Manufacturer Encroachment, Store Brand Introduction and Sales Modes

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Abstract. Reselling and agency selling are two common modes used by manufacturers to sell products through e-tailers, in addition, manufacturers may establish direct channel to encroach on the market, and e-tailers could introduce store brands to compete with them. This paper explores the interaction between the manufacturer's encroachment, sales modes and the e-tailer's store brand strategy. Our findings reveal that e-tailer is more likely to introduce store brand at moderate levels of agency fees when there is no manufacturer encroachment, whereas e-tailer is more likely to introduce store brand at lower or higher levels of agency fees when manufacturer encroaches and choosees a dual-channel structure. In addition, a moderate increase in the quality of the store brand facilitates the e-tailer's the introduction strategy, but a higher quality may have the opposite effect. When the agency fee is at a low level, the manufacturer's direct-only channel structure can deter e-tailer from introducing store brand if the direct channel disadvantage is small; manufacturer's encroachment strategy can also keep store brand out of the market when the agency fee is at a moderate level.

Keywords: reselling; agency selling; manufacture encroachment; store brand; game theory.

1 Introduction

Reselling and agency selling are now common forms of sales when manufacturers and e-tailers cooperate[1]. Reselling refers to the manufacturer wholesales the product to the e-tailer, and the e-tailer then sells it to the customer, e.g., Amazon and Jingdong mainly use this form; agency selling is a new type of sales form, where the manufacturer sells the product directly to the consumer on the e-tailer's platform, and the e-tailer collects a certain percentage of the commission fee from the manufacturer, e.g., Tmall and Pinduoduo[2]. Recently, more and more manufacturers are establishing their own direct channel to sell their products independently of retailers, which knows as "manufacturer encroachment"[3]. For example, Apple not only sells their products on JD, but also sells products through their website[4]. Even more, some manufacturers have abandoned co-operation with other retailers when they have established a direct channel. For example, Epic, a game company, sells its game products only on

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its own official mall and does not share them with other gaming platforms[5]. Although encroachment helps manufacturers to be flexible in pricing and control distribution, it is also expensive for firms to open direct channel. Costs may include advertising promotions, online website development[3], so some companies do not have direct channel, e.g. Jasonwood, a brand selling clothing. Therefore, businesses should weigh the costs and rewards of encroachment.

However, the encroachment may deprive e-tailers of pricing power over their products and lead to a reduction in their demand, as well as intensify price competition among different channels. Faced with this situation, some e-tailers have introduced store brand products to compete with manufacturer. Jingdong has introduced the store brand Jingxuan[2], but there are a number of e-tail platforms such as Pinduoduo do not currently have a store brand.

The above examples show that in reality different companies make different strategic choices: Apple (with direct channel) mainly adopts the reselling mode through Jingdong, and the agency selling mode on Tmall and Pinduoduo platforms, whereas Jasonwood (with no direct channel) adopts the agency selling mode on Jingdong, Tmall, and Pinduoduo platforms, and Epic sells only through its own direct channel. In addition, Pinduoduo have introduced store brands, while Pinduoduo has not. Firms' choice of strategy is complex and ambiguous. From a competitive perspective, manufacturer encroachment and e-tailer introduction of store brand are likely to be interrelated, and may even lead to a breakdown of co-operation between the two parties due to competitive issues; from a co-operative perspective, the two sales modes may lead to different profits and potential impacts due to different pricing rights, which may change the strategic decisions of the companies.

So, how does a manufacturer make the encroachment decision and when should e-tailer introduce the store brand in a system with alternative sales models, and what role does the sales model play in this? What are the implications of the manufacturer's choice to sell only through the direct channel after the encroachment? In this coopetition game, how do manufacturer and e-tailer interact with each other strategically, and what is the impact of other relevant factors? These are questions that companies should pay attention to.

The three main areas of research relevant to this paper include sales models, manufacturer encroachment and store brands. Tian, et al. [1] developed a model in which two competing suppliers sell their products through the same intermediary, and investigated the decision of the intermediary's sales model. Liu, et al. [6]explored the choice of sales model when a manufacturer is faced with two platforms. Shen, et al. [7] investigated the impact of the sales model on the introduction of store brands, and found that the reselling model is easier for the introduction of store brands.

Some scholars have also studied the manufacturer encroachment. Arya, et al. [8] examined the possible beneficial effects of manufacturers opening direct channel. Balasubramanian and Maruthasalam [9], Wang, et al. [10] both examine the manufacturer's encroachment decision in the presence of store brands in the market. Chen, et al. [11] make clear that a manufacturer's online channel can be used as a mechanism to discourage retailers from introducing discount stores. Zhang, et al. [3] consider the question of whether a manufacturer opens a direct channel in a carbon reduction envi-

ronment. Ha, et al. [12] explore the impact of product quality strategies on manufacturer encroachment across different channels.

There are also some literatures that examine the phenomenon regarding the introduction of store brands. Ru, et al. [13] examine the impact of the introduction of store brands on manufacturers. Xiao, et al. [14] analyze the conditions for the introduction of store brands by retailers when the manufacturer has already established a direct channel. Zhang, et al. [15] investigate the interaction between manufacturer encroachment and store brand introduction. Li, et al. [16] discuss the retailer's introduction of store brand and what kind of store brand are introduced from the perspective of product quality. Liao, et al. [17] examine questions about the origin of store brand products.

The above literature discusses the issues of manufacturer encroachment, store brand introduction strategy or sales model strategy, but our study is not the same as them: Existing literature examines manufacturer encroachment and store brand strategies with less consideration of the sales models, meanwhile, none of the existing literature examining manufacturer encroachment considers the case where the manufacturer encroaches and then sells only through the direct channel.

In summary, none of the existing studies can answer the questions we raised earlier. In view of this, this paper incorporates the sales model, manufacturer's encroachment, and store brand introduction strategy into the strategic decisions of supply chain members, then investigates the interaction between the manufacturer's encroachment and sales model and the e-tailer's store brand strategy, and the equilibrium strategy problem of both parties. The main contributions of this paper are: Incorporating manufacturer selling only through direct channel into the model, to consider the key factors such as channel preference and product quality, which further enriches the theoretical study of manufacturer's encroachment; Integrating sales modes into decision-making stage, to analyses the decision-making problems of manufacturer's encroachment and e-tailer's introduction of store brand as well as the interaction problems of the two sides' strategies. Ultimately, providing reference for supply chain members' decision-making from a practical perspective.

