Merchant or Platform? The Business Model Selection Problem of an Online Intermediary

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Merchant or Platform? The Business Model Selection Problem of an Online Intermediary

Completed Research Paper

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Abstract
Online intermediary plays an important role in e-commerce nowadays. Traditionally, it serves as a merchant buying goods from manufacturers and reselling them to consumer. With the development of technology, more and more intermediaries choose to become platforms referring consumers to sellers. It is critical for an intermediary to decide which model to adopt. To address this question, we establish a game-theoretic model with an intermediary and multiple manufacturers competing in selling heterogeneous products. Our analysis indicates that as the heterogeneity among products decreases, either at the production or the consumer side, the intermediary prefers the platform model to the merchant model. Nevertheless, if the products are highly similar, and thus the competition at the retail market is highly intense, the merchant model will be a better choice.

Keywords: Online intermediary, Two-layer supply chain, Two-sided platform, Game theory

Introduction
The exponential growth of the Internet is an influential and important issue that brings new thoughts of managerial strategies in commerce. For instance, eBay, as a representative success of the dot-com bubble, is famous for its C2C (customer-to-customer) auction-type sales. Taobao, founded as an online platform that allows people to trade on, is now one of the most influential marketplace in the world. They revolutionize the way businesses happen and give the general public a playing ground for their market.

eBay, Taobao, and many C2C marketplace are well-known as two-sided platforms. Ryan et al. (2012) define the platform model as “control of the goods is left to the seller, and the intermediary simply matches buyers with sellers.” In other words, a platform does not own the products sold through it. Instead, it provides referrals for the engaged sellers to reach consumers. Consequently, the product prices are set by the sellers. On the contrary, in the traditional supply chain model, which is called the merchant model in this study, a retailer buys products from manufacturers, keeps them as inventories, and resells to consumers. Apparently, by having the ownerships of the products, the retailer set retail prices to maximize its profit. 1

As there are more than one feasible business models of the online selling business, an important issue naturally arises: which model to adopt to maximize the online channel owner’s profit? In this study, we look for critical factors one should consider when deciding which model to adopt. As the owner of the

1 Amazon is an example to mix the two models. While it was founded as a pure online retailer, it later opened its online channel to independent merchants and individuals. Now, on Amazon.com, one often can choose to buy a product from Amazon or a third-party seller. Due to the page limit, the mixture model is not addressed in this paper.
online channel may be a retailer, a platform, or a mixture, in this study we will follow the economics literature to call it an online intermediary. We investigate the strategic impacts of an intermediary on an online market. In particular, we concentrate on the impact of the intermediary's model selection on the industry structure, pricing decisions, and competition intensity.

To address our research question, we construct a stylized model with an online intermediary and several manufacturers producing and selling heterogeneous products. The intermediary has the options of (1) playing the role of a merchant and buying goods from the manufacturers and (2) being a platform and allowing manufacturers to reach end consumers through it. By being a merchant, the intermediary sets product prices with regards to the wholesale prices set by manufacturers. In contrast, by adopting the platform model, the intermediary sets up a revenue sharing proportion, which will be considered by manufacturers when setting their retail prices. By referring consumers to manufacturers, the intermediary shares a part of sales revenues from manufacturers. The problem is more complicated when we take the heterogeneity of manufacturers and products into consideration. The main research question is the intermediary's model selection problem: Which types of model is more beneficial?

The remainder of this study is organized as follows. In the next section, we review some related works with respect to e-tailers, platforms, and referrals. Then we develop a game-theoretic model to describe the interaction among the intermediary and manufacturers. We first analyze the market equilibrium under each of the two business models and then discuss the intermediary’s model selection problem. The last section summarizes our findings and expected results. All proofs are in the appendix.

**Literature Review**

Our model is related to e-tailers (i.e., online retailers), two-sided platforms, and in-store referrals. Below we briefly summarize related works.

Online channels that suppliers may adopt to directly reach end consumers has been widely discussed in academic research. Balasubramanian (1998) models the competition between direct Internet marketers and conventional retailers. When consumers obtain complete knowledge related to the product, each retailer competes with the direct marketer rather than neighboring retailers. In contrast, in a setting where the direct marketer may control the level of information in the marketplace, it is shown that providing information to all consumers may be suboptimal under some circumstances. Tsay and Agrawal (2004) notice that channel conflicts occur due to the fact that a supplier may compete with a reseller, which is its consumer, when building a direct channel. They compare various distribution strategies with a centralized benchmark system and find that the addition of a direct channel alongside a reseller channel is not necessarily detrimental to the reseller. Chiang et al. (2003) and Yoo and Lee (2011) compare the traditional indirect channels, online direct channels, and dual channels considering the impact of consumer acceptance. They conclude that direct marketing reduces system inefficiency. Wu et al. (2015) examine the condition for exclusive or nonexclusive referrals to retailers. They suggest that if the referral segment market size is sufficiently large, the nonexclusive referral is the equilibrium because the benefit of a bigger demand surpasses the loss of double marginalization deterioration. While this stream of literature focuses on the relation and competition in a supply chain, they do not take the other channel option, the platform model, into consideration. We add to this stream by allowing the intermediary to strategically choose between being an e-tailer or a platform.

