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COMPETITION BETWEEN PHYSICAL AND ELECTRONIC CONTENT RETAILERS

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Abstract

We investigate a model in which a monopoly supplier distributes two types of its product through a traditional retailer with a wholesale price contract and an online retailer with an agency contract. Because such an agency contract eliminates the double marginalization problem, the online retailer has a cost advantage over the traditional retailer. Given the advantage of the online retailer, we also consider a possible request by the traditional retailer: the retail price of the online retailer is not smaller than the wholesale price for the traditional retailer. We obtain the following results. An increase in the online retailer's bargaining power over the supplier benefits the two retailers but harms the supplier. Under the request to protect the traditional retailer, the wholesale price *is strictly higher* than that in the baseline model. The retailers' equilibrium prices are also strictly higher than those in the baseline model. The request benefits the supplier and the online retailer, but *harms the traditional retailer*.

Keywords: Agency contract, Price–quantity competition, Dual-channel supply chain, Royalty rate.

JEL Classification: L22, L13, C72, C78.

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1 Introduction

The recent advancement of online platforms facilitates selling digital content, including books, games, movies, and music, and purchasing such content without leaving home. The facilitation of selling and buying digital content is a competitive threat to the traditional brick-and-mortar retailers handling physical content. For instance, in the US book industry, the sales share of e-books was about 20% in 2015 (Gilbert, 2015), and in 2018, 34% of younger consumers, aged 18 to 29, had read e-books in the previous 12 months (Pew Research Center, 2019). The penetration of devices for reading e-books, including e-readers and tablet PCs, is increasing constantly (Deloitte, 2018). Therefore, we easily imagine that the e-books market has a substantial market share. The flipside of the previous argument is that some consumers still prefer traditional paper books to e-books. Even for the younger generation, at least half of consumers had not read e-books. Thus, consumers still purchase both traditional paper books and e-books, depending on preferences, situations, and places (see, for instance, Bergström and Höglund (2020) for the recent trend in e-books in Sweden). We can see such co-existence of physical and digital content in the games, movies, and music industries.[1] Therefore, it is reasonable to investigate a market in which consumers can purchase both physical and digital content.

One advantage of distributing digital content over physical content is lower production costs. In addition to the cost advantage, the different contract types applied to online and brick-and-mortar retailers can create advantages for online retailers. In the US book industry, brick-and-mortar book retailers employ standard wholesale price contracts, although some online retailers (e.g., Apple) use agency contracts. The latter form eliminates the double-marginalization problem and allows the trading pair to be a quasi-integrated firm. Those two advantages of online retailers cause the following additional threat to traditional brick-and-mortar book retailers: online retailers' prices for consumers can be *lower* than the wholesale prices offered to those brick-and-mortar retailers.

The disadvantages mentioned above are reminiscent of the concern about price/margin squeezes in a competitive market with a dominant vertically integrated firm (see, e.g., Bouckaert and Verboven, 2004) because nonintegrated firms cannot earn positive profits if their retail prices are the same as that of integrated firms. Given the disadvantage of brick-and-mortar retailers over online retailers (quasi-integrated firms), brick-and-mortar

[1] For example, see Capcom Co., Ltd. (2020), page 69, for recent trends and forecasts for the games industry.

retailers may request that their upstream content providers avoid imposing wholesale prices that are higher than the providers' retail prices. The request is similar to the remedy in the context of price/margin squeezes. Following such requests, the content providers may impose self-regulation such that the retail prices of the online retailer are not lower than the wholesale prices for the brick-and-mortar retailers.

We investigate a model in which a monopoly supplier distributes two types of its product through a traditional retailer with a wholesale price contract and an online retailer with an agency contract. We also consider the impact of the self-regulation mentioned in the previous paragraph on the three players and the consumer and total surpluses. In the baseline model, we consider the following stage game. First, the supplier and the online retailer negotiate the royalty rate through Nash bargaining, which is a key element in our model. Second, the supplier unilaterally determines the wholesale price for the traditional retailer. Third, observing the trading terms determined before, the traditional retailer and the supplier simultaneously set their own strategic variables. By taking into account the nature of physical and digital content, we assume that the traditional retailer and the supplier via the online retailer compete in quantity and price, respectively (e.g., a subgame in Singh and Vives (1984)). In the self-regulation case, the supplier cannot set a retail price that is lower than the wholesale price for the traditional retailer in the third stage.

The assumption of price–quantity competition is consistent with the standard view on when price and quantity are strategic variables of firms (e.g., the textbook by Belleflamme and Peitz (2015), Section 3.3.3 on page 67). Belleflamme and Peitz (2015) mention that when capacity is unlimited, assuming a firm is a price setter is appropriate; when capacity is limited, assuming a firm is a quantity setter is appropriate. Case 3.4 on page 68 in Belleflamme and Peitz (2015) explains the product characteristics change in the publishing industry: "it seems that the quantity competition model fits better with the batch printing technology (because prices will adjust to sell the existing capacity) and the price competition model with the POD technology (because quantity can be adjusted immediately at the announced prices)" (POD in the quotation is 'publish on demand'). Thus, we think that the market structure discussed in our paper properly captures the nature of product characteristics in real-world industries, including books, games, movies, and music.

We obtain the following results in the baseline model. The equilibrium royalty rate has a positive correlation to the online retailer's bargaining power over the supplier. An increase in the online retailer's bargaining power over the supplier benefits the two retailers but harms the supplier. The wholesale price for the traditional retailer can be higher than the online retailer's retail price in equilibrium. We also obtain the following results in the self-regulation case. The wholesale price is strictly higher than that in the baseline model. The retail prices are also strictly higher than those in the baseline model. The retail price of the online retailer is always binding by the constraint. Self-regulation benefits the supplier and the online retailer but harms the traditional retailer. That is, the attempt to protect the traditional retailer fails. The consumer and total surpluses are smaller than those in the baseline model. Therefore, we should regard suspiciously content suppliers (e.g., publishers, game producers) who employ the remedy discussed here using the excuse that they attempted to protect traditional retailers using "fair trading terms."

