2} \)

Pricing:  

Dual Channel Strategy  

\[ W = P_T, \quad P_T = P_D + \frac{1}{2}[1-\theta]V \]

Dual Channel Strategy  

\[ Q_D = \frac{1}{2} \frac{P_D}{\theta V}, \quad Q_T = \frac{1}{2} \]

Dual Channel Strategy  

\[ \pi_p = \frac{1}{8} \left[ \theta V - P_D \right], \quad \pi_r = \frac{1}{16} \left[ \theta V - 2P_D \right], \quad CS = \frac{1}{32} \left[ \theta V - 2P_D \right] \]

(b) When \( P_{D\text{Dual}} \leq P_D < P_{D\text{Single}} = \frac{\theta [C_T + 3V]}{4} \)
Pricing: \[ W = \bar{P}_D, \quad P_T = \frac{\bar{P}_D}{\theta} \]

Quantities: \[ Q_D = 0, \quad Q_T = 1 - \frac{\bar{P}_D}{\theta V} \]

Profits and Consumer Surplus: \[ \pi_P = \left( C_T + \bar{V} \right)^2, \quad \pi_R = 0, \quad CS = \frac{\bar{V} - C_T}{8V} \]

(c) When \( \bar{P}_D \geq P_D^{\text{Single}} \)

Pricing: \[ W = \frac{C_T + \bar{V}}{2}, \quad P_T = \frac{C_T + 3\bar{V}}{4} \]

Quantities: \[ Q_D = 0, \quad Q_T = \frac{\bar{V} - C_T}{4V} \]

Profits and Consumer Surplus: \[ \pi_P = \frac{\bar{V} - C_T}{8V}, \quad \pi_R = \frac{\bar{V} - C_T}{16V}, \quad CS = \frac{\bar{V} - C_T}{32V} \]

While the fixed price model is a special case of the wholesale model, the results are quite different reflecting the retailer’s choice to set the fixed price prior to the start of the game. When consumers prefer traditional goods to digital goods in the marketplace (i.e. \( \theta < 1 \)), then there are several thresholds for the price of the digital goods which drive the optimal strategy. When the price set for the digital goods is relatively low (\( \bar{P}_D < P_D^{\text{Dual}} \)), then the sales of the digital goods can effectively augment the sales the traditional goods without cannibalization. When the price set for the digital goods is in an intermediate range (\( P_D^{\text{Single}} \leq \bar{P}_D \leq P_D^{\text{Single}} \)), then the publisher’s profit is higher when they utilize an equivalent price strategy. Finally, when the price set for the digital goods is relatively high (\( P_D^{\text{Single}} < \bar{P}_D \)), then the publisher optimally utilizes the single channel strategy selling only traditional goods.

In the fixed price model, the retailer keeps the digital goods price at \( \bar{P}_D \) regardless of the product characteristics. However, conceding control of the price may result in an unfavorable short-term outcome in terms of the retailer’s profit. For example, the retailer in this case will actually earn a negative profit for the dual channel strategy, and zero profit for the equivalent price strategy. In most supply chains, the negative profit would be unacceptable to the retailer and consequently, the retailer would not agree to such a contract. However, empirical/anecdotal evidence exists which indicates that indeed, this was the situation for Amazon. In fact, an article in The New Yorker states simply that, "Amazon had been buying many e-books from publishers for about thirteen dollars and selling them for $9.99, taking a loss on each book in order to gain market share and encourage sales of its electronic reading device, the Kindle," (Auletta, 2010). 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, such 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.

**IMPLICATIONS FOR DIGITAL GOODS MANAGEMENT**
In this section, we compare and contrast the agency model with the wholesale model as well as the fixed price model. To serve as a benchmark, we include the results from a vertically integrated supply chain and provide the details concerning the derivation in the appendix. In fact, recent media has disclosed that the retailer Amazon is moving aggressively toward publishing in-house by hiring editors and expanding their publishing department (Streitfield, 2011; Stone, 2012). It’s interesting to explore the impact of such vertical integration on the optimal pricing and consumer surplus measures. We summarize all of the possible channel strategies under different supply chain structures in the following Table 2.

Table 2: Possible Channel Strategies of Dual Channel Supply Chain in Digital Goods

<table>
<thead>
<tr>
<th>Supply Chain Structure</th>
<th>$\theta &lt; 1$</th>
<th>$\theta \geq 1$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Price Model</strong></td>
<td>• Single Traditional/Equivalent Channel</td>
<td>• Single Digital/Equivalent Channel</td>
</tr>
<tr>
<td></td>
<td>• Dual Chanel</td>
<td></td>
</tr>
<tr>
<td><strong>Agency Model</strong></td>
<td>• Single Traditional Channel</td>
<td>• Single Digital/Equivalent Channel</td>
</tr>
<tr>
<td></td>
<td>• Dual Chanel</td>
<td></td>
</tr>
<tr>
<td><strong>Wholesale Model</strong></td>
<td>• Dual Channel</td>
<td>• Single Digital/Equivalent Channel</td>
</tr>
<tr>
<td><strong>Integrated Supply Chain</strong></td>
<td>• Dual Channel</td>
<td>• Single Digital/Equivalent Channel</td>
</tr>
</tbody>
</table>

We begin the analysis by considering the situation when consumers prefer digital goods over 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 3.