Numerous studies investigate the impact of two-sided platforms (called intermediaries, informediaries, or gate keepers in these studies) which provides information rather than physical goods. Baye and Morgan (2001) consider a price sharing platform that sets up subscription and advertising fees for consumers and retailers respectively. To maximize profit, the gate keeper would set low subscription fees but high advertising fees. They also find that the platform results in lower equilibrium prices and potential inefficiency. Chen et al. (2002) study a price-listing informediary that allows retailers to decide whether to join. They find that the profit of an enrolled retailer may go up or down when the referral informediary reaches more consumers, where the direction depends on the combination of a demand increasing effect, a competition effect, and a price discrimination effect. Furthermore, the referral informediary prefers an exclusive strategy of allowing only one of the retailers to enroll. Iyer and Pazgal (2003) investigate the conflict between academic result and empirical observations of online platform’s price accordance. They find that the average prices that consumers pay through an informediary depends on the number of inside retailers. Viswanathan et al. (2007) theoretically and empirically show that consumers who search for price information online pay lower prices for automobiles than those who do not search. Arnold et al. (2011) study the market with asymmetric customer segments. They show that in equilibrium the firm with the smaller loyal market is more likely to advertise its price.
through the gatekeeper but adopts a higher advertised price distribution than that of the firm with a larger loyal market. In contrast with the aforementioned papers, our study includes both types of business models, e-tailer and platform, and allows the intermediary to search for its optimal strategy. The endogeneity of the strategic choice is our main focus.

The literature about a firm’s endogenous choice on providing referrals is of a small body. Cai and Chen (2011) adopt a game-theoretic model to study the referral decisions faced by competing retailers. They show that although retailers have to share profit with their competitors, one-way and mutual referrals may both be beneficial under certain market conditions. Because of the fact that referrals help retailers expand the aggregate market, these competing retailers may use the referrals to align the retailer’s incentives and facilitate implicit collusion. Ryan et al. (2012) study an environment with a marketplace and a retailer. The marketplace can decide to sell similar and competing product of that sold by a retailer. They conclude that the pure competition equilibrium arises when the retailer is sufficiently weak, and the pure coordination equilibrium arises when consumers do not strongly prefer the marketplace to the retailer. Motivated by these two studies, we consider an online intermediary which can choose to serve as a merchant or a platform. Our study supplements theirs by taking the heterogeneity of production processes and product features into consideration.

Model

**Intermediary and manufacturers.** We consider a market with an intermediary (she) and two manufacturers (for each of them, he) producing substituting products. Manufacturers are heterogeneous at the production side. More precisely, manufacturer $i \in \{1, 2\}$ has an exogenous unit production cost $c_i$. To save notation, we set $c_1 = c \geq 0$ and normalize $c_2$ to 0, where $c \in [0, 1]$ measures the difference of the unit product cost between the two firms. We call product $i$ as the product manufactured by manufacturer $i, i \in \{1, 2\}$.

Each manufacturer may establish one of two relationships with the intermediary. If the intermediary serves as a merchant for manufacturer $i$, she will purchase product $i$ from manufacturer $i$ at a wholesale price $w_i$. She then decides the retail price $p_i$ for product $i$. As manufacturer $i$ needs to choose his wholesale price, we say the two players are in mode W. On the contrary, if the intermediary serves as a platform for manufacturer $i$, the manufacturer will set the retail price $p_i$. This is therefore called mode R. By referring consumers to manufacturer $i$, the intermediary shares revenues for product $i$ sold through her by setting a revenue sharing ratio $r_{i,2}$

**Industry structures.** In the most general situation, the platform may be flexible to serve the two manufacturers in different modes. There will then be four possible industry structures: RR (the intermediary is a pure platform), WW (the intermediary is a pure merchant), WR (the intermediary is a merchant for manufacturer 1 but a platform for manufacturer 2), and RW (the opposite of WR). The profit of manufacturer $i \in \{1, 2\}$ in structure $k \in \{RR, WR, RW, WW\}$ is denoted by $\pi_i^k$, and that of the intermediary is $\pi_f$. We denote the demand of product $i$, which naturally depends on the prices of both products, by $D_i(p_i, p_2)$ or simply $D_i$. For manufacturer $i$, his profit is $w_i - c_iD_i$ under the W mode or $(1 - r_{i,2})p_i - c_iD_i$ under the R mode. For the intermediary, her profit from product $i$ is $\pi_i - r_{i,2}p_iD_i$ under the W mode or $\pi_i - \pi_iR$ under the R model. Her total profit is then the sum of the profits from the two products. The complete list of profit notations is in Table 1.