To understand the importance of assuming price–quantity competition in the self-regulation case, we consider a modified model in which the two retailers compete in price instead of through price–quantity competition. The price competition model differs from the main model as follows. The supplier can indirectly control the traditional retailer's quantity through its price, inducing the supplier to consider the wholesale revenue in the retail pricing stage. The supplier credibly sets the online retail price that is strictly higher than the wholesale price under any degrees of bargaining power and product differentiation. However, in the price–quantity competition, such a consideration for the wholesale revenue in the retail pricing stage does not exist, and the supplier ignores the wholesale revenue when it sets its retail price. In the modified model, self-regulation does not work because of the supplier's less aggressive pricing policy in the downstream market. We can conclude that price–quantity competition is crucial to obtaining the anti-competitive effect of self-regulation.

The remainder of this paper is organized as follows. Section 2 surveys the related papers. Section 3 constructs the model. Section 4 analyzes the game and shows the results. Section 5 analyzes the effect of self-regulation on retail prices. Section 6 discusses the case in which two retailers compete in price and how contract forms influence firms' profits. Section 7 offers concluding remarks.

2 Related Literature

There are a few papers discussing price–quantity competition with vertical relations (e.g., Manasakis and Vlassis, 2014; Yang et al., 2015; Basak and Wang, 2016; Fanti and Scrimitore, 2019). We discuss two categories of papers whose market structure is the same as ours: (i) endogenous choices of price and quantity in asymmetric downstream duopoly models, (ii) optimal channel structures. The purposes of those papers, however, differ from ours.

Fanti and Scrimitore (2019) extend Arya et al. (2008) to investigate price versus quantity competition in market structures similar to ours: a vertically integrated firm supplies upstream inputs to an independent downstream firm, which is its downstream competitor, and each of them chooses price or quantity as its strategic variable before they compete in the downstream market, as in Singh and Vives (1984) (see also Bylka and Komar (1976); Reisinger and Ressner (2009), and the comprehensive survey of Tremblay and Tremblay (2019)). Their main themes are the endogenous choices of those strategic variables and the implications of the results. The royalty rate and the self-regulation discussed in our model are beyond the scope of their papers.

The model in the supplementary appendix in Lei (2019) is the closest to ours. The market structures in her model and ours use price–quantity competition, as in Fanti and Scrimitore (2019). The difference between her model and ours is threefold. First, the main focuses of the two models are different. She investigates the optimal channel structure for a monopoly manufacturer, as in Chiang et al. (2003) and Arya et al. (2007). We investigate the equilibrium royalty rate and the impact of self-regulation by an upstream firm, but fix the dual-channel supply chain. Second, the properties of the realized royalty rates in the two models differ from each other. The endogenous royalty rate in her model binds at the exogenous upper bound because the retailer unilaterally sets the royalty rate. The endogenous royalty rate in our model can range from 0 to 1 because we consider Nash bargaining. Third, self-regulation by the supplier is only discussed in our model. In this sense, we should regard our model as an extension of price–quantity competition in a direction different from her extension.

Similar to the discussion of price/margin squeezes (see, for instance, the recent survey by Jullien et al. (2014)), we also consider (self-)regulation in which the supplier's retail price is not lower than the wholesale price for the traditional retailer. An interesting feature of the regulation is the following: self-regulation increases the wholesale price for the traditional retailer as well as the supplier's retail price. This feature has a detrimental effect on the profit of the (nonintegrated) traditional retailer. The detrimental effect differs from the standard result in the literature regarding price/margin squeezes, which shows that a ban on price squeezes is always preferable for downstream competitors through lower wholesale prices or higher retail prices (Sidak, 2008; Choné et al., 2010; Petulowa and Saavedra, 2014). Our contrasting result stems from the price–quantity competition. When the supplier sets the retail price, it does not consider the wholesale revenue through the traditional retailer, the quantity setter. The lack of concern about the wholesale revenue in the price-setting stage accelerates downstream competition. The self-regulation mentioned above induces the supplier to set a higher wholesale price in order to commit to setting a higher retail price in the downstream competition, mitigating the downstream competition. Therefore, an increase in the wholesale price through the self-regulation does not occur in the standard price competition because of indirect control.

Because online retailers with agency contracts are similar to store-within-store retail formats, our paper complements the literature of store-within-store formats in traditional retailers (Jerath and Zhang, 2010; Netemeyer et al., 2012). Our additional contribution to the literature is twofold: (1) the endogenous choice of the royalty rate between the supplier and the online retailer under Nash bargaining, which differs from Abhishek et al. (2016), Tian et al. (2018), and Zennyo (2019, 2020), also considering endogenous choices of royalty rates; (2) self-regulation restricting the pricing policy of the supplier. Those two discussions also contribute to the literature on agency contracts (e.g., Foros et al., 2017; Johnson, 2017; Tan and Carrillo, 2017; Maruyama and Zennyo, 2020). Although the themes of those papers differ from ours, the market structure of Zennyo (2019) partially overlaps with that of ours. We discuss the difference between Zennyo (2019) and our paper in Section 6.

3 The Model

A monopolistic supplier produces a good and distributes it through two retailers: (i) a traditional retailer who resells a physical version of the good and (ii) an e-commerce retailer who handles a digital version of the good. For the sake of clarity, we focus on a book market where a monopolistic publisher publishes a book and sells it through a traditional bookstore (henceforth referred to as *T-retailer*) and an e-commerce platform (*E-retailer*). T-retailer sells a traditional paper version of the book (hereafter, we refer to it as *paper book*), and E-retailer sells an electronic version of the book (*e-book*).

