RESELLING OR AGENCY SELLING ? CONSUMER VALUATION, QUALITY DESIGN, AND MANUFACTURERS' COMPETITION

[1]LU HSAIO, [2]XIN MA, [3]YING-JU CHEN

[1]Chung Hsing University, Taiwan,
[2]Monash University, Australia
[3]Hong Kong University of Science & Technology, HK
E- mail: [1]hsiaolu@dragon.nchu.edu.tw, [2]xin.ma@monash.edu, [3]imchen@ust.hk

Abstract - Retail e-commerce yields lucrative revenue in many industries. In this work, we pro- vide a strategic perspective by investigating how consumer valuation, product quality, and manufacturers competition influence the choice of selling agreement using stylized models. The utility and valuations of consumers are involved in analyzing strategic decisions under different selling agreements that are not trivial to analyze. We first show that an agency selling agreement induces a higher retail price, but this can benefit the entire channel; under this agreement, the agency fee and consumer valuation present a nonmonotonic (approximately U-shaped) relation. Because of double marginalization, reselling agreement induces the manufacturer to make a low-quality product compared to the agency selling agreement, but such the low-quality product is only profitable for the manufacturer. Second, when introducing manufacturers' competition, the agency selling agreement can induce a wider quality difference: higher high-quality and lower low-quality. Besides, the agency selling agreement hurts the manufacturer and the entire channel, but this is a preferred format for the low-quality manufacturer. Both the high-quality manufacturer and the entire channel are profitable to choose the reselling agreement; offering a high-quality product can hurt the manufacturer remains robust. Third, the first-mover manufacturer can get a lower profit than the follower retailer. Moreover, when comparing scenarios with alternative sequences of making decisions, first-mover can lead to a disadvantage, in that both supply chain parties prefer to act later rather than earlier. Our work also explains the rationale for why e-commerce firms in China now pay more attention to low-end consumers.

Keywords - Channel Structures, Consumer Valuation, Quality Design, Game Theory.

I. INTRODUCTION

E-commerce has become an integral part of our daily lives, and U.S. retail e-commerce sales were estimated at $160.3 billion in the first quarter of 2020, accounting for 11.8% of total U.S. retail sales (The Department of Commerce, 2020). Traditionally, online retailers act as an intermediary, i.e., resellers, to connect buyers and consumers (Tian et al, 2018). How- ever, U.S. online retailers, e.g., Amazon, have broken away from this traditional business model and adopted the agency selling mode (Abhishek et al., 2016). This transformation generates buoyant profits for online retailers. For example, the net sales of Amazon and its marketplace increased 26% to $75.5 billion in the first quarter of 2020 compared with thenet sales in the same period in 2019 (Amazon, 2020). In an age of growing prosperity, retail e-commerce and associated marketing services also have strong growth in other countries. For instance, Alibaba's revenue is $13,932 million in 2019, and this is an increase of 51% year-over-year (Alibaba, 2019).

The adoption of different selling agreements in a retail channel may affect profitability of stakeholders, e.g., consumers, the retailer, and the manufacturer. In the agency selling, the manufacturer is in charge of the product quality and determines the retail price. In contrast, in the reselling mode, the retailer purchases products from the manufacturer and acts as a retail terminal to decide the retail price. Both selling agreements have become popular business models in many industries. For example, Hello Baby is an essential intermediary between the manufacturer and consumers to offer a wide range of baby products and sells it through online marketplaces. The e-commerce firms, e.g., JD.com, prefers to take a commission fee between 2%∼5% (E-Commerce Agency, 2019).

In recent years, e-commerce firms are growing faster in China, the world's second largest economy, especially dominated by two giants Alibaba and JD.com. As the third-largest e-commerce firm in China, Pinduoduo encourages consumers to share the information and links of products they purchase with friends or families to participate in group buying. That is, the manufacturer and the retailer should satisfy groups of consumers who has similar valuations. Besides, to compete with Alibaba and JD.com, Pinduoduo aims to meet demands of low-valuation consumers with low-quality products through its online marketplace services. In 2019, 55% of Pinduoduos gross merchandising value came from tier three cities and rural areas (Kharpal, 2020).

Despite the feasibility of different retail formats, it is unclear how the manufacturer should determine product features with different quality grades under reselling and agency selling agreements. Our work fills this research gap and extends the literature of multi- channel retailing by examining strategic pricing and production decisions; that is, how do the manufacturer and the retailer offer not only different

quality grades, but also different prices for low- and high-valuation consumers. We aim to investigate the unique effects of channel structures on pricing and quality decisions in the centralized channel and the decentralized channel under different selling formats.

Our work is related to the literature on channel retailing and retail competition, for example, Tian et al., (2018), Abhishek et al. (2016), Hsiao and Chen (2014) and Hsiao and Chen (2013). These studies focus exclusively on channel structure design via introducing the Internet channel (the online platform) by the manufacturer. Unlike these studies, we shed new light on the effects of consumers' utility on the channel structure design. We also provide insights into how the manufacturer may control product quality under different selling agreements. Specifically, we attempt to provide a critical analysis of the effects of the retail channel structures on the strategic decisions to answer the following research questions. Which selling agreements would be preferred for the retailer, the manufacturer, and consumers? Is there a consensus channel decision can be achieved to maximize the profit of entire channel? What are the impacts of consumers' utility on channel design? Does manufacturers' competition influence the product quality and the stakeholders' profit?

To analyze these interesting research questions, we consider the manufacturer(s) sell(s) a type of product through a monopolistic retailer to consumers. The Stackelberg game models are formulated to capture the interactions among the manufacturer, the retailer, and consumers, in different retail channels. Our analytical results reveal several important and interesting findings in both centralized and decentralized distribution channels.

Specifically, we start with a benchmark model in a centralized distribution channel. We then investigate the effects of agency selling and reselling agreements on the strategic channel decisions. Our results show that, unlike an agency selling channel, the manufacturer does not focus on improving the product quality in either a centralized or a reselling channels. To stimulate the retailer to target a profitable market, the manufacturer would be induced to improve product quality under the agency selling agreement; this can attract more high-valuation consumers since they are not sensitive to the retail price.

We further conduct comparative statics analysis to characterize the role of strategic selling decisions for both the manufacturer and the retailer. First, we find that agency selling agreement induces the higher retail price and product quality, but this can benefit the entire channel. Due to the double marginalization, the reselling agreement induces the manufacturer to make a low-quality product compared to the agency selling agreement, but such the low-quality product is only profitable for the manufacturer.

Second, in contrast to the finding in Shi et al. (2013) that the manufacturer prefers to maintain higher product quality in a centralized channel than in a decentralized channel; our work finds that the manufacturer is induced to provide the higher product quality in a decentralize channel by choosing either agency selling or reselling agreements. We further show that, even if offering the products with the same quality level, the reselling channel (i.e., the decentralized channel) cannot generate a higher consumer surplus than the centralized channel. Our results show that, in such a scenario, the manufacturer adds friction to the channel; that is, the manufacturer dominates the entire channel and benefits the most than both the retailer and consumers. We also find that, regarding the channel profit, selecting the agency selling agreement can bring slightly higher profit than choosing the reselling agreement.