<table>
<thead>
<tr>
<th>Mode for Manufacturer 1</th>
<th>Mode for Manufacturer 2</th>
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<tbody>
<tr>
<td>W</td>
<td>$\pi_i^{WW}$, $\pi_i^{WR}$, $\pi_i^{WR}$, $\pi_i^{WR}$</td>
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<tr>
<td>R</td>
<td>$\pi_i^{RW}$, $\pi_i^{WW}$, $\pi_i^{WW}$, $\pi_i^{WW}$</td>
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2 In practice, some intermediates charge a fixed listing fee from manufacturers posting product information on their platforms. As a fixed fee is typically absent in a wholesale relationship, we assume that the intermediary cannot charge a listing fee to make fair comparisons.
In this study, we assume that the platform will choose whether to adopt structure WW or RR but cannot implement WR or RW. This can be a reasonable assumption, as adopting a mixture model brings more challenges and costs at both the technology and management sides. To convey with the practice, we further restrict the intermediary to set a single revenue sharing ratio \( r \) for both manufacturers under the RR structure.

**Product demands.** To capture the heterogeneity of products and the impact of prices, we adopt the model of Bertrand competition of heterogeneous products (Gibbons, 1992). More precisely, we assume that the demand of product \( i \) is

\[
D_i(p_1, p_2) = 1 - p_i + bp_{3-i},
\]

where \( i \in \{1, 2\} \) and \( b \in [0, 1) \). In this setting, a product’s demand is negatively affected by its own price but positively affected the competing product’s price. The exogenous parameter \( b \) measures the degree of similarity of the two products or intensity of competition. The larger \( b \) is, the more similar the two products are. The competition then becomes more intense, as one’s price affects the other’s demand more significantly. Note that \( b \) is restricted to be strictly less than 1, as the direct impact of one’s price should be higher than the indirect impact of the competitor’s price.

The sequence of events is depicted in Figure 1. First, the intermediary chooses a model, platform or merchant. Second, if the platform model is chosen, the intermediary sets a revenue sharing proportion for manufacturers; otherwise, the two manufacturers’ set their wholesale prices simultaneously. Third, the retail prices of the two products are either set by the intermediary under the platform model or the two manufacturers simultaneously under the merchant model. Finally, products are sold and all players gain their profits.

![Figure 1. Time Sequence](image)

Table 2 lists the parameters and decision variables.

<table>
<thead>
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<th>Table 2. List of Notations</th>
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<tr>
<td>Parameters</td>
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<tr>
<td>( b )</td>
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<tr>
<td>( c_i )</td>
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<tr>
<td>( c )</td>
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<td>Decision variables</td>
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<td>( w_i )</td>
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<td>( r )</td>
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**Analysis**

In this section, we first characterize the best strategy for each player in different scenarios. We focus on two scenarios: the pure merchant model (WW) and pure platform model (RR). As a result, the intermediary has the information of which business model can maximize its own profit. We then discuss how the intermediary’s optimal business model changes in response to the heterogeneity of...
manufacturers/products at the supply and demand sides. It is investigated which parameters affect the decision of the firms and the equilibrium industry structure. Based on our findings, we connect our results to real world suggestions.

**Merchant Model**

When the merchant model is adopted by the firms, the intermediary becomes a retailer that purchases products from the manufacturers and resells to consumers. In this case, the retailer owns the products and has more sovereignty over its pricing decision. Therefore, she may set prices to maximize her profit, i.e., she solves

\[
\pi_i^{WW} = \max_{p_1, p_2} (p_1 - w_1)D_1 + (p_2 - w_2)D_2 = \max_{p_1, p_2} (p_1 - w_1)(1 - p_1 + b p_2) + (p_2 - w_2)(1 - p_2 + b p_1)
\]

subject to \(D_1 \geq 0\) and \(D_2 \geq 0\). By predicting how the wholesale prices will affect the retail prices and demands, the two manufacturers’ play a simultaneous game, in which each of them solves

\[
\pi_i^{WW} = \max_{w_i} (w_i - c_i)D_i, i = 1, 2.
\]

The equilibrium prices and profits are summarized in Lemma 1.

