Optimal Decisions for the Manufacturer by Introducing the Store Brand

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Abstract: In recent years, with the rapid development of private brands, e-commerce platforms have faced strategic choices regarding whether to introduce and how to produce their own private brands. This paper constructs a three-party supply chain model consisting of well-known brand manufacturers, well-known brand enterprises, and e-commerce platforms. Based on the agency sales model, it studies the market invasion strategies of e-commerce platforms' private brands and the impact of different strategies on each participant in the supply chain. The research finds that the platform will always introduce its own private brand to maximize profits; its outsourcing strategy is jointly influenced by the production cost of the third party and the brand spillover effect - only when the cost is moderate and the spillover effect is significant will the platform choose well-known brand manufacturers; otherwise, it tends to choose third-party production. The brand spillover effect is always beneficial to manufacturers and detrimental to enterprises, while its impact on the platform depends on the level of commission rate. The research provides theoretical basis and management implications for the private brand strategy of e-commerce platforms.

Keywords: Store brand; National brand; Brand Spillover; Brand competition; Channel Selection

1. Introduction

In recent decades, store brands have been grown as a rapid speed. According to the Private Label Manufacturers Association annual sales of store brand surged by 34% compared to 2019. In Europe, store brand's market share has reached 38.4% by the first half of 2024, a 0.5% increase compared to 2023. This trend can be attributed to several factors. Firstly, as the volatile economic situation, more and more consumers pay attention to the cost-performance ratio when shopping and choose store brand as an alternative to national brand. Secondly, retailers rigorously maintain the quality of their store brands and consistently innovate to ensure that their products match or even surpass the quality of national brands, often at lower prices. Jingzao, JD.com's store brand, has stated that their principle is" same quality, lower price". Taking the clothing industry as an example, the mark-up rate of traditional clothing brands is very high, while it is only 10% of Jingzao, which offers fabric quality that is on par with national brands yet the selling price is lower [1]. Thirdly, store brands nowadays are no longer limited to basic commodities, but own a variety of categories including home appliance, personal care, fitness equipment and more, catering to consumers' demands and performances. In Texas and Mexico, H-E-B owns over 300 groceries selling more than 3000 kinds of products [2]. Amazon sells 9% of its apparels, shoes and accessories from its store brands, which is expected to reach 25 billion in revenue by 2022. Its store brands include Great Value, Marketside and so on, covering a variety of leading categories such as food, household goods, clothing, and footwear. Fourthly, introducing store brand may help e-tailers to expand their business [1], enhance competitiveness [1,2], increase consumers' loyalty to them [3] and create differentiated competitive advantage [4,5], therefore plenty of e-tailers are actively launching their own store brands.

If an e-tailer decides to introduce a store brand, he must consider the outsourcing issues related to the store brand [6,7]. Wu indicates that e-tailers need to take into account multiple factors, including product competition, platform service, and brand positioning [5]. Noteworthy, although e-tailers may have an advantage over manufacturers in terms of warehousing, logistics, and storefronts, they often lack the expertise in product development and manufacturing. Additionally, it costs a lot to produce in-house. As a result, most electronic retailers reckon out-sourcing as a better option [1,8,9]. There are two typical avenues for retailers to outsource: they can have a contract manufacturer (CM) produce the store brand, who also manufacture national brand, or seek out a third-party which is different from the CM specializing in producing store brand. It is worth mentioning that national brands often invest more time and resources in product development, besides they possess superior market and advertising strategies to attract consumers thus enhance customer trust [10]. As a result, most consumers tend to have greater confidence in the manufacturers of national brands and perceive a higher quality of national brands than that of store brands [2,11]. If store brands are produced by the CM, they will obtain a higher quality perception from consumers. In other words, brand reputation spills over from a strong(national) brand to a weak(store) brand because of their product source from the same contract manufacturer, we name this phenomenon as brand spillover [3,9,11]. Actually, brand spillover can not only promote consumers' quality perception, but also further increase demand for store brand [12-16]. For this reason, many e-tailers use brand spillover to attract consumers. For example, JERXUN, a home appliance

brand of JD com, whose products are manufactured by Guangdong Xinbao Electrical Appliances Holdings Co., who is also the contract manufacturer of Siemens, Xiaomi, and Electrolux [17]. Speakers of Echo, a store brand of Amazon, are manufactured by Foxconn, which also manufacture electronic products of Apple, Huawei and Xiaomi [3]. Noteworthy, brand spillover is not just in the retail industry, but also in other fields such as automobiles and consumer electronics.

However, it always means that e-tailers needs to pay a higher wholesale price when he source store brand from CMs, so when targeting the lower-tier customer market, e-tailers are more inclined to opt for a third-party rather than the CM to produce store brands. This strategy allows them to source products at more competitive wholesale prices, thereby expanding their consumer base. Pingduoduo, a prominent e-retail platform in China, has announced that the majority of its store brand products are sourced from third-party manufacturers, which enables the company to reduce costs, particularly advantageous when targeting the lower-tier consumer market [17]. These phenomenon raise two interesting questions: Should an e-tailer introduce his store brand? If so, Which channel should be chosen to manufacture it?

Some scholars suggests that the introduction of store brand is beneficial to the supply chain. On the one hand, it helps alleviate the double marginalization problem for both national brand manufactures (NBMs) and e-tailers [4,5,18]. On the other hand, NBMs always increase prices of national brand and obtain higher profit when introducing store brand [1819]. Conversely, others suggests that the boom of the store brand is a threat to national brand [20-22]. Data from Wal-Mart indicates a significant surge in the omni-channel sales of its Great Value store brand products, with a nearly 40% increase observed in the first quarter of 2018 compared to the same period in the previous year. Additionally, the sales figures for the luggage and travel goods brand Airport, as well as the sports brand Cup's, experienced a remarkable doubling in comparison to the prior year's performance [6]. This growth motivates the following interesting research questions: how can the store brand of an e-tailer impact other parties of the supply chain?

Moreover, supply chain structures plays an important role on each parties' decisions within the supply chain [19,23,24]. Nowadays, a plenty of retailer platform start to use agency model, that is, a NBM sell national brand directly to consumers through a platform while paying a portion of the sales as agency commission. Compared to the traditional wholesale model, agency model could diminish the double marginalization effect [6] and helps manufacturers control prices as well as sales volume [7] of national brands freely. For example, the brands Camel and Jack Jones offer products for sale by embracing the agency selling platforms such as dangdang.com and Alibaba. Amazon provides an agency model for sellers to sell their products to consumers directly with the commission varying between 8% for certain categories like computers and consumer electronics to 45% for Amazon Device Accessories [3]. Similarly, Walmart provides the same model and charge the commission at the range of 8% to 20%. Under the agency, e- tailers sell his store brand and earn a commission from the profit of national brand, thus need to balance the competition between these two brands and carefully trade off the increase of store brand and the reduction of national bran [25-27].

Through the above questions, we investigate the optimal sourcing strategy of store brand for an e-tailer considering the implications of brand spillover. To obtain a better understanding of the brand spillover phenomenon, we develop a model with one contract manufacturer (CM), a national brand manufacturer (NBM) and an e-tailer. Under the agency, the NBM sources his national brand from the CM and then directly sell his national brand to consumers at the platform while paying a commission to the e-tailer. The e-tailer considers whether to introduce his store brand which is positioned as a weak brand alternative to the national brand. And if so, which channel to choose. He can source store brand from the CM or by a third-party which is different from the CM and does not participate in the production of the national brand. If it is produced by the CM, it will exist a brand spillover.

