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The Impact of Private Label Policy under Online Direct Selling on the Performance of OEM Supply Chain

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Abstract: *In this paper, we consider a decentralized OEM supply chain that consists of a national brand manufacturer and an OEM (Original Equipment Manufacturer) supplier. In addition to product production for the national brand manufacturer, the OEM supplier can also introduce a private label to sell through the online direct channel. Through the establishment and analysis of the mathematical model, we study the market conditions under which the OEM supplier should directly sell the private label online and the impacts on the performance of the OEM supply chain. The results show that the OEM supplier will directly sell a private label online if and only if the substitute level of the private label to the national brand is at an intermediate level and the online selling cost is sufficiently low. In addition, we find that the private label policy under online direct selling can significantly improve the profit of the entire OEM supply chain.*

Key words: *OEM supply chain; private label; online direct selling; Stackelberg game*

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I. Introduction

The OEM (Original Equipment Manufacturer) production mode has appeared and rapidly developed due to the economic globalization. It means that national brand manufacturers are responsible for product design, outsource all or part of production to OEM suppliers, and then sell the final products to consumers (Chen and Chen 2014). For example, IBM, Nike, and LV have all established partnerships with OEM suppliers in different regions of the world.

However, the profit margins of OEM suppliers are extremely low because the production process has the lowest added value. Especially in recent years, the rising labor cost in China has further reduced the profit margins of OEM suppliers and prompted national brand manufacturers to gradually transfer some orders to Southeast Asia, Africa and other regions (Wang and Zhou 2007). OEM suppliers must develop a new source of profit to solve this situation, which creates the private label policy under online direct selling.

The current OEM production mode provides opportunities for OEM suppliers to develop private labels. From the supply side, OEM suppliers can learn from advanced R&D ability to design products and create their own brands, including product manufacturing technology and design concepts. From the demand side, national brand manufacturers tend to target high value consumers, and cannot cover the left consumers who have lower valuations and prefer product quality to brand premiums. OEM suppliers' private labels can perfectly meet the needs of this consumer group.

One the other hand, the prevalent online retailing can provide an opportunity to solve the sales channel problem for OEM suppliers' private labels. OEM suppliers can directly sell the private labels to consumers through e-commerce platform providers. Currently, the private label policy under online direct selling has been widely used in practice and attracted a large number of consumers' attention. For example, the platform Biyao provides a direct communication between the world top brand manufacturers' OEM suppliers and consumers. These OEM suppliers introduce private labels with the roughly same quality as national products but lower prices. The apparel company Genanx has also built a new e-commerce mode "from OEM to brand" to develop the private label policy under online direct selling.

Motivated by the interesting practice, in this study, we will explore the following questions. First of all, how should OEM suppliers make optimal sales decisions based on the trade-off between online direct selling costs and consumers' purchasing decisions between the national brand products and private labels? Second, when should OEM suppliers adopt the private label policy under online direct selling? Finally, what are the impacts of the private label policy under online directly selling on the performance of OEM supply chain. To solve these questions, we consider a decentralized supply chain that consists of an OEM supplier and a national brand manufacturer and develop a Stackelberg game model. Our analytical results show that the OEM supplier should directly sell a private label online if and only if the substitute level between the private label and the national brand is at an intermediate level and the online selling cost is sufficiently low. In addition, OEM's private label strategy can increase the performance of the entire OEM supply chain.

Our study contributes to the literature on private labels and supplier encroachment. Relevant academic research on the introduction of private labels by downstream retailers has been widely studied (Pauwels and Srinivasan, 2004; Choiand Coughlan, 2006; Amaldoss and Shin, 2015; Li and Zhou, 2016). Since the introduction of private labels by retailers may hurt manufacturers' profits, some scholars study how manufacturers can deal with the negative impacts (Nasser et al. 2013). Ru et al. (2015) and Li et al. (2018) explore the problem of supply chain coordination when the private label is introduced. The above literature explores downstream retailers' private label policy; however, our study differs to the above research to consider upstream suppliers' private label policy. Different private label owners have different supply chain power, which will affect the performance of the supply chain. Furthermore, upstream suppliers do not have channels to reach consumers; therefore, we need to consider their direct selling cost when the private label is introduced.