**Lemma 1.** Under the merchant model, the equilibrium wholesale prices are \(w_1^* = \frac{(2+b)+2c}{4-b^2}\) and \(w_2^* = \frac{(2+b)+bc}{4-b^2}\), retail prices are \(p_1^* = \frac{(6-b-2b^2)+2(1-b)c}{2(4-b^2)(1-b)}\) and \(p_2^* = \frac{(6-b-2b^2)+b(1-b)c}{2(4-b^2)(1-b)}\), demands are and the manufacturer’s profits are \(\pi_1^{WW} = \frac{((2+b)+bc)^2}{2(4-b^2)^2}\) and \(\pi_2^{WW} = \frac{((2+b)+bc)^3}{2(4-b^2)^3}\). Moreover, we have \(w_1^* \geq w_2^*, p_1^* \geq p_2^*\), and \(\pi_1^{WW} \leq \pi_2^{WW}\). The intermediary earns the profit

\[
\pi_i^{WW} = \frac{(2+b)^2-2(2+b)^2c+(1-b)c^2-3b^2-4(1-b)c^2}{4(4-b^2)^2(1-b)}.
\]

Since manufacturer 2 is more cost-effective in the market, he sets a lower wholesale price and induces a lower retail price compared to manufacturer 1. By utilizing his advantage, he captures a larger market share and earns a higher profit. It is also observed that the intermediary’s profit decreases as manufacturer 1’s cost goes up.

Lemma 1 also shows that, in equilibrium, the two products will both appear on the market. In other words, the intermediary’s optimal strategy is always to sell both products regardless how high the cost difference is. With the control of both product prices, the intermediary maximizes his profit by properly dividing the market into two segments. The existence of the intermediary alleviates the competition between the two manufacturers.

**Platform Model**

In the platform model, the intermediary acts as a two-sided platform that matches buyers and sellers. A revenue sharing proportion is set by the intermediary. Manufacturers own the products; therefore, the retail prices of products are set by the manufacturers. The intermediary has no direct control of the products’ pricing strategies. All she may do is to use the revenue sharing proportion to indirectly affect the equilibrium retail prices.

The intermediary sets the revenue sharing proportion \(r \in [0, 1]\) to maximize her profit

\[
\pi_i^{RR}(r) = r(p_i D_i + p_2 D_2).
\]

Then the two manufacturers simultaneously set their retail prices by solving

\[
\pi_i^{RR} = \max_{p_i} ((1 - r)p_i - c_i)D_i, i = 1, 2.
\]

All these optimization problems are subject to the demand non-negativity constraints \(D_1 \geq 0\) and \(D_2 \geq 0\). In Lemma 2, we first characterize the manufacturers’ equilibrium decisions given the revenue sharing proportion \(r\).

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3 The only exception is that \(D_1 = 0\) if \(b = 0\) and \(c = 1\), i.e., the two products are independent, and the unit cost of product 1 is as high as the maximum consumer willingness-to-pay.

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Lemma 2. Given the revenue sharing proportion \( r \), the equilibrium retail prices in the platform model are \( p_1^* = \frac{(2+b)(1-r)+2c}{(4-b^2)(1-r)} \) and \( p_2^* = \frac{(2+b)(1-r)+bc}{(4-b^2)(1-r)} \), where \( p_1^* \geq p_2^* \). The manufacturers earn the profits
\[
\pi_1^{RR} = \frac{1}{1-r} \left( \frac{(2+b)(1-r)+(2+b)^2c}{(4-b^2)(1-r)} \right)^2 \\
\pi_2^{RR} = \frac{1}{1-r} \left( \frac{(2+b)(1-r)+bc}{(4-b^2)} \right)^2
\]
The intermediary’s profit is
\[
\pi_I^{RR}(r) = \frac{r(2r(1-r)+b(2+b)^2(1-r)+c(3b^2-4)c^2)}{(4-b^2)^2(1-r)^2}
\]
Lemma 2 summarizes the equilibrium prices of products in response to the revenue sharing proportion \( r \) from the manufacturers’ perspective. Both products’ prices increase in the revenue sharing proportion since the revenue sharing proportion acts as sales cost. Furthermore, similar to the merchant model, manufacturer 2 benefits from his lower production cost. With the cost advantage, he sets a lower price and attracts more consumers. With the manufacturers’ responses in mind, the intermediary looks for \( r \) to maximize \( \pi_I^{RR}(r) \) derived in Lemma 2. Though the complicated structure of \( \pi_I^{RR}(r) \) makes it impossible to have a closed-form expression for the intermediary’s optimal \( r \), in the next lemma we present some analytical properties regarding the intermediary’s problem.