The results can be summarized as follows. Firstly, the e-tailer will definitely choose to introduce the store-brand, but this decision may not necessarily have a positive impact on CM and NBM. Secondly, while previous scholars have largely posited that store brand always benefits from brand spillover, this paper challenges that notion, suggesting that the e-tailer opts for the CM to produce store brand just when the production cost from a third-party manufacturer is moderate and the spillover effect is significant. Thirdly, contrary to the intuitive expectation that the e-tailer would avoid sourcing from a third-party when the production cost provided by the third-party is high, our findings diverge from conventional wisdom. Under the agency model, the e-tailer will source his store brand from the third-party when the sourcing cost from the third-party is either very high or very low. Fourthly, this study examines the interplay between brand spillover and sourcing strategy under the agency model with examining the brand spillover's impact on the NBM and the CM, an area that has not been addressed in existing literature. Lastly, this paper primarily discusses the influence of production cost and spillover effect on the e-tailer's sourcing strategy, providing a comprehensive analysis that extends beyond the scope of previous studies.

The remainder of this paper is organized as follows. Section 2 reviews the related literature, and Section 3 sets up the model. We derive the equilibrium outcome in Section 4 and analyze the implications of brand spillover in Section 5 and section 6. Finally, we conclude in Section 7. All proofs are presented in the appendix.

2. Literature Review

Two research streams are relevant to this paper: the first stream concerns the market penetration and management of store brand, while the second is about brand spillover.

Numerous scholars have researched the introduction of store brand by e-tailer under different supply chain structures and factors. Liu discussed how an e-tailer with

a store brand to achieve profit maximum by advertising strategy [6]. Ru examined the effect of e-tailers' relative bargaining power and the channel power shift on store brand introduction decision and its market share [28]. They showed that when the e-tailer owns a relative great market power will less likely to introduce his store brand, or when the channel power shift from the NBM to the e-tailer, the e-tailer will decrease the market share of store brand. Moreover, scholars explored the situation with multiple e-tailers in the market each has the potential to introduce their own store brands. And they suggested e-tailers should introduce their store brands when the competition is fierce, although they obtain less profit [29]. Under agency model, Li discussed store brand's optimal sourcing strategy for e-tailers, however, his research mainly starts from the perspective of the e-tailer and the CM, failing to consider the decision-making and influence of the NBM [1].

Some scholars expanded their research to examine the influence of store brand introduction on supply chain. Chen investigated how the development of store brand capabilities by e-tailers in a decentralized supply chain affects the overall efficiency of the supply chain [2]. Cheng researched the implication of the introducing store brand within a three-echelon supply chain (manufacturer-distributor-retailer). Their finding reveals the introduction of store brand makes a positive effect on all parties of the supply chain, which is contrast to the two-echelon scenario [19].

Considering a scenario with one national brand manufacturer and multiple retailers, where only one retailer can introduce a store brand, scholars have explored the decision-making process and the impact on the national brand. The introduction of a store brand in such a setting can have varying effects on the national brand, depending on the competitive strength of the store brand. Gao suggests that the entry of a new brand into the market tends to lower the prices of existing brands [8]. This implies that the introduction of store brand could potentially reduce the prices of national brand [22]. Steiner summarized the literature on the competition between national brands and store brands, concluding that store brand of a large e-tailer can constrain the market power of national brands, which is something that else manufacturing brands can't achieve [30]. This indicates that when a retailer introduces a store brand, it can significantly alter the competitive landscape, potentially limiting the pricing power of the national brand. Groznik and Heese showed that the introduction of store brand can cause channel conflict and analyzed the impact of national brand manufacturer's commitment ability [4].

We just find a limited paper study the sourcing channel selection issue of store brand. Berges- Sennou showed that consumer loyalty and consumer segment are two main factors affecting whether e-tailers sourcing store brand from the NBM or a third-party [31]. In addition, Li researched how production costs and consumer sensitivity coefficient to service make influence on e-tailer's sourcing strategy [1]. Hsiao investigated the interaction between information disclosure by the e-tailer and the NBM about store brand's supplier and the channel of store brand's introduction [29]. Kumar and Tong discussed similar questions as well. Yet, all of their researches focus on the perspective of consumers and production costs, without considering the effect of brand spillover when discussing store brand's supplier selection issues [32, 33].

This paper also related to brand spillover. Previous scholars discussed the brand spillover within a single brand. Zhou explored the impact of brand spillover from in-store promotion on store brand's channel selection [5]. Analogously, Sebri examined spillover effect between different categories of the same retailer [34]. Regarding the brand spillover between different brands, there is a substantial body of research that concentrates on brand alliances- the association between two or more brands can lead to various spillover effects- are typically between brands with comparable market power while without competitive relationship [35-38]. The most common form is co-branding. For example, Nike and Apple collaborated to invent Apple Watch, a popular equipment with a special application that helps monitor physical activity. Now, the co-branding campaign provides a new activity named Nike+, achieving technology built into apparel and sports gear to sync with Apple iPhone apps to track workouts. Noteworthy, most of papers believe the spillover has a positive effect, whereas Lei declared that linkages between brands may be harmful to the supply chain [39].

Brand spillover between competing firms has been discussed by researchers as well, the majority of them thought it makes negative effect under the competitive scenario. Such as the spillover of negative chatter, food crisis incidents and brand scandals [40-42]. Currently, researches of positive effect between competing firms is still limited. Wu investigate a supply chain within a weak brand decides whether to use brand spillover whereas a strong determines selling channel of his own brand products [9]. They demonstrated that employing brand spillover strategy does not necessarily benefit the retailer when the direct- selling cost is moderate and the brand spillover level is weak. This result aligns with our study, indicating that utilizing brand spillover effects is advantageous for the e-tailer only when certain conditions related to production costs from the third-party and brand spillover are meet a certain range. Wu developed a model with a weak-brand firm, a strong-brand firm and a CM in the market and investigated whether the weak-brand firm should use such brand spillover as a marketing strategy considering different firms' characteristics and market conditions, and the finding shows that the adoption of brand spillover by the weak-brand firm can benefit all three parties under certain circumstances [11]. His article, based on the perspective of the CM and the weak-brand firm, emphasizes the impact of different sourcing structures on their optimal strategies, neglecting the effects of weak-brand firm's introducing and brand spillover on the NBM. When considering how factors impact the e-tailer's optimal outsourcing strategy, it focus on the in-house production costs and the consumer's perception of the original brand power. In contrast, our

article places greater emphasis on the influence of brand spillover on outsourcing strategy.

Furthermore, in contrast to the two aforementioned articles that focus on the wholesale model, this study adopts the agency model. Particularly worth mentioning, the agency model can lead to different dynamics in terms of brand spillover because it may encourage closer alignment between the supplier and the e-tailer's interests. In fact, the e-tailer might be more prone to improve the demand for national brand which is directly tied to his profit.

3. Base Model

Consider a distribution channel involving a contract manufacturer (CM), a national brand manufacturer (NBM) and an e-tailer. The CM produces national brand and supplies them to the NBM at a unit wholesale price, w_n. For analytical transparency, the unit production cost of the CM is normalized to zero. Under agency model, the NBM sells his products directly to customers at a unit retail price, pn, while the e-tailer charges a commission for each unit of sales (strategy S1). Let r be the commission rate for the national brand. In practical scenario, the commission rate has already been predetermined in various industries. For example, Amazon charges 15% for books, 8% for cell phone devices, and 6% for personal computers [43]. Therefore, we assume that r is exogenously given in the base model and $0 < r < \frac{1}{2}$ to ensure that the profit of the NBM is always positive [44-45].

