The Agency Model for Digital Goods: Strategic Analysis of Dual Channels in Electronic Publishing Industry

Yinliang (Ricky) Tan, Janice Carrillo
Dept. of Information Systems and Operations Management, Warrington College of Business Administration,
University of Florida, Gainesville, FL - USA

***Abstract*--The advent of digital goods has made a significant impact on the current traditional (physical) goods markets for items such as movies, music, video games, and books. Firms that manage both a traditional and a digital goods distribution channels are facing many emerging operational challenges. One of the most pivotal challenges is the supply chain contract model for the distribution of digital goods alongside their traditional counterparts. Recently, the agency model utilized by the e-book publishing industry has been highlighted in the press as a result of the U.S. Department of Justice's lawsuit against Apple, Inc. The regulators claim that the agency model is hurting this industry as well as the consumer's welfare because e-book prices have increased after the introduction of agency model. We investigate the strategic impact of the agency model by formulating a dual channel model in comparison with the prevalent wholesale model. Contrary to current press presaging the negative impact of the agency model, we find that the equilibrium price of digital goods is lower in the agency model than in the wholesale model. Furthermore, the agency model can mitigate the double marginalization effect of the supply chain and improve the consumers' surplus.**

I. INTRODUCTION

The book publishing industry is currently experiencing a "Digital Revolution" [24] impacting both demand and also supply chain relations. While the sales of traditional books have been relatively flat for decades, the introduction of the e-book as a digital good 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 [18], "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." According to the recent report by the Association of American Publishers (AAP), the e-books sales have reached $282.3 million in the first quarter 2012 while the Hardcover sales only amount to $229.6 million in the same time period. While the first generation of e-book reader was released by Amazon on Nov. 19, 2007, customers can now also read their e-books on their PCs, laptops, tablets, and smartphones conveniently through the Kindle 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 lawsuit against Apple, Inc[1]. The agency model utilized by the e-book publishing industry is central to this lawsuit. In the agency model, the publisher sets the price of the digital goods and the retailer who serves as an agent retains a percentage of the revenue. The U.S. Justice Department prosecutors argued that Apple used publishers' dissatisfaction with Amazon's aggressive e-book discounting to shoehorn itself into the digital-book market in 2010. Apple proposed the controversial agency model to let the publishers set prices of e-books. Later the publishers required that all the retailers including Amazon should adopt this new pricing model. Fig.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 hurts the consumer's benefits. A federal judge ruled on July 10th, 2013 [22] that Apple colluded with major publishers, but Apple is still appealing the legal ruling.

In this paper, we analyze the consequential strategic distribution decisions facing retailers, suppliers, and policy makers alike in the face of "Digital Revolution" [24]. 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 two prevalent supply chain pricing schemes for the digital goods whereby the prices of the digital goods are set utilizing different mechanisms. We refer to the situation where the publisher chooses the price for the e-books as "Agency Model". Under the agency model, the retailer retains a fixed proportion α of the digital book's sales revenue. According to the media report [28], the current value of α is 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. The wholesale model represents the current price setting game between the publisher and retailer in which the publisher offers versions of both the digital book and the traditional book at two separate wholesale prices. The retailer is free to offer the book to the consumer at their preferred retail prices. The pricing 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.

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

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

Through our comparison of these two 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. Actually, Amazon is creating a "loss leader" by compensating consumer for each Kindle book they sell at $9.99 [21]. In this study, we provide a more complete assessment of the long-term effect (i.e. equilibrium) of two prevalent pricing schemes shows 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 oped article in the Wall Street Journal [23] 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 bestselling and other books) for e-books fell to $7 from $9 after the introduction of the agency 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 or the wholesale 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 two pricing schemes? We study these issues and provide valuable managerial insights to policy makers as well as the executives in related industries by formalizing a game theoretic model. Also note that although our focus in this study is on the e-books industry, our results can resonate beyond e-books, with broader implication for providers of other digital goods including music and movies.

The rest of the paper is organized 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 agency model and wholesale model, respectively, in section 4, we compare both profit and consumer surplus measures under these two pricing schemes in section 5. The last section concludes this study by highlighting the implications and future research directions.

II. LITERATURE REVIEW

A. 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. [2] proposes a conceptual model to analyze the value chain of online digital music industry. Buxmann et al. [3] 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. By considering network effects, Bhargava et al. [1] demonstrate that the intermediary in an electronic market can potentially offer different levels of service quality to target various consumer segments. Jones and Mendelson [16] conclude that the digital goods markets are dominated by a single firm because they lack the segmentation inherent in physical goods markets.

Two additional papers specifically address issues facing the e-Book industry. The first one is by Jiang and Katsamakas [15], which use 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. Although this paper provides some managerial insights in e-Book industry, 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 [14] 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 can cause 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 of the traditional goods.