With the rapid development of e-commerce, upstream suppliers can encroach downstream retail market through the online direct channels, which is similar to the private label policy under online direct selling in our study. Chiang et al. (2003), Arya et al. (2007), Cattani et al. (2007) and Yoon (2016) point out that the encroachment of upstream suppliers can achieve a win-win outcome for supply chain members. Wang et al. (2018) show that manufacturers' join in the third-party e-commerce platform always harm retailers' profits. Some other scholars focus on how downstream retailers can cope with supplier encroachment. For example, Huang et al. (2018) show that retailers' sharing low-demand information can reduce competition in downstream channels, and can further prevent suppliers from establishing direct sales channels. Li et al. (2013) and Lei et al. (2014) study the intrusion problem of suppliers in the asymmetric information, and analyze the impact of the establishment of direct sales channels on the original single channel supply chain. Liu et al. (2017) study how retailers can cooperate with the new direct sales channels that are developed by manufacturers. The above literature all considers a same product's sales; however, our study discusses the competition between two different products in the market, which involves consumers' choices between the OEM private label and the national brand. In addition, the upstream suppliers are core enterprises in the supply chains of the above literature; however, the downstream national brand manufacturers are the core enterprise in OEM supply chains.

The remainder of our paper is organized as follows. We describe the model through Section Ⅱ. In section Ⅲ, we analyze the model and compare the equilibrium results of OEM supply chain members with or without private label brands. Finally, we summarize management implications of real production operation.

II. Model

Consider a decentralized supply chain that consists of an original equipment manufacturer (OEM) supplier and a national brand manufacturer (hereafter, the manufacturer for short). As the leader of the OEM supply chain, the manufacturer (he) outsources the production of the national brand product to the OEM supplier (she) at a unit wholesale price w, and then specifies a retail markup m for the end product to sell to the end consumers. In addition to producing the national brand for the manufacturer, the OEM supplier can introduce her private label product (as a competitive brand of the national brand) and directly sell to consumers through an online channel at a unit retailing price pand a unit selling cost d. For simplicity, we normalize both the production cost for the national brand and the private label to be zero. Figure 1 presents the channel structure of the OEM supply chain.

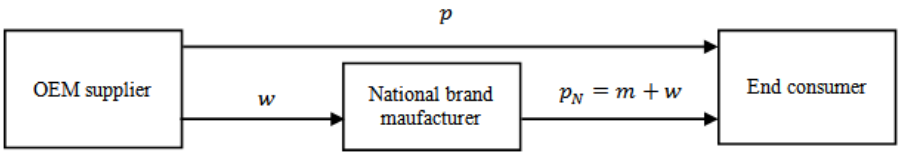

Figure 1 The Channel Structure of the OEM Supply Chain

The sequence of the events is as follows. First, the manufacturer decides the retailing markup mfor the national brand product. Second, the OEM supplier decides whether to introduce her private label product. Third, the OEM supplier determines the wholesale price w for the national brand product (the retailing price $m + w$ for the national brand product is thus determined) and sets the retailing price p for the private label product simultaneously. Fourth, consumers make purchasing decisions to maximize their utilities.

When the OEM supplier introduces a private label, consumers can choose between a national brand product and a private label product. There is a continuum of heterogeneous consumers whose valuations (denoted as random variable v) of the national brand product are uniformly distributed over $[0,1]$. The valuation of the private label for the consumer with valuation v is γv, where $\gamma \in (0,1)$ represents the substitute level of the private label product to the national brand product. According to Ru et al. (2015) and

Mills (1995), the demands for the two brand products are as follows:

$$D_N = \begin{cases} 1 - \frac{m+w-p}{1-\gamma} & if\ \frac{p}{\gamma} < (m+w), \\ 1-m-w & otherwise. \end{cases} \quad (1)$$

$$D_{PL} = \begin{cases} \frac{\gamma(m+w)-p}{\gamma(1-\gamma)} & if\ \frac{p}{\gamma} < (m+w), \\ 0 & otherwise. \end{cases} \quad (2)$$

III. Analysis

In this section, we firstly study the benchmark case where the OEM supplier does not introduce any private labels. Then, we analyze the optimal selling decisions for the OEM supplier and the manufacturer when the private label policy under online direct selling can be adopted.

3.1 No private label

When the OEM supplier does not introduce a private label, each consumer will purchase the national brand product if and only if the valuationvis greater than the retailing price $p_N = m + w$. Then, the OEM supplier's profit function can be expressed as

$\pi_O^N(w) = (1-m-w)w.$ (3)

The manufacturer's profit function can be expressed as

$\pi_M^N(m) = (1-m-w)m.$ (4)

We have the following proposition to characterize the optimal selling decisions for the benchmark case.