Lemma 3. The function \( \pi_I^{RR}(r) \) is quasi-concave in \( r \in [0,1] \). Therefore, there exists a unique \( \hat{r} \in [0,1] \) that satisfies \( \frac{d\pi_I^{RR}(r)}{dr} \big|_{r=\hat{r}} = 0 \). The intermediary’s optimal revenue sharing proportion \( r^* \) satisfies
\[
r^* = \begin{cases} 
\hat{r} & \text{if } \hat{r} \leq 1 - \frac{(2-b^2)c}{2+b} \\
\hat{r} & \text{otherwise}
\end{cases}
\]
Lemma 3 states the existence and uniqueness of the optimal revenue sharing proportion \( r^* \) to maximize the profit of the intermediary in the platform model. There are two special values of \( r \) mentioned in Lemma 3. On the one hand, \( \hat{r} \) is the ideal optimal \( r \) which satisfies the first-order condition of the quasi-concave profit function. \( r \), on the other hand, is the cap of the feasible region of \( r \) derived from the demand constraints. Therefore, the first-order point \( \hat{r} \) is the optimal feasible revenue sharing proportion for the intermediary when it does not reach the cap \( \hat{r} \). Once \( \hat{r} \) violates the cap, \( \hat{r} \) is the optimal feasible revenue sharing proportion.

As aforementioned, the product prices increase in the revenue sharing proportion. While the revenue sharing proportion represents a tool for the intermediary to extract revenue from manufacturers, once it goes beyond the cap, manufacturer 1 earns nothing and stops raising its product price. As a result, manufacturer 2 would also stop raising its product price. Consequently, the intermediary no longer benefits from raising the proportion once it goes beyond the cap.

By utilizing Lemmas 2 and 3, we are able to (maybe numerically) derive the equilibrium of the market in the platform model. Given the values of \( b \) and \( c \), the intermediary can first numerically search for the first-order point \( \hat{r} \) and compare it with the upper bound \( \hat{r} \) to find the optimal \( r^* \). Substituting \( r^* \) into Lemma 2 then gives us the equilibrium retail prices, product demands, and manufacturers’ profits.

**Comparisons**

We are now ready to address our main research question: Merchant and platform, which one is better?

As Lemma 3 shows, there is no closed-form expression for \( r^* \) in the platform model. As it is hard to derive the profit of the intermediary, we do a numerical study to obtain some intuitions first. For each combination of \( b \in [0,1] \) and \( c \in [0,1] \), we numerically find \( r^* \) and the associated platform’s profit \( \pi_I^{RR} \) under the merchant model. We then compare that with the platform’s profit \( \pi_I^{RR} \) under the merchant model, which may be calculated by the closed-form formula we derived. Figure 2 is a visualization of our result.
A first look at Figure 2 will give us the following idea: When $b$ or $c$ is large, the merchant model is better; on the contrary, when $b$ and $c$ are both small, the platform model is better. This idea is analytically proved in the following proposition.

**Proposition 1.** There exist two cut-off values $\hat{b}_1 \in (0,1)$ and $\hat{c}_1 \in (0,1)$ such that for all $(b, c) < (\hat{b}_1, \hat{c}_1)$, we have $\pi_i^{WW} < \pi_i^{RR}$. On the contrary, there exist $\hat{b}_2 \in (\hat{b}_1, 1)$ and $\hat{c}_2 \in (\hat{c}_1, 1)$ such that for all $(b, c) > (\hat{b}_2, \hat{c}_2)$, we have $\pi_i^{WW} > \pi_i^{RR}$.

We find that the intermediary prefers the merchant model when $b$ goes up but prefers the platform model when $b$ goes down. When $b$ increases, the competition is more intense. Therefore, the products’ prices under the platform model will become lower due to the two manufacturers’ head-to-head competition. As the system profit goes down, the intermediary’s goes down as well. On the contrary, under the merchant model, the intermediary can control the retail prices and prevent excessive price competition. This explains why the merchant model is preferred when $b$ is large.

Under the merchant model, the two manufacturers will decide their wholesale prices differently considering their different production costs. When $c$ increases, the discrepancy between the products at the production side increases, and the resulting difference in wholesale prices increases. Nevertheless, if the intermediary chooses the platform model, only one single revenue sharing proportion must be applied to both manufacturers. Such inflexibility would hurt the intermediary when the two products are highly different at the production side, as in that case the two manufacturers’ actually prefer quite different revenue sharing ratios. As a result, the intermediary prefers the merchant model when $c$ increases.

One may argue that this finding is prone to the assumption that only one revenue sharing proportion is applied to both products. While this may be true from the perspectives of model and analysis, we would like to note that in practice most platforms do adopt this single proportion policy for each product category. In other words, different proportions may be applied for different kinds of products (3C, apparels, books, etc.), but only one proportion is set for all products from all manufacturers within one category. We set up our model to fit this feasibility constraint faced by real-world platforms in industry.