Besides the national brand products, the e-tailer also has the option for its store brand, which serves as a substitute for the national brand. If there is store brand introduced, we consider two supply channels of it: produced by the CM (strategy S2) or by a third-party (strategy S3) which is different from the CM and does not participate in the production of the national brand. Under the strategy S2, the CM supplies both the national brand and the store brand at wholesale prices w_n and w_s, respectively. In turn, the NBM resells national brand directly to customers by the e-tailer, while the e-tailer sourced store brand from the CM and resell it to customers at a unit retail price p_s. Let θ_i denote the customers' quality perception of the national brand and the store brand, where $i = n, s$. Generally, national brands have much more positive impact on the product quality perception than store brands [9], and consumers' quality perception of store brands will be much higher if they are produced by the national brand manufacturers [46]. Thus, we have $\theta_n = 1 > \theta_s$. To ensure a certain level of competitive and substituted between the two products (store brand and national brand), consumers' quality perception of the store brand should not be too low. Thus we have $\frac{1}{2} < \theta_s < 1$. Throughout this article, we assume that the information about manufacturers of both the national brand and the store brand are publicly available. Therefore, when the e-tailer adopts Strategy S2 (i.e., produce the store brand from the CM), it will generate a spillover effect β that increases consumers' perception of the quality of the store brand. Hence, we assume $\theta_s = \theta + \beta(1-\theta)$under strategy S2, where $\beta \in [0,1]$. Differ with strategy S2, the e-tailer source the store brand from a third-party at a unit cost cs without brand spillover, which is exogenous [4].

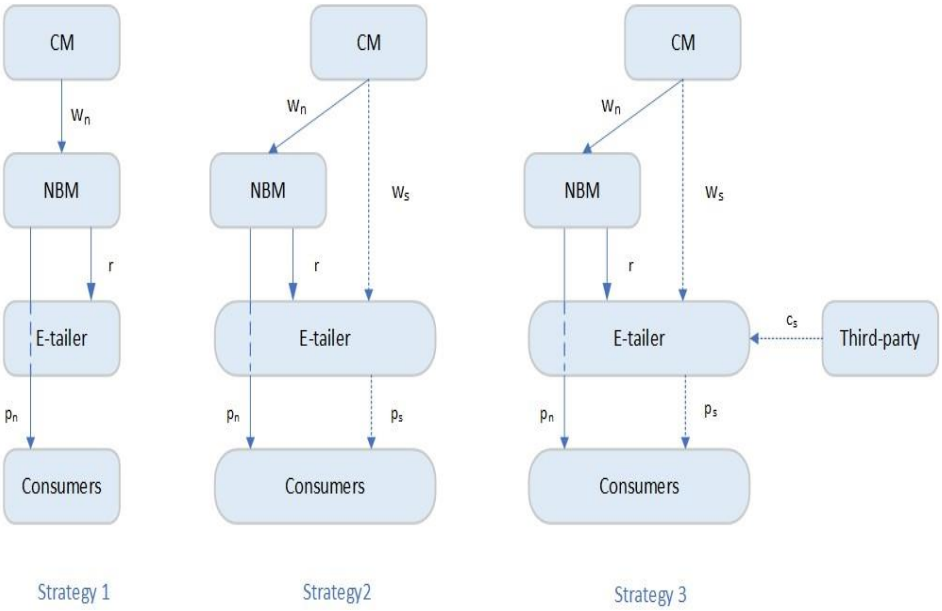

Figure 1. Sequence of Events and Decisions

Hence, demands for the two products have the following linear forms:

$$p_n = 1 - q_n - q_s \quad (1)$$

$$p_s = \theta_s - q_n - q_s \quad (2)$$

Furthermore, when there is no store brand introduction, customers only make their purchasing decision for the national brand, and the demand for the national brand is:

$$p_n = 1 - q_n \quad (3)$$

In our models, the unit production costs of the CM (manufacture the national brand, as well as the store brands) and the third-party manufacturer are assumed to be zero. If the unit production costs of both the products are greater than zero and are not identical, the retailer may consider the production efficiencies (costs) when she

makes sourcing decisions. However, since we focus on the retailer's strategic concerns (i.e., the influence of the brand spillover) about sourcing decisions, we abstract the production cost factor away to simplify our analysis.

We consider that the CM is the leader of the channel, sequentially followed by the NBM and the e-tailer. The sequence of events is illustrated in Figure 1. All notations are formulated in Table 1.

Table 1. Decision variables and model parameters

Parameters	Description
$p_n,\ p_s$	Retail prices of the national brand and the store brand, respectively
$q_n,\ q_s$	Demands of the national brand and the store brand, respectively
w_n, w_s	Wholesale prices of the national brand and the store brand given by the CM, respectively
θ_n, θ_s	consumers' quality perception of the national brand and the store brand, respectively
r	The commission rate for the national brand
β	The brand spillover of the store brand
c_s	Unit production cost when the e-tailer source the store brand from a third-party

4. Equilibrium Results

Strategy S1: without store brand introduction

Denote$\pi_c^1$and π_m^1as the profit of the CM and the NBM under strategy S1, respectively. Then under Strategy S1, the profit function of the CM is

$$\pi_c^1 = w_n q_n \tag{4}$$

where the w_n and the q_n as the wholesale price and demands of the national brand, respectively. We analyze the problem backwards by first characterizing the equilibrium quantity. The NBM's objective function is

$$max\pi_m^1 = (1-r)p_n q_n - w_n q_n \tag{5}$$

where the first term is the revenue derived from selling the national brand to consumers and deducts the commission by the e-tailer, the last terms is the wholesale price from the CM. Given wholesale price w_n, the NBM decides the demand qn to maximize his expected profit

$$q_n^1 = \frac{r-1+w_n}{2(r-1)} \tag{6}$$

We now study the wholesale price decision of the CM. By putting q_n^1 into π_c^1, we can get the equilibrium wholesale price of the national brand under strategy S1

$$w_n^{1*} = \frac{1-r}{2} \tag{7}$$

Thus, we have the equilibrium demand of the national brand is

$$q_n^{1*} = \frac{1}{4} \tag{8}$$

$$p_n^{1*} = \frac{3}{4} \tag{9}$$

Theorem 1. Denote π_e^{1*}as the profit of the e-tailer. Under strategy S1, the equilibrium profit of all the supply chain members are

$$\pi_n^{1*} = \frac{1-r}{16} \tag{10}$$

$$\pi_e^{1*} = \frac{3r}{16} \tag{11}$$

$$\pi_c^{1*} = \frac{1-r}{8} \tag{12}$$

Theorem 1 shows that the profit of all the supply chain members are depended by the commission rate r. Specifically, profit of the e-tailer (π_e^{1*}) increases with the increase of the commission rate while the NBM's and the CM's profit decrease. For the CM, the marginal profit of the NBM will decrease as the commission rate increase, resulting in the CM to reduce the wholesale price of the national brand to ensure the NBM's profitability and continued sources from him. Therefore, the profit of the CM will decrease. However, the increase in commission to the e-tailer is greater than the reduced cost at the CM, thus the profit of the NBM still decrease.