2 The Mode

2.1 Mode Framework

We consider a supply chain with a NB manufacturer (follower) and an e-tailer (leader). The manufacturer (he) has the option to establish the direct channel (encroach on the retail market), and then, he also could choose whether to cooperate with e-tailer or not (dual-channel or direct-only channel) if he encroached. In addition, the e-tailer (she) has the option to introduce her own store brand (SB). Further, there are two selling modes (reselling mode and agency selling mode) for manufacturer to select if he collaborates with e-tailer. Figure 1 illustrates the market structures under ten scenarios.

2.2 Demand

We assume that consumers are heterogeneous in their willingness to pay for the product. Let v represent the consumer's willingness to pay for the perceived value of product, which follows the uniform distribution over [0,1]. The manufacturer has two options to sold his NB product: retail channel or direct channel. We assume that retail channel is preferred by cosumers, so the consumer preference for retail channel is 1 and for direct channel is α ($0<\alpha<1$). The manufacturer produces the NB product which sold in the retail channel or direct channel and e-tailer could introduce the SB product. We assume that quality of NB product is higher than SB product which is widely used in literatures[10, 13], so we normalize the NB product quality to 1 and SB product quality to β ($0<\beta<1$).

Following the Zhang[15], combining the perceived assumption of preference for different channel and quality for different product, we denote $0<\beta<\alpha<1$, which means the preceived value of NB product sold through the direct channel is higher than that of SB product sold by the e-tailer. Therefore, consumer's utility that buying different products from different channel are as follows: $U_r = v - p_r$ when buy NB product through retail channel, $U_d = \alpha v - p_d$ when buy NB product through direct channel, $U_s = \beta v - p_s$ when buy SB product through retail channel. Under different ten scenarios, we can obtain the demand functions by comparing the consumer's utility that buying different products from different channel:

$$nNR \text{ and } {}^{nNA}: \ q_r = 1 - p_r \tag{1}$$

$$dNR \text{ and } {}^{dNA}: \begin{cases} q_r = 1 - \dfrac{p_r - p_d}{1-\alpha} \\ q_d = \dfrac{p_r - p_d}{1-\alpha} - \dfrac{p_d}{\alpha} \end{cases} \tag{2}$$

$$nSR \text{ and } {}^{nSA}: \begin{cases} q_r = 1 - \dfrac{p_r - p_s}{1-\beta} \\ q_s = \dfrac{p_r - p_s}{1-\beta} - \dfrac{p_s}{\beta} \end{cases} \tag{3}$$

$$dSR \text{ and } {}^{dSA}: \begin{cases} q_r = 1 - \dfrac{p_r - p_d}{1-\alpha} \\ q_d = \dfrac{p_r - p_d}{1-\alpha} - \dfrac{p_d - p_s}{\alpha - \beta} \\ q_s = \dfrac{p_d - p_s}{\alpha - \beta} - \dfrac{p_s}{\beta} \end{cases} \tag{4}$$

$$sN: \ q_d = 1 - \frac{p_d}{\alpha} \tag{5}$$

$$sS:\begin{cases} q_d = 1 - \dfrac{p_d - p_s}{\alpha - \beta} \\ q_s = \dfrac{p_d - p_s}{\alpha - \beta} - \dfrac{p_s}{\beta} \end{cases} \tag{6}$$

2.3 Profit Function

We followed the literatures[6, 14, 15] and assume that the production cost of NB product and SB product is zero. In reality, the difference in production between NB product and SB product is ambiguous. Although the high quality usually leads to high cost, the manufacturer has more experience or advantage in production which means that he has the high efficiency in production, so it is hard to determine the production cost relationship between the two products. Such an assumption is to control the cost effect on our study. The manufacturer incurs the cost when he encroaches the retail market (establish the direct channel) and e-tailer also has cost in encroachment (introduce the SB product). Without loss of generality, we assume that the encroachment behavior of manufacturer and e-tailer incurs the fixed cost F and G, respectively.

Comparing to the reselling mode, the manufacturer could determine the retail price of NB on the e-tailer under the agency selling mode, so the e-tailer charges an agency fee θ base on the sales of NB product in the retail channel. For clarity, Table 1 summarizes our notation for ease of reference.

Table 1. Notations and descriptions

Symbol	Definition
$x \in \{d, n\}$	manufacturer's encroachment and non-encroachment strategy
$y \in \{N, S\}$	the e-tailer does not introduce SB; introduces SB
$z \in \{R, A\}$	reselling mode; agency selling mode
π_m^{xyz} , π_e^{xyz}	the profit of manufacturer and e-tailer under scenario xyz
w^{xyz}	wholesale prices of national brand
p_s^{xyz} , q_s^{xyz}	price and demand of SB products under scenario xyz
p_d^{xyz} , q_d^{xyz}	price and demand of NB products in the direct channel under scenario xyz
p_r^{xyz} , q_r^{xyz}	price and demand of NB products in the retail channel under scenario xyz
θ	agency fee
β	quality of SB
α	consumer's preference for direct channel
F	fixed cost of introduction SB
G	fixed cost of encroachment

Figure 1 shows the sequence of strategy decisions and pricing: (1) The strategy decision stage. The manufacturer first decides whether or not to establish the direct channel and channel structure (direct-only channel and dual-channel) if he encroached. Then e-tailer determines whether to introduce the SB product; after observing these actions. (2) The pricing stage. Under the reselling mode: First, manufacturer determines the wholesale price (w) of NB and direct-channel price (p_d) if any. Sec-

ond, e-tailer set the ending price of NB (p_r) and SB (p_s) if any. Under the agency selling mode: First, manufacturer determines the price of NB in retail channel (p_r) and direct-channel (p_d) if any. Second, e-tailer set the price of SB price (p_s) if any.

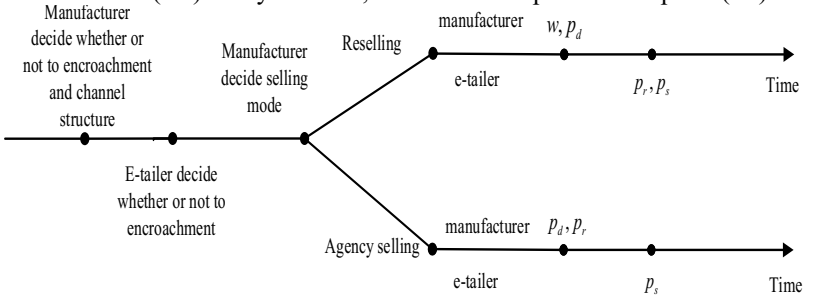

Fig. 1. The game sequence

3 Equilibrium Solutions

Given the manufacturer and e-tailer's strategies, there are ten possible combinations: $\{nNR, nNA, nSR, nSA, sN, sS, dNR, dNA, dSR, dSA\}$. In this section, we will derive the equilibrium solutions in each scenario.