First, we assume that the distribution processes of the paper book and the e-book are different. For the paper book, T-retailer determines its sales quantity, q_t, because it must consider the stock of the book. By contrast, for the e-book, the monopolistic supplier and E-retailer sign an agency contract that allows the supplier to set its retail price, p_e, directly without worrying about stock of the book. This assumption is consistent with the standard view on when price and quantity are strategic variables of firms (e.g., Belleflamme and Peitz (2015), Section 3.3.3 on page 67 and the discussion in Section 1). To describe the price–quantity competition in the retail market, we use the demand system in Singh and Vives (1984) and Fanti and Scrimitore (2019). The inverse demand functions for the paper book and the e-book are:

$$p_t = \alpha - q_t - \gamma q_e, \tag{1}$$

$$p_e = \alpha - q_e - \gamma q_t, \tag{2}$$

where $\alpha(>0)$ is a positive constant and $\gamma \in [0, 1)$ is the degree of product substitutability between the two products. Hereafter, the subscripts t and e denote the T-retailer and E-retailer, respectively. Note that the demand system means that the product characteristics of the paper book and the e-book generate horizontal product differentiation.

The monopolistic supplier transacts with T-retailer and E-retailer with a *wholesale contract* and an *agency contract*, respectively. With a wholesale contract, the supplier determines its wholesale price before T-retailer sets its sales quantity, q_t. With an agency contract, the supplier sets the retail price of the e-book, p_e, directly, and the supplier and E-retailer split sales revenues according to a royalty rate, r, that is determined before the supplier determines p_e. Concretely, the supplier pays r times its revenue earned via the E-retailer's channel to the E-retailer. We believe that this assumption fits the reality where most publishers adopt wholesale contracts with brick-and-mortar bookstores, and those publishers adopt agency contracts with online retailers to sell e-books. Dantas et al. (2014) and Gilbert (2015) describe the pricing arrangements between publishers and retailers in book industries.

For notational simplicity, we assume that their marginal costs of producing or selling the books are zero. If the marginal cost of producing one unit of the paper book is positive, an equilibrium wholesale price is more likely to be higher than an equilibrium supplier's retail price. Therefore, the assumption on the marginal costs is not restrictive in our case.

The profits of the supplier and the retailers are:

$$\begin{aligned}
\pi_s &= w_t q_t + (1-r)p_e q_e = w_t q_t + (1-r)p_e(\alpha - \gamma q_t - p_e),\\
\pi_t &= (p_t - w_t)q_t = ((1-\gamma)\alpha + \gamma p_e - (1-\gamma^2)q_t - w_t)q_t,\\
\pi_e &= r\,p_e q_e = r\,p_e(\alpha - \gamma q_t - p_e),
\end{aligned} \tag{3}$$

where the subscript s represents the supplier. For the royalty rate, r, we assume that it is determined by bargaining between the supplier and E-retailer in advance, given the E-retailer's bargaining power over the supplier is $\beta \in (0,1)$.

In sum, the timing of the game is as follows.

Stage 1. The supplier and E-retailer determine the royalty rate, r, through bargaining.

Stage 2. The supplier sets a wholesale price, w_t, for T-retailer.

Stage 3. T-retailer and the supplier choose its sales quantity, q_t, and the price of the e-book, p_e, simultaneously.

We solve by backward induction.

4 Analysis

In this section, we analyze the baseline model.

4.1 Stage 3

To begin with, we derive the results of Stage 3. In this stage, T-retailer sets q_t and the supplier sets p_e simultaneously. They maximize their profits expressed in (3) given the wholesale price, w_t, and the royalty rate, r. The first-order conditions of T-retailer and the supplier are:

$$\frac{\partial \pi_t}{\partial q_t} = (1-\gamma)\alpha + \gamma p_e - 2(1-\gamma^2)q_t - w_t = 0, \quad \frac{\partial \pi_s}{\partial p_e} = (1-r)(\alpha - \gamma q_t - 2p_e) = 0. \tag{4}$$

$\partial \pi_s / \partial p_e$ in (4) gives us two remarks on the pricing of the supplier. First, it does not internalize the profit through the wholesale price w_t, leading to fiercer competition in the downstream market. The discrepancy between the internalization and the maximization stems from the price–quantity competition discussed here. If the strategic variable of T-retailer is also price (say p_t), T-retailer's quantity is a function of p_t and p_e (say $q_t(p_t, p_e)$) and then the supplier indirectly takes into account the wholesale profit, $w_t q_t(p_t, p_e)$, mitigating the discrepancy. Second, the supplier does not care about the royalty rate, r. As the royalty rate increases, the discrepancy mentioned above becomes serious.

From (4), we obtain the optimal quantity and price:

$$q_t(w_t) = \frac{\alpha(2-\gamma) - 2w_t}{4 - 3\gamma^2}, \quad p_e(w_t) = \frac{\alpha\left(2 - \gamma - \gamma^2\right) + \gamma w_t}{4 - 3\gamma^2}. \tag{5}$$

We can check that $\partial q_t(w_t)/\partial w_t < 0$ and $\partial p_e(w_t)/\partial w_t > 0$; that is, T-retailer reduces its sales quantity of the paper book and the supplier raises its retail price for the e-book when the wholesale price of the paper book increases. Therefore, the supplier can intensify or weaken the retail competition by adjusting the wholesale price.