We also consider two extensions to examine the robustness of our results. We first investigate the influence of the upstream competition on the stakeholders' decisions and channel profit. Interestingly, the upstream competition results in a lower agency fee charged by the retailer; but the retailer becomes more profitable in such a decentralized distribution channel. We also find that the low-type manufacturer prefers to reduce the retail price, regardless of whether the retailing agreement is the agency selling or the reselling format. In contrast, offering high-quality product cannot help the high-type manufacturer to dominate the market demand, which can slash his profit as well.

Under the agency selling agreement, we also extend our basic model by examining the effect of the first-mover on the product quality and stakeholders' profitability. We find that, acting as a leader, the retailer prefers to charge a greater agency fee and it is independent of consumers' valuation. Interestingly, responding such a higher agency fee, the manufacturer benefits from offering the low-quality product which can ensure his profit by expanding the market demand.

Our work makes several contributions. First, our work contributes the multi- channel retailing literature by revealing effects of consumer valuations and quality grades. Our analytical results on how the pricing and production decisions of the retailer and the manufacturer under different retailing agreements and how these decisions affect the channel profit are new insights to this research area. Second, our work provides a theoretical framework that how the manufacturer determines the product features in terms of different quality grades by consideration the characteristics of channel structures and consumer

valuation. Especially, under the agency selling agreement, our result shows that the agency fee and consumer valuation presents a nonmonotonic (approximately U-shaped) relation. Third, our work identifies the different pricing and production preferences for each stakeholder. Our results show that, under the agency selling agreement, the first-mover advantage does not exist.

The rest of this paper is organized as follows. Section 2 reviews relevant literature. The description of the model setup is presented in Section 3. The equilibrium retail prices, and product qualities are analyzed under three types of retailing agreements in Section 4. The comparison analysis is conducted across three strategic retail channels in Section 5. In Section 6, three extensions are investigated to the robustness of our analytical results. Concluding remarks and suggestions for future work are discussed in Section 7. The proofs will be given in the appendix to this paper.

II. LITERATURE REVIEW

This paper focuses on investigating the strategic choice of channel structure, which con- tributes to two streams of the emerging literature: (i) the determinants of channel structures, and (ii) the impacts of consumers' preferences on strategic channel decisions. Interested readers can refer to Chen et al., (2019) for more comprehensive and the latest review about the research opportunities of the innovative online platforms.

The first stream of related research is related to the determinants of channel structures. Hagiu and Wright (2015) address the relative importance of the suppliers' versus the intermediary's private information to decide the optimal tailoring of marketing activities. By analyzing the fundamental trade-offs faced by an intermediary, the managerial implications are proposed for the intermediaries for different types of products. Abhishek et al., (2016) study a setting with two competing retailers and one manufacturer. They find that the agency selling (resp. reselling) is preferred when sales in the e-channel lead to a negative (resp, stimulated) effect on the demand in the traditional channel. This is mediated by the competition between e-retailers. Tian et al. (2018), in contrast, examine the competition between upper stream suppliers by considering three types of selling strategies (centralized, agency selling, and reselling). They disclose that the pure marketplace mode is the preferred choice when order-fulfillment costs are small and supplier product offerings are highly differentiated. In addition, Pu et al. (2020) and Li et al. (2020) investigate the re- tailers' competition between an e-channel and a traditional channel. The papers mentioned above do not study the effectiveness of the fixed commission contract under the agency selling channel. Unlike these studies, we aim to study the fundamental trade-offs that are not raised in these works. Specifically, we extend the literature by investigating the first-mover advantage and examining the influences of consumer valuations and product quality on the strategic choice between agency selling and reselling.

In addition, Ryan et al. (2012) study a setting where a supplier sells goods through its marketplace and/or choose to sell goods through the retailer. They find that the total system profit is unable to be maximized when the supplier competes with the retailer for a portion of the market. Tan and Carrillo (2017) analyze the strategic pricing for both the agency model and the wholesale model. They find that the revenue-sharing mechanism and the publisher's control over the price contribute to the benefits of the agency model. Unlike the aforementioned studies, our work formalizes a framework with endogenous product quality. This setting creates meaningful distinctions in multi-channel management and emphasizes fundamental trade-offs that are not raised in the earlier works. Besides, Shi et al. (2013) find that a manufacturer always generates higher product quality in a centralized channel than in a decentralized channel. In contrast, we find that the manufacturer can provide the same quality product (resp. high-quality product) in a decentralized channel under the reselling agreement (resp. the agency selling agreement).

This paper is also related to the literature about how consumers' preferences affect strategic channel decisions. The 'intrinsic' valuation of consumers (i.e., the willingness-to- pay of consumers) for a product is usually defined as a binary variable, for example, Gao and Su (2016). That is, a portion of consumers has a positive value for the product and the rest has zero value if they dislike the product. In addition, the willingness-to-pay of consumers for the product quality is assumed to be uniformly distributed in the interval [0, 1], for example, Shi et al. (2013), Jerath et al. (2017), Lu et al. (2018). This setting is extended to [0, v], where v is a consumer's 'intrinsic' valuation (Hsiao and Chen, 2014), to facilitate meaningful closed-form expressions. To capture the uncertainty behavior of a consumer, the valuation of consumers is assumed to be uniformly distributed in the interval [x, 1] (Ma et al., 2020), where x describes the likelihood of satisfaction of consumers from purchase a product. Unlike these studies, our work extends the literature by considering a generalized setting to describe the variety between consumers' valuation and its willingnessto pay in different market segments; to describe this variety, we introduce a distribution family F^K where $K \in (0,\infty)$. This setting captures the heterogeneity of consumers' valuation in a comprehensive way (Debo et al., 2005).

By integration of the above two streams of literature, our work also contributes to the growing strategic channel management literature. For example, Jiang et al. (2011) study strategic interaction between a platform owner and two types of sellers (with high and low demand). In the Internet era, Hsiao and Chen (2014), Luo and Sun (2016), and Abhishek et al., (2016) investigate the role of electronic retailing when making the strategic choice of the channel structure. Hao et al. (2017) analyze the differences in advertising between the mobile platform and agency pricing. Shen et al. (2018) focus on the pricing issue only when a manufacturer chooses a retail channel through a reseller and/or a platform retailer. Zhang et al. (2019) only investigate the function of the commission fee in an agency selling channel. Considering the consumer valuation, our study contributes to this literature by fully investigating the pricing, production, and channel decisions for manufacturers and a retailer with various economic trade-offs under different channel structures. Besides, Tian et al. (2018) study the strategic decisions of competing suppliers and a retailer to determine a more beneficial channel configuration. However, Tian et al. (2018) do not investigate the product quality and marginal valuation of consumers as we have studied in our research. To best of our knowledge, our work is the first to explore multi-channel retailing by considering multiple effects of consumer valuation, quality design, and manufacturers' competition.

III. MODEL

We consider a supply chain with a manufacturer who sells a product to consumers through multiple types of retail channels based on different contractual agreements with a retailer. We assume both the manufacturer and the retailer are risk-neutral profit maximizers. Thus, the manufacturer and the retailer can jointly optimize their profits in a centralized scenario, i.e., the centralized distribution channel. The manufacturer could also collaborate with the retailer based on an agency selling agreement, which allows the manufacturer to sell the product directly to the end consumers; in return, the manufacturer has to share a fraction $\gamma \in [0,1]$ of revenue with the retailer as a fee for accessing consumers based on the platform/physical store operated by the retailer, e.g., JD.com requires a deposit of $15,000, a fee of $1000 and in the case of the sale will take a commission between 2 and 5 % (E-Commerce Agency, 2019). Following the reselling agreement, the retailer could opt for a reseller business that allows the retailer to resell the product bought from the manufacturer to consumers; that is, in such a scenario, the retailer is essentially the middleman between the manufacturer and consumers, e.g., Hello Baby offers a wide range from several lesser- known baby brands, sells on many online marketplaces, and ships worldwide.