Table 3: Comparison of different models when $\theta \geq 1$

<table>
<thead>
<tr>
<th></th>
<th>Agency Model/Integrated Supply Chain</th>
<th>Wholesale Model</th>
<th>Fixed Price Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Price</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Goods Price, $P_D$</td>
<td>$\theta V$</td>
<td>$3\theta V$</td>
<td>$P_D$</td>
</tr>
<tr>
<td>Wholesale price, $W_D$</td>
<td>n/a</td>
<td>$\theta V$</td>
<td>$P_D$</td>
</tr>
</tbody>
</table>

| **Quantities**       |                                      |                 |                  |
| Digital Goods, $Q_D$ | $\frac{1}{2}$                      | $\frac{1}{4}$  | $1 - \frac{P_D}{\theta V}$ |
| Traditional Goods, $Q_T$ | 0                                    | 0               | 0                |

| **Profit**           |                                      |                 |                  |
| Publisher’s profit, $\pi_P$ | $\frac{1}{4}[1-\alpha] \theta V$ | $\frac{\theta V}{8}$ | $P_D - \frac{P_D^2}{\theta V}$ |
Tan & Carrillo
The Agency Model in the Electronic Publishing Industry

Retailer’s profit, $\pi_R$

\[ \frac{1}{4} \alpha \theta \hat{V} \quad \frac{\theta \hat{V}}{16} \quad 0 \]

Supply chain, $\pi_R + \pi_P$

\[ \frac{\theta \hat{V}}{4} \quad \frac{30 \hat{V}}{16} \quad \hat{P}_D - \frac{\hat{P}_D^2}{\theta \hat{V}} \]

Consumer Surplus, $CS$

\[ \frac{\hat{V}}{8} \quad \frac{\hat{V}}{32} \quad \frac{1}{2} [1 - \frac{\hat{P}_D}{\theta \hat{V}}][\hat{V} - \frac{\hat{P}_D^2}{\theta}] \]

**Proposition 1:** When the consumer acceptance level of digital goods $\theta$ is greater than one, the equivalent price strategy and single digital channel strategy dominate the dual channel strategy and yield same profit across all different scenarios.

The proof of this proposition directly follows from the preceding analysis of each model. The intuition behind this result is that consumers prefer digital goods to traditional goods when $\theta$ is greater than one. In this situation, digital goods have a relative cost advantage over traditional goods, which leads to zero sales in the traditional goods channel. One should notice that the profit is the same for the publisher to accept the single digital goods strategy or equivalent price strategy. Consequently, the strategy decision here should be based on the company’s marketing initiative and customer service support (e.g., there may exist some loyal customers who insist on printed books, and so the publisher and retailer may open the traditional goods channel to satisfy their requirement). We also notice that the agency model enjoys the same supply chain profit as in the integrated supply chain case, which leads to our next proposition.

**Proposition 2:** When the consumer acceptance level of digital goods $\theta$ is greater than one, the Agency Model achieves supply chain coordination.

Since the sales volume drops to zero for the traditional goods, the agency model essentially mimics a simple revenue sharing scheme whereby the retailer only shares a pre-determined proportion $\alpha$ of her revenue with the publisher. As established in previous literature (Cachon & Lariviere, 2004), the supply chain will reach its coordination under this pricing scheme. And we also notice that the supply chain performances of the wholesale and fixed price models are suboptimal due to the double marginalization effect.

Further, our results reveal that the fixed price strategy is not a realistic pricing model for the retailer when consumer prefers 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 $\hat{P}_D$ and extract the entire surplus. Essentially, this result is consistent with our observations that Amazon’s fixed price policy is only a short term marketing strategy by creating a “loss leader.” Apparently such strategy is not viable when the digital goods market matures.

From Table 3, we also find that there exists a region of 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 $\alpha$ provides practical guidance for managers operating in the e-book industry. From a theory perspective, this is also a very interesting result because as 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 abandoning its pricing right and solely relying upon the publisher’s pricing decision. In summary, we find that when the consumer acceptance level of digital goods is greater than one, the agency model is a very efficient contract form not only improving the supply chain performance but also benefiting the retailer and publisher individually. Next we focus on the strategic channel design when the consumer acceptance level of digital goods is less than one. We concentrate on the comparison between the agency model and wholesale model followed by the fixed price model.

**Proposition 3:** Consider the situation where the consumer acceptance level of the digital goods
\( \theta \) is less than one. If the revenue sharing proportion, \( \alpha \in [0.25, 0.5] \), then the dual channel strategy is optimal for the Agency Model, and also the Agency Model yields a higher profit (than the wholesale model) for both the publisher and the retailer. When both players adhere to a single channel strategy for the Agency Model, this strategy yields a lower profit than the dual channel strategy using the Wholesale Model for both the publisher and the retailer.

It’s straightforward to show that both the publisher and retailer earn a lower profit with the single traditional channel strategy under the agency model as compared with the dual channel strategy with the wholesale model. The intuition behind this result is that the single traditional channel strategy under the agency model only captures the market for traditional goods, while the dual channel strategy under the wholesale model attracts both the traditional and digital goods consumers. The agency model under this situation fails to share the revenue from the digital goods between the publisher and retailer.

We also note that when the revenue sharing proportion \( \alpha \) is between 25% and 50%, both the publisher and the retailer enjoy a higher profit with the dual channel strategy under an agency model as compared with the wholesale model. Interestingly, numerous reports (Rich & Stone, 2010; WSJ, 2012) indicate that the value of \( \alpha \) 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. To further assess the pricing and consumer welfare issues between these two pricing models, we have the following proposition.