4.2 Stage 2

In Stage 2, given the quantity and price in (5), the supplier chooses the optimal w_t that maximizes its profit. The supplier tries to balance the wholesale revenue of the paper book and the sales revenue of the e-book.[2] The optimal wholesale price is:

$$w_t(r) = \frac{\alpha\left\{8 - 4r\gamma - 2(4-r)\gamma^2 + (1+2r)\gamma^3\right\}}{2\left\{8 - \gamma^2(7-r)\right\}}. \tag{6}$$

From (6), it is straightforward that $\partial w_t(r)/\partial r < 0$. If, for example, the supplier's share of the e-book's revenue decreases, the supplier places weight on the wholesale revenue of the paper book and lowers the wholesale price to intensify the downstream competition.

4.3 Stage 1

At last, in Stage 1, expecting the results that we have seen so far, the supplier and E-retailer negotiate over the royalty rate, r. For simplicity, we assume that E-retailer's outside option is zero. However, we assume, if the negotiation breaks down, the supplier sells the paper book only through T-retailer. At that time, the supplier sets $w_t^o \equiv \alpha/2$

[2] This trade-off between the two sources of revenue is similar to that of vertically integrated producers (VIP) who consider both wholesale revenue from independent retailers and sales revenue of their integrated retailers (see, e.g., Arya et al. (2008) and Arya and Mittendorf (2018)).

and T-retailer chooses $q_t^o = \alpha/4$, where the superscript o indicates the case in which the supplier executes its outside option. Therefore, the outside option of the supplier is:

$$O_s = \frac{\alpha^2}{8}. \tag{7}$$

The equilibrium royalty rate, r^*, solves the following problem,

$$\max_r \, [\pi_s(r) - O_s]^{1-\beta}[\pi_e(r)]^{\beta}, \tag{8}$$

where

$$\pi_s(r) = \frac{\alpha^2 \left\{12 - 8\gamma - 3\gamma^2 - 4\left(2 - \gamma - \gamma^2\right) r\right\}}{4\left\{8 - (7 - r)\gamma^2\right\}}, \tag{9}$$

and

$$\pi_e(r) = \frac{\alpha^2 \left(8 - 2\gamma - 5\gamma^2\right)^2 r}{4\left\{8 - (7 - r)\gamma^2\right\}^2}. \tag{10}$$

We represent the equilibrium royalty rate in the following proposition.

Proposition 1 *In equilibrium, as a result of their Nash bargaining, the supplier and E-retailer set the royalty rate as:*

$$r^* = \frac{1}{\beta\gamma^2\left(16 - 8\gamma - 7\gamma^2\right)} \Big\{ -(8 - 2\gamma - 5\gamma^2)^2 + \beta\gamma^2(16 - 16\gamma + \gamma^2) + (8 - 2\gamma - 5\gamma^2)\sqrt{(8 - 2\gamma - 5\gamma^2)^2 - 2(1 - \beta)\beta\gamma^2(16 - 16\gamma + \gamma^2)} \Big\}. \tag{11}$$

Hereafter, the superscript '$*$' represents the equilibrium outcome in the baseline model. We obtain the equilibrium profit of the supplier, that of T-retailer, and that of E-retailer, π_s^*, π_t^* and π_e^*, respectively. The other variables such as q_i^*, p_i^* for $i = t, e$, and w_t^* are also derived and shown in the Appendix.

The simple but tedious partial derivatives of r^* with respect to β and γ respectively lead to $\partial r^*/\partial\beta > 0$ for any β and γ and $\partial r^*/\partial\gamma < 0$ if $\beta < 1/4$ or if $\gamma < 4/5$ (sufficient conditions). The former outcome is intuitive in that the stronger bargaining power of E-retailer leads to its higher profit share. We explain the latter complex outcome. The royalty rate r is based on the additional contribution of E-retailer, which is related to the two channels' relative profitabilities. An increase in γ has two contrasting effects: (i) accelerating retail competition, which diminishes E-retailer's profitability, and (ii) enhancing the direct channel advantage of E-retailer because of the nonexistence of double-marginalization. The mixture of the two effects causes the nonmonotonicity of $\partial r^*/\partial\gamma$. Similarly, the signs of $\partial p_e^*/\partial\gamma$ and $\partial w_t^*/\partial\gamma$ are not uniquely determined.

Comparing the equilibrium outcomes, we obtain the following proposition.

Proposition 2 *In the equilibrium of the baseline model, the supplier may set the retail price of the e-book below the wholesale price of the paper book depending on β and γ, that is,*

$$w_t^* > p_e^* \quad if \quad \begin{cases} 0 < \beta \le \dfrac{12}{47} \text{ and } 0 < \gamma < 1, \text{ or} \\ \dfrac{12}{47} < \beta < \dfrac{1}{2} \text{ and } 0 < \gamma < \dfrac{4\sqrt{4-9\beta+6\beta^2}-8\beta}{4-\beta}. \end{cases} \tag{12}$$

The supplier may implement *below-wholesale-price retail pricing* when E-retailer's bargaining power, β, is less than half and the degree of substitution, γ, is less than the certain threshold value. A small value of β means that the supplier's bargaining power over E-retailer is strong, and therefore $(1-r^*)$ is large. At that time, the supplier prioritizes the sales revenue of the e-book, $(1-r^*)p_e q_e$, over the wholesale revenue of the paper book, $w_t q_t$. The supplier tries to weaken the degree of competition and earn larger sales revenue from the e-book by raising both w_t and p_e. Because the increase in w_t is greater than that of p_e, Proposition 2 holds when β is small. We will examine the partial derivatives of several parameters including w_t^* and p_e^* with respect to β in the next subsection.

A small value of γ corresponds to the situation where the retail competition is moderate. This case also makes the supplier focus on its sales revenue from the e-book and is likely to cause the implementation of below-wholesale-price retail pricing.