Strategy S2: with store brand introduction and manufactured by the CM

In this scenery, the e-tailer decides to introduce its store brand and sourced by the CM, and the composition of the NBM's profit is similar to the strategy S1

$$\pi_m^2 = (1-r)p_n q_n - w_n q_n \tag{13}$$

Profit of the e-tailer are composed by two parts: commission paid by the NBM for selling national brand under the agency and the revenue derived from reselling the store brand.

$$\pi_e^2 = r p_n q_n - (p_s - w_s)q_s \tag{14}$$

where the w_n and the q_s as the wholesale price and demand of the store brand, respectively. We first determine the NBM and the e-tailer's optimal decision on the order quantity. The NBM and the e-tailer's objective function are

$$max\pi_m^2 = (1-r)p_n q_n - w_n q_n \tag{15}$$

$$max\pi_e^2 = r p_n q_n - (p_s - w_s)q_s \tag{16}$$

$$q_n^2 = \frac{2-2w_n+w_s-\theta-\beta(1-\theta)+r(\theta+\beta(1-\theta)-2-w_s)}{r^2-4r+3} \tag{17}$$

$$q_s^2 = \frac{r^2-1+(1+r)w_n-2(1-r)w_s+2(1-r)(\theta+\beta(1-\theta))}{r^2-4r+3} \tag{18}$$

We now study the wholesale price decision of the CM. Differ with the strategy S1, we have the store brand introduction and manufactured by the CM, thus the profit of the CM's profit increased the wholesale revenue of the store brand from the e-tailer

$$\pi_c^2 = w_n q_n + w_s q_s \tag{19}$$

By putting q_n^2 and q_s^2 into the π_c^2, we can get the equilibrium wholesale price of the national brand under the strategy S2

$$w_n^{2*} = \frac{(1-r)(3-r(5-2(\theta+\beta(1-\theta))))}{6-8r} \tag{20}$$

$$w_s^{2*} = \frac{(1-r)(3(\theta+\beta(1-\theta))-2r)}{6-8r} \tag{21}$$

Thus, we have the equilibrium demand of the national brand and the store brand are

$$q_n^{2*} = \frac{2-2r-(\theta+\beta(1-\theta))}{6-8r} \tag{22}$$

$$q_s^{2*} = \frac{(1-r)(2(\theta+\beta(1-\theta)-1)}{6-8r} \tag{23}$$

$$p_n^{2*} = \frac{5-7r-(1-2r)(\theta+\beta(1-\theta))}{6-8r} \tag{24}$$

$$p_s^{2*} = \frac{r-1+(5-6r)(\theta+\beta(1-\theta))}{6-8r} \tag{25}$$

When the commission rate increases, the NBM ensures his marginal profit by raising the retail price of the national brand, which leads to consumers' less demand for the national brand and increasing the demand for the store brand.

Theorem 2. By putting thew_n^{2*}, w_s^{2*} q_n^{2*} andq_s^{2*}into the profit functions, parties' optimal profit are given by

$$\pi_m^{2*} = \frac{(1-r)(2r-2+\theta+\beta(1-\theta))^2}{4(3-4r)^2} \quad (26)$$

$$\pi_e^{2*} = \frac{(12r^3+(1-2(\theta+\beta(1-\theta))^2+r^2(4(\theta+\beta(1-\theta))^2-19)+3r(2-3\beta^2(\theta-1)^2+(2-3\theta)\theta+\beta(2-8\theta+6\theta2)))}{4(3-4r)^2} \quad (27)$$

$$\pi_c^{2*} = \frac{(1-r)(1-r-(1-\beta)\beta-\theta+\beta(3-2\beta)\theta+(\beta-1)^2\theta^2)}{6-8r} \quad (28)$$

The prices (p_n^{2*}, p_s^{2*}) and demands (q_n^{2*}, q_s^{2*}) for both products are related to the brand spillover.

With a greater brand spillover, the quality perception of the store brand will be higher, which would have a positive influence on its sales. As a result, the e-tailer will increase the store brand's retail price and get more revenue from the store brand. However, it may cause a reduction in the sales volume of the national brand resulting in the NBM decreasing its retail price and get a lower profit. Given that spillover effect of the store brand are attributed to the CM, thus he will increase the wholesale price of the store brand to achieve a higher profit. Although sales volume of the national brand will reduce, an increasing revenue from supplying the store brand is sufficiently large and exceeds the loss from supplying fewer national brand products, so the CM will be willing to manufacture the store brand when the brand spillover is large enough.

Strategy S3: with store brand introduction and manufactured by a third-party

In this scenery, the e-tailer decides to introduce his store brand and sourced by a third-party, the composition of the NBM's profit as same as the above cases

$$\pi_m^3 = (1-r)p_nq_n - w_nq_n \quad (29)$$

and the profit of the e-tailer are still composed by the commission from the NBM of national brand and the revenue derived from reselling the store brand. However, unlike strategy S2, the store brand are manufactured by a third-party in this point, therefore the wholesale cost of the store brand is no longer w_n, but c.

$$\pi_e^3 = rp_nq_n - (p_s - c)q_s \quad (30)$$

According to the above strategies, we first analysis the NBM and the e-tailer's optimal decision on the order quantity, the NBM and the e-tailer's objective function are

$$max\pi_m^3 = (1-r)p_nq_n - w_nq_n \quad (31)$$

$$max\pi_e^3 = rp_nq_n - (p_s - c)q_s \quad (32)$$

where c is the cost of the store brand that sourced from the third-party who doesn't manufacture national brand, and it is exogenous because of the fierce market competition [4].

Given wholesale price w_n and cost c, the NBM and the e-tailer decide their demands qn and q_s respectively to maximize their expected profit

$$q_n^3 = \frac{2+c-2r-cr-2w_n-\theta+r\theta}{r^2-4r+3} \quad (33)$$

$$q_s^3 = \frac{2cr-1-2c+r^2+w_n+rw_n+2\theta-2r\theta}{r^2-4r+3} \quad (34)$$

Although under strategy S3 we have the store brand introduction, it is produced by a third-party, therefore the CM's profit is the same as under the strategy S1

$$\pi_c^3 = w_nq_n \quad (35)$$

By putting q_s^3 into the π_c^3, we have equilibrium wholesale price of the national brand under strategy S3

$$\pi_n^{3*} = \frac{(1-r)(2+c-\theta)}{4} \quad (36)$$

Thus, we have equilibrium demands of the national brand and the store brand are

$$q_n^{3*} = \frac{2+c-\theta}{6-2r} \quad (37)$$

$$q_s^{3*} = \frac{2-c(r-7)-7\theta+r(2+\theta)}{4(r-3)} \quad (38)$$

$$p_n^{3*} = \frac{(r-5)(2+c-\theta)}{4(r-3)} \quad (39)$$

$$p_s^{3*} = \frac{2+c(r-5)-7\theta+r(3\theta-2)}{4(r-3)} \quad (40)$$

Under strategy S3, the prices (p_n^{3*},p_s^{3*}) and demands (q_n^{3*},q_s^{3*}) for both products are related to the consumers' quality perception for the store brand. When the perception of quality increases, more consumers purchase the store brand and it's retail price would increase. However, the demand for the national brand decrease and the NBM will lower it's retail price. Additionally, the CM will set a lower wholesale price of the national brand because of the lower demand.