Scenario *nNR* and *nNA*

The profit functions of manufacturer and e-tailer under scenario *nNR* are $\pi_m^{nNR} = w^{nNR} q_r^{nNR}$, $\pi_e^{nNR} = (p_r^{nNR} - w^{nNR}) q_r^{nNR}$. The profit functions of manufacturer and e-tailer under scenario *nNA* are $\pi_m^{nNA} = (1-\theta) p_r^{nNA} q_r^{nNA}$, $\pi_e^{nNA} = \theta p_r^{nNA} q_r^{nNA}$. We solve the problems using backward induction. All equilibrium solutions are as shown in the Table 2.

Table 2. The equilibrium solutions in *nNR* and *nNA*

	nNR	*nNA*
w	1/2	-
p_r	3/4	1/2
q_r	1/4	1/2
π_m	1/8	$(1-\theta)/4$
π_e	1/16	$\theta/4$

Scenario *nSR* and *nSA*

The profit functions of manufacturer and e-tailer under scenario *nSR* are $\pi_m^{nSR} = w^{nSR} q_r^{nSR}$, $\pi_e^{nSR} = (p_r^{nSR} - w^{nSR}) q_r^{nSR} + p_s^{nSR} q_s^{nSR} - G$. The profit functions of manufacturer and e-tailer under scenario *nSA* are $\pi_m^{nSA} = (1-\theta) p_r^{nSA} q_r^{nSA}$, $\pi_e^{nSA} = \theta p_r^{nSA} q_r^{nSA} + p_s^{nSA} q_s^{nSA} - G$. We solve the problems using backward induction. All equilibrium solutions are as shown in the Table 3.

Table 3. The equilibrium solutions in *nSR* and *nSA*

	nSR	*nSA*
w	$(1-\beta)/2$	-
p_r	$(3-\beta)/4$	$(1-\beta)/(2-\beta-\beta\theta)$
p_s	$\beta/2$	$\beta(1+\theta)(1-\beta)/2(2-\beta-\beta\theta)$
q_r	$1/4$	$1/2$
q_s	$1/4$	$(1-\theta)/2(2-\beta-\theta)$
π_m	$(1-\beta)/8$	$(1-\theta)(1-\beta)/2(2-\beta-\beta\theta)$
π_e	$(1+3\beta)/16-G$	$(1-\beta)(4\theta-\beta(-1+2\theta+3\theta^2))/(4(2-\beta-\beta\theta)^2)-G$

Scenario *dNR* **and** *dNA*

The profit functions of manufacturer and e-tailer under scenario *dNR* are $\pi_m^{dNR}=w^{dNR}q_r^{dNR}+p_d^{dNR}q_d^{dNR}-F$, $\pi_e^{dNR}=(p_r^{dNR}-w^{dNR})q_r^{dNR}$. Under reselling mode, the manufacturer should set the wholesale price no more than the price of the direct channel ($p_r^{dNR}\geq w^{dNR}$), to prevent the e-tailer from buying NB products in direct channel. The profit functions of manufacturer and e-tailer under scenario *dNA* are $\pi_m^{dNA}=(1-\theta)p_r^{dNA}q_r^{dNA}+p_d^{dNA}q_d^{dNA}-F$, $\pi_e^{dNA}=\theta p_r^{dNA}q_r^{dNA}$. We solve the problems using backward induction. All the equilibrium solutions are as shown in the Table 4.

Table 4. The equilibrium solutions in *dNR* and *dNA*

	dNR	*dNA*
w	$\alpha/2$	-
p_d	$\alpha/2$	$(1-\alpha)\alpha(2-\theta)(1-\theta)/A_1$
p_r	$1/2$	$2(1-\theta)(1-\alpha)/A_1$
q_d	0	$(1-\theta)\theta/A_1$
q_r	$1/2$	$(2-\alpha(2-\theta)-2\theta)/A_1$
π_m	$\alpha/4-F$	$(1-\alpha)(1-\theta)^2/A_1-F$
π_e	$(1-\alpha)/4$	$(2(1-\alpha)(2-\alpha(2-\theta)-2\theta)(1-\theta)\theta)/A_1^2$

Where $A_1=4(1-\theta)-\alpha(2-\theta)^2$.

Scenario *dSR* **and** *dSA*

The profit functions of manufacturer and e-tailer under scenario *dSR* are $\pi_m^{dSR}=w^{dSR}q_r^{dSR}+p_d^{dSR}q_d^{dSR}-F$, $\pi_e^{dSR}=(p_r^{dSR}-w^{dSR})q_r^{dSR}+p_s^{dSR}q_s^{dSR}-G$. Meanwhile, we solve the solutions under the constraint $p_d^{dSR}\geq w^{dSR}$. The profit functions of manufacturer and e-tailer under scenario *dSA* are $\pi_m^{dSA}=(1-\theta)p_r^{dSA}q_r^{dSA}+p_d^{dSA}q_d^{dSA}-F$, $\pi_e^{dSA}=\theta p_r^{dSA}q_r^{dSA}+p_s^{dSA}q_s^{dSA}-G$. We solve the problems using backward induction. All the equilibrium solutions are as shown in the Table 5.