If we look at Figure 2 more deeply, we would obtain an interesting observation at the top-left corner. There is a region of moderate $c$ (roughly between 0.75 and 0.85) such that the impact of $b$ on the optimal model is non-monotone. When $b$ is either small or large, the intermediary prefers the merchant model, but when $b$ is of moderate size, the intermediary’s preference is ambiguous.
model; in contrast, the platform model is more advantageous when b stays in the medium. We may again analytically confirm this observation.

**Proposition 2.** There exist \( c_1 \in (0,1) \) and \( c_2 \in (c_1,1) \) such that for all \( c \in [c_1, c_2] \), there exist \( b_1 \in (0,1) \) and \( b_2 \in (b_1,1) \) such that \( \pi^{WW}_1 > \pi^{RR}_1 \) if \( b < b_1 \) or \( b > b_2 \) but \( \pi^{WW}_1 < \pi^{RR}_1 \) if \( b \in (b_1, b_2) \).

While c is large, the impact of the cost difference dominates the selection of models. In other words, with a huge gap between products at the production side, the intermediary has no choice but to adopt the merchant model. Similarly, when c is small, the platform model becomes dominant. When c is moderate, the impact of the competition intensity enlarges. When b is large, the intense price competition still hurts the profit of the intermediary. Therefore, taking control of product prices is a solution to avoid intense competition. However, when b is small, the two products are quite different at the consumer side, a situation that is quite similar to the case that c is large. The disadvantage of relying on only one single revenue sharing product is too significant for the intermediary. The merchant model is thus preferred.

In conclusion, the two business models exhibit quite different natures. Under the merchant model, the notorious “double marginalization” problem increases the retail prices to an inefficient level due to the multi-layer structure of the supply chain. The platform model is an effective tool for the intermediary to bypass the double marginalization problem and increase the profits of the industry and itself. Nevertheless, the platform model has two drawbacks. On the one hand, it pushes the manufacturers into a battleground and face head-to-head competition on the consumer market. This may greatly reduce the retail prices and all the firms in the system. On the other hand, it suffers from the restriction that only one revenue sharing proportion can be applied to all products and manufacturers in the same product category. The two drawbacks together make the platform model a less preferred model when the products are quite similar (when b is large) or quite different (when b is small).

**Conclusions**

In this study, we establish a game-theoretic model to examine the model selection problem of an online intermediary. There are manufacturers offering heterogeneous products, and the intermediary has the option to decide how to cooperate with them by choosing either the merchant model or the platform model. The main difference between the two models is whether the intermediary owns the power of setting prices. Through our analysis, we show that the profitability of the two models is governed by the similarity of the products at the production and consumer sides. When the two products are quite different at either side, the platform model is less profitable due to the infeasibility of setting different revenue sharing proportions for different products. Moreover, when the similarity of the products is high, the intense manufacturer-to-manufacturer competition under the platform model hurts the intermediary significantly. The intermediary should then choose to be a merchant to serve as a buffer and reduce the intensity of competition.

The result has several avenues for further research. First, the mixture model that combines both the merchant and platform models can be further studied. Second, in our current study, the intermediary cannot influence the demand of customers. In reality, intermediary might provide mechanism that affect customers’ valuation on the product such as advertisement, data technology, better services, etc. It is interesting how these options may influence the decisions of the players in the environment. Third, if manufactures have the power to reach the consumer directly, the problem gets more interesting and complicated.

To highlight the impact of industry structure and competition intensity on the pricing decisions, we omit demand uncertainty in our model; otherwise, the intermediary would have a strong incentive favoring the platform model. We also assume that there is no information asymmetry in the market. If the product quality is hidden to consumers, quality risk may force the intermediary to choose the merchant model. Nevertheless, it would contribute more to the literature if we further study the joint impact of these factors.

**Appendix**

**Proof of Lemma 1.** We first verify the concavity of the objective function. Since \( V^2 \pi^{WW}_1(p_1, p_2) = \begin{bmatrix} -2 & 2b \\ 2b & -2 \end{bmatrix} \), and its leading principals are \(-2 < 0\) and \( \begin{bmatrix} 4 - 4b^2 > 0 \end{bmatrix} \), \( \pi^{WW}_1(p_1, p_2) \) is negative definite. This implies that the first-order condition will be necessary and sufficient for an optimal
solution. Let’s omit the constraints for a while. The first-order condition gives us \( \frac{\partial \pi_i^{WW}}{\partial p_i} = (1 - 2p_i^* + bp_2 + w_i) + b(p_2 - w_2) = 0 \), i.e., \( p_i^* = \frac{1 + 2bp_2 + w_i - bw_2}{2} \). Similarly, we have \( p_2^* = \frac{1 + 2bp_2 + w_i - bw_2}{2} \).