B. OM/Dual Channel Literature

Several conceptual papers discuss the implications of the digital economy on operations management. Specifically, Hayes [13] gives an overview of the challenges faced by the traditional operation management theories in the digital economy. Geoffrion [12] poses a four-stage framework to solve these challenges. Karmarkar and Apte [17] 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 Operation Management literature focuses on dual channel models of distribution. Chiang et al. [8] and [9] 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 direct channel increases overall profitability of the supply chain by reducing the degree of double marginalization between the manufacturer and retailer. Interestingly, they determine that the introduction of direct channel may not always be detrimental to the traditional retailer because of the price reduction on wholesale price to the retailer. Our research extends their work not only by incorporating digital goods but also considering alternate supply chain structures and different pricing schemes. Cattani et al. [6] also find that under an equal-pricing framework, the traditional retailer does not need to view the addition of direct channel as harmful competition but rather a mechanism for segmenting the market to benefit both the manufacturer and the retailer.

A substantial number of research papers focus on the dual channel problem in physical goods only. Interested readers in this topic should refer to the Cattani et al. [5] and Tsay and Agrawal [27] who review the recent research related to the coordination and competitive models of dual channel management.

C. Contribution to the Literature

Although a number of papers have discussed the influence of information/digital goods in several different aspects, there is little research addressing the specific impact of alternate pricing schemes on the supplier, retailers and consumers. While several authors have analyzed the impact of the digital goods conceptually, we focus on a comprehensive distribution decision model to offer the managerial insights for regulators and business managers. 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. Specifically, we compare profitability for two alternative pricing schemes for the digital goods utilizing game theory methodologies: (a) Agency Model, and (b) Wholesale Model. In addition, we incorporate consumer surplus and social welfare measures into our analysis to highlight the implications of these alternate pricing schemes on consumers. 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.

III. 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 MODEL VARIABLES

Variable	Description
V	Consumer valuation on traditional (physical) goods
$\bar{V}$	Consumer reservation value, highest price the consumer is willing to pay
P_T	Retail price of traditional goods
P_D	Retail price of digital goods
C_T	Cost of printed book to the publisher including production and logistics cost
W_T	Wholesale price of traditional goods charged by the publisher
θ	Consumer acceptance level of digital goods; $\theta > 0$
α	Proportion of the revenue that the retailer keeps from the sale of digital goods; $0<\alpha<1$
V_k^l	Valuation threshold for consumers buying from channel k (k=D or T)
V^e	Valuation threshold for consumers are indifferent from both channel
Q_T	Demand for traditional goods
Q_D	Demand for digital goods
$\pi_{i,k}$	Net profit of player i (i=P or R) on the supply chain associated with channel k (k=D or T)
CS_K	Total consumer surplus associate with channel k (k=D or T)
SW	Total Social Welfare

A. 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.,$V \in [0, \bar{V}]$. 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_T^I. The total market size is normalized to one, thus the demand for the traditional goods is:

$$Q_T = Pr(V - P_T \geq 0) = (\bar{V} - P_T)\frac{1}{\bar{V}} \qquad (1)$$

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 traditional goods single channel, the publisher's profits are characterized by:

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

The retailer's profit are determined by

$$\pi_{R,T} = (P_T - W_T)Q_T = (P_T - W_T)(\bar{V} - P_T)\frac{1}{\bar{V}} \qquad (3)$$

Similar to many models based on Mussa and Rosen [19], we introduce a variable to represent the non-negative consumer acceptance level θ, to capture the consumers' perception of digital goods. Practically speaking, if θ is greater than one, it denotes the situation where consumers prefer digital goods to traditional goods and vice versa. The variable θ is influenced by the retailer or publisher by means of introduction of new technology, lowering the price of digital publication, 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[2] [20]. If a digital goods channel exists with the retailer pricing at P_D and the consumers' valuation is θV, then the resulting consumer surplus is $\theta V - P_D$. If this quantity 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:

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

There are two common cost structures [7] for digital goods, which are fixed-fee licensing (FFP) and per-copy licensing (PCP). We use a per-copy licensing scheme in our study, which is the current 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 [26], 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 αP_D as profit, where α denotes the proportion of sales that retailer keeps and $1 - \alpha$ denotes the proportion of sales that the upstream publisher retains.

B. 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 ([8], [9] and [10]). The surplus from buying the traditional goods and the digital goods are $V - P_T$ and $\theta V - P_D$, respectively. We characterize $V^e = \frac{P_T - P_D}{1-\theta}$ as the level where consumers are indifferent buying from either channel and thus we have the following result.

If the consumer's acceptance level θ 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 θ 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 $C_T \leq \bar{V}(1 - \theta)$ to eliminate uninteresting cases where demand of traditional goods is less than zero.

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

[2] In this study, we do not restrict the value of θ 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.