In reality, consumers are sensitive to the quality of the product, and each consumer is willing to purchase at most one unit of product. The marginal valuation of each consumer is denoted by θ and the population of consumers is normalized to one. We assume θ is continuously distributed with cumulative distribution function (CDF) denoted by $F(\theta)$, and its probability density function (PDF) is denoted by $f(\theta)$ over the interval [0,1]. This assumption is commonly used in the literature, for example, Shi et al., (2013), Jerath et al. (2017), Lu et al., (2018). In addition, for the purpose of exposition, we assume $F(\theta)$ and $f(\theta)$ follow a distribution family F^K where $K \in (0, \infty)$. Thus, $F(\theta)$ and $f(\theta)$ can be formulated as: $F(\theta)=1-(1-\theta)^K$ and $f(\theta)= K(1-\theta)^K-1$, where a larger $K(K>1)$ implies a retail market consisting of more low-valuation consumers, a large amount of consumers with higher valuation in a market is active when $K< 1$, and θ follows a uniform distribution over the interval [0,1] when $K = 1$. This assumption has been applied to study market segmentation, see Debo et al., (2005). Given the retail price p and the quality q, the utility of each consumer with valuation θ is $u\theta = \theta q - p$. We formulate this particular utility function because the valuation of each consumer shows increasing in the value of willingness to pay; the sensitivity to product quality increases (consistent with the intuition that consumers prefer to pay more to buy a high-quality product); and the utility decreases in product price as consumers are profit-driven. Intuitively, the consumer will purchase the product if u_θ is nonnegative, that is, $\theta \geq p/q$. Thus, the market demand can be obtained, i.e., $Q = 1 - F(p/q) = (1 - p/q)^K$.

The marginal production cost of the manufacturer depends on the quality of a product. We assume the production cost is strictly increasing and convex in the product quality that the manufacturer chooses. For the purpose of exposition, we consider a convex production cost $cq^2/2$ for any quality level of q, where c is the unit production cost. The assumption is in line with the literature, see, for example, Zhang et al., (2019), Li (2021). In the model, the quality directly affects a consumer's willingness to pay for the product. In a larger sense, the product's quality may refer to the physical characteristics of the product, e.g., usability and maintainability, and the consumers' perceived value, e.g., aesthetics, safety, and service level. The product's quality is fully observed by the retailer and consumers, e.g., the quality information can be obtained from online reviews.

The goal of our work is to investigate the incentives of the manufacturer and retailer for choosing different contractual agreements either a reselling agreement or an agency selling agreement. The model in our work is a Stackelberg game where the manufacturer is a Stackelberg leader, and the retailer is a Stackelberg follower. We assume consumers purchase one unit of

product through one channel. In Section 4, a benchmark model under the centralized distribution channel is extended to incorporate endogeneity of the shopping preferences of consumers across the agency selling and the reselling channels. Based on the contractual agreements and sales channels illustrated above, we analyze the payoffs for the manufacturer and the retailer and derive equilibrium outcomes in the next section.

IV. EQUILIBRIUM ANALYSIS

In this section, we characterize the equilibrium outcomes under three configurations of the selling channels, including the centralized distribution channel, the agency selling channel, and the reselling channel. We start with the benchmark case, i.e., the centralized distribution channel. In this case, the manufacturer acts as a central planner who manages the strategic decisions (i.e., pricing and product quality). This allows us to investigate the incentives of the manufacturer for implementing different selling agreements. Following this, we then look at the agency selling and the reselling agreements, where both the manufacturer and the retailer are a profit maximizer in their interest.

4.1. The Centralized Distribution Channel

For benchmarking purposes, let us first consider the centralized distribution channel; that is, to meet specific requirements of consumers, the manufacturer is able to operate production and pricing based on the complete knowledge of consumers' willingness to pay. We aim to compare this scenario with the other two contractual agreements to investigate the strategic functions of two agreements and incentives for the manufacturer implementing these two agreements. Formally, in the centralized channel, the supply chain profit can be formulated as follows,

$$\max_{p,q>0} \Pi^0(p,q) = \left(p - \frac{1}{2}cq^2\right) Q, \tag{1}$$

The manufacturer aims to maximize the supply chain profit by determining the optimal retail price and product quality simultaneously. We use the superscript "0" to denote the payoff function and analytical results in such a scenario.

Proposition 1. In the centralized distribution channel, the optimal retail price and product quality are $p^0 = 4 / [c(2+K)^2]$ and $q^0 = 2/[c(2+K)]$.

From Proposition 1, we observe that the optimal price and quality are changing along with the production cost and the valuation of consumers. The optimal results show that the manufacturer can ensure the higher quality to attract high-valuation consumers since they are typically less price-sensitive than the bargain hunters. In addition, when consumer valuations are concentrated at the low end, the trade-off is shifted towards the lower retailprice which leads to the sacrificed product quality. The limit of the optimal price and quality converge to constant values when the market goes through a major downturn (facing an increase of K). Meanwhile, an interesting result can be observed; that is, there exists a sharp increase when K decreases, and this means the high-valuation consumers are more willing to buy a product even after price increases; accordingly, the manufacturer is better off covering the substantial growth of the market demand Q using the high-quality products. From Proposition 1, we find that, in the centralized distribution channel, when the production becomes more efficient, the manufacturer would prefer to improve the product quality to retain the mass of consumers with higher valuation; otherwise, the product quality has to be reduced avoiding expensive retail price since the lower valuation consumers will not be able to afford it.

4.2. The Agency Selling

In this section, both the manufacturer and the retailer enter into an agency selling agreement. The manufacturer sells the product for accessing consumers through the store/platform operated by the retailer. Thus, the manufacturer needs to share a fraction of its revenue, i.e., γpQ, with the retailer. In this setting, the manufacturer is Stackelberg leader, and the retailer is the Stackelberg follower. First, the manufacturer determines the product quality q. Second, he then decides the retail price p. Third, the retailer decides the agency fee γ. We use the superscript "AS" to denote the payoff functions and results in this scenario. The decision problems of the manufacturer and the retailer are formulated as follows:

$$\max_{p,q\geqslant 0} \Pi_M^{AS}(p,q|\gamma) = \left[(1-\gamma)p - \frac{1}{2}cq^2\right] Q, \tag{2}$$

$$\max_{0\leqslant\gamma\leqslant 1} \Pi_R^{AS}(\gamma|p,q) = \gamma pQ, \tag{3}$$

Following the standard backward induction approach, we first study the manufacturer's pricing decision and its product quality decision; we then investigate the retailer's decision regarding the agency fee. The equilibrium outcomes of the manufacturer and the retailer are summarized in the following proposition.