Table 5. The equilibrium solutions in *dSR* and *dSA*

	dSR	*dSA*
w	$\alpha(\alpha-\beta)/(2\alpha-\beta)$	-
p_d	$\alpha(\alpha-\beta)/(2\alpha-\beta)$	$(1-\alpha)\alpha(\beta-\alpha)(1-\theta)(2-\theta)/A_2$
p_r	$(\alpha(2-\beta)-\beta)/(4\alpha-2\beta)$	$(1-\alpha)(\beta-\alpha(2-\beta))(1-\theta)/A_2$
p_s	$(\alpha\beta-\beta^2)/(4\alpha-2\beta)$	$(1-\alpha)\beta(1-\theta)(2-\theta)(\beta-\alpha)/(2A_2)$
q_d	0	$(1-\theta)\theta(\beta+\alpha\beta-2\alpha)/(2A_2)$
q_r	$1/2$	$\alpha^2(2-\theta)+\beta(1-\theta)-\alpha(2+\beta-2\theta)/A_2$
q_s	$\alpha/(4\alpha-2\beta)$	$(\alpha-1)\alpha(2-\theta)(1-\theta)/(2A_2)$
π_m	$\alpha(\alpha-\beta)/(4\alpha-2\beta)-F$	$(1-\alpha)(a(-2+\beta)+\beta)(1-\theta)^2/(2A_2)-F$
π_e	$\frac{\beta^2-4\alpha^3-2\alpha(\beta^2+2\beta)+\alpha^2(5\beta+4)}{4(2\alpha-\beta)^2}-G$	$(1-\alpha)(1-\theta)A_3/(4A_2^2)-G$

Where $A_2=\alpha^2(2-\theta)^2+2\beta(1-\theta)-\alpha(4-4\theta+\beta(2-2\theta+\theta^2))$,

$A_3=4\beta^2(1-\theta)\theta-\alpha^3(2-\theta)(8\theta+\beta(2-7\theta+\theta^2))-\alpha\beta(16(1-\theta)\theta-\beta(4-8\theta+9\theta^2-\theta^3))+$

$\alpha^2(16(1-\theta)\theta+\beta(4+9\theta^2-\theta^3)+\beta^2(4-12\theta+5\theta^2-\theta^3))$.

Scenario *sN* and *sS*

The profit functions of manufacturer and e-tailer under scenario *sN* are $\pi_m^{sN}=p_d^{sN}q_d^{sN}-F$, $\pi_e^{sN}=0$. The profit functions of manufacturer and e-tailer under scenario *sS* are $\pi_m^{sS}=p_d^{sS}q_d^{sS}-F$, $\pi_e^{sS}=p_s^{sS}q_s^{sS}-G$. We solve the problems using backward induction and all the equilibrium solutions are as shown in the Table 6.

Table 6. The equilibrium solutions in *sN* and *sS*

	sN	*sS*
p_d	$\alpha/2$	$\alpha(\alpha-\beta)/(2\alpha-\beta)$
p_s	-	$(\alpha-\beta)\beta/(4\alpha-2\beta)$
q_d	$1/2$	$1/2$
q_s	-	$\alpha/(4\alpha-2\beta)$
π_m	$\alpha/4-F$	$\alpha(\alpha-\beta)/(4\alpha-2\beta)-F$
π_e	0	$\alpha\beta(\alpha-\beta)/(4(2\alpha-\beta)^2)-G$

4 Analysis of Strategy Decisions

4.1 Decision of Sales Mode

Lemma 1.

(1)*If manufacturer does not encroach and e-tailer does not introduce SB, the manufacturer will choose the agency selling mode if* $\theta\in(0,1/2]$*; otherwise, the manufacturer will choose reselling mode.*

(2)*If* manufacturer *does not encroach but e-tailer introduces SB, the manufacturer will choose the agency selling mode if* $\theta \in (0,\theta_1]$*; otherwise, the manufacturer will choose reselling mode;*

(3)If manufacturer encroaches but e-tailer does not introduce SB, the manufacturer will choose the agency selling mode if $\theta \in (0,\theta_2]$*; otherwise, the manufacturer will choose reselling mode;*

(4)If manufacturer encroaches and e-tailer introduces SB, the manufacturer will choose the agency selling mode if $\theta \in (0,\theta_3]$*; otherwise, the manufacturer will choose reselling mode;*

Where $\theta_1=(2+\beta)/(4-\beta)$, $\theta_2=2(1-\alpha)/(2-\alpha)$, $\theta_3=(1-\alpha)(2\alpha-\beta)/(2\alpha-\alpha^2-\beta)$.

Lemma 1 suggests that when the e-tailer's agency fee is low, the manufacturer will choose the agency selling model, otherwise she will choose the reselling model. It is common-sense that a higher agency fee significantly reduces the manufacturer's revenue from the e-tailer, which motivates the manufacturer to choose the reselling model.

4.2 Strategies for E-Tailer Introduction of SB

Proposition 1.

(1)Under scenarios that manufacturer has not encroached on the retail market:

(i) When $\theta \in (0,1/2]$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_1]$*; otherwise, she forgoes introduction.*

(ii) When $\theta \in (1/2,\theta_1]$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_2]$*; otherwise, she forgoes introduction.*

(iii) When $\theta \in (\theta_1,1)$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_3]$*; otherwise, she forgoes introduction.*

(2)Under scenarios that manufacturer has encroached on the retail market and chosen direct-only channel structure, the e-tailer introduces the SB product if introduction cost $G \in (0,G^{sS-sN}]$*; otherwise, she forgoes encroachment.*

(3)Under scenarios that manufacturer has encroached on the retail market and chosen dual-channel structure:

(i) When $\theta \in (0,\theta_2]$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_5]$*; otherwise, she forgoes introduction.*

(ii) When $\theta \in (\theta_2,\theta_3]$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_6]$*; otherwise, she forgoes introduction.*

(iii) When $\theta \in (\theta_3,1)$*, the e-tailer introduces the SB product if introduction cost* $G \in (0,G_7]$*; otherwise, she forgoes introduction.*

Where

$$G_1=\frac{\beta(1-\theta)^2(1-\beta-\beta\theta)}{4(2-\beta-\beta\theta)^2}$$

$$G_2 = \frac{16\theta + 4\beta(2-5\theta-3\theta^2) - \beta^2(5-6\theta-11\theta^2) - 4}{16(2-\beta-\beta\theta)^2}$$

$$G_3 = \frac{3\beta}{16}$$

$$G_4 = \frac{\alpha(\alpha-\beta)\beta}{4(2\alpha-\beta)^2}$$

$$G_5 = \frac{\begin{array}{l}(1-a)^2\alpha\beta(2-3\theta+\theta^2)(16\beta(1-\theta)^3(3\theta-2)+\alpha^3(2-\theta)^4(2-7\theta+\theta^2)-\alpha^2(2-\theta)^3(8(1-4\theta+3\theta^2)\\ +\beta(4-12\theta+5\theta^2-\theta^3))+4\alpha(1-\theta)(-4(1-\theta)^2(5\theta-2)+\beta(16-56\theta+56\theta^2-24\theta^3+5\theta^4)))\end{array}}{4(\alpha(2-\theta)^2-4(1-\theta))^2(-\alpha^2(2-\theta)^2-2\beta(1-\theta)+\alpha(4-4\theta+\beta(2-2\theta+\theta^2)))^2}$$

