Consider the manufacturer's green production strategies when retailers introduce private label

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Abstract. As consumers become more eco-conscious, manufacturers are investing in green production. Yet, the launch of retailer's private label threatens their market. This raises questions, such as how manufacturers should modify their brand’s green level in response, and whether retailers should outsource production for private label. This paper introduces a Stackelberg game model to study these aspects under various production scenarios. This study found that retailer producing private label by itself is more beneficial to it. And manufacturer’s brand’s green level will be lower if private label is introduced.

Keywords: private label; green manufacturing; production mode.

1 Introduction

As consumers become increasingly eco-conscious, the greenness of products significantly impacts purchasing choices. Green product symbols are essential for establishing consumer trust. Accenture's 2022 Chinese Consumer Insight report highlights that 43% would pay more for green items, and 68% of consumers can identify sustainable brands. Instituting green production improves a company's supply chain sustainability and competitive edge. Simultaneously, with the introduction of private labels by some retailers to meet consumer demands, the relationship between manufacturers and retailers has evolved from mere cooperation to a more complex co-competition.

In previous studies, Karray and Martín found that retailer's introduction of private labels encroaches upon the market share of manufacturers' brands, causing them losses[1]. Therefore, Wang et al studied the channel strategies of manufacturers when retailers introduce their own brands [2]. Cheng et al researched the impact between the introduction of private labels and manufacturers' green investment under different sales models[3]. For a long time, private labels have been regarded as a key for retailers to expand their business and an important marketing tool [4]. Yet, these studies missed the impact of private labels' production models. Hence, this paper zeroes in on varying private label production methods and studies their effect on green manufacturers when introduced.
2 Model Description

According to Amrouche's study, manufacturers' brands and private labels together split the total market demand\[^5\]. The reputation of private labels is lower than that of manufacturers' brands. Hence, we denote the potential market size of manufacturers' brands as 1, and \(a \in (0, 1)\) represents the potential market size of private labels. As a approach 1, it signifies a greater market potential for private labels. Table 1 is the specific symbol description.

Referring to the research by Li et al (2021)\[^6\], the demand functions for manufacturers' brands and private labels are represented, where 'm/r' subscript stands for manufacturers' brands and private labels respectively. The demand function is as follows

\[
d_m = 1 - p_m + \theta(p_r - p_m) + \delta g, \quad d_r = 1 - p_r + \theta(p_m - p_r) + \delta g.
\]

The specific symbol description is shown in the Table 1.

### Table 1. Symbol Description

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>(a)</td>
<td>Basic market size of private label</td>
</tr>
<tr>
<td>(\theta)</td>
<td>Product competition intensity coefficient</td>
</tr>
<tr>
<td>(\delta)</td>
<td>Consumer green sensitivity coefficient</td>
</tr>
<tr>
<td>(\beta)</td>
<td>Green investment coefficient</td>
</tr>
<tr>
<td>(c)</td>
<td>Unit production cost of retailer’s private label</td>
</tr>
<tr>
<td>(w_i^j)</td>
<td>Wholesale price of two brands</td>
</tr>
<tr>
<td>(p_i^j)</td>
<td>Retail price of two brands</td>
</tr>
<tr>
<td>(\pi_i^j)</td>
<td>Profit of manufacturer and retailer</td>
</tr>
</tbody>
</table>

**Lemma 1** In the NR mode, here are the equilibrium results:

\[
W_m^{NR*} = \frac{2\beta}{4\beta - \delta^2}, \quad p_m^{NR*} = \frac{3\beta}{4\beta - \delta^2}, \quad g^{NR*} = \frac{2\beta}{4\beta - \delta^2}, \quad \pi_m^{NR*} = \frac{\beta}{8\beta - 2\delta^2},
\]

\[
\pi_r^{NR*} = \frac{\beta^2}{(-4\beta + \delta^2)^2}.
\]

**Lemma 2** In the ER mode, here are the equilibrium results:

\[
W_m^{ER*} = \frac{2\beta(1 + c\theta)}{-\delta^2 + 4\beta(1 + \theta)}, \quad p_m^{ER*} = \frac{+2(1 + a + c)\theta)}{2(1 + \theta)(-\delta^2 + 4\beta(1 + \theta))},
\]

\[
g^{ER*} = \frac{\delta + c\delta\theta}{-\delta^2 + 4\beta(1 + \theta)}, \quad p_r^{ER*} = \frac{a + c + \theta + a\theta + 2c\theta + \frac{\delta^2(1 + c\theta)}{\delta^2 - 4\beta(1 + \theta)}}{2 + 4\theta}.
\]
\[ \pi_m^{MR^*} = \frac{\beta (1 + c \theta)^2}{-2\delta^2 + 8\beta(1 + \theta)}, \quad \pi_r^{MR^*} = \frac{A}{(-4 + \delta^2)^2} \]

\[ A = (1 + \theta)((1 + a - c)\delta^2 - 8\beta(1 + a - c)\delta^2 (a - c + \theta + a\theta - 2c\theta) + 4\beta^2 (1 + 2\theta + 4\theta^2 + 4(1 + \theta)^2) - 6c\theta(1 + 2\theta) - 8a(1 + \theta)(c - \theta + 2c\theta) + c^2 (1 + 2\theta)(4 + \theta(8 + \theta))) \]