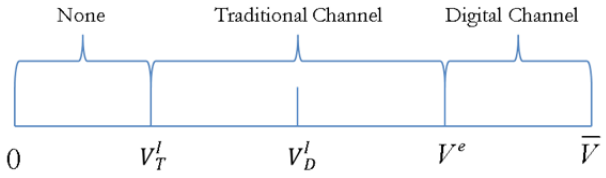

Figure 2. Consumers purchasing choice under $V_T^I < V_D^I$ when θ ≥ 1

For the case when $V_T^I \geq V_D^I$, then $V^e < V_D^I < V_T^I$. Therefore consumers whose valuation is in the interval $[0, V_D^I]$ will not purchase from either channel, consumers with valuation in the interval $[V_T^I, \bar{V}]$ will choose to purchase from the traditional 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 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:

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

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

Case2 $\boldsymbol{\theta < 1}$: Analogously, we can derive the demand function when $\theta < 1$, which denotes the situation where consumers prefer the traditional goods to digital goods:

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

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

IV. AGENCY MODEL VS. WHOLESALE MODEL

In this section, we analyze the two current 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 DOJ lawsuit [22], "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 two different scenarios including the Agency and Wholesale Models. The publisher has access to original content from the authors and serves as the game leader by moving first in both games. The retailer as the follower will observe the publisher's decision and then make her best response accordingly. We have described the details of two pricing models in Fig. 3. We also assume that in both stages of the game, both the publisher and the retailer have the same information about the consumer demand and the cost of the publishing company (complete and perfect information).

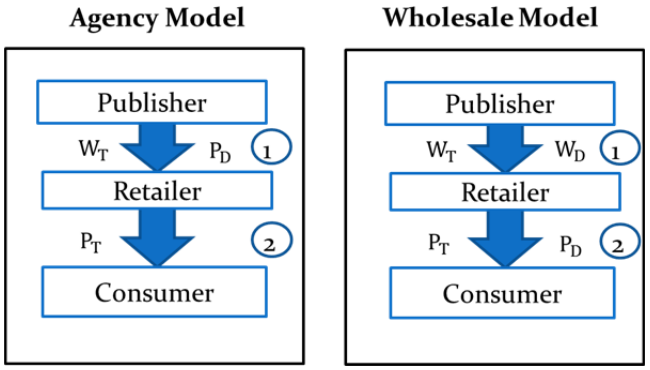

Figure 3. Decision Sequence for the Publishing Industry

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 [8]). In the dual channel strategy, demand will be positive in both distribution channels. In the single channel strategy, the retailer will only open either 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 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 requirement). The problem is solved by utilizing the backward induction technique.

One of the key arguments in the Department of Justice (DOJ) 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 as Fishman and Rob [11], 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 $CS = CS_T + CS_D = \frac{1}{2}(\bar{V} - V^e)Q_T + \frac{1}{2}(V^e - V_D^I)Q_D$ when $\theta \leq 1$ and the dual channel strategy has been chosen. If the single (traditional) channel strategy or equivalent price strategy has been selected, then $CS = CS_T + CS_D = 0 + \frac{1}{2}(\bar{V} - V_T^I)Q_T$. And corre-

spondingly, we analyze profit, consumer surplus and social welfare measures when $\theta \geq 1$.

A. Agency Model

Under an agency model, the publisher takes control of retail pricing. In the first stage (of a two-stage game), 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 α is industry specific and exogenous. Essentially, the retailer (such as Amazon.com) simply becomes a sales agent from which consumers can purchase the e-book. The retailers are not allowed to charge a different price from the publisher's decision for the digital goods. In the optimization problem, we first solve the retailer's problem,

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

After characterizing the optimal value of $P_T = argmax\ \pi_R(W_T, P_D)$, we substitute back into the publisher problem to decide the optimal wholesale price W_T and digital goods price P_D.

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

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. A similar set of steps can be repeated to obtain the solutions when $\theta \geq 1$. 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 dual channel strategy and equivalent price strategy) and $P_T < \frac{P_D}{\theta}$ (i.e. corresponding to 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:

$$P_T^*(W_T, P_D) = \begin{cases} \frac{1}{2}(P_D + \alpha P_D + \bar{V} - \theta\bar{V} + W_T) & if\ P_T^* > \frac{P_D}{\theta}\ (Dual\ Channel) \\ \frac{P_D}{\theta} & if\ P_T^* = \frac{P_D}{\theta}\ (Equivalent\ Price) \\ \frac{\bar{V}+W_T}{2} & if\ P_T^* < \frac{P_D}{\theta}(Single\ Traditional) \end{cases} \quad (9)$$

After a comparison of the retailer's profit under different strategies, we find that the difference in profit ${\pi_R}^{Single} - {\pi_R}^{Equi} = \frac{(\theta(\bar{V}+W_T)-2P_D)^2}{4\theta^2\bar{V}} > 0$, which suggests that the retailer will always prefer the single channel strategy to the equivalent price strategy under agency model. Consequently, we concentrate 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: ${\pi_R}^{Single} - {\pi_R}^{Dual} = \frac{\Delta}{4(\theta-1)\theta\bar{V}}$, where $\Delta = \alpha^2 {P_D}^2\theta + 2\alpha P_D(P_D(\theta - 2) + \theta(\bar{V} - \theta\bar{V} + W_T)) + \theta({P_D}^2 - 2P_D((\theta-1)\bar{V} + W_T) + \theta\left((\theta - 1)\bar{V}^2 + {W_T}^2\right)$. 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, the publisher utilizing a dual channel strategy is facing the following optimization problem,

$$\max_{W_T,P_D} \pi_P = \pi_{P,D} + \pi_{P,T} = (1-\alpha)P_D {Q_D}^{Dual} + (W_T - C_T){Q_T}^{Dual} \quad (10)$$
$$s.t. \Delta \geq 0$$