$$G_6 = \frac{\begin{array}{l}(\alpha-1)(\alpha^4(2-\theta)^4+4\beta^2(1-\theta)^3+\alpha\beta(1-\theta)^2(16(\theta-1)+\beta(\theta^2-4-4\theta))\\ +\alpha^2(16(1-\theta)^3+\beta(1-\theta)^2(28-4\theta-\theta^2)+\beta^2\theta(8-9\theta+2\theta^2))-\alpha^3(2-\theta)(16(1-\theta)^2+\beta(6-3\theta-\theta^3)))\end{array}}{4(-\alpha^2(2-\theta)^2+2\beta(\theta-1)+\alpha(4-4\theta+\beta(2-2\theta+\theta^2)))^2}$$

$$G_7 = \frac{\alpha(\alpha-\beta)\beta}{4(2\alpha-\beta)^2}$$

Corollary 1.*(1)* G_4, G_5 *and* G_7 *increase with* α; G_6 *increase first then decrease with increasing* α; G_1, G_2, G_3 *are irrelevant to* α*.(2)* G_3 *increase with* β; G_1, G_2, G_4, G_5 *and* G_6 *increase first then decrease with increasing* β*.(3)* G_1 *decrease with* θ; G_2 *increase with* θ; G_5 *decrease first then increase with increasing* θ; G_6 *increase first then decrease with increasing* θ; G_3, G_4, G_7 *are irrelevant to* θ.

Proposition 1 shows that the conditions under which store brand are introduced are mainly influenced by the e-tailer's agency fee and the introduction cost. E-tailer chooses to introduce store brand when the introduction cost is low, otherwise she does not, while the agency fee affects the size of the threshold of the introduction cost in different scenarios.

The conditions for the introduction of store brands when the manufacturer does not encroach are shown in Figure 2. When the agency fee is small, the introduction cost of store brands decreases with the agency fee, this is because the existence of store brand products weakens the profitability of the retail channel, and with the increase of θ, the e-retailer's revenue growth in the non-introduction of store brands is larger than that of the introduction case, so it leads to a decrease of G_1. When the agency fee is in the moderate range, the introduction cost increase as the agency fee increases; when the agency fee is high the manufacturer chooses the reselling model, so the introduction condition is independent of the agency fee. Figure 3 shows that the conditions for the introduction of store brands when the manufacturer chooses a direct-only structure after encroachment are unaffected by the agency fee, which is obvious because the manufacturer does not sell through e-tailer. Figure 4 shows the conditions for the introduction of store brands when the manufacturer chooses a dual-channel structure after the encroachment. When the agency fee is small, the cost threshold G_5, which is the root when e-tailer's payoff in scenario dSA equals that in scenario dNA, decrease first then increase with increasing θ, the e-tailer's payoff in these two scenarios have

the similar concave relationship with θ (both π_e^{dSA*} and π_e^{dNA*} climbs first and then drops with θ), but θ leads to more significant changes in e-tailer's profit under dNA compare to dSA (curves are more curved relative to changes in agency fee). When the agency fee is moderate, the introduction cost threshold is positive only when the quality of store brand is moderate (e.g., Figure 4(c)), which suggests that at this point the e-tailer will not introduce lower or higher quality store brands. When the agency fee is high, the introduction condition is independent of the agency fee.

When manufacturer does not encroach, e-tailer is more likely to introduce store brands at moderate levels of agency fee, while when manufacturer encroaches and chooses a dual-channel structure, e-tailer is more likely to introduce store brands at lower or higher rates. The reasons for this are: lower agency fee generate lower revenues when the manufacturer does not encroach, and higher agency fees cause the manufacturer to raise prices, which leads to low levels of demand, both of which result in low profits for the e-tailer; whereas when the manufacturer encroachment occurs, moderate levels of agency fee cause the e-tailer to introduce store brands under agency selling (dSA), and not to introduce them under reselling mode (dNR), and reselling mode of direct sales in the channel does not invade the market ($q_d^{dNR*}=0$), e-tailer is less affected by direct sales and can make considerable profits without introducing store brand, so the willingness to introduce store brands is low. Corollary 1(2) shows that as the quality of the store brand increases, the introduction cost threshold increases, which implies that improvement in the quality of store brands facilitates e-tailer's introduction strategies (compare Figure 2(b) and (c), Figure 3(b) and (c), Figure 4(b) and (c)); however, when the quality of store brands is high, the increase in β has the opposite effect on the introduction of the store brand (compare Figure 3(c) and (d), Figure 4(c) and (d)), this is because higher product quality can lead to fierce competition and harm e-tailer.

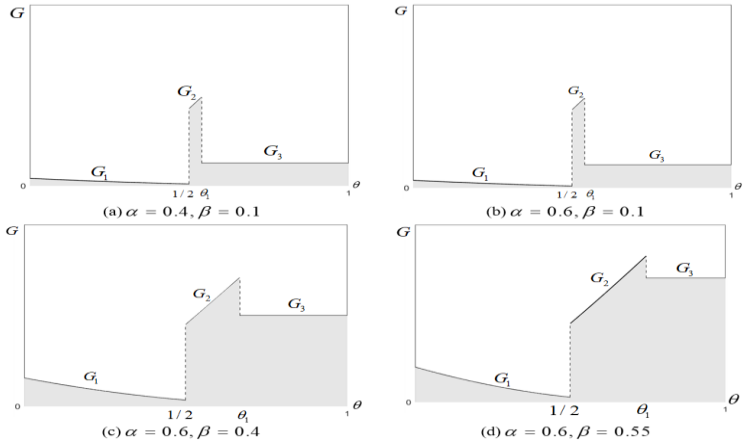

Fig. 2. Store brand introduction decisions when manufacturer does not encroach (the grey area is the introduction of store brand)