Solving the two equations leads to \( p_1^* = \frac{1 + (1 - b)w_1}{2(1 - b)} \) and \( p_2^* = \frac{1 + (1 - b)w_2}{2(1 - b)} \).

Based on the response of the intermediary, manufacturer \( i \) maximizes his profit \( \pi_i^{WW}(w_i) = (w_i - c_i) \times \frac{1 - w_i + bw_2}{2}, i = 1, 2 \). As \( \pi_i^{WW}(w_i) \) is concave \( \left( \frac{d^2 \pi_i^{WW}(w_i)}{dw_i^2} = -1 < 0 \right) \), the first-order condition requires the optimal wholesale price \( w_i^* \) to satisfy \( w_i^* = \frac{1 + bw_2 - c_i}{1}, i = 1, 2 \), where \( c_1 = c \) and \( c_2 = 0 \). Solving the two equations for the two manufacturers results in \( w_1^* = \frac{(2 + b) + 2c_1 + bc_2}{4 - b^2} \) and \( w_2^* = \frac{(2 + b) + 2c_2}{4 - b^2} \). By plugging in \( w_1^* \) and \( w_2^* \) to the expressions of \( p_1^* \), \( \pi_1^{WW} \), and \( \pi_2^{WW} \), we may obtain the equilibrium retail prices and profits given in the lemma.

Finally, we check the ignored constraints. We have \( D_1 = 1 - p_1 + bp_2 = \frac{(2 + b)(1 - r - 2)c}{2(4 - b^2)} \geq 0 \) if and only if \( c \leq \frac{2 + b}{2 - b^2} \), which is true because \( c \leq 1 \leq \frac{2 + b}{2 - b^2} \). We also have \( D_2 = 1 - p_2 + bp_1 = \frac{(2 + b)(1 - r - 2)c}{2(4 - b^2)} \geq 0 \). This completes the proof.

**Proof of Lemma 2.** Since \( \pi_i^{RR} \) is concave \( \left( \frac{d^2 \pi_i^{RR}}{dp_i^2} = -2(1 - r) < 0 \right) \), we get the optimal \( p_i \) by applying the first-order condition \( \frac{d \pi_i^{RR}}{dp_i} = 0 \) for manufacturer \( i \) and yield \( p_i^* = \frac{(1 - r)(1 + 2bp_3 - c_1)}{2(1 - r)} \), where \( c_1 = c \) and \( c_2 = 0 \). Solving the two equations results in \( p_i^* = \frac{(2 + b)(1 - r) + 2c_1 + bc_3 - c_1}{(4 - b^2)(1 - r)} \). The equilibrium demands and the intermediary’s profit as a function of \( r \) can then be obtained by plugging in \( p_i^* \) into their formulas.

**Proof of Lemma 3.** Through several steps of arithmetic, we obtain
\[
\begin{align*}
h(r) &= -2(2 + b)^2r^3 + 6(2 + b)^2r^2 + (-6(2 + b) - (2 + b)^2bc + (3b^2 - 4)c^2)r \\
&+ (2 + b)^2 + (2 + b)^2bc + (3b^2 - 4)c^2 = 0
\end{align*}
\]

as the first-order condition \( \frac{d^2 \pi_i^{RR}(r)}{dr} = 0 \). We then have \( h(0) = 2(2 + b)^2 + (2 + b)^2bc + (3b^2 - 4)c^2 < 0 \). To show that \( h(0) > 0 \), note that \( \frac{d^2 h}{dr^2}(0) = 2(3b^2 - 4) < 0 \), which implies that \( h(0) \) is concave in \( c \) and has its minimum at either \( c = 0 \) or \( c = 1 \). The facts \( h(0)|_{c=0} = 2(2 + b)^2 > 0 \) and \( h(0)|_{c=1} = b + 9b + 12b + 4 > 0 \) together let us conclude that \( h(0) > 0 \). Moreover, we have \( h(1) = 2(3b^2 - 4)c^2 < 0 \). As we also have \( \frac{dh}{dr}|_{c=1} = -6(2 + b)^2(r - 1)^2 - 2(2 + b)^2bc + (3b^2 - 4)c^2 < 0 \), we know \( h(r) \) starts at \( h(0) > 0 \), monotonically decreases as \( r \) goes up, and eventually reaches \( h(1) < 0 \). In other words, \( \pi_i^{RR}(r) \) is quasi-concave. Therefore, there exists a unique first-order solution \( \hat{r} \in (0, 1) \) that satisfies \( \frac{d \pi_i^{RR}(r)}{dr} = 0 \).