By checking that the Hessian matrix is negative definite, we know that the above problem is jointly concave in W_T and P_D. From the FOCs, we obtain the optimal solution to the unconstrained problem $P_D^* = \frac{\theta\bar{V}}{2}$ and $W_T^* = \frac{1}{2}(C_T + \bar{V} - \alpha\theta\bar{V})$. Further, the strategy alignment constraint simplifies to $\Delta' = \frac{1}{4}\theta^2({C_T}^2 - 2\alpha C_T(\theta-1)\bar{V} - (1-\theta)(1+\alpha(\alpha\theta-2))\bar{V}^2)$. 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. In such case, 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 $W_T^* = \frac{C_T+\bar{V}}{2}$. Thus we can characterize the optimal solution for the agency model. Notice that under the case when $\theta \geq 1$, the single digital channel strategy and equivalent price strategy are the optimal channel strategy choices and they lead to the same solution. We summarize the results in the following lemma.

Lemma 1. *Under the agency model, the equilibrium entails:*

(i) When $\theta < 1$,

Pricing:

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

Single Channel Strategy $\{ W_T = \frac{C_T+\bar{V}}{2},\ P_T = \frac{1}{4}(C_T + 3\bar{V})\}$

Profits:

Dual Channel Strategy $\{ \pi_P = \frac{1}{8}[(1+\theta-2\alpha\theta)\bar{V} + C_T(-2 + \frac{C_T}{\bar{V}-\theta\bar{V}})], \pi_R = \frac{1}{16}(\bar{V} - \theta\bar{V} + 4\alpha\theta\bar{V} + \frac{{C_T}^2}{\bar{V}-\theta\bar{V}} - 2C_T)\}$

Single Channel Strategy $\{ \pi_P = \frac{(C_T-\bar{V})^2}{8\bar{V}}, \pi_R = \frac{(C_T-\bar{V})^2}{16\bar{V}}\}$

(ii) When $\theta \geq 1$,

Pricing:

Equivalent Price/Single Channel Strategy $\{P_D = \frac{\theta\bar{V}}{2}, P_T \geq \frac{\bar{V}}{2}\}$

Profits:

Equivalent Price/Single Channel Strategy $\{ \pi_P = \frac{1}{4}(1-\alpha)\theta\bar{V}, \pi_R = \frac{1}{4}\alpha\theta\bar{V}\ \}$

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 $\pi_P{}^{Dual} - \pi_P{}^{Single} = (1-2\alpha)\bar{V}^2 + \frac{{C_T}^2}{1-\theta} \geq 0$. We have illustrated these two constraints with respect to the revenue sharing proportion α and consumer acceptance level θ in the following figure. 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 α 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. The following figure is an illustration of the special case where $\bar{V}$ =30 and C_T=3, but further numerical experimentation shows that the configuration is robust to the different values of $\bar{V}$ and C_T.

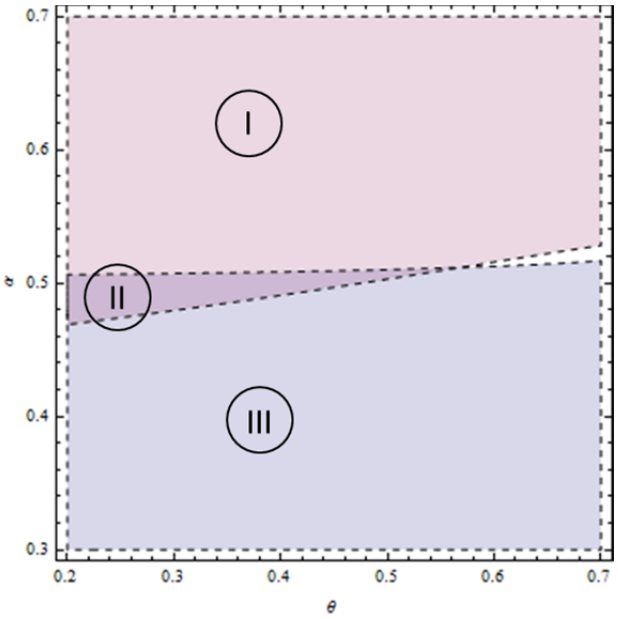

Figure 4. Illustrations of Feasible and Optimal Regions of Dual Channel Strategy in Agency Model $\theta < 1$ ($\bar{V} = 30$ and $C_T = 3$)

Note: The reason we choose the value of θ between 0.2 to 0.7 is a result of previous empirical evidence that most readers are willing to pay 20%-70% of the traditional book price for the same digital version of the book [20].