**Lemma 3** In the MR mode, here are the equilibrium results:

\[ w_m^{MR^*} = \frac{1}{4} \left( 1 + a - \frac{2(-1 + a)\beta}{-\delta^2 + \beta(2 + 4\theta)} \right), \quad w_r^{MR^*} = \frac{1}{4} \left( 1 + a + \frac{2(-1 + a)\beta}{-\delta^2 + \beta(2 + 4\theta)} \right), \]

\[ p_m^{MR^*} = \frac{3}{8} \left( 1 + a - \frac{2(-1 + a)\beta}{-\delta^2 + \beta(2 + 4\theta)} \right), \quad p_r^{MR^*} = \frac{3}{8} \left( 1 + a + \frac{2(-1 + a)\beta}{-\delta^2 + \beta(2 + 4\theta)} \right), \]

\[ g^{MR^*} = \frac{\delta - a\delta}{4\beta - 2\delta^2 + 8\beta\theta}, \quad \pi_m^{MR^*} = \frac{1}{16} \left( 1 + a \right)^2 + \frac{2(-1 + a)\beta}{-\delta^2 + \beta(2 + 4\theta)}, \]

\[ \pi_r^{MR^*} = \frac{(1 + a)^2 \delta^4 - 4(1 + a)^2 \beta \delta^2 (1 + 2\theta) + 8\beta^2 (1 + 2\theta)(1 + a^2 + (1 + a)^2 \theta)}{32(\delta^2 - 2\beta(1 + 2\theta))^2} \]

## 3 Model Analysis

This part assesses the balance results and earnings of four models, focusing on the effects of market size on retailers, competition's influence on supply chain profits, and the impact of costs on own brand's production. Due to the complexity of profit function in the equilibrium results, we use numerical simulations for strategic analysis. To confirm the results, we perform regression analysis on relevant data from previous studies, obtained through interviews with supply chain businesses, setting the parameters as per that data. \((\theta = 0.2, \beta = 4, c = 0.3, \delta = 0.6)\)

### 3.1 Impact of private label market size on the production model

Fig. 1 indicates that as own brand's market size grows, it's profitable for e-commerce platforms to introduce them. When the market size of private brands is very small, introducing private brands can damage retailers' profits. When the market share nears manufacturers' level \((a > 0.8)\), it's beneficial for the retailer to independently produce private labels due to higher consumer acceptance. Independent development provides pricing autonomy, which outweighs the extra costs in the long run. This also explains why some e-commerce platforms choose to independently create their own brands, such as JD.com's fresh food brand "King Seek," many of whose fresh food products come
from JD.com's own plant factories. This initiative is a response to the growing domestic demand for high-standard fresh food.

3.2 The Impact of Competitive Intensity and market size on the Green Level

Fig 2 shows that national brand's green level decreases amid increasing competition with private labels, indicating manufacturers lower their products' green level to minimize profit loss in the face of such competition. Across three different production modes, manufacturers vary in their decisions on green level. It's highest when retailers independently produce private label and lowest when manufacturer produce private labels for retailer.

Fig 3 shows that as the size of the private brand market expands, in the three modes, only when the manufacturer processes the private brand on behalf of the manufacturer, will the manufacturer's decision on green level decrease with the expansion of the private brand market size. In addition, under the NR/ER model, the green level will not change with the increase of the private brand market size. Therefore, we can believe that when manufacturers produce private label for retailers, the expansion of the private brand market brings additional profits to manufacturers. Blindly increasing the green level is actually harmful to themselves, so manufacturers will choose to reduce the green level of their products.
3.3 The Impact of Competitive Intensity on the profit

In the Fig 4 and Fig 5, we can see that as the intensity of competition changes, the profit of retailers is greater than that of not introducing them, indicating that introducing private label is beneficial to them. In addition, we observed that under the resale model, the profit of retailer is more likely to reach its maximum under the ER model. But private label’s introduction is no beneficial to manufacturer. However, Fig 5 shows that as the intensity of competition increases, only in the ER model, retailer’s profit get higher. Therefore, the increase of market competition intensity is not always good for manufacturer and retailer, only when the retailer produces private brand can he benefit from the increase of market competition intensity.

Combining the insights from Fig 4 and Fig 5, we can observe that a win-win situation in terms of production mode is only possible when the competition intensity is low. That is to say, when the competition intensity is low, retailers should choose manufacturers to produce their private labels, as this allows both parties to maximize their profits.

![Fig. 4. Impact of Competitive Intensity on the manufacturer’s profit](image1)

![Fig. 5. Impact of Competitive Intensity on retailer’s profit](image2)

4 Conclusion

This paper mainly explores the impact of introducing private labels on green manufacturers under different production models. The main findings of this research are as follows:

(1) As the market size of private labels expands, retailers should pursue self-production of private label. The introduction of retailer's private labels may result in manufacturers reducing the green level of their brands to minimize profit loss. However, when the market size of private brands is very small, introducing private brands can damage retailers' profits.

(2) As the intensity of competition increases, manufacturers are more inclined to OEM for retailers' private labels, while retailers prefer to produce independently. It is difficult for the two to cooperate in terms of production methods. Only when the
competition intensity is very low, retailers should choose manufacturers to produce their private labels, that is a win-win situation.

(3) When manufacturers produce private label for retailers, the expansion of the private brand market brings additional profits to manufacturers. Blindly increasing the green level is actually harmful to themselves, so manufacturers will choose to reduce the green level of their products.

In summary, while the introduction of private labels can be advantageous for retailers under certain conditions, achieving a win-win situation with manufacturers requires mutual agreement on the production mode of private brands.

However, there are shortcomings in this paper's considerations. In the current market, some e-commerce platforms allow manufacturers direct access to consumers. This model is known as the agency model, where the e-commerce platform takes a proportional cut of the manufacturer's sales revenue. Therefore, whether this new sales model will impact private labels and the green production of manufacturers is a direction for future research. Additionally, e-commerce platforms could consider purchasing private labels from professional third-party manufacturers instead of seeking help from competitors.

Reference