**Proposition 4:** When consumer acceptance level of digital goods \( \theta \) is less than one and \( \alpha \in [0.25, 0.5] \), we compare the dual channel strategy under the Agency Model with the Wholesale model and find,

\[
\begin{align*}
& \text{a)} \quad P_D^{\text{Agency}} < P_D^{\text{Wholesale}}, \quad P_T^{\text{Agency}} < P_T^{\text{Wholesale}}, \quad W_T^{\text{Agency}} < W_T^{\text{Wholesale}} \\
& \text{b)} \quad Q_D^{\text{Agency}} > Q_D^{\text{Wholesale}}, \quad Q_T^{\text{Agency}} = Q_T^{\text{Wholesale}} \\
& \text{c)} \quad \pi_p^{\text{Agency}} - \pi_p^{\text{Wholesale}} = \frac{[1 - 2\alpha]}{8} \theta \dot{V} > 0, \quad \pi_R^{\text{Agency}} - \pi_R^{\text{Wholesale}} = \frac{[4\alpha - 1]}{4} \theta \dot{V} > 0, \\
& \quad \pi_{\text{SC}}^{\text{Agency}} - \pi_{\text{SC}}^{\text{Wholesale}} = \frac{\theta \dot{V}}{16} > 0 \\
& \text{d)} \quad CS^{\text{Agency}} - CS^{\text{Wholesale}} = \frac{1}{32} \left[ \dot{V} + \frac{2C_T}{1 - \theta} \right] > 0
\end{align*}
\]

These results show that when utilizing a dual channel strategy, the supply chain profit under the agency model outperforms those associated with the wholesale model by \( \frac{\theta \dot{V}}{16} \). 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, \( Q_D^{\text{Agency}} > Q_D^{\text{Wholesale}} \), while the demand for the traditional goods are kept the same under these two pricing schemes, \( Q_T^{\text{Agency}} = Q_T^{\text{Wholesale}} \). 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 the consumer prices, \( P_D \) and \( P_T \). Specifically, the publisher charges a price of \( P_D^{\text{Agency}} = \frac{\theta \dot{V}}{2} \) for the digital goods under the agency model, and the publisher also charges the same wholesale price \( W_D^{\text{Wholesale}} = \frac{\theta \dot{V}}{2} \) 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 
\[ P_D^{Wholesale} = \frac{3\theta V}{4} \], 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, 
\[ CS_{Agency} - CS_{Wholesale} > 0 \].

Now we conceptualize the similarities and differences between the agency model and a traditional revenue sharing contract. Under a traditional revenue sharing contract, the retailer pays the supplier a wholesale price plus a percentage of the revenue she gains. The core idea of this traditional revenue sharing contract is that the retailer shares the revenue with the supplier in exchange for a reduction in the wholesale price (Cachon & Larieviere, 2005). The agency model works with a similar mechanism where the retailer and supplier/publisher agree to split the revenue from the sales of the digital goods. Consequently, we observe a reduction in the wholesale price of the traditional goods \( W_T \) as well as the digital goods \( W_D \). In fact, the wholesale price for the digital goods \( W_D \) drops to zero since the retailer only serves as a sales agent and there is no wholesale transaction of the digital goods between the supplier/publisher and retailer.

Although the agency model and revenue sharing contract are similar, they are not identical. First, the revenue sharing contract can achieve supply chain coordination but the agency model cannot. A key driver of this result is that the agency model is a “partial revenue sharing” contract in the sense that it only alleviates the double marginalization effect of the digital goods but not the traditional goods. Second, different from a revenue sharing contract, the sales price is determined by the upstream supplier/publisher instead of the retailer in the agency model as shown in Hao and Fan (2014). Third, the implementation and administration of the agency model is simpler than the traditional revenue sharing contract in physical goods. Due to advanced information technologies, publishers/suppliers and e-book retailers can easily share and validate information concerning the sales of digital goods. One of the most significant limitations of a traditional revenue sharing contract as highlighted by Cachon and Larieviere (2005) is the administrative burden imposed on the firms.

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 of the agency and fixed price models.

**Proposition 5:** When the consumer acceptance level of digital goods \( \theta \) is less than one, 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 appendix. The prosecutors from the U.S. 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. Then many retailers including Amazon switched their pricing model from the fixed price to the agency model. Consequently, the consumers’ welfare has been compromised because of 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 previously discussed, the fixed price model is not a viable pricing model in the long-term. In this situation, Amazon adheres to a fixed price model by compensating the consumers from their deep pockets. We believe the original very low fixed price ($9.99 for New York Times best-selling books) is merely a strategic move to lock-in consumers and build market share/awareness for the digital platform. Our research indicates that the in the long-run (i.e. equilibrium), the agency model may be a better pricing model for the digital goods market.
EXTENSIONS

Incentive Alignment

In the basic model, to concentrate on the strategic implication of the different pricing model as well as considering the forward-looking retailer, we do not incorporate the incentive alignment issue in the 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 another strategy based on her profit. We illustrate this in the agency model where the results of the wholesale model and fixed price model follow in a similar fashion.