4.4 Effects of countervailing power

To take a more in-depth look at the equilibrium characteristics of the baseline model, we analyze how a change in β affects the equilibrium results in this subsection. We derive the following proposition.

Proposition 3 *An increase in E-retailer's bargaining power lowers the retail price of the e-book. Moreover, this increases T-retailer's profit as well as E-retailer's profit; however, it reduces the supplier's profit. Specifically,*

$$\frac{\partial p_e^*}{\partial\beta} < 0, \ \frac{\partial w_t^*}{\partial\beta} < 0, \ \frac{\partial \pi_t^*}{\partial\beta} > 0, \ \frac{\partial \pi_e^*}{\partial\beta} > 0, \ \frac{\partial \pi_s^*}{\partial\beta} < 0. \tag{13}$$

First, we can confirm that countervailing power leads to a lower retail price in our model.

Second, it may be more surprising that T-retailer improves its profit from an increase of E-retailer's bargaining power. These two effects arise from the supplier's reaction to an increase in β. In the previous subsection, we examined the supplier's action when β is small. Now, when β increases, the supplier places more weight on the wholesale revenue of the paper book over the retail revenue of the e-book. As a result, the supplier lowers both p_e and w_t, that is, $\partial p_e^*/\partial\beta < 0$ and $\partial w_t^*/\partial\beta < 0$.[3] Even though the retail price of the paper book, p_t, also decreases, both $(p_t - w_t)$ and q_t increase. Consequently, T-retailer can earn more profit when E-retailer's bargaining power becomes strong.

As an aside, in addition to the supplier's profit, total sales of the e-book decrease in β, specifically, $\partial p_e^* q_e^*/\partial\beta < 0$. In our model, an increase in E-retailer's bargaining power does not promote e-book sales, but rather suppresses e-book sales because, for its profit, the supplier comes to depend more on the wholesale revenue of the paper book when β becomes large.

5 Effects of self-regulation on below-wholesale-price retail pricing

Proposition 2 in the previous section shows the possibility that the wholesale price for T-retailer is higher than the retail price of E-retailer even if we have assumed that the marginal costs of the two books are zero. The higher wholesale price causes T-retailer to complain that the supplier's pricing policy significantly limits the competitiveness of T-retailer in the retail market.

In this section, we consider a simple way to escape the imbalance between the wholesale price and the retail price of E-retailer, by examining the idea in the context of price/margin squeezes (Bouckaert and Verboven, 2004; Jullien et al., 2014). We impose on the supplier the following self-regulation regarding w_t and p_e: $w_t \leq p_e$, which prevents the supplier from setting a w_t that is higher than p_e. We will derive new equilibrium results with this self-regulation and compare them with those of the baseline model.

[3] This mechanism is very similar to those revealed in Chen (2003) and Matsushima and Yoshida (2018). In their papers, a supplier, which deals with a dominant retailer and fringe retailers under wholesale contracts, responds to an increase in the dominant retailer's bargaining power by lowering the wholesale price for fringe retailers to boost its sales through the fringe retailers.

5.1 Results under self-regulation

In the same vein as the baseline model, we derive a subgame perfect Nash equilibrium by backward induction. After this, we focus on the case when $\beta = 1/2$ to derive a unique equilibrium. By comparing the results with those of the baseline model, we first derive the following proposition about the equilibrium prices.

Proposition 4 *In the equilibrium of the self-regulated supplier case,*

- *the retail price of the e-book is set equal to the wholesale price of the paper book;*
- *the wholesale price is higher than that of the baseline model;*
- *the retail prices are also higher than those of the baseline model.*

Specifically, for $\gamma \in (0, 1)$*,*

$$p_e^R = w_t^R = \frac{\alpha}{2} > w_t^*, \tag{14}$$

$p_e^R > p_e^*$ *and* $p_t^R > p_t^*$*, where the superscript 'R' represents the equilibrium outcome in the self-regulated supplier case.*

Proposition 4 tells us that the regulation, which seemingly lowers the wholesale price w_t, has anti-competitive effects on the retail competition. The supplier anticipates the expected outcome of Stage 3, in which the wholesale price set in Stage 2 is the lower bound of its retail price set in Stage 3. Setting a higher wholesale price allows the supplier to commit itself to set a high retail price of the e-book in Stage 3.

Next, we check the effects of the regulation on the firms' profits.

Proposition 5 *The supplier's self-regulation,* $w_t \leq p_e$*,*

- *increases the profit of the supplier and that of* E*-retailer;*
- *decreases the profit of* T*-retailer.*

That is, for $\gamma \in (0, 1)$*,*

$$\pi_s^R > \pi_s^*, \ \ \pi_e^R > \pi_e^*, \ \ \pi_t^R < \pi_t^*. \tag{15}$$

With the self-regulation, the supplier and E-retailer earn more profit and T-retailer earns less profit compared with the baseline model. These results may be apparent from Proposition 4. The self-regulated supplier can commit to set a higher p_e when it sets a higher w_t.

The supplier controls the competitive environment in the downstream market by setting a higher w_t, which leads to a weaker competitive environment for E-retailer. As a result, the supplier and E-retailer can improve their profits. By contrast, because of such a higher wholesale price, T-retailer cannot improve its profit although the downstream competition becomes moderate.

5.2 Welfare analysis

Finally, we examine the effect of the self-regulation on social welfare and consumer surplus. Before checking the welfare effect, we examine the effect on industry profits. Regarding industry profits, we have the following result.