Proposition 2. Under the agency selling agreement,

(i) the equilibrium product qualityq^{AS} is obtained by solving the following equation:

$$\frac{(1-K)cq}{6} + \frac{(2cq)^{2/3}}{12}\left[(3\sqrt{3\alpha_2} + \alpha_1)^{1/3} - (3\sqrt{3\alpha_2} - \alpha_1)^{1/3}\right]$$

$$= \frac{5+Kcq-\sqrt{K^2c^2q^2-2(8+K)cq+25}}{4};$$

(ii) the equilibrium agency fee

$$\gamma^* = 1 - \frac{(1-K)cq^{AS}}{6} - \frac{(2cq^{AS})^{2/3}}{12}[(3\sqrt{3\alpha_2} + \alpha_1)^{1/3} - (3\sqrt{3\alpha_2} - \alpha_1)^{1/3}],\ where\ \alpha_1 = 54K(1+K) + (1-K)(2-4K-7K^2)cq^{AS}\ and\ \alpha_2 = K(1+K)[K^3(31)c^2(q^{AS})^2 - 108K(1+K) + 4\alpha_1].$$

Proposition 2 characterizes the equilibrium product quality and agency fee when the retailer accepts the agency selling agreement. We show that the manufacturer's objective function Π^{AS} is concave in q and the optimal quality is unique. It is noteworthy that the equilibrium agency fee is dependent on the product quality q, product cost c, and K. We validate the equilibrium agency fee $\gamma*$ using a numerical example by setting $K \in [0.1, 2.5]$. As we can see from Figure 1(a), the association between $\gamma*$ and K presents a U-shaped curve characteristic. This result implies that the retailer is more likely to charge a higher agency fee when the market consists of the homogeneous consumers. Interestingly, the lowest agency fee is charged when a market consists of a little bite more low-end consumers ($K \approx 1.3$, $\gamma \approx 0.3989$). Besides, as we can see from Figure 1(b), the product quality is decreasing in K. We will conduct a detailed comparison analysis in § 5.

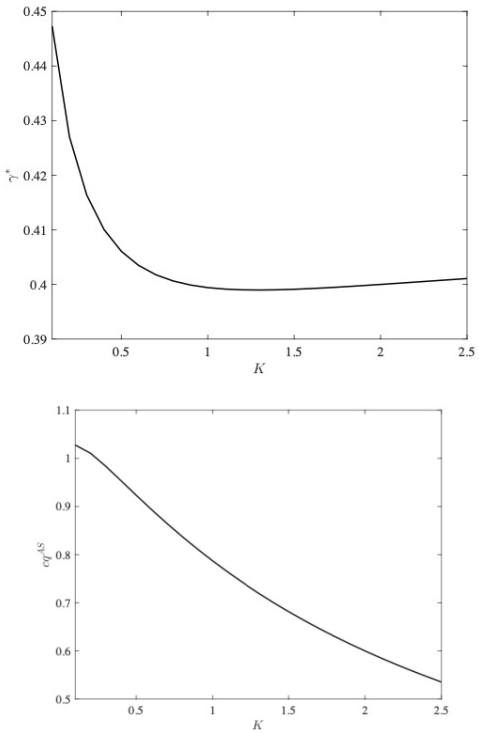


Fig.1.(a & b) The effects of K on the equilibrium agency fee γ^* and product quality q^{AS}

4.3. The Reselling

In this section, we study a case that the retailer enters into a reselling agreement with the manufacturer. This operational mode is similar to the selling format which is commonly used in brick-and-mortar retailing. That is, the retailer purchases the product from the manufacturer and then sells the product to the consumer. In this game setting, the manufacturer is the Stackelberg leader and the retailer is the Stackelberg follower. The decision sequence of events is as follows. First, the manufacturer determines the quality of the product to consumers and the wholesale price to the retailer. Second, given observed wholesale price, the retailer responds by determining retail price.

By backward induction, we first analyze the retailer's strategic sales decisions. Then, the best response problem of the manufacturer will be examined and the equilibrium out- comes will be characterized. Given the manufacturer's wholesale price and product quality, the retailer maximizes her profit by determining the optimal sales price. Let the super-script "RS" be the payoff functions and analytical results in this scenario. The retailer's decision problem can be formulated as follows,

$$\max_{p \geqslant 0} \Pi_R^{RS}(p|w,q) = (p-w)Q,$$

Lemma 1. There exists a unique retail price $p^* = (q + wK)/(1 + K)$ to maximize the retailer's profit.

Having characterized the best response to the retailer's sales price, we can then return to analyze the manufacturer's strategic decisions. Given the sales price derived in Lemma 1, the manufacturer aims to maximize his profit by determining the optimal product quality and wholesale price. The manufacturer's decision problem can be developed as follows,

$$\max_{w,q \geqslant 0} \quad \Pi_M^{RS}(w,q|p) = \left(w - \frac{1}{2}cq^2\right)Q, \tag{5}$$

Proposition 3. Under the reselling agreement,

(i) the retailer's equilibrium retail price is $p^{RS} = (4+6K)/[c(1+K)(2+K)^2]$;

(ii) the manufacturer's equilibrium wholesale price and product quality are $w^{RS} = 4/[c(2+K)^2]$ and $q^{RS} = 2/[c(2+K)]$.

This proposition first shows that, unlike in a centralized distribution channel, the re- tailer's equilibrium retail price is affected by the manufacturer's wholesale price and product quality in the reselling channel. Thus, the manufacturer can make strategic wholesale and production decisions that could stimulate the retailer to target a profitable market. That is, since the manufacturer is the Stackelberg leader, the market demand is ultimately determined by the product quality and the wholesale price. When consumer valuations are concentrated at the high end, the manufacturer would be induced to enhance the product quality, and accordingly, the retail price will also increase to offset the increased production cost; however, this strategy would not

drive down the manufacturer's profit. In contrast, when consumer valuations are concentrated at the low end, the manufacturer would reduce the product quality to avoid losing profits.

V. COMPARISON ANALYSIS

We have separately discussed three types of retailing channels and identified equilibrium outcomes accordingly. The results are influenced by the consumer valuation and the prod- uct quality cost. In this section, we carry out comparative statics analysis regarding the results among three types of operational modes and characterize the role of strategic sell- ing for both the manufacturer and the retailer. The equilibrium profits of the centralized, agency selling, and reselling channels are summarized in Table 1.

Scenarios	Centralized Channel	Agency Selling	Reselling
Π_M	$\frac{2}{(2+K)^2 c}\left(\frac{K}{2+K}\right)^K$	$\left[(1-\gamma^*)p^{AS} - \frac{1}{2}c(q^{AS})^2\right]Q^{AS}$	$\frac{2}{(2+K)^2 c}\left(\frac{K^2}{2+3K+K^2}\right)^K$
Π_R	–	$\gamma^* p^{AS} Q^{AS}$	$\frac{2K}{(1+K)(2+K)^2 c}\left(\frac{K^2}{2+3K+K^2}\right)^K$
Channel Profit	$\frac{2}{(2+K)^2 c}\left(\frac{K}{2+K}\right)^K$	$\Pi_M^{AS} + \Pi_R^{AS}$	$\frac{2(1+2K)}{(1+K)(2+K)^2 c}\left(\frac{K^2}{2+3K+K^2}\right)^K$