The timing and information are exactly the same as the basic model and we start the analysis right after solving the retailer’s pricing problem. We obtain the retailer’s optimal response in price from equation (9). Instead of directly solving the publisher’s optimization problem, we need to first compare the retailer’s profit under different strategies. Substituting the prices from equation (9) into the retailer’s profit function, we find that

\[
\pi_R^{\text{Single}} - \pi_R^{\text{Equi}} = \frac{\theta \left( \hat{V} + W_T - 2P_D \right)^2}{4\theta^2\hat{V}} > 0 ,
\]

which suggests that the retailer will always prefer the single channel strategy to the equivalent price strategy under the agency model. Consequently, we focus on the profit comparisons between the single channel strategy and dual channel strategy. The difference of the profits between these two strategies is as follows:

\[
\pi_R^{\text{Single}} - \pi_R^{\text{Dual}} = \frac{\Delta}{4[\theta - 1]\theta \hat{V}} ,
\]

where

\[
\Delta = \alpha^2 P_D^2 \theta + 2\alpha P_D [P_D (\theta - 2) + \theta (\hat{V} - \theta \hat{V} + W_T)] + \theta (P_D^2 - 2P_D \theta - 1) \hat{V} + W_T^2 + \theta (\theta - 1) \hat{V}^2 + W_T^2]
\]

. If \( \Delta \geq 0 \), then the retailer prefers the dual channel strategy, otherwise the retailer prefers the single traditional channel strategy. This constraint is carried over when we solve the publisher’s problem to ensure the strategy preference alignment between the retailer and the publisher. Specifically, now the publisher utilizing a dual channel strategy is facing the following optimization problem,

\[
\max_{P_D, W_T} \pi_p = \pi_{P,D}^{\text{Dual}} + \pi_{P,T}^{\text{Dual}} = (1 - \alpha) P_D Q_{D}^{\text{Dual}} + \left| W_T - C_T \right| Q_{T}^{\text{Dual}}
\]

(10)

From the FOCs, we obtain the optimal solution to the unconstrained problem \( P_D^* = \frac{\theta \hat{V}}{2} \) and

\[
W_T^* = \frac{1}{2} [C_T + \hat{V} - a\theta \hat{V}] .
\]

Further, the strategy alignment constraint simplifies to

\[
\Delta = \frac{1}{4} \theta^2 \left[ C_T^2 - 2\alpha C_T (\theta - 1) \hat{V} - (1 - \theta) (1 + \alpha (a\theta - 2)) \hat{V}^2 \right] .
\]

If this constraint is violated, it corresponds to the situation where the publisher offers the dual channel strategy, but the retailer’s best response is to adopt the single traditional channel strategy instead. In this situation, the equilibrium does not exist because the publisher and retailer’s preferences are not the same. By following a similar set of steps, we solve the publisher’s problem with the single
channel strategy and it’s straightforward to show that the optimal wholesale price
\[ W_T = \frac{C_T + \hat{V}}{2}. \]
Thus we can characterize the optimal solution for the agency model.

Recall that under the situation when \( \theta < 1 \), the dual channel strategy equilibrium is possible if \( \Delta' \geq 0 \), in which case the publisher and the retailer have the preference alignment of dual channel strategy. However this condition does not necessarily guarantee that the dual channel strategy is optimal for the publisher. The publisher will choose to implement the dual channel strategy only when \( \pi_{P_{\text{Dual}}} - \pi_{P_{\text{Single}}} = [1 - 2\alpha] \hat{V}^2 + \frac{C_T^2}{1 - \theta} \geq 0 \). We have illustrated these two constraints with respect to the revenue sharing proportion \( \alpha \) and consumer acceptance level \( \theta \) in the following Figure 5. Region I combined with region II represent the preference alignment constraint whereby the retailer prefers the dual channel strategy. Consistent with our intuition, the retailer prefers the dual channel strategy only when the value of \( \alpha \) is relatively high, otherwise the retailer has no incentive to sell the digital goods. In contrast, the publisher prefers the dual channel strategy to the single traditional channel strategy when he retains a larger portion of the revenue from the digital goods sales (corresponding to regions II and III in the following figure). As a result, the region II represents the situation where both the retailer and the publisher optimally choose the dual channel strategy.

Figure 5: Illustration of Regions in Dual Channel Strategy with Incentive Alignment, \( \theta < 1 \)
(Note: The above figure is an illustration of the case where \( \hat{V} = 30 \) and \( C_T = 3 \). Further numerical experimentation shows that the configuration is robust to the different values of \( \hat{V} \) and \( C_T \).)

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 (notice that the parameter range identified in Figure 5 is smaller than in Figure 4). But there always exists a feasible range (i.e. Region II is robust to the change of parameters) where both the retailer and the publisher optimally choose the dual channel strategy and all the results in the previous section carry over. 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, the managers can adopt different values for the revenue sharing proportion $\alpha$ based on the different product characteristics such as: valuation, production and logistics costs and consumers’ perception of digital goods. More importantly, the retailer is forward-looking. As we have shown earlier in the fixed price model that 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 momentary 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 different from the agency model, the conflict incentive issue does not exist in the wholesale and fixed price model when imposing the incentive alignment consideration.