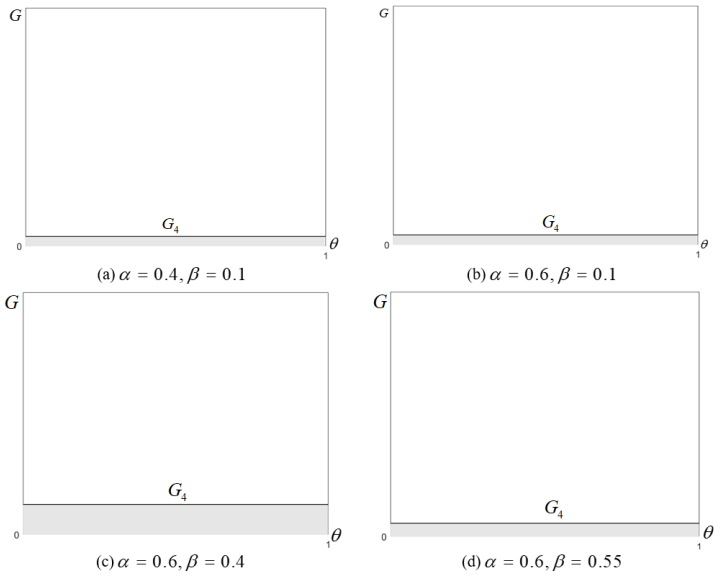

Fig. 3. Store brand introduction decisions when manufacturer chooses direct-only channel structure after encroachment (the grey area is the introduction of store brand)

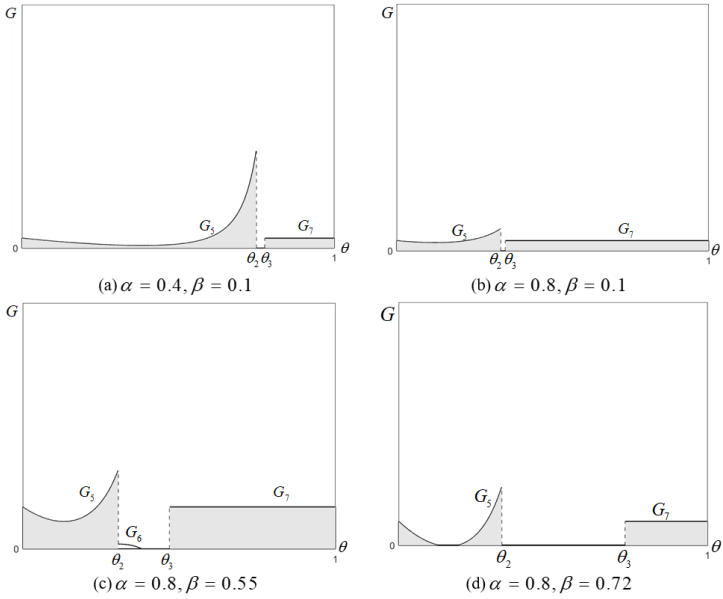

Fig. 4. Store brand introduction decisions when manufacturer chooses dual channel structure after encroachment (the grey area is the introduction of store brand)

4.3 Strategies for Manufacturer Encroachment and Channel Structure

When manufacturer has established the direct channel, manufacturer and e-tailer must decide to choose the direct-only channel structure or dual-channel structure. We compare the manufacturer and e-tailer's optimal payoffs under those two structures when the e-tailer has introduced the SB product and has not, respectively. Then, we derive the sub-game equilibrium for channel structure and get the following proposition.

4.3.1 If the Manufacturer has Encroached, Which Channel Structure will be Chosen?

Proposition 2. *When the manufacturer has encroached on the retail market, the manufacturer chooses the direct-only structure if* $\theta \in (0, \theta_2], G \in (G_4, G_5]$*; the manufacturer and e-tailer choose the direct-only structure if* $\theta \in (\theta_2, \theta_3], G \in (G_4, +\infty)$ *or* $\theta \in (\theta_3, 1)$*, there is no difference between the manufacturer's choice of the direct-only structure and the dual channel structure; otherwise, he always chooses the dual-channel structure.*

Proposition 2 presents the conditions under which the manufacturer chooses different channel structures. When the agency fee is low, the manufacturer will choose either the direct-only channel structure or the dual channel structure and sell it on the e-tailer's platform in agency selling mode. However, if consumers have a high preference for the direct channel ($\alpha > \alpha'$), the e-tailer will introduce store brand under the dual-channel structure and not introduce under the direct-only channel structure, the manufacturer will choose to sell its products only through the direct channel in order to avoid the threat of store brand. When the agency fee is moderate and the cost of store brand introduction is high, or the agency fee is high, the manufacturer's choice of a direct-only or dual-channel structure is the same. This is because when the agency fee is moderate and the cost of store brand introduction is high, e-tailer does not introduce store brand, and the manufacturer chooses the reselling model if he cooperates with the platform. The manufacturer's direct channel under the dual channel structure does not generate sales ($q_d^{dNR*} = 0$) and is only used as an advertising or a threat to the e-tailer, so the direct channel does not generate revenue, and the wholesale revenue generated by the retail channel is the same as the revenue under the direct-only channel structure ($\pi_m^{dNR*} = \pi_m^{sN*}$).When the agency fee is high, the same situation as above arises regardless of whether the e-tailer introduces a store brand or not. In other cases, the manufacturer chooses a dual channel structure.

4.3.2 Manufacturer Encroachment Decisions.

Based on the results of previous studies, the manufacturer's encroachment decision is obtained by comparing the manufacturer's profit under no encroachment with the profit under encroachment. Existing literature [1] suggests that the agency fees of e-tailer is basically in the range of 5%-25%, e.g., Jingdong's agency fees are in the range of 3%-10%; therefore, this paper considers the game equilibrium in the case of a reasonable agency fee, i.e., $\theta \in (0, 0.5)$.

Proposition 3.