Table 1: Equilibrium Outcomes under Three Retailing Agreements

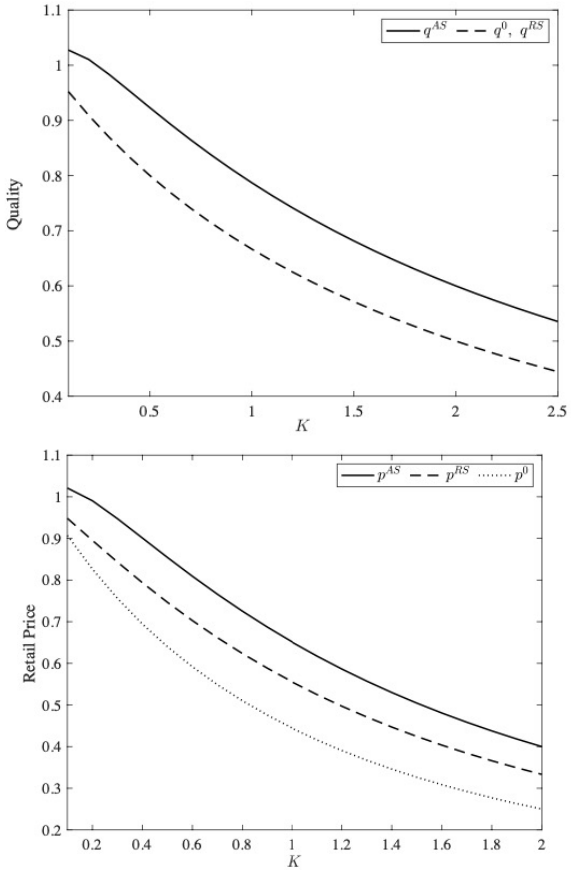
5.1. Quality and Pricing

We first investigate the equilibrium outcomes from the quality, pricing, and demand aspects. The proposition and numerical examples below present the comparison with three retailing decisions.

Proposition 4. Comparing the equilibrium outcomes of qualities, retail prices, and market demand under three strategic retailing channels, we have (i) $q^{AS}>q^{RS} = q^0$; (ii) $p^{AS}>p^{RS}>p^0$; (iii) $Q^0>Q^{AS}\geq Q^{RS}$.

Interestingly, the comparison results in Proposition 4(i) show that the manufacturer prefers to offer the higher quality product in the agency selling channel than in a centralized channel, i.e., $q^{AS}>$ q0. In addition, the higher quality level cannot be achieved, even if the manufacturer is the leader in the reselling channel, i.e., $q^{RS} = q^0$. In the agency selling channel, the manufacturer needs to balance marginal profit and agency payment; thus, improving the product quality and setting a higher retail price is an appropriate strategy for the manufacturer. Besides, choosing the agency selling agreement can assist the manufacturer in obtaining a larger market demand in a decentralized channel. That's why in the agency selling channel, both the quality and the retail price are the highestones compared with the other two channels.

We also validate our analytical results using numerical examples by setting c = 1 and K$\in$ [0.1, 2]. Compared to the agency selling agreement, Figure 2(a) and (b) show that the manufacturer prefers to target the low-end consumers by offering the product with a lower retail price and a lower quality under both reselling and centralized agreements. There is another interesting result. As we can see from Figure 2(c), the market demand under the agency selling agreement is slightly higher than the demand obtained under the reselling agreement. This result implies that offering the highest product quality cannot bring a significant advantage to dominate the retail market. That is, the pursuit of productquality can impact the manufacturer's profit-driven objective as this manner wears off the benefits of a greater market share.



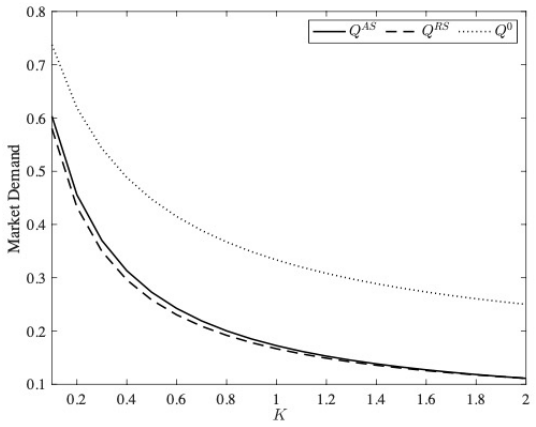


Fig.2. (a & b& c)The effects of K on equilibrium outcomes.

5.2.Profitability of Stakeholders

In this section, we examine the profitability among the consumers, the retailer, the manufacturer, and the entire channel across three different channel configurations. We start by assessing the profits of the retailer and the manufacturer under the agency selling and the reselling channels, respectively. We then discuss the impact of consumers' valuation on channel profit, and the effect of the retailing channel agreement on the consumer surplus.

Proposition 5. Under reselling and agency selling agreements, we have following results:

(i) $\Pi_M^{RS} > \Pi_M^{AS}$ and $\Pi_R^{AS} > \Pi_R^{RS}$;
(ii) Π_M^{RS} and Π_R^{AS} are decreasing when the market consists of more low-valuation consumers;
(iii) Π_M^{AS} and Π_R^{RS} are not monotonic in K; specifically, Π_M^{AS} is increasing in K if $K \in [0,\tau_m]$; otherwise, Π_M^{AS} is decreasing in K, where $\tau_m \approx 0.2$; Π_R^{RS} is increasing in K if $K \in [0,\tau_r]$; otherwise, Π_R^{RS} is decreasing in K, where $\tau_r \approx 0.3$.

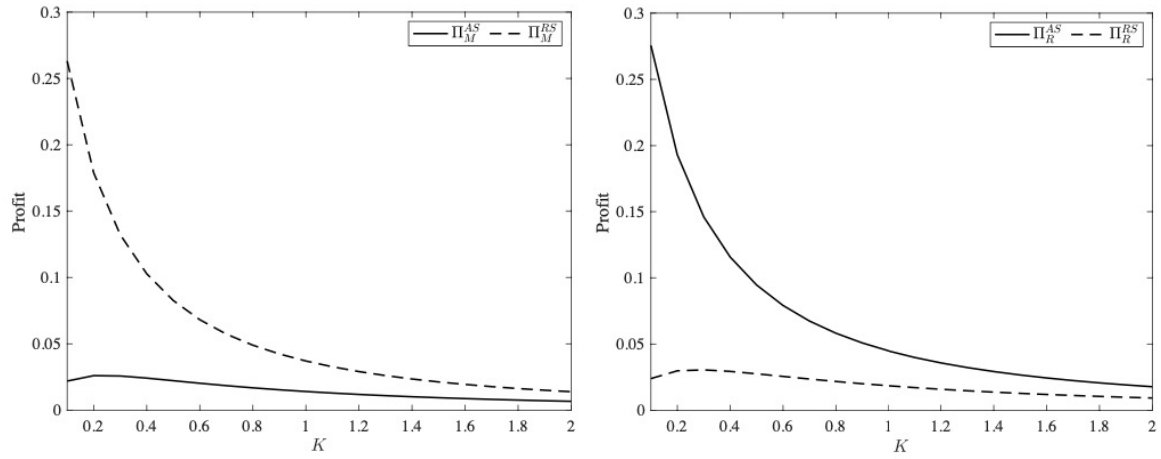


Fig.3. (a & b) The effects of K on profits.

The intuitions of Proposition 5 are summarized as follows. The manufacturer prefers to choose the reselling agreement, while the retailer is more profitable by choosing the agency selling agreement. As we can see from Figure 3, under the reselling agreement (the agency selling agreement, resp.), the manufacturer's profit (the retailer's profit, resp.) is decreasing when the consumer valuations are concentrated at the low-end. That is, when K increases, the manufacturer has to offer the low-quality product and reduce the wholesale price accordingly, so that the retailer has an incentive to satisfy the low-end consumers by setting a lower sales price under the reselling agreement.