Endogenous Revenue Sharing Proportion

In the preceding analysis, we assumed that in the agency model, the revenue sharing proportion, $\alpha$, is exogenously fixed. A natural extension to this assumption is to study what factors may possibly impact this revenue sharing proportion. In this section, we consider $\alpha$ to be an endogenous variable that is determined through negotiations between the publisher and retailer. The timing of the negotiated agency model is as follows. First, the publisher and retailer establish the revenue sharing proportion through negotiations. If there is a disagreement, the negotiations break down and both publisher and retailer leave with zero profit. If both parties agree on a negotiated revenue sharing proportion, then the publisher will declare the wholesale price $W_T$ and digital goods retail price $P_D$ simultaneously. Third the retailer will respond to the publisher’s decision by setting the corresponding retailer price $P_T$. 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 specific 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. For example, the publisher may have more influence or bargaining power when they release a best-selling author’s new book. The limiting cases of $\beta=0$ and $\beta=1$ corresponds to a revenue sharing proportion unilaterally set by the publisher and retailer, respectively. The publisher’s and retailer’s profit are denoted by $\pi_P(W_T, P_D, P_T, \alpha)$ and $\pi_R(W_T, P_D, P_T, \alpha)$, respectively. As a result, the negotiated revenue sharing proportion, $\alpha_N$, is the solution of the following Nash bargaining formulation:

$$\alpha_N = \arg \max_{\alpha} \left[ \frac{\pi_P(W_T, P_D, P_T, \alpha)}{\pi_R(W_T, P_D, P_T, \alpha)} \right]^{\theta}(11)$$

The details of derivations are provided in the appendix. When $\theta \geq 1$, it’s 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 keeps, $\alpha_N$, precisely reflects the bargaining power of the retailer in the negotiation. Next, we present the insights from the comparative statics when $\theta < 1$ in the next proposition. **Proposition 6**: When the revenue sharing proportion, $\alpha_N$, is determined through Nash bargaining,
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. The second part of this proposition states that the negotiated revenue sharing proportion \( \alpha^N \) is increasing in response to an increase of consumer acceptance level \( \theta \) when the publisher’s bargaining strength is sufficiently pronounced (i.e. \( 1-\beta \in [2/3,1] \)) and decreasing when the retailer’s bargaining power is relatively high (i.e. \( \beta \in [1/3,1] \)). As discussed in section 5, an increase of the consumer acceptance level \( \theta \) 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 \( \alpha^N \) 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. The similar reasoning applies to the case when the retailer has relative bargaining advantage. When the reservation price \( \check{V} \) increases, the market demand of the digital goods will decrease. Consequently, the publisher demands a higher revenue sharing proportion to compensate for the loss from the diminished demand in digital goods when he has a relative bargaining advantage. Similarly, the retailer will accept a higher revenue sharing proportion when she has a higher relative bargaining power.

The influence of the cost \( C_T \) works exactly the opposite way as the reservation price's effect on \( \alpha^N \).

**CONCLUSIONS 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 of these digital goods alongside traditional goods have become problematic in digital goods supply chains. In this paper, we formulate a dual retail channel model whereby the retailer can sell both physical and digital goods simultaneously. The prices for the physical goods are determined using a traditional wholesale type model, where the supplier determines the wholesale price and the retailer determines the price for that good in the marketplace. One of the supply chain members has control of the pricing for this digital goods in the market. We consider three different scenarios, each associated with different pricing control for the digital goods. Under the first scenario, the publisher determines (a) the price of the digital goods in the marketplace and (b) the wholesale price for the traditional goods, and profit from the digital goods supply chain is shared via an agency model. In the second scenario, the retailer determines the price of the digital goods in addition to the price of the traditional goods, and profit is shared using a traditional wholesale model for the two channels. The third scenario is a variation of the second 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 to motivate and illustrate these scenarios. Initially, Amazon utilized a fixed priced policy for their digital books, pricing most of their digital books at $9.99. However, several publishers demanded control over the pricing for the digital books. In a well-publicized negotiation (Stone, 2004), several publishers colluded with Apple to demand an agency pricing structure also with Amazon whereby the publishers controlled the price of the digital book. Consequently, Amazon adopted the publisher controlled agency pricing model for many of its newer titles. As a result, publishers are pricing the digital goods fairly high (in comparison to the $9.99 policy). The U.S. Department of Justice argued that after switching from the traditional wholesale model to the agency model, the increased price of digital goods impacted consumers negatively.

Our analysis shows that under specific equilibrium conditions, the agency model actually outperforms the traditional wholesale model for distributing digital and traditional goods simultaneously. According to our research (as shown in Proposition 3), the optimal price for the digital goods using an agency model is actually lower than the price set utilizing a wholesale model. A counterintuitive result of this agency model is that the supply chain profit and consumer surplus can be higher than other pricing strategies. Consequently, there are benefits associated with the agency model which have been overlooked in the press.

A recent headline in the popular press (Stone, 2012), states plainly that, “Amazon wants to burn the book business,” intimating that Amazon favors the digital goods platform over traditional book sales. Indeed, our research shows that when the consumer acceptance level of the digital goods becomes greater than that of the traditional goods, then a dual channel strategy is never optimal regardless of the pricing policy (i.e. agency or wholesale model). More specifically, when the consumer acceptance level of digital goods $\theta$ is greater than one, the single digital channel strategy will dominate the dual channel strategy in all different scenarios. In this situation, both the retailer and the publisher optimally choose to sell their products only through the digital channel.

We briefly note some limitations of this paper and provide interesting directions for future research. First, we utilize utility models to determine the relative market shares for each individual channel. A stochastic model of demand may yield interesting implications with regards to inventory management. By incorporating stochastic demand and inventory costs, we could further illustrate a key differential between traditional and digital goods. Second, we have considered the monopoly market with only one publisher with single retailer. This setting is in line with the practice that Amazon controls the majority market shares of the e-books market as well as the theory that a single firm will dominate the digital goods market (Jones & Mendelson, 2011). However, it might be interesting to incorporate the competition between multiple retailers and publishers. Specifically, one could study the effect of most-favored-nation (MFN) provision in the agency model, which is widely used in industry.