Theorem 3. By putting thew_n^{3*}、 w_s^{3*}、 $q_n^{3*}$and q_s^{3*} into the profit functions, parties' profit are given by

$$\pi_m^{3*} = \frac{(1-r)(2+c-\theta)^2}{4(r-3)^2} \quad (41)$$

$$\pi_s^{3*} = \frac{((c^2(49+(r-18)r)+(7\theta-2)^2+r^2(\theta(12+\theta)-12)-2c\left(r^2(6+\theta)+7(7\theta-2)-2r(8+9\theta)\right)-2r(\theta(16+9\theta)-20))}{16(r-3)^2} \quad (42)$$

$$\pi_c^{3*} = \frac{(1-r)(2+c-\theta)^2}{8(3-r)} \quad (43)$$

Theorem 3 demonstrates that both the CM and the NBM's profit decrease as consumers' quality perception of the store brand (perception in short) increases. For the e-tailer, his profit depends on the perception and cost of the store brand sourced from the third-party. When the cost is small ($0 < c \le -14 - 16r + 6r^2 + 49\theta - 18r\theta + \frac{r^2\theta}{49} - 18r + r^2$) the e-tailer's profit follows the same trend as the increase in the perception. This is for the reason that the e-tailer's profit mainly comes from the resale revenue of the store brand, and the increase revenue in store brand's exceeds the decrease in the commission from the national brand at this time. Conversely, when the cost is high ($-14 - 16r + 6r^2 + 49\theta - 18r\theta + \frac{r^2\theta}{49} - 18r + r^2 < c < 1$), the e-tailer's profit will increase with the enhancement of the perception. This is due to the higher perceived quality leading to a substantial revenue of the store brand, which offset the reduced commission from the national brand and result in a decrease in profit for the e-tailer.

5. Comparisons and Analyses

5.1 Whether to Introduce Store Brand

Proposition 1

The e-tailer will always consider introducing store brand, which may not always be beneficial for the NBM and CM. Specifically, it is related to the cost that provided by the third-party and consumers' quality perception of store brand.

Proposition 1 shows that e-tailer is always be willing to introduce store brand, considering his profit maximization. This observation aligns with the growing prevalence of store brands as evidenced in recent studies [1]. However, some scholars argue that store brand introduction invariably negatively affects the NBM [4,2022], prompting the NBM to implement strategies to prevent the entry of store brands into the market. Conversely, others believe that the exist of store brand can help to sell national brand as a higher price, which provide a positive effect on the NBM [18,19]. As we demonstrate, under agency model whether the introduction of store brand benefit the NBM is related to e-tailer's sourcing strategy. On the one hand, if the e-tailer adopt strategy S2 (with store brand introduction and manufactured by the CM), store brand's market entry must do harm to national brand and reduce the NBM's. This is for the reason that the production by the CM will generate brand spillover, leading consumers' higher quality perceptive and reducing purchase of national brand in favor of store brand. On the other hand, if strategy S3 be adopted, then store brand's market entry isn't always reduce the NBM's profit, which is related to sourcing cost. Only when the cost is lower ($0 < c < 1 - r^2$) and the quality perception from consumers is higher ($1 + 2c + r^2 < \theta < 1$), does the introduction of store brand become detrimental to the NBM, otherwise, the NBM tends to prefer the introduction of store brand and manufactured by the third-party. Store brand's introducing captures a portion of market share from national brand, however, when the cost is higher, the e-tailer has to increase the price of store brand to ensure a certain marginal profit, which gives the NBM an opportunity to raise the price of national brand as well, thereby he will obtain greater profit. Furthermore, if the quality perception of store brand isn't great enough, consumers may not choose store brand instead of national brand. In this case, profit of the NBM remains substantial, and he would still prefer the e-tailer to introduce store brand and have it produced by the third-party.

From the perspective of the CM, if the e-tailer adopts strategy S2, he will increase his revenue streams by producing store brand, at this time, the CM can increase his marginal profit by setting a higher wholesale price of national brand (w_n), thereby achieving profit maximization. Furthermore, if the e-tailer adopts strategy S3, the result is related to sourcing cost from the third-party. When the cost is higher ($c > q - 3(1-r)^2 - 9 + r + \theta$), the e-tailer will propose a higher price to ensure marginal profit, which will also increase the price and demand for national brand, allowing the CM to increase the wholesale price for national brand and gain more profit.

5.2 E-tailer's Optimal Sourcing Strategy

According to proposition 1, we have the e-tailer will always introduce store brand to achieve profit maximum. In this part, we examine the e-tailer's optimal outsourcing strategy, taking into account the introduction of store brand. We determine the e-tailer's best option by comparing the maximum profit attainable under these two strategies.

Proposition 2

Define

$$\overline{\beta} = \begin{cases} 1, & 0 < c < c_3 \\ \beta_1, & c_3 < c < c_1 \\ 0, & c_1 < c < c_2 \\ \beta_1, & c_2 < c < c_4 \\ 1, & c_4 < c \end{cases} \tag{44}$$

It is optimal for the e-tailer to select strategy S3 if $\beta < \bar{\beta}$ otherwise it is optimal for the e-tailer to select strategy S2. Where the value of c_1, c_2, c_3 and c_4 are described in Appendix A, and satisfied $0 < c_3 < c_1 < c_2 < c_4$ (The values of c_1, c_2, c_3, c_4 and β_1 are detailed in the appendix.).

Proposition 2 shows that the e-tailer is always willing to introduce store brand because it will bring additional revenue enhance his competitiveness in the market. Thus, we discuss the e-tailer's optimal strategy with store brand introduction. When the cost for the e-tailer to purchase store brand from a third-party satisfied $0 < c < c_3$, the e-tailer is more inclined to sourced it from the third-party given that a greater marginal profit. When the cost c within the range of $c_3 < c < c_1$ or c, the e-tailer's optimal strategy is related to the brand spillover β. If β is "high" ($\beta_1 < \beta < 1$), the e-tailer is more willing to have store brand manufactured by the CM, otherwise, he will sourced from the third-party.

However, when the cost $c_1 < c < c_2$ and $c > c_4$ we have arrived at two interesting findings. First, if the cost within the range of $c_1 < c < c_2$, the e-tailer always sources store brand from the CM, profit accrued by e-tailer through selling store brand diminish as the cost escalate. Even though strategy S3 results in the NBM selling more national brand and providing higher commissions to the e-tailer compared to strategy S2, the higher cost of obtaining store brand under strategy S3 is far greater than the wholesale price from the CM under strategy S2 and even outweigh the increase in commissions. Consequently, profit of the e-tailer will decreases under strategy S3.

Secondly, contrary to common belief, when the cost the e-tailer sources store brand from the third-party exceeds a certain threshold (i.e., $c > c_4$), the e-tailer still prefers to have store brand manufactured by the third-party rather than CM. This is because under strategy S3 as the cost increase, the price of store brand rises, consequently leading to a decrease in demand for store brand and more consumers purchase national brand. Furthermore, the higher price of store brand and greater demand for national brand provide the NBM with an opportunity to increase the prices of national brand. Therefore, the NBM's profit

increase, leading to a corresponding rise in the commissions received by the e-tailer from the NBM, which eventually surpasses the commissions earned under Strategy S2. When the cost c satisfied the range of $c > c_4$, the increase in commissions has outweighed the adverse effects of the reduced store brand prices on profit, hence the e-tailer retains the preference for the third-party over the CM in the production of store brand. (As shown in **Figure2**)

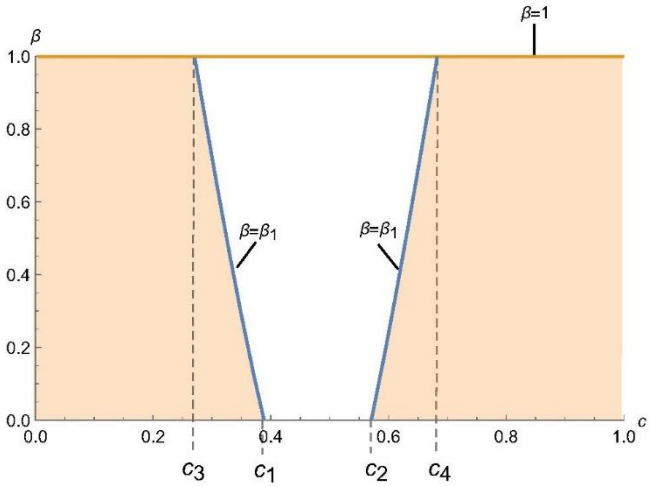

Figure 2. The optimal strategy of e-tailer

5.3 Impact of the E-Tailer'S Outsourcing Strategy on the NBM and the CM

According to proposition 1, we have already know that the e-tailer will always with store brand introduction, implying the strategy S1 is never selected. Thus we will focus exclusively on strategy S2 and strategy S3 in this subsection.