From Fig. 4, it appears that the dual channel strategy under the agency model is somewhat limited as a result of the conflict of interest between the retailer and the publisher. However, in practice, it may be possible for the publisher to contractually obligate the retailer to adhere to a dual channel strategy. It's also possible that mangers can segment their market by adopting different values for the revenue sharing proportion α based on the different book characteristics such as: valuation, production and logistics costs and consumers' perception of digital goods. Later in the paper, we further develop the advantages of agency model under the dual channel strategy.

B. 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 their preferred wholesale price for traditional goods $\boldsymbol{W_T}$ and digital goods $\boldsymbol{W_D}$, 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 $\boldsymbol{\theta < 1}$. We summarize the results of the wholesale model in Lemma 2 and proofs are provided in Appendix A.

Lemma 2. Under wholesale model, the equilibrium entails:

(i) When $\theta < 1$,

Pricing:

$$\textit{Dual Channel Strategy}\ \{W_T = \tfrac{C_T+\bar{V}}{2}, W_D = \tfrac{\theta\bar{V}}{2}, P_D = \tfrac{3\theta\bar{V}}{4}, P_T = \tfrac{1}{2}\left(\bar{V} + \tfrac{C_T+\bar{V}}{2}\right)\}$$

Profits:

$$\textit{Dual Channel Strategy}\ \{\pi_P = \tfrac{1}{8}[\bar{V} + C_T\left(\tfrac{C_T}{\bar{V}-\theta\bar{V}} - 2\right)], \pi_R = \tfrac{1}{16}[\bar{V} + C_T\left(\tfrac{C_T}{\bar{V}-\theta\bar{V}} - 2\right)]\}$$

(ii) When $\theta \geq 1$,

Pricing:

$$\textit{Equivalent Price/Single Channel Strategy}\ \{W_T \leq \tfrac{C_T+\bar{V}}{2}, W_D = \tfrac{\theta\bar{V}}{2}, P_D = \tfrac{3\theta\bar{V}}{4}, P_T = \tfrac{3\bar{V}}{4}\}$$

Profits:

$$\textit{Equivalent Price/Single Channel Strategy}\ \{\pi_P = \tfrac{\theta\bar{V}}{8}, \pi_R = \tfrac{\theta\bar{V}}{16}\}$$

V. ANALYSIS

In this section, we compare and contrast the agency model with the wholesale model. To serve as a benchmark, we include the results from the vertically integrated supply chain. To motivate our analysis, recent media has disclosed that the retailer Amazon is moving aggressively toward publishing in-house by hiring editors and expanding their publishing department [24] and [25]. We have summarized all of the possible channel strategies under different supply chain structure in the following table 2.

TABLE 2: POSSIBLE CHANNEL STRATEGIES OF DUAL CHANNEL SUPPLY CHAIN IN DIGITAL GOODS

Supply Chain Structure	$\boldsymbol{\theta < 1}$	$\boldsymbol{\theta \geq 1}$
Agency Model	• Single Traditional Channel • Dual Chanel	• Single Digital Channel • Equivalent Price
Wholesale Model	• Dual Channel	• Single Digital Channel • Equivalent Price
Integrated Supply Chain	• Dual Channel	• Single Digital Channel • Equivalent Price

We begin the analysis by considering the situation when consumer prefer the digital goods to the traditional goods (i.e. $\boldsymbol{\theta \geq 1}$).

Proposition 1: *When the consumer acceptance level of digital goods θ is greater than one, the equivalent price strategy and single digital channel strategy will dominate the dual channel strategy in all different scenarios.*

The proof of this proposition directly follows from the preceding analysis. The intuition behind this result is that consumers prefer digital goods to traditional goods when θ 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 are 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 θ is greater than one, the agency model achieves supply chain coordination.*

In Table 3, we summarize the equilibrium results for all scenarios. Since the sales volume drops to zero for the traditional goods, the agency model essentially mimics a revenue sharing scheme whereby the retailer only shares a predetermined proportion α of her revenue with the publisher. As established in previous literature [4], the supply chain will reach its coordination under this pricing scheme. And we also notice that the supply chain performance of wholesale model is suboptimal due to the double marginalization effect.

From the above table, we also find that there exists a region of revenue sharing proportion $\alpha \in (\frac{1}{4}, \frac{1}{2})$ such that both the publisher and the retailer strictly prefer the agency model to the wholesale model. This Pareto improving region of α provides practical guidance for the managers operating in the e-book industry. In summary, we find that the agency model is a very efficient contract form when consumer acceptance level of digital goods is greater than one. Next we focus on the strategic channel design when consumer acceptance level of digital goods is less than one. We first compare the agency model under the dual channel strategy with the wholesale model.