Besides, there is an interesting effect of a lower K. Under the agency selling agreement, the manufacturer's profit is increasing in K first, it is maximized when $K = \tau_m$, and then it is decreasing when K goes beyond the threshold τ_m. A similar result also is obtained when the retailer enters into the reselling agreement. Recall that, the retailer prefers to charge a lower agency fee when the manufacturer provides the high-quality product. This in turn implies that setting a higher retail price can increase the manufacturer's revenue. In contrast, our results show that, the manufacturer benefits the most by accepting the reselling format instead of choosing the agency selling format.

The numerical results also imply that the retailer and the manufacturer have different preferences in the decentralized channel settings. The retailer prefers the agency selling agreement since she may obtain a large proportion of the manufacturer's revenue; while the manufacturer prefers to choose the reselling agreement since there is no significant difference in the market demand by offering the low-quality product. Tan and Carrillo (2017) find that, when the revenue-sharing proportion is in the interval [0.25,0.5], 'both the publisher and the retailer prefer the agency model to the wholesale model'. In contrast, we find that, under the agency selling agreement, the manufacturer cannot benefit from

prioritizing the product quality, see Figures 2(a) and 3(a). Surprisingly, we show that the retailer benefits most under such the agreement, even if she is not the leader in this game, see Figure 3(b).

Proposition 6. Comparing the consumer surplus under three strategic retailing channels, we have $CS^0 > CS^{AS} > CS^{RS}$.

Proposition 6 shows that the centralized distribution channel is the most profitable option for the consumers compared to both the reselling and agency selling channels. It is because the wholesale price under the reselling channel is equal to and greater than the retail price under the centralized channel and agency selling channel, respectively. This higher wholesale price leads to downward pressure on the retailer's pricing decision under the reselling channel. Thus, the consumer surplus under the reselling channel is the lowest one. Compared with the agency selling channel, the product quality and retail price are higher in the centralized channel. In addition, an interesting result can be obtained; in contrast to Ma et al. (2020) that, when the product quality is endogenous, the decentralized channel can generate a higher consumer surplus (with a higher-quality product) than the centralized channel (with a lower-quality product), by Propositions 4, 5, and 6, we find that, even if offering the same quality products, i.e., $q^0 = q^{RS}$, the reselling channel cannot generate a higher consumer surplus than the centralized channel. That is, the manufacturer benefits the most than both the retailer and consumers in the reselling channel.

VI. MODEL EXTENSIONS

Based on our base models, we discuss three extensions in this section. We first examine the impacts of competition between manufacturers on the channel configuration choice. We then consider a case if the retailer acts as the Stackelberg leader under the agency selling agreement.

6.1.Two Competing Manufacturers

In this section, we consider a configuration consisting of two competing manufacturers (1 & 2) who decides products' qualities and sells substitutable products through a common intermediary (i.e., a platform or a retailer). The competing manufacturers offer different qualities of products to satisfy customers' expectation. For the purpose of exposition, we assume θ follows the uniform distribution over the interval [0,1] and $q_2 > q_1$. The assumption is in line with the marketing and operations management literature, for example, Jerath et al. (2017) and Lu et al. (2018).Thus, the market demands of two manufacturers are $Q_1 = (p_2 - p_1)/(q_2 - q_1) - p_1/q_1$ and $Q_2 = 1 - (p_2 - p_1)/(q_2 - q_1)$, respectively.

Under the reselling agreement, the manufacturers first decide the quality of its product (q_1 and q_2). Second, he determines the wholesale prices (w_1 and w_2). Third, the retailer determines the retail prices p_1 and p_2. The payoff functions of two manufacturers and the retailer are developed as follows:

$$\Pi_{M1}^{RS} = \left(w_1 - \frac{1}{2}cq_1^2\right) Q_1,$$
$$\Pi_{M2}^{RS} = \left(w_2 - \frac{1}{2}cq_2^2\right) Q_2,$$
$$\Pi_R^{RS} = (p_1 - w_1)Q_1 + (p_2 - w_2)Q_2.$$

We solve this game model by backward induction. For any given products qualities and wholesale prices, we first analyze the retailer's best response. We then investigate the equilibrium outcomes that can maximize the profits of the manufacturers and the retailer.

Following the similar procedure, we also investigate the decisions under the agency selling agreement. In such a scenario, the retailer announces the agency fee first. Then, the competing manufacturers determine their products qualities and retail prices, respectively. The payoff functions of two manufacturers and the retailer are developed as follows:

$$\Pi_{M1}^{RS} = \left[(1-\gamma)p_1 - \frac{1}{2}cq_1^2\right] Q_1,$$
$$\Pi_{M2}^{RS} = \left[(1-\gamma)p_2 - \frac{1}{2}cq_2^2\right] Q_2,$$
$$\Pi_R^{RS} = \gamma(p_1Q_1 + p_2Q_2).$$

Proposition 7. Under reselling and agency agreements with two competing manufacturers, the equilibrium outcomes are summarized in Table 2 with respect to product qualities, wholesale prices, retail prices, agency fee, and profits.

Agreements \ Decisions	$(\tilde{q}_1, \tilde{q}_2)$	$(\tilde{p}_1, \tilde{p}_2)$	$(\tilde{w}_1, \tilde{w}_2)$
Reselling (RS)	$(\frac{0.3987}{c}, \frac{0.8195}{c})$	$(\frac{0.2744}{c}, \frac{0.6364}{c})$	$(\frac{0.1500}{c}, \frac{0.4531}{c})$
Agency Selling (AS)	$(\frac{0.3930}{c}, \frac{0.8967}{c})$	$(\frac{0.2100}{c}, \frac{0.6774}{c})$	-

Agreements \ Decisions	$\tilde{\gamma}$	$(\tilde{\Pi}_{M1}, \tilde{\Pi}_{M2})$	$\tilde{\Pi}_R$	$\tilde{\Pi}_{\text{Channel}}$
Reselling (RS)	-	$(\frac{0.0121}{c}, \frac{0.0164}{c})$	$\frac{0.0470}{c}$	$\frac{0.0755}{c}$
Agency Selling (AS)	0.3728	$(\frac{0.0214}{c}, \frac{0.0016}{c})$	$\frac{0.0490}{c}$	$\frac{0.0721}{c}$

Table 2: The equilibrium outcomes of a channel with two competing manufacturers and one retailer

Under the AS agreement, the differences in both quality and retail prices are greatest than the equilibrium outcomes obtained under the RS agreement. To investigate effects of competition between two manufacturers, we also consider a configuration consisting of one manufacturer and one retailer.

In addition, our results might help explain why e-commerce firms in China now pay more attention to low-end consumers. Both Alibaba and JD mainly focus on consumers in large cities in China since they were founded. In contrast, by offering the low-quality

products, Pinduoduo focuses on dominating the low-end consumers from smaller cities and rural areas. Pinduoduo's revenue increased dramatically and was up 91% in the December quarter; meanwhile, Alibaba's revenue was up 38% (Kharpal 2020). To fend off Pinduoduo, both Alibaba and JD lunched dedicated apps, Taobao Tejia and JD Jingxi, receptively, in the battle for the low-end consumers.