Proposition 6 *The supplier's self-regulation, $w_t \leq p_e$, increases industry profits when the degree of substitution is higher than the specific value, $\hat{\gamma}$;*

$$\pi_s^R + \pi_t^R + \pi_e^R > \pi_s^* + \pi_t^* + \pi_e^* \text{ if } \hat{\gamma} < \gamma < 1, \tag{16}$$

where $\hat{\gamma} \simeq 0.727$. Otherwise, if $0 < \gamma < \hat{\gamma}$, industry profits decrease.

The self-regulation can be detrimental to the industry profit although it benefits the profits of some firms.

Now we discuss consumer surplus and social welfare. We define consumer surplus as:

$$CS \equiv \sum_{i=t,e} \left\{ \int_0^{q_i} (\alpha - x_i - \gamma q_j - p_i)\, dx_i \right\}, \tag{17}$$

where $j \neq i$, and social welfare is

$$SW \equiv CS + \pi_s + \pi_t + \pi_e. \tag{18}$$

Comparing those of the baseline model and those of the self-regulated supplier case, we can derive the following proposition.

Proposition 7 *The supplier's self-regulation, $w_t \leq p_e$, decreases both consumer surplus and social welfare, that is, for $\gamma \in (0, 1)$,*

$$CS^* > CS^R, \quad SW^* > SW^R. \tag{19}$$

In addition to the increase in the retail prices, the retail quantities are lower for most values of γ. Therefore, the introduction of the regulation reduces the consumer surplus. Moreover, even though the regulation may increase industry profits, it decreases social welfare for all γ.

6 Discussion

6.1 Price competition

We now develop a modified model in which the two retailers compete in price instead of the price–quantity competition. When we introduce price competition into the retail market, (i) the supplier does not use below-wholesale-price retail pricing and (ii) the self-regulation, $w_t \leq p_e$, does not have any effect on the outcome. To examine these results, we solve the self-regulation case with price competition and show that the constraint is not binding, $w_t < p_e$, in equilibrium.

The maximization problems of T-retailer and the self-regulated supplier in the retail pricing stage are:

$$\max_{p_t} \ \pi_t = (p_t - w_t)q_t, \quad \max_{p_e} \ \tilde{\pi}_s = w_t q_t + (1-r)p_e q_e + \lambda(p_e - w_t), \tag{20}$$

where $\lambda \geq 0$ is a Lagrange multiplier. The first-order conditions are:

$$\begin{aligned} \frac{\partial \pi_t}{\partial p_t} &= \frac{\alpha(1-\gamma) - 2p_t + \gamma p_e + w_t}{1-\gamma^2} = 0, \\ \frac{\partial \tilde{\pi}_s}{\partial p_e} &= \frac{\alpha(1+\gamma)(1-r) - 2(1-r)p_e + \gamma(1+r)p_t + \gamma w_t}{(1-\gamma^2)} - \lambda = 0. \end{aligned} \tag{21}$$

Note that the supplier internalizes the wholesale revenue contrary to the price–quantity model; the supplier's first-order condition includes w_t, although that in equation (4) does not include. This consideration for the wholesale revenue in the retail pricing stage differs from the supplier's pricing in the baseline model, and it increases the retail price of the E-retailer.[4] From equation (21), we obtain optimal retail prices and the condition for the

[4] From equation (4), T-retailer's reaction function in the baseline case is $q_t(p_e) = \{(1-\gamma)\alpha + \gamma p_e - w_t\}/2(1-\gamma^2)$, and we can see that $\partial w_t q_t(p_e)/\partial p_e > 0$ for all $\gamma \in (0,1)$. Therefore, the lack of consideration for the wholesale revenue makes the supplier more aggressive, and decreases p_e to less than the optimal level for the supplier who cares about the wholesale revenue.

constraint, $w_t \leq p_e$, is binding. The constraint is binding if and only if:

$$\lambda = \frac{-\alpha(2-\gamma-\gamma^2)(1-r) + \{4-3\gamma-\gamma^2-(4-\gamma-\gamma^2)r\}w_t}{2(1-\gamma^2)} > 0, \tag{22}$$

in other words, if and only if

$$\begin{aligned} &0 < r \leq \frac{4-3\gamma-\gamma^2}{4-\gamma-\gamma^2} \equiv \bar{r}, \ \textit{and} \\ &w_t \geq \frac{\alpha(2-\gamma-\gamma^2)(1-r)}{4-3\gamma-\gamma^2-(4-\gamma-\gamma^2)r} \equiv \bar{w}_t. \end{aligned} \tag{23}$$

We consider two cases in Stage 2: (Case A) $w_t \geq \bar{w}_t$ (the constraint in Stage 3 can be binding); (Case B) $w_t \leq \bar{w}_t$ (the constraint in Stage 3 is binding if and only if $w_t = \bar{w}_t$).

Case A ($w_t \geq \bar{w}_t$) In this case, the optimal retail prices are:

$$\begin{aligned} p_t^b(w_t) &= \frac{\alpha(1-\gamma)+(1+\gamma)w_t}{2}, \\ p_e^b(w_t) &= w_t. \end{aligned} \tag{24}$$

Taking these prices as given, the supplier sets w_t to maximize its profit subject to the constraint (23); the supplier solves the following maximization problem.

$$\max_{w_t} \ \pi_s(p_t^b(w_t), p_e^b(w_t)) + \lambda^b (w_t - \bar{w}_t), \tag{25}$$

where $\lambda^b \geq 0$. Then, the optimal wholesale price and the Lagrange multiplier are:

$$\begin{aligned} w_t^b &= \frac{\alpha(2-\gamma-\gamma^2)(1-r)}{4-3\gamma-\gamma^2-(4-\gamma-\gamma^2)r} = \bar{w}_t, \\ \lambda^b &= \frac{\alpha\gamma\{1-\gamma+r(1+\gamma)\}\{3+\gamma-r(2+\gamma)\}}{4-3\gamma-\gamma^2-(4-\gamma-\gamma^2)r}. \end{aligned} \tag{26}$$

We can also check that λ^b is always positive for any $r \in (0, \bar{r}]$. In the range $w_t \geq \bar{w}_t$, $w_t = \bar{w}_t$ is optimal in Stage 2.