Proposition 3: *When the consumer acceptance level of digital goods θ is less than one, we compare the dual channel strategy under the Agency Model with the Wholesale model and find,*

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

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

c) ${\pi_P}^{Agency} - {\pi_P}^{Wholesale} = \frac{(1-2\alpha)}{8}\theta\bar{V}$, ${\pi_R}^{Agency} - {\pi_R}^{Wholesale} = \frac{(4\alpha-1)}{4}\theta\bar{V}$, ${\pi_{SC}}^{Agency} - {\pi_{SC}}^{Wholesale} = \frac{\theta\bar{V}}{16} > 0$

d) $CS^{Agency} - CS^{Wholesale} = \frac{1}{32}(\bar{V} + \frac{2C_T}{1-\theta}) > 0$

TABLE 3: COMPARISON OF WHOLESALE MODEL AND AGENCY MODEL WHEN $\theta \geq 1$

	Wholesale Model	Agency Model/ Integrated Supply Chain
Price		
Digital Goods Price, P_D	$\frac{3\theta\bar{V}}{4}$	$\frac{\theta\bar{V}}{2}$
Wholesale price W_D	$\frac{\theta\bar{V}}{2}$	*n/a*
Sales Volume		
Digital Goods, Q_D	$\frac{1}{4}$	$\frac{1}{2}$
Traditional Goods, Q_T	*0*	*0*
Profit		
Publisher's profit, π_P	$\frac{\theta\bar{V}}{8}$	$\frac{1}{4}(1-\alpha)\theta\bar{V}$
Retailer's profit, π_R	$\frac{\theta\bar{V}}{16}$	$\frac{1}{4}\alpha\theta\bar{V}$
Supply chain profit, $\pi_R + \pi_P$	$\frac{3\theta\bar{V}}{16}$	$\frac{\theta\bar{V}}{4}$

These results show that when utilizing a dual channel strategy, the supply chain profits under the agency model outperforms those associated with the wholesale model by $\frac{\theta\bar{V}}{16}$. This difference stems from the fact that the digital goods demand in the agency model is strictly higher than the demand in the wholesale model, ${Q_D}^{Agency} > {Q_D}^{Wholesale}$, while the demand for the traditional goods are kept the same under these two pricing schemes, ${Q_T}^{Agency} = {Q_T}^{Wholesale}$. Essentially, the publisher charges a price of ${\mathrm{P_D}}^{Agency} = \frac{\theta\bar{V}}{2}$ for the digital goods under the agency model, and the publisher also charges the same wholesale price ${W_D}^{Wholesale} = \frac{\theta\bar{V}}{2}$ under the wholesale model, but the retailer adds an additional markup under the wholesale model for the digital goods. In equilibrium, the price for the digital goods is ${\mathrm{P_D}}^{Wholesale} = \frac{3\theta\bar{V}}{4}$, 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, $CS^{Agency} - CS^{Wholesale} > 0$. For a supply chain with both traditional goods and digital goods, the agency model can coordinate the supply chain and resolve the double marginalization partially by improving both parties' profit as well as consumer's surplus.

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. In addition, prices for digital books rose after Amazon and other retailers agreed to utilize the new agency model. Through the analysis above, we find that contrary to popular press and the prosecutor's argument, consumer surplus and company's profits are enhanced with the utilization of the agency model. 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. We believe that the initial price increase for digital goods after introducing the agency model (i.e. from $9.99 to $12.99 and $14.99) was not due to the agency model but instead that Amazon's original retail price of the digital goods was too low. In this situation, Amazon may be adhering to a "fixed price" model (i.e. selling all new books at the same price) which appeals to customers, although the price is actually lower than that which is predicted by both the agency and wholesale models. The original very low fixed price (i.e. $9.99 for New York Times Best Sellers) is merely a strategic move to lock-in consumers and build market share/awareness for the digital platform, which is not viable in the long-run.

In Proposition 3, we focus on the dual channel strategy utilizing both agency and wholesale models. Now we analyze the relative profits for both firms under agency and wholesale models for the case when θ is less than one. Also, we further illustrate the viability of the dual channel strategy under the agency model.

Proposition 4: *Consider the situation where the consumer acceptance level of the digital goods θ is less than one. When the dual channel strategy is optimal for the agency model, then the agency model yields a higher profit (than the wholesale model) for both the publisher and the retailer when $\alpha \in [.25,.5]$. 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.*

When the revenue sharing proportion α 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 profit under the wholesale model. However, 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 agency model only captures the market for traditional goods, while the dual channel strategy under the wholesale model attract 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.

The dual channel strategy in the agency model seems to be problematic due to the incentive incompatibility between the publisher and retailer. 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. A general insight to resolve this issue is that the publisher and retailer need to negotiate a product specific revenue sharing proportion α based on the different characteristics of the product. Some more complicated contract forms may also attract the firms to adopt the dual channel strategy.

There also exists a natural force to persuade the firms adopt the dual channel strategy, which is the increasing consumer acceptance level of θ. To illustrate, policies which Amazon has initiated to promote a higher value of θ include the following: consecutive price decreases for the Kindle reader, more features and functions added to the digital book reader (e.g. Paperwhite technology), the introduction of multiple Kindle reading applications on different platforms, the capability to borrow the book through Kindle Library, as well as increased availability of free materials. As we show in the previous proposition, the single digital goods channel strategy under the agency model coordinates the supply chain and generates higher profit for both the publisher and the retailer when the consumer acceptance level θ is greater than one. Firms may have an incentive to include more attractive features into the digital devices early on in the life-cycle of these digital products, thereby "locking-in" consumers for the future. As a result, they would like to introduce the digital goods by utilizing a dual channel strategy under agency model even the single traditional channel strategy leads to a momentary higher profit.