Now we take the constraints into consideration. First, \( D_2 = \frac{(2 + b)(1 - r) + bc}{(4 - b^2)(1 - r)} \geq 0 \). However, \( D_1 = \frac{(2 + b)(1 - r) - (2 + b)^2c}{(4 - b^2)(1 - r)} \geq 0 \) if \( c \leq \frac{(2 + b)(1 - r)}{2 - b^2} \), i.e., \( r \leq \hat{r} = 1 - \frac{2 - b^2}{2 + b} \). Therefore, if \( \hat{r} \leq \hat{r} \), \( \hat{r} \) is optimal; if not, then \( \hat{r} \) is optimal.

**Proof of Proposition 1.** When \( c = 0 \) and \( b = 0 \), \( \hat{r} = \max \frac{r}{2} = 1 \). Therefore, we have \( r^* = 1 \) and \( \pi_i^{RR} = \frac{1}{2} \). By plugging \( c = 0 \) and \( b = 0 \) into Lemma 1, we derive \( \pi_i^{WW} = \frac{1}{8} \). The facts that \( \pi_i^{RR} \big|_{b=c=0} > \pi_i^{WW} \big|_{b=c=0} \) and both profit functions are continuous result in our first conclusion regarding the existence of \( \hat{b}_1 \in (0, 1) \) and \( \hat{c}_1 \in (0, 1) \). On the contrary, when \( c \) and \( b \) both approach 1, \( \hat{r} \) approaches to a value around 0.81, which is greater than \( \hat{r} \). Therefore, \( r^* = \hat{r} = \frac{2}{3} \) and \( \pi_i^{RR} = \frac{8}{3} \). In this case, \( \pi_i^{WW} \) approaches infinity. Again, because all functions are continuous, we obtain our second conclusion regarding the existence of \( \hat{b}_2 \in (0, 1) \) and \( \hat{c}_2 \in (0, 1) \).

**Proof of Proposition 2.** Consider the case that \( c = \frac{4}{5} \). Through several steps of arithmetic, we obtain
\[
\begin{align*}
h(\hat{r})|_{c=\frac{4}{5}} &= \frac{2(\frac{4}{5})^2 (2 - b^2)^3}{2 + b} + \left(\frac{4}{5}\right)^2 b(2 - b^2)(2 + b) + \left(\frac{4}{5}\right)^2 \left(2 - \frac{4(2 - b^2)}{2 + b}\right)(3b^2 - 4) \cdot \frac{1}{5} \cdot \frac{1}{5}.
\end{align*}
\]
\[ h(\hat{r})|_{c=\frac{4}{5}} > 0 \] for all \( b \in (0,1) \), which implies that \( r^* = \hat{r} \) when \( c = \frac{4}{5} \). We then have \( \pi_l^{RR}(r^*)|_{c=\frac{4}{5}} = \frac{(b+1)^2(4b^2+5b+2)}{5(b+2)(b^2-2)^2} \). The comparison between the two models can be conducted by investigating the sign of

\[ g(b) = \pi_l^{RR}(r^*)|_{c=\frac{4}{5}} - \pi_l^{WW}|_{c=\frac{4}{5}} \]

\[ = \frac{(b + 1)^2(4b^2 + 5b + 2)}{5(b+2)(b^2-2)^2} - \frac{4b^3 + 4b^2 + 4b + 2}{50(b+2)^2(b+2)^2(1-b)} \]

\[ = \frac{40b^5 + 54b^4 - 249b^6 - 278b^5 + 478b^4 + 544b^3 - 204b^2 - 208b + 48}{50(b+2)^2(b-1)(b+2)(b^2-2)^2} \].

It can be easily verified that there are exactly 2 roots \( \tilde{b}_1 \) and \( \tilde{b}_2 \) for \( g(b) \) in \([0,1]\) such that \( g(\tilde{b}_1) = 0 \), \( g(\tilde{b}_2) = 0 \) and \( \tilde{b}_1 \approx 0.216 < 0.606 \approx \tilde{b}_2 \). Given the facts that \( g(0) = -\frac{3}{200} < 0 \), \( g(b) \to -\infty \) as \( b \to 1 \), and \( g\left(\frac{1}{2}\right) \approx 0.0196 > 0 \), we conclude that \( g(b) < 0 \) if \( b < \tilde{b}_1 \) or \( b > \tilde{b}_2 \) and \( g(b) > 0 \) if \( b \in (\tilde{b}_1, \tilde{b}_2) \). The statement in the proposition then follows due to the continuity of all profit functions.

**References**


