Pricing and coordination with consideration of piracy for digital goods in supply chains

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A B S T R A C T

Sales of digital goods via traditional channels are affected by those on digital channels, and thus a competitive relationship often exists. In addition, due to the ease of piracy, digital goods may suffer from a fall in demand, which intensifies competition. This study considers a single supplier who sells digital goods, which may be pirated, to customers through two independent and different retail channels, such as traditional and digital ones, which may compete with each other in terms of service and price. To consider the effects of piracy on demand, a Stackelberg game is utilized to determine the optimal gain-sharing ratio and the equilibrium prices for all channel members with an aim to maximize the profit of the entire supply chain. It is found that an increase in piracy would force retailers to compete in a smaller market, and thus lead to a decrease in profits for each channel member. Therefore, a retailer who has a greater market share and is capable of managing a lower piracy rate would gain more profits by setting a higher price.

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1. Introduction

Digital goods differ from traditional ones in the characteristic of having a relatively high fixed cost but extremely low marginal one, meaning that the profits increase quickly as the sales volume rises (Turban et al., 2008). However, since digital goods are easy to copy and can be transmitted at low cost, this makes piracy easier and cheaper. Piracy is copying or utilizing a product without permission from the party who owns the copyright, and it often has unfavorable impacts on the wider society, even though consumers are obviously pleased to obtain the product for free (Johnson, 1985). Yang, Wang, and Mourali (2015) investigated two forms of music piracy in schools and colleges, unauthorized downloading and sharing, in order to prevent them, while Jacobs, Heuvelman, Tan, and Peters (2012) studied downloading behavior in the context of digital movie piracy. The findings showed that the influence of any knowledge of the related laws on the expected economic outcomes is negative. Various ways to prevent piracy are proposed in the literature (Khouja & Park, 2008; Khouja & Rajagopalan, 2009; Wu & Chen, 2008), and while most studies suggested that piracy has negative effects, some considered that it may actually increase demand and thus enhances profits (Conner & Rumelt, 1991). Hsu, Wang, and Wu (2013) indicated that the government should do whatever is in its

power to protect intellectual property and punish piracy, as this will motivate firms to invest in innovation. Appleyard (2015) examined a number of practical cases to propose six lessons in developing effective anti-piracy strategies. The author concludes that these could guide managers to protect existing rights and engage with new market paradigms.

Digital goods sold by different channels have different values to consumers and retailers. Consumers may prefer the physical versions of products, as it gives more value through the experience of real possession, even though they have to wait to receive these, in contrast to digital copies, which can be delivered immediately. On the other hand, offering a physical version means retailers have to bear the production, inventory, and distribution costs, and though these can be easily cut by selling the virtual version on the Internet, such an arrangement may not be satisfactory for many consumers, who may enjoy the atmosphere of a real store. In sum, while these two channels may grow the entire market, they also create dilemmas for customers and retailers. Moreover, they bring more competition to the market (Jiang & Katsamakas, 2010; Kim, Chang, & Shocker, 2000). Competition may occur for each different channel if the product is sold in different forms, and the manufacturer would therefore postpone or stagger the selling periods for different channels or sell the product only in a single one. Such practices are common in the film industry, as movies often only have online versions sold after their DVD versions have been available for a while, while some are never offered online. However, in any case the demand is usually highest when a product first becomes available on the market, and generally decreases dramatically after this initial period. Therefore,

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digital goods are now often sold by both virtual and physical channels at the same time. Different approaches may be used to avoid competition in such cases; for example, selling products only by a single channel, offering different editions of the product and bundling (Koukova, Kannan, & Ratchford, 2008), or deferring the selling times for other channels to avoid competition between two similar and substitutable products (Thorsten, Henning, Sattler, Eggers, & Houston, 2007).

As digital channels have been introduced to the market, so competition has become more intense. The traditional channel often address this by adding value, while the digital channel may reduce the price by taking advantage of its low (or zero) marginal cost to attract more consumers. This may eventually result in a price war, and make the market unprofitable for each channel member. Members in the supply chain thus have to horizontally and vertically coordinate with each other to obtain the maximum profits. Supply chain coordination has been extensively studied (Bernstein & Federgruen, 2003; Cachon, 2004; Jeuland & Shugan, 1983; Pan, Lai, Leung, & Xiao, 2010), and the coordination mechanism adopted in this context may involve various different considerations, such as a wholesale price contract (Raman et al., 2005), rebate contract (Leng & Parlar, 2010; Pasternack, 2008), revenue sharing (Cachon & Lariviere, 2005; Giannoccaro & Pontrandolfo, 2004), and quantity discount (Rhee, van der Veen, Venugopal, & Nalla, 2010). Among these, revenue-sharing coordination has been widely applied in industries which have extremely low marginal costs, such as those that sell digital products on the Internet (Foros et al., 2009). Moreover, revenue-sharing coordination, which can prevent price wars, is widely applied in the DVD rental industry (Gerchak, Cho, & Ray, 2006). It is not uncommon in practice for retailers to share their sales revenues with suppliers. Hence, it may be important for suppliers and retailers to share the profits in the supply chain, especially when demand for digital goods is affected by piracy. Moreover, some inducements may be needed to encourage each channel member to behave according to the mutual agreement, even if there is a good gain-sharing mechanism. Extensive research on the pricing strategy under such competition has been carried out (Tang & Xing, 2001; Viswanathan, 2005; Yan, Wang, & Zhou, 2010; Cai, 2010; Kogan et al., 2013; Chang and Walter, 2015), indicating the importance of coordination for such a competitive multi-channel market. Therefore, this study demonstrates how a supplier and retailers can coordinate by the use of a contractual gain-sharing mechanism, and determine the equilibrium prices and the optimal gain-sharing ratio when a digital product is sold in a supply chain under the multi-channel competition with consideration of piracy.