VI. CONCLUSION AND FUTURE RESEARCH

In this paper, we have formulated 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 good in the market. We consider two different scenarios, each associated with different pricing control for the digital goods. Under the first scenario, the publisher determines the price of the digital goods in the marketplace, and also the wholesale price for the traditional goods, and profit is shared for the digital goods using 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.

We utilize 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 [24], several publishers colluded with Apple to demand an agency pricing structure also with Amazon whereby the publishers controlled of 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 impacts 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 [24], 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 θ 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 which provides 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 where there exists one publisher with single retailer. Although 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 [16] it might be interesting to incorporate the competitions between the 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 models impact 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 man

REFERENCES

[1] Bhargava, H. K., Choudhary, V. and Krishnan, R., "Pricing and product design: Intermediary strategies in an electronic market," *International Journal of Electronic Commerce*, 5(1), 37-56, 2000

[2] Bockstedt, J. C., Kauffman, R. J. and Riggins, F. J., "The move to artist-led on-line music distribution: A theory-based assessment and prospects for structural changes in the digital music market," *International Journal of Electronic Commerce*, 10(3), 7-38, 2006

[3] Buxmann, P., Strube, J. and Pohl, G., "Cooperative pricing in digital value chains–the case of online music," *Journal of Electronic Commerce Research*, 8(1), 32-40, 2007

[4] Cachon, G. and Lariviere, M., "Supply Chain Coordination with Revenue-Sharing Contracts: Strengths and Limitations," *Management Science*, 51(1), 30-44, 2005

[5] Cattani, K., Gilland, W. and Swaminathan, J. M., "Coordinating traditional and internet supply chains" in *Handbook of Quantitative Supply Chain Analysis* D. Simchi-Levi, D. Wu, M. Shen (Editors), Kluwer Academic Publishers, Boston, Massachusetts, 2004

[6] Cattani, K., Gilland, W., Heese, H. S. and Swaminathan, J., "Boiling frogs: Pricing strategies for a manufacturer adding a direct channel that competes with the traditional channel," *Production and Operations Management*, 15(1), 40, 2006

[7] Chellappa, R. K. and Shivendu, S., "Upstream contracts in supply chain for digital goods," *INFORMS Conference on Information System and Technology*, 2007

[8] Chiang, W. K., Chhajed, D. and Hess, J. D., "Direct marketing, indirect profits: A strategic analysis of dual-channel supply-chain design," *Management Science*, 49(1), 1-20, 2003

[9] Chiang, W. K. and Chhajed, D., "Multi-channel supply chain design in B2C electronic commerce," *Supply Chain Optimization*, J.Geunes, P.M.Pardalos (Editors), Springer, New York, NY, 2005.

[10] Dumrongsiri, A., Fan, M., Jain, A. and Moinzadeh, K., "A supply chain model with direct and retail channels," *European Journal of Operational Research*, 187(3), 691-718, 2008

[11] Fishman, A. and Rob, R., "Product Innovation by a Durable-Good Monopoly," *RAND journal of Economics*, 31(2), 237-252, 2000
[12] Geoffrion, A. M., "Progress in operations management," *Production and Operations Management*, 11(1), 92-100, 2002
[13] Hayes, R. H., "Challenges posed to operations management by the "new economy"," *Production and Operations Management*, 11(1), 21-32, 2002
[14] Hu, Y. and D. Smith, "The Impact of Ebook Distribution on Print Sales: Analysis of a Natural Experiment," Working paper, *Carnegie Mellon University*, 2011
[15] Jiang, Y. and Katsamakas, E., "Impact of e-book technology: Ownership and market asymmetries in digital transformation," *Electronic Commerce Research and Applications*, 9(5), 386-399, 2010
[16] Jones, R. and Mendelson, H., "Information goods vs. industrial goods: Cost structure and competition," *Management Science*, 57(1), 164-176, 2011
[17] Karmarkar, U. S. and Apte, U. M., "Operations management in the information economy: Information products, processes, and chains," *Journal of Operations Management*, 25(2), 438-453, 2007
[18] L.A. Times (2011, May 19). *Amazon: consumers buying more Kindle eBooks than print books* [Online]. Available: http://latimesblogs.latimes.com/technology/2011/05/amazon-says-it-now-sells-more-kindle-ebooks-than-print-books.html
[19] Mussa, M. and Rosen, S., "Monopoly and product quality," *Journal of Economic Theory*, 18(2), 301-317, 1978
[20] PricewaterhouseCoopers, "The Future of eBooks, Technology, Medial & Telecommunications," 2011
[21] Rich, M. (2009, May 16). *Steal This Book (for $9.99)* [Online]. Available: http://www.nytimes.com/2009/05/17/weekinreview/17rich.html?pagewanted=all&_r=0
[22] Ryan, M.W., et al. (2013, July 10). *Opinion & Order* [Online]. Available: http://www.justice.gov/atr/cases/f299200/299275.pdf
[23] Schumer, C. E. (2012, July 17). *Memo to DOJ: Drop the Apple E-Books Suit* [Online]. Available: http://online.wsj.com/article/SB10001424052702303740704577527211023581798.html
[24] Stone, B. (2012, January 25). *Amazon's hit man* [Online] Available: http://www.businessweek.com/magazine/amazons-hit-man-01252012.html
[25] Streitfield, D. (2011, August 16). *Amazon set to publish pop author* [Online] Available: http://www.nytimes.com/2011/08/17/technology/amazon-set-to-publish-tim-ferriss.html?_r=0
[26] Sundararajan, A., "Nonlinear Pricing of Information Goods," *Management Science*, 50(12), 1660-1673, 2004
[27] Tsay, A. A and Agrawal, N., "Channel conflict and coordination in the ECommerce age," *Production and Operations Management*, 13(1), 93-110, 2004
[28] WSJ Staff (2012, April 11). *What is 'Agency Pricing'?* [Online]. Available: http://blogs.wsj.com/digits/2012/04/11/what-is-agency-pricing/