Proposition 3

With considering the store brand introduction, impacts of its different outsourcing strategies on the NBM and the CM are as follows:

(1) Strategy S3 is always beneficial to the NBM, and he will never considering strategy S2. The preference of CM for outsourcing strategies is related to the cost of store brand from the third-party. When the cost is low (i.e., $0 < c < \theta - 2 + \frac{2r(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)2\theta^2)}{4r-3}$), CM is prefers strategy S2. Otherwise, he prefers strategy S3.

Proposition 3 further substantiates part of the conclusions drawn in proposition 1, namely that the NBM will never prefer strategy S2. In other words, the market entry of store brands is detrimental to the national brand and results in a reduction of the NBM's profits. This provides an explanation for why many NBMs adopt various measures and strategies to avoid sharing manufacturers with store brands. For instance, some NBMs sign contracts with CMs that stipulate the CM can only produce the national brand. Such contractual arrangements are beneficial in protecting the interests of NBMs, as they ensure CMs focus on producing the NBM's products while reducing potential market and brand impact on NBMs from manufacturing store brands. This approach enables NBMs to better control the quality and market positioning of their products while reducing the risk of direct competition with store brands. However, other researchers have shown that several CMs participate in manufacturing store brands and maintain relationships with NBMs by offering favorable terms. Typically, NBMs will enjoy an attractive wholesale price when purchasing the national brand from these CMs. It should be noted that in our research, we assume there is only one CM in the market and the NBM must outsource their national brand from the CM. Therefore, the CM will not concede more benefits in order to maintain the relationship with the NBM. On the contrary, if the e-tailer introduces a store brand and sources it from a third-party, the NBM has the opportunity to gain more profit due to a higher price. Consequently, when the e-tailer has already decided on a store brand introduction, the NBM always prefers that the store brand be manufactured by a third-party.

Under strategy S3, when the cost of sourcing store brand from the third-party increases, the e-tailer will ensure his marginal profit by raising the price of the store brand, which leads to a decrease in consumers' purchases of the store brand. Furthermore, the price and demand for national brand will increase, the CM will gain a greater profit as well. When the cost exceeds a certain threshold (i.e., $c > \theta - 2 + \frac{2r(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)2\theta^2)}{4r-3}$)the increase in the CM's profit will be greater than that obtained from manufacturing store brand under strategy S2. At this point, the CM is unwilling to manufacture store brand. Instead, when the cost is below the threshold (i.e., $c < \theta - 2 + \frac{2r(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)2\theta^2)}{4r-3}$, the wholesale price w_n offered by the CM is also lower. Therefore, the CM will achieve profit maximization by manufacturing store brand.

5.4 Pareto Analysis

In this subsection, we aim to find a store brand sourcing strategy that is profitable for the e-tailer, the NBM and the CM.

Proposition 4

When the cost of sourcing store brand from a third-party exceeds a threshold (c>c_p, adopting strategy S3 is always profitable for the e-tailer, the NBM and the CM.

Similarly, because the e-tailer definitely considers store brand introduction, we will only discuss strategy S2 and strategy S3 in this subsection. Firstly, from the perspective of NBM, strategy S2 is always better than strategy S3. Consider the preference of e-tailer and the CM, figure 3 intuitively describe the profit's trend of e-tailer and CM under two different strategies as the cost varies. According to figure 3, when the cost c > cp (in region 4), adopting Strategy S3 is more profitable for both the e-tailer and the CM, which is satisfied to the NBM as well, thus Pareto optimality is achieved in region 4. Furthermore, in region 1 and region 3, the CM is prefer to strategy S2 as the manufacturer of both national brand and store brand.

However, opting for strategy S3 will provide more profits for e-tailer than strategy S2 in these two regions, so the e-tailer prefers to source his store brand from a third-party rather than the CM, and the CM may only obtain a smaller profit. It should be noted that, the scenario where the CM acts as the store brand manufacturer only occurs when the e-tailer and CM prefer strategy S2 meanwhile, otherwise, the CM will not produce store brand. And based on the above, we can infer that, compared to the e-tailer, the CM is more likely to prefer choosing Strategy S2. Interestingly, adopting Strategy S3 is more profitable for both the e-tailer and the CM in region 2. Therefore, in this case, the situation where the CM acts as the store brand manufacturer will occur, which is also the only scenario where the CM produces the store brand. However, under this circumstance, the NBM's profits will decrease, making the condition for Pareto optimality is not met.

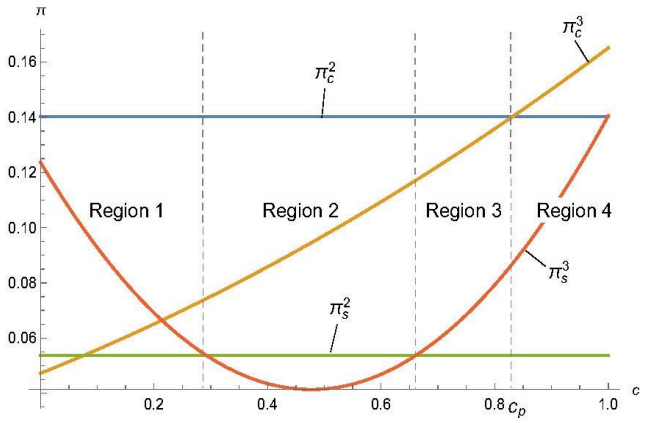

Figure 3. Pareto analysis

6. Conclusions

This paper investigates the issue of an e-tailer's store brand sourcing in competition with a national brand under agency model. We consider three scenarios regarding the introduction of the store brand, which determine optimal outsourcing strategies for the e-tailer, and discuss the Pareto optimal for the e-tailer, National Brand Manufacturer (NBM), and Contract Manufacturer (CM). Furthermore, we discuss the role of brand spillover in the e-tailer's choice of outsourcing strategy and its impact on NBM and CM's profits under the agency model. Our results show that brand spillover, commission ratios, the cost of store brand when sourcing from a third-party and consumers' quality perception are key determinants of the research outcomes.

The key findings and managerial insights of this study are summarized as follows. First, considering profit maximization, the e-tailer will always introduce store brand. However, this decision may not necessarily have a positive effect on CM and NBM, which is related to the e-tailer's outsourcing cost from a third-party and consumers' quality perception of store brand.

Second, with store brand introduction, the e-tailer's optimal strategy for store brand's outsourcing is influenced by the cost of sourcing from a third-party and the degree of brand spillover. According to our study, the e-tailer would only consider the CM as store brand's manufacturer if the cost is moderate and brand spillover surpasses a certain threshold, otherwise he will opt to source from a third-party. Intriguingly, our findings reveal that even when the cost of sourcing from a third-party is high, the e-tailer is still willing to choose the third-party as store brand's manufacturer. This can be attributed to the agency model which creates a strong correlation between the e-tailer's profit and the demand for the national brand. When the cost surpass a certain threshold, the price of the store brand increases, leading to an increasing demand of national brand with a greater price. Consequently, this results in a positive impact on the e-tailer's profits. Similarly, the CM's preference for store brand outsourcing strategies is also cost-dependent. As the cost decreases, the CM is more inclined to manufacture the store brand. Conversely, when the cost is high, the CM will focus solely on producing the national brand. On the other hand, when the cost is higher, the CM will only produce national brand. However, the NBM consistently opposes sharing the CM with store brand because of brand spillover, which may reduce the demand and price of national brand, causing his profit decrease.