Conflict will always occur when new channels enter the market, resulting in double marginality and lowering the profit as a whole for the supply chain, since every channel member aims to achieve profit maximization for themselves (Yan et al., 2010; Yao & Liu, 2005). Therefore, an appropriate coordination mechanism which can be used in different situations for different overall benefits is essential. Moreover, some studies derived the equilibrium prices for channel members with coordination by considering the supply chain as a whole and aiming to maximize the overall profit. Yan and Ghose (2010) derived the Bertrand equilibrium prices in consideration of independent firms in a dual-channel competitive market. Li, Zhu, and Huang (2009) utilized a Nash equilibrium model to describe how both the manufacturer and retailer can earn more profit in cooperation. Yan (2008) analyzed the equilibrium prices for a mixed online and traditional retail channel in order to maximize profits, and suggested that a profit-sharing policy can be as an incentive to coordinate online and traditional channels to achieve overall optimization. However, it is not applicable in practice to assume that both parties would completely cooperate with each other. This study thus focuses on a supply chain in which a supplier sells digital goods that can be pirated and sold at the same time by both the traditional channel with physical carriers, and the virtual channel with digital carriers. This supplier does not directly enter the market, but instead sells the digital product through another two independent

retailers who sell it in different forms, which can be mutually substituted under service and price competition. Different proportions of revenue sharing are adopted for different retailers in this study to obtain the maximum profit for each channel member.

The rest of this paper is organized as follows: section two describes the research problem and presents the notations adopted in the proposed model. Section three shows the research framework and the model formulation regarding the research problem, while section four performs analytical and numerical analyses to obtain the managerial implications. Finally, section five gives the conclusion and states the contributions of this work and suggestions for future studies.

2. Competition of digital goods on dual channels

The schema used in this study is extended from Yan and Ghose's work (2010) and considers a single supplier that provides similar and substitutable digital goods to customers by two different retailing channels which offer different services and prices, and analyses how the supplier and the two retailers can coordinate by the use of a revenue-sharing mechanism to set their prices with an aim of maximizing the profits of the supply chain as a whole. Here, the digital goods are defined as those products that can be digitalized. For example, the contents of books, DVDs, CDs and professional software can be digitalized and sold on the Internet, while they can also be sold at physical stores.

Fig. 1 shows the framework of the research model, with a powerful supplier and two asymmetric retailers considered in the system. The supplier sells digital goods in two different forms through a traditional physical channel and an Internet virtual channel, respectively, and the two retailers then sell the product to consumers not only at different prices, but also with different services, including promotion, exhibition of products, advertisements, the time needed to obtain the product, and the shopping atmosphere. The supplier is the Stackelberg leader who declares wholesale prices and the revenue-sharing rule to the retailers as a coordination mechanism. The retailers select their price and service level independently, a Nash equilibrium is established, and profits are realized. The customers will transfer between the two market channels due to the retailers' competition. Moreover, the influence of piracy is considered in the framework, and the elasticity and cross-elasticity of price are also measured in this study.

The notations used in this study are summarized in Table 1.

Suppose that D_r is the demand faced by the traditional market channel, and γ_r is its corresponding piracy rate, while D_d is the demand faced by the digital market channel, and γ_d is its corresponding piracy rate. Compared with the virtual channel, since the traditional physical channel usually cannot fulfill a large demand when the product is first introduced to the market, due to the high carrier cost and insufficient inventory space, consumers would have to wait a long time for delivery. In such cases, unsatisfied consumers may not be willing to wait, and thus turn to purchase the product from the digital market channel, even though the physical channel can often provide a more comfortable shopping atmosphere. S_r denotes the service level provided by the retailer of traditional market channel. Compared with the physical channel, the product may have a late launching time or even not be available via the digital channel. In such cases, consumers may turn to purchase the product from the retailer of the traditional market channel. S_d denotes the service level provided by the digital channel, and $S_r \geq S_d$ is assumed in this study. The assumption indicates the traditional retailer's service level is better than the online retailer's. It is reasonable in practice that a customer is willing to pay a higher price to buy a product from a traditional retailer. Because they expect to get a higher level of service.

LF_s denotes the supplier's expense for purchasing the copyright from the product creator, and some royalty may also need to be paid to the product creator for each sold product. Suppose that W_r and W_d denote the marginal costs that the supplier charges the traditional and digital channels, respectively, which include the cost of the royalty paid to