(1)When $\theta, G \in \Omega_1$, *the manufacturer encroaches to the market when* $F \in (0, F_1]$ *(i.e., dNA), while forgoes encroachment otherwise (i.e., nNA);*

(2)When $\theta, G \in \Omega_2$, *the manufacturer encroaches to the market when* $F \in (0, F_2]$ *(i.e., dNA), while forgoes encroachment otherwise (i.e., nSA);*

(3)When $\theta, G \in \Omega_3$, *the manufacturer encroaches to the market when* $F \in (0, F_3]$ *(i.e., dSA), while forgoes encroachment otherwise (i.e., nNA);*

(4)When $\theta, G \in \Omega_4$, *the manufacturer encroaches to the market when* $F \in (0, F_4]$ *(i.e., dSA), while forgoes encroachment otherwise (i.e., nSA);*

(5)When $\theta, G \in \Omega_5$, *the manufacturer encroaches to the market when* $F \in (0, F_5]$ *(i.e., dNR), while forgoes encroachment otherwise (i.e., nNA);*

(6)When $\theta, G \in \Omega_6$, *the manufacturer encroaches to the market when* $F \in (0, F_6]$ *(i.e., dNR), while forgoes encroachment otherwise (i.e., nSA);*

(7)When $\theta, G \in \Omega_7$, *the manufacturer encroaches to the market when* $F \in (0, F_7]$ *(i.e., dSR / sS), while forgoes encroachment otherwise (i.e., nNA);*

(8)When $\theta, G \in \Omega_8$, *the manufacturer encroaches to the market when* $F \in (0, F_8]$ *(i.e., dSR / sS), while forgoes encroachment otherwise (i.e., nSA);*

(9)When $\theta, G \in \Omega_9$, *the manufacturer encroaches to the market when* $F \in (0, F_9]$ *(i.e., sN), while forgoes encroachment otherwise (i.e., nNA);*

(10)When $\theta, G \in \Omega_{10}$, *the manufacturer encroaches to the market when* $F \in (0, F_{10}]$ *(i.e., dNR/sN), while forgoes encroachment otherwise (i.e., nNA).*

Where

$$\Omega_1 : \{\theta \in (0, \min(\theta_2, 0.5)], G \in (G_1, +\infty) \cup G \in (G_5, +\infty)\}$$

$$\Omega_2 : \{\theta \in (0, \min(\theta_2, 0.5)], G \in (G_5, G_1]\}$$

$$\Omega_3 : \{\theta \in (0, \min(\theta_2, 0.5)], G \in (G_1, G_5] \cup G \in (G_1, G_4]\} \cup \{\theta \in (\theta_2, \min(\theta_3, 0.5], G \in (G_1, G_6]\}$$

$$\Omega_4 : \{\theta \in (0, \min(\theta_2, 0.5)], G \in (0, G_5] \cup G \in (0, G_1]\} \cup \{\theta \in (\theta_2, \min(\theta_3, 0.5)], G \in (0, \min(G_1, G_6)]\}$$

$$\Omega_5 : \{\theta \in (\theta_2, \min(\theta_3, 0.5)], G \in (\max(G_6, G_1), G_4]\}$$

$$\Omega_6 : \{\theta \in (\theta_2, \min(\theta_3, 0.5)], G \in (G_6, G_1]\}$$

$$\Omega_7 : \{\theta \in (\theta_3, 0.5), G \in (G_1, G_4]\}$$

$$\Omega_8 : \{\theta \in (\theta_3, 0.5), G \in (0, G_1]\}$$

$$\Omega_9 : \{\theta \in (0, \min(\theta_2, 0.5)], G \in (G_4, G_5]\}$$

$$\Omega_{10} : \{\theta \in (\theta_2, 0.5), G \in (G_4, +\infty)\}$$

$$F_1 = \frac{\alpha(1-\theta)\theta^2}{4(4(1-\theta) - \alpha(2-\theta)^2)}$$

$$F_2 = \frac{(1-\theta)(2\beta(1-\theta)^2 + \alpha\theta^2 - \alpha\beta(2-4\theta+3\theta^2))}{2(\alpha(2-\theta)^2 - 4(1-\theta))(-2+\beta+\beta\theta)}$$

$$F_3 = \frac{\alpha(1-\theta)(\alpha\theta^2 - \beta(2-2\alpha(1-\theta)-2\theta+\theta^2))}{-4\alpha^2(2-\theta)^2 - 8\beta(1-\theta) + 4\alpha(4-4\theta+\beta(2-2\theta+\theta^2))}$$

$$F_4 = \frac{(1-\theta)(\alpha^2\theta^2 + \alpha\beta\theta(-2+\alpha(2-3\theta)+\theta) - \beta^2((1-\theta)^2 + \alpha^2(1-\theta^2) - \alpha(2-2\theta+\theta^2)))}{2(2-\beta-\beta\theta)(-\alpha^2(2-\theta)^2 - 2\beta(1-\theta) + \alpha(4-4\theta+\beta(2-2\theta+\theta^2)))}$$

$$F_5 = \frac{1}{4}(\alpha+\theta-1)$$

$$F_6 = \frac{\alpha}{4} - \frac{(1-\theta)(1-\beta)}{2(2-\beta-\beta\theta)}$$

$$F_7 = \frac{\alpha(\alpha-\beta)}{2(2\alpha-\beta)} - \frac{1-\theta}{4}$$

$$F_8 = \frac{1}{8}\left(\frac{4\alpha(\alpha-\beta)}{2\alpha-\beta} + \frac{4(1-\beta)(1-\theta)}{-2+\beta+\beta\theta}\right)$$

$$F_9 = \frac{1}{4}(\alpha+\theta-1)$$

$$F_{10} = \frac{1}{4}(\alpha+\theta-1)$$

Corollary 2. *(1)* F_1, F_2, F_3, F_4, F_5, F_6, F_7, F_8, F_9, F_{10} *all increase with* α *.(2)* F_1, F_5, F_9, F_{10} *are irrelevant to* β *;* F_2 *and* F_6 *increase with* β *;* F_3, F_4, F_7, F_8 *decrease with* β *.(3)* F_1, F_3, F_4, F_5, F_6, F_7, F_8, F_9, F_{10} *all increase with* θ, F_2 *decrease first then increase with increasing* θ.

Based on the results of Proposition 3, under the condition that all equilibrium solutions are guaranteed to be meaningful, we obtain the equilibrium of the game under different intervals respectively, as shown in Figure 5-7.

As in Corollary 2 (1), with the increase of α, the threshold of the manufacturer's encroachment cost increases and the equilibrium region of the manufacturer's encroachment expands, which indicates that increasing the consumer's preference for the direct channel benefits the encroachment strategy (compare Figure 5(a) and (b), Figure 7(b) and (d)). However, when $\theta \in (\theta_2, \min(\theta_3, 0.5)]$, comparing Figure 6(a) and (b), the decrease of α is not favorable to encroachment but at the same time increases the lower bound θ_2, and the cost of encroachment F_5, F_6 is positively correlated with θ, so the decrease in α increases the equilibrium outcome of the manufacturer's encroachment.