Proposition 1. If the OEM supplier does not introduce a private label, the optimal wholesale price and profit of the OEM supplier are $w^N = \frac{1}{4}$ and $\pi_O^N = \frac{1}{16}$, respectively. The optimal retailing markup and profit of the manufacturer are $m^N = \frac{1}{2}$ and $\pi_M^N = \frac{1}{8}$, respectively.

Proof of Proposition 1. Clearly, $\pi_O^N(w)$ is a strict concave function on w. Based on the first order condition, we have $w^N = \frac{1-m}{2}$ is optimal. Based on the OEM supplier's optimal response, $\pi_M^N(m)$ can be rewritten as $\left(1-m-\frac{1-m}{2}\right)m$, which is a strict concave function on m. Then, based on the first order condition, we have $m^N = \frac{1}{2}$ is optimal, and we thus have $w^N = \frac{1}{4}$, $\pi_M^N = \frac{1}{8}$, and $\pi_O^N = \frac{1}{16}$.□

Proposition 1 characterizes the equilibrium outcomes with no private label, which is a benchmark for the research of OEM's private label policy under online direct selling.

3.2With private label

Now, the OEM supplier is allowed to introduce the private label to sell to the end consumer directly. In this case, if $p < \gamma(m+w)$, the OEM supplier's profit function can be expressed as

$$\pi_O^W(p,w) = w\left(1 - \frac{m+w-p}{1-\gamma}\right) + (p-d)\left[\frac{\gamma(m+w)-p}{\gamma(1-\gamma)}\right], \quad (5)$$

where the first term of equation (5) represents the profit of producing the national brand for the manufacturer, and the second term of the equation (5) represents the profit of selling the private label directly online. If $p \geq \gamma(m+w)$, the OEM supplier's profit function is consistent with equation (3).

Given the retail markup mfor the national brand, we first study the OEM supplier's optimal wholesale price decision for the national brand and the optimal retailing price decision for the private label. The results are characterized in Lemma 1.

Lemma 1. If and only if $m > \frac{d}{\gamma}$, the OEM supplier will introduce a private label, and the optimal wholesale price and the private label retail price are $w^W = \frac{1-m}{2}$ and $p = \frac{\gamma+d}{2}$, respectively.

Proof of Lemma 1. It can be examined that $\pi_O^W(p,w)$ is a strict joint concave function on p and w. According to the first order condition, we have $p = \frac{\gamma+d}{2}$ and $w^W = \frac{1-m}{2}$ are optimal. To satisfy the constraint $p < \gamma(m+w)$, we have $m > \frac{d}{\gamma}$ must hold.□

Lemma 1 shows that the OEM supplier will directly sell a private label online if and only if the manufacturer's retailing markup is sufficiently high, the online direct selling cost is sufficiently low, or the substitute level of the OEM supplier's private label to the national product is sufficiently high. Based on Lemma 1, we next study the manufacturer's optimal retailing markup decision for the national brand to maximize his profit. If $m > \frac{d}{\gamma}$, the manufacturer's profit function can be expressed as

$$\pi_M^W(m) = \left(1 - \frac{m+w-p}{1-\gamma}\right)m = \left(1 - \frac{m+\frac{1-m}{2}-\frac{\gamma+d}{2}}{1-\gamma}\right)m. \quad (6)$$

If $m \le \frac{d}{\gamma}$, the manufacturer's profit function is consistent with equation (4). The following proposition characterizes the optimal retailing markup decision of the manufacturer.

Proposition 2. The optimal retail markup decision m^W for the national brand is as follows.

(1) For $0 < d < (3-2\sqrt{2})$:

$$m^W = \begin{cases} \frac{1}{2} & if\ 0 < \gamma < 2d, \\ \frac{d}{\gamma} & if\ 2d \le \gamma \le \frac{1+d-\sqrt{d^2-6d+1}}{2}\ or\ \frac{1+d+\sqrt{d^2-6d+1}}{2} \le \gamma < 1, \\ \frac{1-\gamma+d}{2} & if\ \frac{1+d-\sqrt{d^2-6d+1}}{2} < \gamma < \frac{1+d+\sqrt{d^2-6d+1}}{2}. \end{cases}$$

(2) For $(3-2\sqrt{2}) \le d < \frac{1}{2}$: $m^W = \begin{cases} \frac{1}{2} & if\ 0 < \gamma \le 2d, \\ \frac{d}{\gamma} & if\ 2d < \gamma < 1. \end{cases}$

(3) For $\frac{1}{2} \le d < 1$: $m^W = \frac{1}{2}$.