6.2.Prioritize Agency Fee

In this section, we consider a different sequence under the agency selling agreement. In this game setting, the retailer is the Stackelberg leader and the manufacturer is the Stackelberg follower. The sequence of events is as follows. First, the retailer announces the agency fee, which is a fraction of the manufacturer's retail price. Second, given the observed agency fee, the manufacturer decides the retail price and the quality of the product. We begin by looking at the manufacturer's decisions given the agency fee, and we then analyze the retailer's strategic decision. This modeling setting is similar to the retailer's agency model proposed by Tan and Carrillo (2017). However, the revenue-sharing proportion is exogenous in their work; in contrast, this is an endogenous variable in our model setting.

By backward induction, the first step is to examine the manufacturer's strategic pro- duction and sales decisions. Given the agency fee γ, the manufacturer aims to maximize his expected profit by choosing the optimal retail price and product quality. We use a symbol '˘' to describe the payoff functions and analytical results in this case. The manufacturer's decision problem can be formulated as follows,

$$\max_{p,q\geqslant 0} \breve{\Pi}_M(p,q|\gamma) = \left[(1-\gamma)p - \frac{1}{2}cq^2\right]Q,$$

Having understood the manufacturer's strategic decisions, the retailer's problem is formulated as follows:

$$\max_{0\leqslant\gamma\leqslant 1} = \breve{\Pi}_R(\gamma|p,q) = \gamma p^*(1-p^*/q^*)^K.$$

Proposition 8. When the retailer acts as a leader under the agency selling agreement,

(i) the retailer's equilibrium agency fee is γ* = 1/2;

(ii) the manufacturer's equilibrium retailprice and product quality are $p^* = 2/[c(2+K)^2]$ and $q^* = 1/[c(2+K)]$.

Proposition 8 characterizes the equilibrium outcomes when the retailer accepts the agency selling agreement. Surprisingly, it is noted that the equilibrium agency fee is independent of K, the retail price, and production quality; that is, whether the market demand is high or low, the retailer always prefers to choose a revenue-sharing scheme with a pro- portion 0.5. The manufacturer is no need to worry about setting a higher retail price that may lead to downward pressure on losing the market basis. Accordingly, the manufacturer always needs to pay 50% of revenue as the agency fee to the retailer for accessing consumers, and this would ensure the manufacturer could obtain a stable market basis.

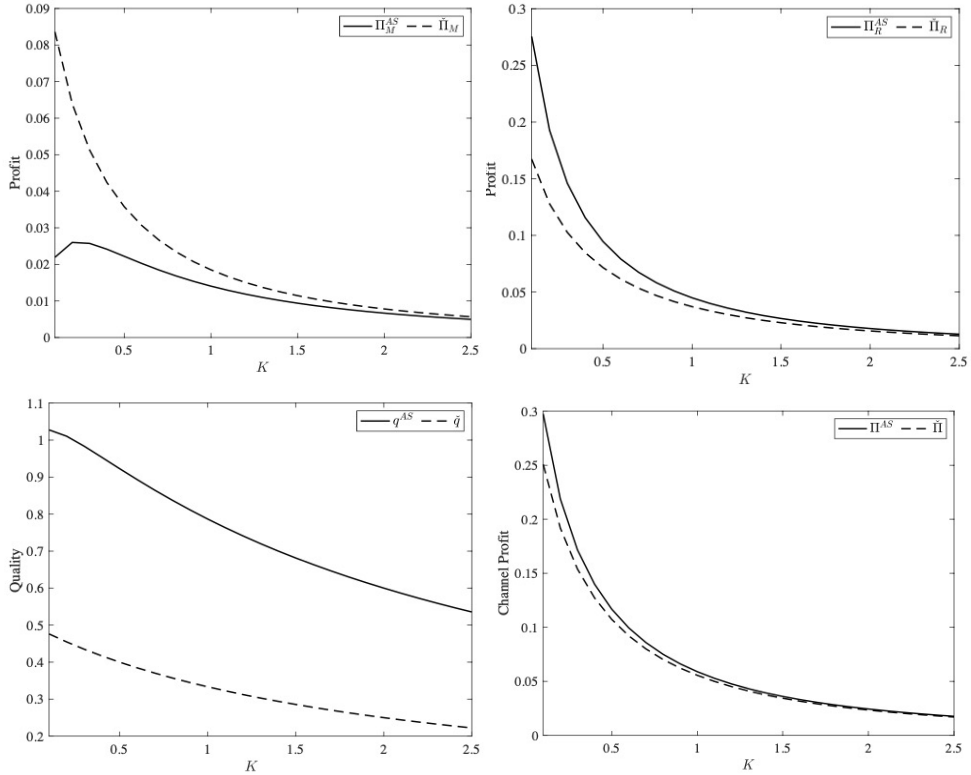


Fig.3. (a & b & c& d) The profits and product quality under the agency selling format with different decision sequences.

Compared to the centralized distribution channel, both the retail price and product quality are affected by the agency fee under the agency selling channel. Thus, the manufacturer's retail price should remain low to attract consumers and sustain market demand. In addition, consumers have lower price sensitivity if they prefer to buy an exclusive product from the prestigious manufacturer. Consumers are less sensitive to the price if there is no significant quality difference compared with other alternative products on existing features. Given different decision sequences under the agency selling agreement, we also compare the profits of the manufacturer and the retailer. An interesting result can be observed: the first-mover advantage does not exist under the agency selling agreement. That is, the leader cannot maximize its profit, but the follower can obtain a higher profit under the agency selling agreement. In addition, there is another interesting result: when the retailer acts as a leader, the manufacturer benefits the most by offering a low-quality product; see Figures 3(a) and (c). This is because, facing a higher agency fee, the manufacturer has to sacrifice quality and set a lower retail price to obtain the maximum market share. In short, as we can see from Figure 3 (d), when $K< 1$, offering a high-quality product increases the profit of the entire channel; in contrast, when $K> 1$, there is no significant difference in the channel profits between offering the high-quality product and setting a higher agency fee ($\gamma* = 0.5$).

VII. CONCLUSION

Consider significant growth in the implementation of various selling agreements in e- commerce, it is necessary to understand the operational conditions which could benefit various market participants, i.e., the manufacturer(s), the retailer, and consumers. Specifically, we formulate the Stackelberg game models to study the strategic interactions between the manufacturer(s) and a monopolistic retailer in a retail channel under different contractual agreements. The identified equilibrium outcomes can provide useful instructions for designing a robust retail channel. To better understand the analytical results and operating conditions identified in our paper, we numerically quantify the value of key parameters by comparing equilibrium retail prices, product qualities, profits, and consumer surplus under different selling agreements.

Conventional wisdom posits that double marginalization makes the decentralized sup- ply channel offers poor services. For example, Shi et al. (2013) show that the manufacturer prefers to maintain higher product quality in a centralized channel than in a decentralized channel. In contrast, we show that, under the reselling agreement, the manufacturer can ensure the product quality, which is equivalent to quality achieved in the centralized distribution channel; besides, the highest product quality is maintained by the manufacturer under then agency selling agreement.

We also obtain some interesting results. First, compared to the centralized channel, the manufacturer cannot obtain a greater market demand, even if he maintains the same product quality. Second, under the agency selling agreement, offering the high-quality product is not a profitable strategy for the manufacturer, but this agreement benefits the retailer. Thus, choosing the reselling agreement is an appropriate strategy for the manufacturer to expand the market demand; under such an agreement, the manufacturer prefers to lower product price and quality for targeting the low-end consumers. Third, offering high-quality product can benefits consumers, even if this strategy slightly increases the channel profit. The retailer benefits the most to serve high-end consumers with high-quality products.