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

APPENDIX

Appendix A

Wholesale Model Scenario Proof. $\theta \geq 1$
We begin to solve the problem when $P_T \leq \frac{P_D}{\theta}$ (corresponding to dual channel strategy / equivalent price strategy),

$$\max_{p_r, p_t} \pi_r = \pi_{r,t} = (P_D - W_D)Q_D + |P_T - W_T|Q_T$$

$$\text{s.t. } P_T \leq \frac{P_D}{\theta}$$

We write out the Lagrangian function $L = (P_D - W_D)Q_D + |P_T - W_T|Q_T + \lambda \left( \frac{P_D}{\theta} - P_T \right)$ and get two sets of the solutions from first order conditions (FOCs for brevity henceforth), which are

$$P^i_D[W_T, W_D] = \frac{\theta V + W_D}{2}, \quad P^i_T[W_T, W_D] = \frac{W_T + V}{2} \quad \text{with } \lambda = 0$$

and

$$P^i_D[W_T, W_D] = \frac{\theta V + W_D}{2}, \quad P^i_T[W_T, W_D] = \frac{\theta V + W_D}{2} \quad \text{with } \lambda = \frac{W_D - W_T}{\theta} \frac{1 - \theta}{V}. \quad \text{The second solution corresponds to the equivalent price strategy (i.e. binding constraint) where the sign of lagrangian multiplier is positive. Similarly, we solve the retailer’s problem under single channel strategy and get } P^i_D[W_D] = \frac{\theta V + W_D}{2}. \quad \text{Notice that in the single channel strategy; the price of traditional goods is too high such that the demand of traditional goods drops to zero.}$$

After substituting the values into the publisher’s problem, we solve for the optimal wholesale prices facing the publisher. In the dual channel strategy, FOCs leads to $W_D^{\text{Dual}} = (C_T + \hat{V})/2$ and $W_D^{\text{Dual}} = \frac{\theta V}{2}$, however the dual channel strategy does not satisfy the constraint $P_T \leq \frac{P_D}{\theta}$, so dual channel strategy is not an equilibrium solution. Next we solve the publisher’s problem with equivalent price strategy. Since the demand of traditional goods drops to zero in both equivalent price strategy and single channel strategy, both strategies result in the same solution. It’s straightforward to show that $\pi_r$ is concave in $W_D$ by verifying the second order condition (SOC for brevity henceforth). Thus solving the FOCs leads to the optimal solution $W_D^{\text{Equivalent}} = W_D^{\text{Single}} = \frac{\theta V}{2}$.

**Wholesale Model Scenario Proof. $\theta < 1$**

We begin to solve the problem when $P_T \geq \frac{P_D}{\theta}$ (corresponding to dual channel strategy / equivalent price strategy). The retailer face the following optimization problem,

$$\max_{p_r, p_t} \pi_r = \pi_{r,t} = (P_D - W_D)Q_D + |P_T - W_T|Q_T$$

$$\text{s.t. } P_T \geq \frac{P_D}{\theta}$$

We first show that $\pi_r$ is jointly concave in $P_D$ and $P_T$ by examining the Hessian.
\[ H = \begin{bmatrix}
\frac{2}{(\theta-1)V} & \frac{2}{(1-\theta)V} \\
\frac{2}{(1-\theta)V} & \frac{2}{\theta(\theta-1)V}
\end{bmatrix} \]

It’s straightforward to check that the Hessian matrix is negative definite. So the FOCs are necessary and sufficient to get the solutions. We get 
\[ P_D^i(W_T, W_D) = \frac{1}{2} \left( \theta \dot{V} + W_D \right), \]
\[ P_T^i(W_T, W_D) = \frac{\dot{V} + W_T}{2}. \]
If the constraint is binding, the solution is equivalent to the single channel strategy which we present next.

Similarly we solve the retailer's problem when \( P_T < \frac{P_D}{\theta} \) (corresponding to single traditional strategy) and get 
\[ P_T^i(W_T, W_D) = \frac{\dot{V} + W_T}{2}. \] Anticipating the retailer’s response, the publisher is facing the following optimization problem:
\[
\max_{W_T, W_D} \pi_p = W_D Q_D^{Dual} + (W_T - C_T) Q_T^{Dual} \quad \text{or} \quad \max_{W_T} \pi_p = (W_T - C_T) Q_T^{Single}
\]
We can show that \( \pi_p \) is (jointly) concave in \( W_T \) (and \( W_D \)). Thus solving the FOCs leads to the optimal solution, where 
\[ W_T^{Dual} = \frac{C_T + \dot{V}}{2} \quad \text{and} \quad W_D^{Dual} = \frac{\theta \dot{V}}{2}, \]
while
\[ W_T^{Single} = \frac{C_T + \dot{V}}{2}. \]
We can verify that \( \pi_p^{Dual} \) is always higher than \( \pi_p^{Single} \). As a result, the corresponding profit of the publisher under this case becomes
\[ \pi_p^{Dual} = \frac{1}{8} \left[ \dot{V} + C_T \left( \frac{C_T}{V - \theta \dot{V}} - \frac{2}{\theta} \right) \right]. \]