Proof of Proposition 2. It can be examined that $\frac{d^2\pi_M^W(m)}{dm^2} < 0$ holds when $m > \frac{d}{\gamma}$. Thus, $\pi_M^W(m)$ is a strict concave function on m. According to the first order condition, we have $m^W = \frac{1-\gamma+d}{2}$ is optimal. To satisfy $m^W > \frac{d}{\gamma}$, $-\gamma^2 + \gamma(1+d) - 2d > 0$ must hold. We define the functions $t(\gamma) = -\gamma^2 + \gamma(1+d) - 2d$ and $j(d) = d^2 - 6d + 1$. Clearly, $j(d) > 0$ holds when $0 < d < (3-2\sqrt{2})$. Then, $t(\gamma) = 0$ has two solutions and $t(\gamma) > 0$ holds when $\frac{1+d-\sqrt{d^2-6d+1}}{2} < \gamma < \frac{1+d+\sqrt{d^2-6d+1}}{2}$. In this case, the optimal retailing markup is $m^W = \frac{1-\gamma+d}{2}$. When $(3-2\sqrt{2}) \le d < 1$, $j(d) \le 0$ holds. We thus have $t(\gamma) \le 0$. In this case, we have $m^W = min\left\{\frac{d}{\gamma}, \frac{1}{2}\right\}$. If the online direct selling cost is sufficiently high (i.e., $\frac{1}{2} \le d < 1$), we then have $\frac{d}{\gamma} > \frac{1}{2}$ holds, and we thus have $m^W = \frac{1}{2}$.□

Proposition 2 indicates that when the online direct selling cost is sufficiently high (i.e., $\frac{1}{2} \le d < 1$), the OEM supplier does not consider to introduce a private label, and thus the decisions of both parties are not affected by the possible private label policy. When the online direct selling cost is at an intermediate level (i.e., $(3-2\sqrt{2}) \le d < \frac{1}{2}$), though it is still not profitable for the OEM supplier to introduce a private label, the possible private label policy will cause the manufacturer to reduce the retailing price of the national brand product if the substitute level of the private label to the national brand is sufficiently high (i.e., $2d < \gamma < 1$).

Only when the online direct selling cost is sufficiently low (i.e., $0 < d < (3-2\sqrt{2})$), the OEM supplier may introduce a private label. In this case, the OEM supplier's private label decision will be directly determined by the substitute level of the private label to the national brand. When the substitute level is sufficiently low (i.e., $0 < \gamma < 2d$), the OEM supplier will not introduce a private label due to the low attraction of the product, and thus the equilibrium decisions of both parties are consistent with the benchmark case. When the substitute level rises to an intermediate level (i.e., $2d \le \gamma \le \frac{1+d-\sqrt{d^2-6d+1}}{2}$), the private label will have a negative impact on the sales the national brand products. Therefore, the manufacturer will prevent the OEM supplier from introducing a private label by reducing the retailing price of the national brand product. Interestingly, when the substitute level is at an intermediate level (i.e., $\frac{1+d-\sqrt{d^2-6d+1}}{2} < \gamma < \frac{1+d+\sqrt{d^2-6d+1}}{2}$), the OEM supplier's private label product becomes more prevalent. In this case, the manufacturer cannot effectively prevent the OEM supplier's private label policy; therefore, two products are sold to the market simultaneously. It can be examined that the OEM supplier has a larger range to adopt the private label policy under a lower online selling cost. When the substitute level is sufficiently high (i.e., $\frac{1+d+\sqrt{d^2-6d+1}}{2} \le \gamma < 1$), the two products are very close and form a fierce competition. In this case, the private label does not have a complementary role for the national brand product to cover the consumers with lower valuations. Hence, the national brand can easily attract more consumers by reducing the retailing price, and the introduction of the private label has no additional advantages. Based on Proposition 2, we will further explore the impacts of the private brand policy under online direct selling on the performance of OEM supply chain.