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) using backward induction,

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

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

We write out the Lagrangian function $L = (P_D - W_D)Q_D + (P_T - W_T)Q_T + \lambda(\frac{P_D}{\theta} - P_T)$ and get two sets of the solutions from FOCs, which are $P_D^*(W_T, W_D) = \frac{\theta\bar{V}+W_D}{2}$, $P_T^*(W_T, W_D) = \frac{W_T+\bar{V}}{2}$ with $\lambda = 0$ and $P_D^*(W_T, W_D) = \frac{\theta\bar{V}+W_D}{2}$, $P_T^*(W_T, W_D) = \frac{\theta\bar{V}+W_D}{2\theta}$ with $\lambda = \frac{W_D - W_T\theta}{(1-\theta)\bar{V}}$. After substituting the value back into objective function, we find that the second solution $\pi_R{}^{Equi}(W_T, W_D) = \frac{(W_D-\theta\bar{V})^2}{4\theta\bar{V}}$ leads to the higher profit, which implies that the constraint is binding because the sign of Lagrangian multiplier is positive.

Similarly we solve the retailer's problem under single channel strategy and get the exact same solution as in the equivalent price strategy. We next focus on the case of equivalent price strategy.

After solving the retailer's problem, the publisher is facing the following optimization problem,

$$\max_{W_D} \pi_P = \pi_{P,D} = W_D Q_D{}^{Equi}$$

We can show that π_P is concave in W_D by verifying the SOC. Thus solving the FOCs leads to the optimal solution $W_D{}^* = \frac{\theta\bar{V}}{2}$. The corresponding profit of the publisher under this case becomes $\pi_P{}^{Equi} = \frac{\theta\bar{V}}{8}$.

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,

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

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

We first show that π_R *is* jointly concave in P_D and P_T by examining the Hessian.

$$H = \begin{bmatrix} \frac{2}{(\theta-1)\bar{V}} & \frac{2}{(1-\theta)\bar{V}} \\ \frac{2}{(1-\theta)\bar{V}} & \frac{2}{\theta(\theta-1)\bar{V}} \end{bmatrix}$$

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 $P_D^*(W_T, W_D) = \frac{1}{2}(\theta\bar{V} + W_D)$, $P_T^*(W_T, W_D) = \frac{\bar{V}+W_T}{2}$, and ${\pi_R}^{Dual}(W_T, W_D) = \frac{\theta((\theta-1)\bar{V}^2+2(\bar{V}-\theta\bar{V}+W_D)W_T-{W_T}^2)-{W_D}^2}{4(\theta-1)\theta\bar{V}}$. 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 $P_T^*(W_T, W_D) = \frac{\bar{V}+W_T}{2}$ and ${\pi_R}^{Single}(W_T, W_D) = \frac{(\bar{V}-W_T)^2}{4\bar{V}}$. After taking the difference of profits under two strategies, we get ${\pi_R}^{Dual} - {\pi_R}^{Single} = \frac{(W_D-\theta W_T)^2}{4(1-\theta)\theta\bar{V}} > 0$, which suggests that the dual channel strategy dominate single channel strategy for all the possible value of wholesale prices. As a result, the publisher only needs to consider the dual channel strategy when setting the optimal wholesale prices, W_T and W_D.

Anticipating the retailer's response, the publisher is facing the following optimization problem:

$$\max_{W_T, W_D} \pi_P = \pi_{P,D} + \pi_{P,T} = W_D {Q_D}^{Dual} + (W_T - C_T){Q_T}^{Dual}$$

We can show that π_P is joint concave in W_T and W_D by verifying the Hessian matrix is negative definite. Thus solving the FOCs leads to the optimal solution, where ${W_T}^* = \frac{C_T+\bar{V}}{2}$ and ${W_D}^* = \frac{\theta\bar{V}}{2}$. The corresponding profit of the publisher under this case becomes ${\pi_P}^{Dual} = \frac{1}{8}[\bar{V} + C_T\left(\frac{C_T}{\bar{V}-\theta\bar{V}} - 2\right)]$.