**Appendix B**

**Fixed Price Model Scenario Proof.** \( \theta \geq 1 \)

We solve the problem by backward induction. When \( P_T \leq \frac{P_D}{\theta} \) (corresponding to dual channel strategy / equivalent price strategy), the retailer is facing the following optimization problem
\[
\max_{P_T} \pi_R = \pi_{R,D} + \pi_{R,T} = (\overline{P}_D - W) Q_D + P_T W | Q_T \\
\text{s.t. } P_T \leq \frac{P_D}{\theta}
\]
We form the Lagrangian function 
\[ L = (\overline{P}_D - W) Q_D + P_T W | Q_T + \lambda (\frac{P_D}{\theta} - P_T) \]
and get two sets of the solutions from FOCs, which are 
\[ P_T^i(W) = \frac{2 \overline{P}_D - W + \theta W}{2 \theta} \] with \( \lambda = 0 \) and
The first solution corresponds to dual channel strategy; however this solution does not satisfy the constraint $\frac{P_T}{\theta} \leq \frac{P_D}{\theta}$, so dual channel strategy is not an equilibrium solution and we do not consider the dual channels strategy here. The second solution corresponds to the equivalent price strategy (i.e. binding constraint) where the sign of lagrangian multiplier is positive. Notice that in the single digital channel strategy; the price of traditional goods is too high such that the demand of traditional goods drops to zero. And the digital goods price is exogenous, so the retailer has no decision to make.

Next we solve for the publisher’s problem. We find that both equivalent price strategy and single digital goods strategy lead to the same profit, so we just focus on solving the equivalent price strategy as illustration. After we substitute the retailer’s price into the publisher’s problem, the objective function becomes

$$\pi_p = W - \frac{P_D W}{\theta V}.$$ 

The publisher’s profit is linearly increasing in the value of wholesale price, so we obtain the optimal wholesale price $W^*=\max\{P_T, P_D\}$.

**Fixed Price Model Scenario Proof, $\theta < 1$**

We begin to solve the problem when $P_T \geq \frac{P_D}{\theta}$ (corresponding to dual channel strategy / equivalent price strategy). The retailer faces the following optimization problem,

$$\max_{P_T} \pi_R = \pi_{R,D} + \pi_{R,T} = (P_D - W)Q_D + (P_T - W)Q_T$$

subject to $P_T \geq \frac{P_D}{\theta}$

We form the Lagrangian function

$$L = (P_D - W)Q_D + (P_T - W)Q_T + \lambda (P_T - \frac{P_D}{\theta})$$

and get two sets of the solutions from solving the FOCs, which are

$$P_T(w) = \begin{cases} \frac{1}{2}(2P_D + V - \theta\dot{V}) & \text{with } \lambda = 0 \\ \frac{P_D}{\theta} & \text{with } \lambda = \frac{2P_D - \theta\dot{V}}{\theta V} \end{cases}.$$ 

The first solution is the dual channel solution and we notice that in order for the dual channel strategy to be viable, the exogenous digital goods sales price $P_D$ must be smaller than the cutoff price $P_D^{\text{Dual}} = \frac{\theta\dot{V}}{2}$, otherwise, the exogenous digital goods sale price is too high and the demand of the digital goods becomes zero. The second solution corresponds to the equivalent price strategy (i.e. binding constraint). It’s straightforward to solve the retailer’s problem under single traditional channels strategy and get

$$P_T(w) = \frac{V + W}{2}.$$ 

After characterizing the optimal response by the retailer, we solve for the optimal wholesale price facing the publisher. We first substitute the $P_T = \frac{1}{2}(2P_D + V - \theta\dot{V})$ into the publisher’s problem and the objective simplifies to

$$\pi_p = W\left(1 - \frac{P_D}{\theta V}\right) - \frac{C_T}{2},$$ 

which is linear in the wholesale price. As a result, we set the publisher’s wholesale price at the
\[ W^* = \max \{ P_T, \overline{P}_D \} = \frac{1}{2} \left( 2 \overline{P}_D + \hat{V} - \theta \hat{V} \right) \]  

Next we solve the publisher’s problem under the single channel strategy. The objective function of the publisher becomes

\[ \pi_p = \frac{\left( C_T - W \right) \left( W - \hat{V} \right)}{2 \hat{V}}. \]

Setting the FOC equals to zero, we get

\[ W^* = \frac{C_T + \hat{V}}{2} \]

and correspondingly, we get the optimal

\[ P_T^* = \frac{1}{4} \left( C_T + 3 \hat{V} \right) \]

Recall that in the single traditional channel strategy, the digital goods price has to be set relatively high (i.e. \( P_T < \frac{P_D}{\theta} \)). This cutoff price is characterized by setting

\[ \frac{1}{4} \left( C_T + 3 \hat{V} \right) = \frac{P_D}{\theta}, \]

so we get

\[ P_D^{\text{Single}} = \frac{\theta \left( C_T + 3 \hat{V} \right)}{4}. \]

We have illustrated the critical exogenous digital goods price in the Figure A.1. When \( \overline{P}_D \in (0, P_D^{\text{Dual}}) \), the dual channel strategy is feasible, when \( \overline{P}_D \in (P_D^{\text{Single}}, \theta \hat{V}) \) the single traditional channel strategy is feasible. And when \( \overline{P}_D \in [P_D^{\text{Dual}}, P_D^{\text{Single}}] \) we will have the equivalent price strategy.