Case B ($w_t \leq \bar{w}_t$) When $w_t \leq \bar{w}_t$, the constraint in Stage 3, $w_t \leq p_e$, is not binding. The optimal retail prices are derived by substituting $\lambda = 0$ into the first-order conditions in equation (21):

$$p_t^n(w_t) = \frac{\alpha(2-\gamma-\gamma^2)(1-r) + \{2(1-r)+\gamma^2\}w_t}{(4-\gamma^2)(1-r)},$$
$$p_e^n(w_t) = \frac{\alpha(2-\gamma-\gamma^2)(1-r) + \gamma(3-r)w_t}{(4-\gamma^2)(1-r)} > w_t. \tag{27}$$

Given these prices, the supplier solves the following problem,

$$\max_{w_t} \ \pi_s(p_t^n(w_t), p_e^n(w_t)) + \lambda^n (\bar{w}_t - w_t), \tag{28}$$

where $\lambda^n \geq 0$. We can obtain an interior solution in this case; the constraint, $w_t \leq \bar{w}_t$, is slack. The optimal wholesale price and the Lagrange multiplier are:

$$w_t^n = \frac{\alpha(1-\gamma)(2+\gamma)(1-r)\{4+2\gamma(1-r)-\gamma^2+\gamma^3\}}{2\{8(1-r)-\gamma^2(7-8r-r^2)+\gamma^4\}} < \bar{w}_t,$$
$$\lambda^n = 0. \tag{29}$$

From the discussions in Cases A and B, the supplier prefers the interior solution in Case B to the corner solution in Case A, which is the same as the corner in Case B. This result implies that the supplier does not set w_t that induces the retail price of the E-retailer, p_e, to be binding to w_t. Therefore, the self-regulation, $w_t \leq p_e$, does not affect the equilibrium prices and profits in price competition. Furthermore, the retail price of the E-retailer is not lower than the wholesale price of the T-retailer, w_t, in equilibrium. We can conclude that the price–quantity competition is crucial to obtaining the anti-competitive effect of the self-regulation.

6.2 The contract between the supplier and E-retailer

We have assumed that the supplier and E-retailer are under agency contract because major online retailers such as Amazon and Apple adopt agency contracts to distribute e-books. Following the literature on agency contracts (e.g., Foros et al., 2017; Johnson, 2017; Tan and Carrillo, 2017; Zennyo, 2019; Maruyama and Zennyo, 2020), we investigate which contract form is preferable for the suppliers and E-retailers to distribute the e-book: an agency contract or a wholesale contract.

We modify the model and assume the following timeline. In Stage 1, the supplier and E-retailer determine the wholesale price, w_e, through bargaining. Next, in Stage 2, the supplier unilaterally sets a wholesale price, w_t, for T-retailer. In Stage 3, T-retailer sets its quantity, q_t, and E-retailer sets its price, p_e, simultaneously.[5]

By comparing the equilibrium profits of this wholesale-wholesale model with those of the baseline model, we conclude that both the supplier and E-retailer prefer the agency contract if the E-retailer's bargaining power, β, is lower than $\hat{\beta} \simeq 0.913$ (a sufficient condition). Their preferences for adopting an agency contract are perfectly consistent because of the nature of Nash bargaining: maximizing the total profits first, then splitting them between the players.

Compared with the wholesale contract, the agency contract has an advantage and a disadvantage for their total profits: averting the double-marginalization problem and the supplier's internalization problem discussed in Subsection 4.1. The latter disadvantage comes from the nature of the price–quantity competition: the supplier does not internalize the wholesale revenue from T-retailer when it sets p_e, and therefore it cannot coordinate the revenue from E-retailer and that from T-retailer. However, if the supplier uses the wholesale contracts with both retailers, it will care about the two revenue sources. When β is very high, w_e is at a very low level, implying that the double-marginalization problem is negligible. Employing a wholesale contract is better for both the supplier and E-retailer when β exceeds the threshold value $\hat{\beta}$. On the other hand, the agency contract between the supplier and E-retailer has a detrimental effect on T-retailer's profit for any β and γ.

Related to the two discussions in this section, Zennyo (2019) focuses on the equilibrium contractual form between the supplier and E-retailer in price–price competition under a similar market structure. Here, we briefly describe his model and results, as well as the differences with our paper.

The channel structure is the same as in our paper: there is a monopoly supplier, a traditional retailer (T-retailer), and an e-commerce retailer (E-retailer). The game proceeds as follows. In Stage 1, E-retailer unilaterally offers the royalty rate r to the monopoly supplier. In Stage 2, if the supplier accepts it, the two firms employ the agency contract, in which the supplier sets the retail price of E-retailer in Stage 3, and the supplier unilaterally sets a wholesale price w_t to T-retailer. Otherwise, the supplier unilaterally sets wholesale prices w_t and w_e for both retailers under the wholesale contract, in which T-retailer sets its retail price in Stage 3. In Stage 3, T-retailer and the designated firm under the contract offer their retail prices simultaneously.[6]

[5] The timeline is consistent with the setting where the decisions on w_t and w_e are in Stage 1, and the supplier re-determines w_t if the negotiation on w_e breaks down.