Third, we also conducted a Pareto analysis, where we discovered that a Pareto optimum exists when the cost of store brand from a third-party exceeds a certain threshold. At this point, the third- party will act as a supplier for the store brand. Furthermore, we found that when the cost falls within a certain intermediate range, both the e-tailer and CM will choose strategy S2, meaning that CM becomes the manufacturer for the store brand at this time. However, this does harm to the NBM.

Further research can be done in several directions. For example, this study only considers that NBM sells through an e-tailer under agency model. In practice, the NBM can sell national brand through new retailing that combines online and offline channels. Under this model, NBM may adopt different pricing strategies between online and offline sales and adjust the sales rate to achieve a greater profit. Moreover, this paper finds that brand spillover always harms the NBM under agency model, which may lead NBM to adopt other manufacturing and sales strategies, even end the relationship with CM. Previous studies have discussed that CM maintains the relationship with NBM by offering wholesale price concessions. Strategies such as price subsidies and advertising that e-tailers can adopt to achieve a win-win cooperation with NBM remains to be studied.

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Appendix

Proof of proposition 1

From the perspective of the e-tailer, under the strategy S1 (without store brand introduction), strategy S2 (with store brand introduction and manufactured by the CM), and strategy S3 (with store brand introduction and manufactured by a third-party), the optimal profit functions of the e-tailer are:

$$\pi_s^{1*} = \frac{3r}{16}$$

$$\pi_s^{2*} = \frac{12r^3 + (1 + 2\beta(\theta - 1) - 2\theta)^2 + r^2(4(\beta + \theta - \beta\theta)^2 - 19) + 3r(2 - 3\beta^2(\theta - 1)^2 + (2 - 3\theta)\theta + \beta(2 - 8\theta + 6\theta 2))}{4(3 - 4r)^2}$$

$$\pi_s^{3*} = \frac{c^2(49 + r^2 - 18r) + (7\theta - 2)^2 + r^2(\theta(12 + \theta) - 12) - 2c(r^2(6 + \theta) + 7(7\theta - 2) - 2r(8 + 9\theta)) - 2r(\theta(16 + 9\theta) - 20))}{16(r - 3)^2}$$

When the e-tailer selects strategy S2:

$$\pi_s^{2*} - \pi_s^{1*} = \frac{(1 + 2\beta(\theta - 1) - 2\theta)(4 - 3r - 4r^2 - 8\beta + 18r\beta - 8r^2\beta + 2(4 + r(4r - 9))(\beta - 1)\theta)}{16(3 - 4r)^2}$$

Let $\pi_s^{2*} - \pi_s^{1*} = 0$, we have$\beta_{11} = \frac{1-2\theta}{2(1-\theta)} < 0$or $\beta_{12} = \frac{-4+3r+4r2+8\theta 18r\theta+8r2\theta}{2(4-9r+4r2)(\theta-1)}$

The range of β12 is related to commission rate r:

(1) When$0 < r < \frac{3(6\theta-1)}{8(1+2\theta)} - \frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}}$,we have $\beta_{12} < 0$

(2) When$\frac{3(6\theta-1)}{8(1+2\theta)} - \frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}} < r < \frac{15-\sqrt{33}}{24}$,we have $0 < \beta_{12} < 1$

(3) When $r > \frac{15-\sqrt{33}}{24}$,we have$\beta_{12} > 1$.

Therefore, the results of e-tailers' optimal profit are as follows:

(1) When $0 < r < \frac{3(6\theta-1)}{8(1+2\theta)} - \frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}}$,we have $\pi_s^{2*} > \pi_s^{1*}$

(2) When $\frac{3(6\theta-1)}{8(1+2\theta)}-\frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}}<r<\frac{15-\sqrt{33}}{24}$ and$0<\beta<\beta_{12}$,we have $\pi_s^{2*}<\pi_s^{1*}$

(3)When $\frac{3(6\theta-1)}{8(1+2\theta)}-\frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}}<r<\frac{15-\sqrt{33}}{24}$ and$\beta_{12}<\beta<1$,we have$\pi_s^{2*}>\pi_s^{1*}$

(4) When $\frac{3(6\theta-1)}{8(1+2\theta)}-\frac{1}{8}\sqrt{\frac{73-108\theta+68\theta^2}{(1+2\theta)^2}}<r<\frac{15-\sqrt{33}}{24}$,we have $\pi_s^{2*}<\pi_s^{1*}$

When the e-tailer selects strategy S3,

$$\pi_s^{3*}-\pi_s^{1*}=\frac{\begin{matrix}(49c^2-3r^3+(2-7\theta)^2-14c(7\theta-2)+r^2\big(6+c^2-2c(6+\theta)+\theta(12+\theta)\big)\\+r(13-18c^2+4c(8+9\theta)-2\theta(16+9\theta)))\end{matrix}}{16(r-3)^2}>0$$

From the perspective of the CM, the optimal profits under the strategies S1, S2, and S3 are:

$$\pi_c^{1*}=\frac{1-r}{8}$$

$$\pi_c^{2*}=\frac{(r-1)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)^2\theta^2)}{6-8r}$$

$$\pi_c^{3*}=\frac{(r-1)(2+c-\theta)^2}{8(r-3)}$$

When the e-tailer selects strategy S2:

$$\pi_c^{2*}-\pi_c^{1*}=\frac{(r-1)(1+2\beta(\theta-1)-2\theta)^2}{8(3-4r)}>0$$

When the e-tailer introduces a store brand that is manufactured by the CM, this is always beneficial for the CM because it provides additional revenue streams for him.

$$\pi_c^{3*}-\pi_c^{1*}=\frac{(r-1)1+4c+c^2+r-4\theta-2c\theta+\theta^2}{8(3-4r)}$$

Let $\pi_c^{3*}-\pi_c^{1*}=0$, we have $c_{11}=\theta-2-\sqrt{3-r}<0$, $c_{12}=\theta-2+\sqrt{3-r}>0$.

Therefore, when $c>\theta-2+\sqrt{3-r}$, we have$\pi_c^{3*}>\pi_c^{1*}$, which means introducing a store brand will have a positive effect on CM. Conversely, when $c<\theta-2+\sqrt{3-r}$, we have$\pi_c^{3*}<\pi_c^{1*}$, which means introducing a store brand will have a negative effect on CM.

From the perspective of the NBM, the optimal profits under the strategies S1, S2, and S3 are:

$$\pi_m^{1*}=\frac{1-r}{16}$$

$$\pi_m^{2*}=\frac{(1-r)(2r-2+\beta+\theta-\beta\theta)^2}{4(3-4r)^2}$$

When the e-tailer selects strategy S3:

$$\pi_m^{2*}-\pi_m^{1*}=\frac{(r-1)}{16}(1-\frac{4(-2+2r+\beta+\theta-\beta\theta)^2}{(3-4r)^2}$$

The formula demonstrates that compared to the situation that without store brand introduction, manufactured by CM always has a negative impact on the NBM.

$$\pi_m^{3*}-\pi_m^{1*}=\frac{(r-1)(r^2+16\theta+8c\theta-4\theta^2-7-16c-4c^2-6r)}{16}$$

Let$\pi_m^{3*}-\pi_m^{1*}=0$, we have $\theta_{11}=\frac{7+2c-r}{2}>1$， $\theta_{12}=121+2c+r$

The range of values for θ12 has the following several cases:

When $c>\frac{1-r}{2}$,it is certain that$\theta_{12}>1$, and in this case, $\pi_m^{3*}>\pi_m^{1*}$ always holds;

When $c<\frac{1-r}{2}$, we have$\frac{1}{2}<\theta_{12}<1$. In this case, the optimal profit of NBM is related to the consumers' quality perception(θ): When the θ satisfied: $\frac{1}{2}<\theta<\theta_{12}$, we have $\pi_m^{3*}>\pi_m^{1*}$, which shows that the NBM prefers introducing store brand and manufactured by a third-party. When the θ satisfied: $\theta_{12}<\theta<1$, we have$\pi_m^{3*}<\pi_m^{1*}$, that the NBM prefers without store brand introduction.