**Figure A.1: Critical Exogenous Digital Goods**

<table>
<thead>
<tr>
<th>Dual Channel Strategy</th>
<th>Equivalent Price Strategy</th>
<th>Single Channel Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \overline{P}_D^{\text{Dual}} = \frac{\theta \hat{V}}{2} )</td>
<td>( \overline{P}_D^{\text{Single}} = \frac{\theta \left( C_T + 3 \hat{V} \right)}{4} )</td>
</tr>
</tbody>
</table>

**Appendix C, Vertically Integrated Supply Chain Proof**

Given the demand function in Section 3, if the vertically integrated firm sets the traditional goods sales price \( P_T \) and digital goods sales price \( P_D \), then the profit of the integrated firm becomes:

\[
\pi = \pi_p + \pi_r = \begin{cases} 
\hat{P}_D \left( \hat{V} - \frac{P_T - P_D}{1 - \theta} \right) \frac{1}{\hat{V}} + & P_T - C_T \left( \frac{P_T - P_D}{1 - \theta} - P_T \right) \frac{1}{\hat{V}} \theta \geq 1 \land \hat{P}_T < \frac{P_D}{\theta} \\
\hat{P}_D \left( \hat{V} - \frac{P_D}{\theta} \right) \frac{1}{\hat{V}} \theta \geq 1 \land \hat{P}_T \geq \frac{P_D}{\theta} \\
\left( P_T - C_T \right) \left( \hat{V} - P_T \right) \frac{1}{\hat{V}} \theta < 1 \land \hat{P}_T < \frac{P_D}{\theta} \\
\hat{P}_D \left( \frac{P_T - P_D}{1 - \theta} - \frac{P_D}{\theta} \right) \frac{1}{\hat{V}} + & \left( P_T - C_T \right) \left( \hat{V} - \frac{P_T - P_D}{1 - \theta} \right) \frac{1}{\hat{V}} \theta < 1 \land \hat{P}_T \geq \frac{P_D}{\theta} 
\end{cases}
\]

We sketch the proof as follows. We begin solving this problem under the case where \( \theta < 1 \) and \( P_T \geq \frac{P_D}{\theta} \) and obtain \( P_D = \frac{\theta \hat{V}}{2} \) and \( P_T = \frac{C_T + \hat{V}}{2} \). Then we solve the problem for the case where \( \theta < 1 \) and \( P_T < \frac{P_D}{\theta} \) and find the single traditional goods price \( P_T = \frac{C_T + \hat{V}}{2} \) and the corresponding supply chain profit. Note the profit from the dual channel solution is
always higher than the profit under single traditional goods channel for $\theta < 1$, so we drop the single traditional channel solution. If $\theta \geq 1$, one can show that the demand of the traditional goods falls to zero. Both the equivalent price and single digital goods strategy lead to the same profit.

**Appendix D, Proof of Proposition 5**

We take the difference of the consumer surplus between the agency model and fixed price model and get

$$CS^d - CS^{\text{Agency}} = \frac{1}{16} \left( \frac{8\overline{P}_D^2}{\theta^2 \overline{V}} - \frac{8\overline{P}_D}{\theta} + 3\overline{V} - \frac{C_T^2}{(1-\theta)^2 \overline{V}} \right)$$

Apparently, this difference is a convex and quadratic function of the exogenous digital goods price $\overline{P}_D$. Setting the FOC with respect to $\overline{P}_D$ equal to zero, we get that the difference reaches to its minimum at $\overline{P}_D = \frac{\theta \overline{V}}{2}$. Then we substitute $\overline{P}_D = \frac{\theta \overline{V}}{2}$ back into the difference and get

$$CS^d - CS^{\text{Agency}} = \frac{(\overline{V}[1-\theta]+C_T)(\overline{V}[1-\theta]-C_T)}{16(1-\theta)^2 \overline{V}} > 0.$$ Further, the feasible range of the dual channel strategy in fixed price model is that $\overline{P}_D \in (0, P_{D, \text{Dual}} = \frac{\theta \overline{V}}{2})$. As a result, we know the difference of consumer surplus is always positive.

**Appendix E, Proof of Proposition 6**

We substitute the optimal traditional goods price $P_T$, digital goods price $P_D$, and wholesale price $W_T$ obtained in section 4.1 into the publisher’s and retailer’s profit, $\pi_p(W_T, P_D, P_T, \alpha)$ and $\pi_r(W_T, P_D, P_T, \alpha)$, respectively. Then we solve the following optimization problem under both $\theta < 1$ and $\theta \geq 1$

$$\max_{\alpha} \{\pi_p(W_T, P_D, P_T, \alpha)\}^{1-\beta} \{\pi_r(W_T, P_D, P_T, \alpha)\}^\beta$$

First order condition yields the equilibrium revenue sharing proportion. We characterize the solution as below.

$$\alpha_N = \begin{cases} 
\frac{[1-3\beta]C_T^2 - 2[3\beta-1]C_T \overline{V} + [\theta-1]C_T [\beta [3+\theta]+[1-\theta] C_T \hat{V}]}{4(\theta-1) \theta \overline{V}^2} & \text{if } \theta < 1 \\
\beta & \text{if } \theta \geq 1
\end{cases}$$

From the above expression, we take the comparative statics and get,

$$\frac{\partial \alpha_N}{\partial \beta} \geq 0, \frac{\partial \alpha_N}{\partial \theta} |_{\beta \leq \frac{1}{3}} \geq 0, \frac{\partial \alpha_N}{\partial \theta} |_{\beta > \frac{1}{3}} < 0, \frac{\partial \alpha_N}{\partial \overline{V}} |_{\beta \leq \frac{1}{3}} \geq 0, \frac{\partial \alpha_N}{\partial \overline{V}} |_{\beta > \frac{1}{3}} < 0, \frac{\partial \alpha_N}{\partial C_T} |_{\beta \leq \frac{1}{3}} \geq 0, \frac{\partial \alpha_N}{\partial C_T} |_{\beta > \frac{1}{3}} < 0$$

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