In addition, we examine how the competition between manufacturers impacts on their strategic decisions and the channel profits under different selling formats. First, we find that, under the agency selling agreement, we obtain the greatest differences in both quality and retail prices between two competing manufacturers. Second, the literature shows that the intermediary prefers the reselling agreement that benefits from increasing retail prices (Tian et al. 2018). In contrast, our results show that, under the agency selling agreement, the competitive effect at the upstream can benefit retailer most, even if the manufacturers' competition can lower the agency fee. Third, in the decentralized channel, reducing the retail price is the only way for the low-type manufacturer to stay competitive. Last, offering the high-quality product resulting in the lower profit for the manufacturer remains robust, regardless of whether the upstream is a sole manufacturer or two competing manufacturers. These results might help explain why e-commerce firms in China now prefers to offer low- quality products to satisfy the low-end consumers from rural areas.

We extend our basic model by considering a different decision sequence under the agency selling agreement. We find that, acting as a leader, the retailer prefers to charge a higher and fixed agency fee, which is independent of consumer valuation. Facing such an agency fee, the manufacturer has to lower the retail price and product quality, which contributes to expand its market demand. In particular, we find that, under this agreement, the manufacturer can obtain the same market demand as the demand obtained in a centralized channel; the manufacturer also benefits the most by offering low-quality product. To maximize individual's profit, the first-mover advantage does not exist, regardless of whether the leader is the manufacturer or the retailer, under the agency selling agreement.

Some interesting research directions can be discussed in the future to extend our analysis. First, it might be interesting to consider how the retailer can assist the manufacturer in targeting the consumers with the specific valuation. That is, the retailer is not merely offer the retail platform, but also involves an effort that may increase revenue. Second, some additional services, e.g., free delivery, could be included since these services may benefit consumers' utility and increase operational costs of retail terminal. How would this type of costs influence channel decisions? Further investigation in these directions may lead to more fruitful insights in multi-channel management.

REFERENCES

[1] Abhishek, V., Jerath, K., & Z. Zhang. "Agency selling or reselling? Channel structures in electronic retailing." Management Science, 62(8), 2259-2280.2016.

[2] Alibaba Group. 2019. "Announces March quarter and full fiscal year 2019 results." www.alibabagroup.com/en/news/press pdf/p190515.pdf

[3] Amazon Announces First Quarter Results. 2020. https://s2.q4cdn.com/299287126/files/do c financials/2020/Q1/Amazon-Q1-2020-Earnings-Release.pdf

[4] Armstrong, M. "Competition in Two-side Markets". The RAND Journal of Economics, 37(3), 668-691, 2006.

[5] Bai, J., So, K.C., Tang, C.S., Chen, X., H., Wang. "Coordinating Supply and Demand on an On-Demand Service Platform with Impatient Customers". Manufacturing & Service Operations Management, 21(3), 556-570, 2019.

[6] Chen, Y-J., Dai, T., Korpeoglu, C.G., K¨orpeo˘glu, E., Sahin, O., Tang, C.S., S. Xiao. "Innovative online platforms: Research opportunities." Manufacturing & Service Operations Management, 22(3), 430-445,2019.

[7] Debo, L., Toktay, L. B., Wassenhove, L. N. V. "Market segmentation and product technology selection for remanufacturable products". Management Science, 51(8), 1193- 1205, 2005.

[8] E-Commerce Agency. 2019. How to sell on JD.com. https://ecommercechinaagency.com/how-to-sell-on-jd-com/

[9] Gao, F., X., Su. "Online and offline information for omnichannel retailing" Manufacturing & Service Operations Management 19(1), 84-98, 2016.

[10] Hagiu, A., J., Wright. "Marketplace or reseller?" Management Science, 61(1), 184-203, 2015.

[11] Hao, L., Guo H., R.F., Easley. "A mobile platforms in-app advertising contract under agency pricing for app sales". Production and Operations Management, 26(2), 198-202, 2017.

[12] Hsiao, L., Y., Chen. "The perils of selling online: Manufacturer competition, channel conflict, and consumer preferences". Marketing Letter, 24, 277-292, 2013.

[13] Hsiao, L., Y., Chen. "Strategtic motive for introducing Internet channels in a supply chain." Production and Operations Management, 23(1), 36-47, 2014.

[14] Jerath, K., Kim, S., R., Swinney. "Product quality in a distribution channel with inventory risk." Marketing Science, 2(3), 239-272, 2017.

[15] Jiang, B., Jerath, K., K., Srinivasan. "Firm strategies in the "Mid Tail" of platform-based retailing." Marketing Science, 30(5), 757-775, 2011.

[16] Kamble, V. "Revenue management on an on-demand service platform." Operations Research Letters, 47(5), 377-385, 2019.

[17] Kharpal, A. 2020. Everything you need to know about Pinduoduo, the fast-growing rival to Alibaba and JD in China. www.cnbc.com/2020/04/22/what-is-pinduoduo-chinese- ecommerce-rival-to-alibaba.html

[18] Li, KJ.."Behavior-based quality discrimination". Manufacturing & Service Operations Management, 23(2), 425-436, 2021.

[19] Li, G., Zheng, H., M., Liu. "Reselling or drop shipping: Strategic analysis of E- commerce dual-channel structures". Electronic Commerce Research, 20(3), 475-508,2020.

[20] Lu, T., Chen, Y-J., Tomlin B., Y., Wang. "Selling co-product through a distributor: The impact on product line design." Production and Operations Management, 28(4), 1010- 1032, 2018.

[21] Luo, L, J., Sun. "New product design under channel acceptance: Brick-and-Mortar, Online-Exclusive, or Brick-and-Click." Production and Operations Management, 25(12), 2014-2034, 2016.

[22] Ma, B., Di, C., L., Hsiao. "Return window decision in a distribution channel." Production and Operations Management, 29(9), 2121-2137, 2020.

[23] Pu, X., Sun, S., J., Shao. "Direct Selling, Reselling, or Agency Selling? Manufacturers Online Distribution Strategies and Their Impact." International Journal of Electronic Commerce, 24(2), 232-254, 2020.

[24] Ryan, J.K, Sun, D., X., Zhao. "Competition and coordination in online marketplaces." Production and Operations Management, 21(6), 997-1014, 2012.

[25] Shen, Y., Willems, S.P., Y., Dai. "Channel selection and contracting in the presence of a retail platform." Production and Operations Management, 28(5), 1173-1185, 2018.

[26] Shi, H., Liu, Y., N.C., Petruzzi. "Consumer heterogeneity, product quality, and distribution channels." Management Science, 59(5), 1162-1176, 2013.

[27] Tan, Y., J., Carrillo. "Strategic analysis of the agency model for digital goods." Production and Operations Management, 26(4), 724-741.

[28] The Department of Commerce. 2020. Quarterly Retail E-commerce Sales 1st Quarter 2020. www.census.gov/retail/mrts/www/data/pdf/ec current.pdf

[29] Tian, T., Vakharia A.J., Tan Y., Y., Xu. "Marketplace, reseller, or hybrid: Strategic analysis of an emerging e-commerce model." Production and Operations Management, 27(8), 1595-1610,2018.

[30] Zhang, J., Cao, Q., X., He. "Contract and product quality in platform selling." European Journal of Operational Research, 272(3), 928-944, 2019.

★★★