Proof of proposition 2

According to proposition 1 we have the e-tailer will never give up introducing store brand, thus we just compare strategy S2 and strategy S3 regarding the outsourcing of store brands from different manufacturers.

As we know, under these two strategies, the e-tailer's optimal profits are:

$$\pi_e^{2*}=\frac{\begin{matrix}(12r^3+(1-2(\theta+\beta(1-\theta))^2+r^2(4(\theta+\beta(1-\theta))^2-19)+3r(2-3\beta^2(\theta-1)^2\\+(2-3\theta)\theta+\beta(2-8\theta+6\theta2)))\end{matrix}}{4(3-4r)^2}$$

Thus,

$$\pi_e^{3*}-\pi_e^{2*}=\beta^2(-\frac{(4r^2-9r+4)(\theta-1)^2}{4(3-4r)^2})+\beta(\frac{(\theta-1)(3r+(4+r(4r-9))\theta-2))}{2(3-4r)^2}+$$
$$(\frac{c^2(49+(r-18)r)+(2-7\theta)^2+r^2(\theta(12+\theta))-12-2c(r^2(6+\theta)+7(74(1+r(6+r(12r-19))-4\theta+6r\theta+\big(4+r(4r-9)\big)\theta^2}{16(3-r)^2})$$

Let $\pi_e^{3*}-\pi_e^{2*}=0$, we have$\beta_{21}$and β_{22}.

Where$\beta_{22}<0$ always holds true.

The range of values for β21 has the following several cases:

(1) when $c_1 < c < c_2$, we have $\beta_{21} < 0$
(2) when $c < c_3$ or $c > c_4$, we have$\beta_{21} > 1$
(3) when$c_3 < c < c_1$or $c_2 < c < c_4$, we have$0 < \beta_{21} < 1$
Consequently, the inequality$\pi_e^{3*} > \pi_e^{2*}$is satisfied when either of the following conditions is fulfilled:
(1) 0 < c < c3 or c > c4;
(2) c3 < c < c1, 0 < β < β21;
(3) c2 < c < c4, 0 < β < β21.
And the inequality $\pi_e^{3*} < \pi_e^{2*}$is satisfied when either of the following conditions is fulfilled:
(1) c1 < c < c2
(2) c3 < c < c1 or c2 < c < c4, β1 < β < 1
The expressions for c_1, c_2, c_3, $c_4$and β_1 are as follows:

$$c_1 = \frac{1}{(3-4r)^2(r^2-18r+49)}(2r(96+r(107+8r(6r-25))) + (3-4r)^2(r^2-18r+49)\theta) - 2(63 + \sqrt{(3-4r)^2(3-r)^2(12r^5-43r^4+8r^3+30r^2-84r+49+(r^2-18r+49)((4r^2-9r+4)\theta^2+2\theta(3r-2))}$$

$$c_2 = \frac{1}{(3-4r)^2(r^2-18r+49)}\left(2r\left(96+r\left(107+8r(6r-25)\right)\right) + (3-4r)^2(r^2-18r+49)\theta\right) + 2(63 + \sqrt{(3-4r)^2(3-r)^2(12r^5-43r^4+8r^3+30r^2-84r+49+(r^2-18r+49)((4r^2-9r+4)\theta^2+2\theta(3r-2))}$$

$$c_3 = \frac{1}{(3-4r)^2(r^2-18r+49)}(2r(96+r(107+8r(6r-25))) + (3-4r)2(r2-18r+49)\theta) + 2(63 + \sqrt{(3-4r)^2(3-r)^2(12r^5-43r^4+8r^3+30r^2-84r+49+(r2-18r+49)((4r^2-9r+4)\theta2+2\theta(3r-2))}$$

$$c_4 = \frac{1}{(3-4r)^2(r^2-18r+49)}(2r\left(96+r\left(107+8r(6r-25)\right)\right) + (3-4r)^2(r^2-18r+49)\theta) + 2(63 + \sqrt{(3-4r)^2(3-r)^2(12r^5-43r^4+8r^3+30r^2-84r+49+(r^2-18r+49)((4r^2-9r+4)\theta^2+2\theta(3r-2))}$$

$$\beta_1 = 2(r-3)\left(3r-2\theta(4r^2-9r+4)\right) + (3-4r)\sqrt{\frac{16-(4r^2+4r)\left((r-3)(3r-7)r-4\right)+(4r^2-9r+4)(c-\theta)(28+c(r^2-18r+49)-49\theta+r(32+18\theta-r(12+\theta))))}{(2(r-3)(4r^2-9r+4)(\theta-1))}}$$

Proof of proposition 3

By comparing the optimal profits of NBM and CM respectively under strategies S2 and S3, we can determine the preferences of them for different outsourcing strategies regarding the store brand. This comparison helps in understanding which strategy each party might prefer based on their profit maximization goals.

From the perspective of the NBM, the optimal profits under the strategies S2, and S3 are:

$$\pi_m^{2*} = \frac{(1-r)(2r-2+\beta+\theta-\beta\theta)^2}{4(3-4r)^2}$$

$$\pi_m^{3*} = \frac{(1-r)(2+c-\theta)^2}{4(r-3)^2}$$

Thus we have:

$$\pi_e^{3*} - \pi_e^{2*} = \frac{r-1}{4}(\frac{(2r+\beta+\theta-\beta\theta-2)^2}{(3-4r)^2} - \frac{(2+c-\theta)^2}{(r-3)^2}$$

Consequently, the NBM is always prefers strategy S3.

From the perspective of the CM, the optimal profits under the strategies S2, and S3 are:

$$\pi_c^{2*} = \frac{(1-r)(1-r-(1-\beta)\beta-\theta+\beta(3-2\beta)\theta+(\beta-1)^2\theta^2)}{6-8r}$$

$$\pi_c^{3*} = \frac{(1-r)(2+c-\theta)^2}{8(3-r)}$$

Thus we have:

$$\pi_c^{3*} - \pi_c^{2*} = \frac{r-1}{8}\frac{(2+c-\theta)^2}{r-3} + \frac{8(r-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)^2\theta^2-1)}{8r-6}$$

Let $\pi_c^{3*} - \pi_c^{2*} = 0$, we have $c = \theta - 2 + 2\sqrt{\frac{(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)^2\theta^2)}{4r-3}}$, when $c > \theta - 2 + 2\sqrt{\frac{(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)^2\theta^2)}{4r-3}}$, we have$\pi_c^{3*} > \pi_c^{2*}$, it's better for the CM to have store brand manufactured by a third-party. Conversely, when $c < \theta - 2 + 2\sqrt{\frac{(r-3)(r-1-(\beta-1)\beta+\theta+\beta(2\beta-3)\theta-(\beta-1)^2\theta^2)}{4r-3}}$, we have $\pi_c^{3*} < \pi_c^{2*}$ thus CM is willing to manufacture the store brand.