Proposition 3. If $\frac{1+d-\sqrt{d^2-6d+1}}{2} < \gamma < \frac{1+d+\sqrt{d^2-6d+1}}{2}$, the private brand policy under online direct selling will benefit the entire OEM supply chain, i.e., $\pi_O^W + \pi_M^W > \pi_O^N + \pi_M^N$. In addition, $\pi_O^W + \pi_M^W - \pi_O^N - \pi_M^N$ is

increasing in γ.

As the substitute level of the private label to the national brand increases, the overall performance of the OEM supply chain will increase simultaneously.

Proof of Proposition 3. If $\frac{1+d-\sqrt{d^2-6d+1}}{2} < \gamma < \frac{1+d+\sqrt{d^2-6d+1}}{2}$, we have $\pi_O^W + \pi_M^W - \pi_O^N - \pi_M^N = (\gamma - d)^2 + \frac{3d^2}{1-\gamma} > 0$.

We define the function $g(\gamma) = (\gamma - d)^2 + \frac{3d^2}{1-\gamma}$. Because $\frac{d^2 g(\gamma)}{d\gamma^2} = 2 + \frac{6d^2}{(1-\gamma)^3} > 0$, $\frac{dg(\gamma)}{d\gamma}$ is monotonically increasing in γ. Furthermore, we have $\lim_{\gamma \to \frac{1+d-\sqrt{d^2-6d+1}}{2}} \frac{dg(\gamma)}{d\gamma} > 0$. Thus, $\frac{dg(\gamma)}{d\gamma} > 0$ holds. Then, the results in Proposition 3 is proved. □

Proposition 3 states that the private label policy under online direct selling can be beneficial to the OEM supply chain. The main reason is that the manufacturer will reduce the retailing price of the national brand product when the OEM supplier introduces the private label product. This effect alleviates the double marginalization problem, expands the market demand, and thus improves the overall performance of the OEM supply chain. Proposition 3 also indicates that the advantage of the private label policy that improves the overall profit of the OEM supply chain will enhance with the increase of the substitute level of the private label to the national brand. Figure 2 presents a numerical example for this phenomenon under the parameter $d = 0.16$. When the competitiveness of the two products is stronger (i.e., under a higher γ), the retailing price reduction of the national brand product is more obvious. Then, the double marginalization problem can be alleviated more significant and to more consumers can be served, which will achieve a greater profitability for the entire supply chain.

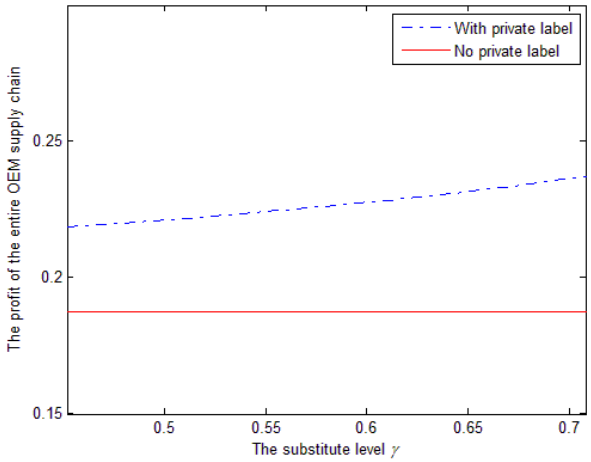

Figure 2 Impact of the substitute level on the entire OEM supply chain

IV. Conclusion and Future Research

In this study, we consider a decentralized OEM supply chain that consists of a national brand manufacturer and an OEM supplier. In addition to product production for the national brand manufacturer, the OEM supplier can also introduce a private label to sell through the online direct channel. We investigate the market conditions under which the OEM supplier should directly sell the private label online and what are the impacts of the strategy on the performance of OEM supply chain. We obtain the following two main insights. (1) The OEM supplier will directly sell a private label online if and only if the substitute level of the private label to the national brand is at an intermediate level and the online selling cost is sufficiently low. In addition, the OEM supplier can adopt the private label policy more easily when the online selling cost is lower. (2) The OEM supplier' private label policy under online direct selling can improve the overall profit of the OEM supply chain. Especially, this advantage is more significant when the substitute level of the private label to the national brand is higher.

In order to take the advantages of the private label policy under online direct selling, how the overall profit is reasonably distributed between the OEM supplier and the brand manufacturer, which can be a future research. Furthermore, we can explore the application of product technology sharing strategies in the OEM supply chain.

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