[6] He also endogenizes the choice of whether the supplier uses E-retailer or not and shows that the

In his study, because of the advantage of the agency contract, the supplier and E-retailer always employ the agency contract in equilibrium, and thus the realized market situation becomes the same as ours.[7] The differences between his study and ours are as follows. First, T-retailer's strategic variable is price in Zennyo (2019) and quantity in our paper; second, the procedure for determining the royalty rate is a unilateral offer in Zennyo (2019) and Nash bargaining in our paper; third, the main focus is the equilibrium contract form in Zennyo (2019) and the market outcomes under price–quantity competition and self-regulation in our paper. Despite these similar situations, we emphasize that our different (but natural) assumptions yield very different outcomes and rich implications. In this sense, we believe that his study and our own complement each other.

7 Conclusion

Per the recent advancement of online platforms facilitating digital content sales, we investigate a model in which a monopoly supplier distributes two types of its product through a traditional retailer with a wholesale price contract and an online retailer with an agency contract. The supplier and the online retailer negotiate the royalty rate through Nash bargaining. A notable feature of our model is assuming that the traditional retailer and the supplier, via the online retailer, compete in quantity and price, respectively. We believe that the assumption of price–quantity competition is consistent with the standard view on when price and quantity are strategic variables of firms (e.g., the textbook by Belleflamme and Peitz (2015), Section 3.3.3 on page 67). We also discuss self-regulation by the supplier such that the retail price of the online retailer is not smaller than the wholesale price for the traditional retailer, seemingly helping the traditional retailer.

Our findings in the baseline model are the following. The equilibrium royalty rate has a positive correlation to the online retailer's bargaining power over the supplier. An increase in the online retailer's bargaining power over the supplier benefits the two retailers but harms the supplier. The wholesale price for the traditional retailer can be higher than the online retailer's retail price in equilibrium. The additional discussion on self-regulation by the supplier leads to the following results. The wholesale price is strictly higher than that

supplier always uses the retailer in addition to T-retailer in equilibrium.

[7] In addition to the advantage of the agency contract discussed above, E-retailer prefers the contract to the wholesale contract because he can obtain a first-mover advantage. See Johnson (2017) for more details.

in the baseline model. The retailers' prices are also strictly higher than those in the baseline model. The retail price of the online retailer is always binding by the constraint. The self-regulation benefits the supplier and the online retailer but *harms the traditional retailer*. The consumer and total surpluses are lower than those in the baseline model. The results should be viewed with an eye toward whether content suppliers (e.g., publishers, game producers) employ the remedy discussed here with the excuse that they are attempting to protect traditional retailers using "fair trading terms."

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8 Appendix

Table 1: Equilibrium outcome for the baseline case and the self-regulation case when $\beta = 1/2$.

	Baseline case	Self-regulation case
r	$\frac{\left\{-(8-2\gamma-5\gamma^2)^2+\beta\gamma^2(16-16\gamma+\gamma^2)+(8-2\gamma-5\gamma^2)\sqrt{(8-2\gamma-5\gamma^2)^2-2(1-\beta)\beta\gamma^2(16-16\gamma+\gamma^2)}\right\}}{\beta\gamma^2\left(16-8\gamma-7\gamma^2\right)}$	$\frac{1}{2+\gamma}$
w_t	$\frac{\alpha\left\{8-4r^*\gamma-2(4-r^*)\gamma^2+(1+2r^*)\gamma^3\right\}}{2\{8-\gamma^2(7-r^*)\}}$	$\frac{\alpha}{2}$
p_e	$\frac{\alpha(8-2\gamma-5\gamma^2)}{2\{8-\gamma^2(7-r^*)\}}$	$\frac{\alpha}{2}$
p_t	$\frac{\alpha\left\{12-2\gamma(2+r^*)-2\gamma^2(6-r)+5\gamma^3\right\}}{2\{8-\gamma^2(7-r^*)\}}$	$\frac{\alpha(3-\gamma)}{4}$
q_e	$\frac{\alpha(8-2\gamma-5\gamma^2)}{2\{8-\gamma^2(7-r^*)\}}$	$\frac{\alpha(2+\gamma)}{4(1+\gamma)}$
q_t	$\frac{\alpha\{2-\gamma(2-r^*)\}}{8-\gamma^2(7-r^*)}$	$\frac{\alpha}{4(1+\gamma)}$
π_s	$\frac{\alpha^2\left\{12-8r^*-4\gamma(2-r^*)-\gamma^2(3-4r^*)\right\}}{4\{8-(7-r^*)\gamma^2\}}$	$\frac{\alpha^2(2+\gamma)}{8(1+\gamma)}$
π_e	$\frac{\alpha^2\left(8-2\gamma-5\gamma^2\right)^2 r^*}{4\{8-(7-r^*)\gamma^2\}^2}$	$\frac{\alpha^2}{8(1+\gamma)}$
π_t	$\frac{\alpha^2(1-\gamma^2)\{2-\gamma(2-r^*)\}^2}{\{8-(7-r^*)\gamma^2\}^2}$	$\frac{\alpha^2(1-\gamma)}{16(1+\gamma)}$
CS	$\frac{\alpha^2\left\{80-16\gamma(4-r^*)-4\gamma^2(15+4r^*-(r^*)^2)+20\gamma^3+25\gamma^4\right\}}{8\{8-\gamma^2(7-r^*)\}^2}$	$\frac{\alpha^2(5+4\gamma+\gamma^2)}{32(1+\gamma)^2}$
SW	$\frac{\alpha^2\left\{304-16\gamma(16-3r^*)-4\gamma^2(69+(r^*)^2)+4\gamma^3(49-16r^*+2(r^*)^2)+5\gamma^4(7+4r^*)\right\}}{8\{8-\gamma^2(7-r^*)\}^2}$	$\frac{\alpha^2(19+20\gamma+3\gamma^2)}{32(1+\gamma)^2}$