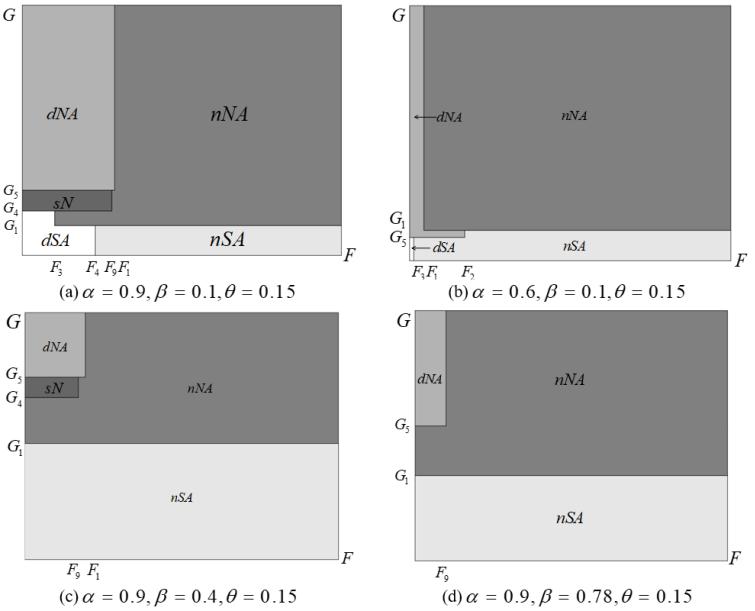

Fig. 5. Equilibrium when $\theta \in (0, \min(\theta_2, 0.5)]$

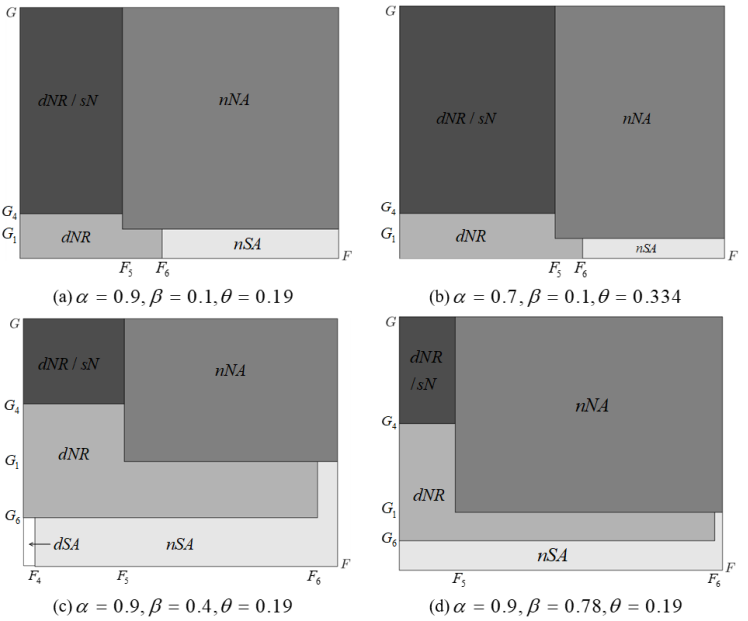

Fig. 6. Equilibrium when $\theta \in (\theta_2, \min(\theta_3, 0.5)]$

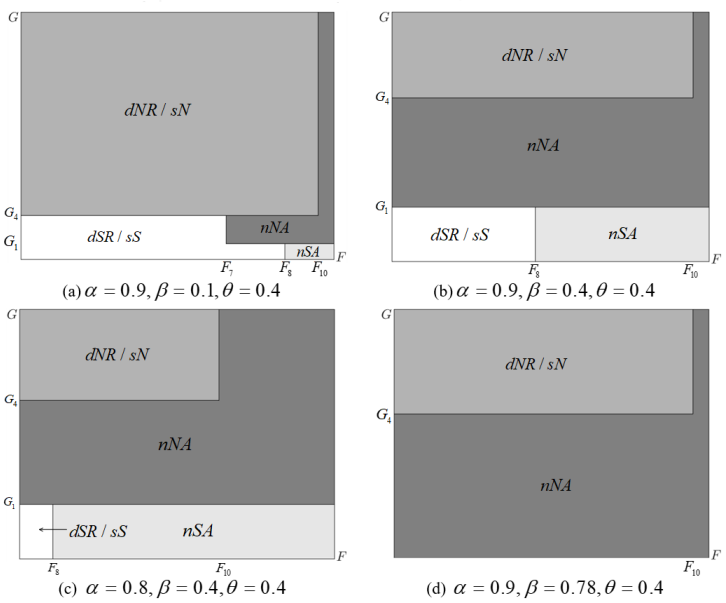

Fig. 7. Equilibrium when $\theta \in (\theta_3, 0.5)$

Proposition 4. *E-tailer can impede manufacturer's encroachment by increasing the quality of store brand or lowering agency fee.*

Proposition 4 suggests that under certain circumstances, e-tailer can take measures to reduce the likelihood of manufacturer encroachment or even prevent this behavior. As shown in Corollary 2, the increase of β facilitates the introduction of store brand, while at the same time inhibiting manufacturer's encroachment strategy (compare Figure 5(a) and (c), Figure 6(a) and (c), Figure 7(a) and (b)). As β increases, the quality gap between the store brand and the manufacturer's products continues to decrease, the manufacturer faces competitive pressure on its products to lower the price of products, resulting in lower profits, so that the manufacturer's cost (F_3, F_4, F_7, F_8) for establishing direct sales channels also decreases. The cost threshold for manufacturer encroachment is negative when β increases above a certain threshold, i.e. $F_3 < 0$ when $\beta > \beta_1'$, encroachment will not result in increased profits for manufacturer. This is because, when β reaches a high level, the competition for products in the market is very intense, and adding a new sales channel at this time will make the originally tight market seem even more crowded, at which time the revenue from the direct sales channel cannot make up for the loss of profit from the retail channel, so the manufacturer forgoes the encroachment. However, when β is at a high level, an increase in β does not favor the introduction of e-tailer store brand. Comparing Figure 5(c) and (d), Figure 6(c) and (d), Figure 7(b) and (d), it is found that higher β reduces the area of store brand introduction, because higher quality leads to intense competition, so it does not favor the introduction of store brand by e-tailer.

Comparing Figure 5(a), Figure 6(a) and 7(a), combined with Corollary 2(3), the threshold for encroachment decreases in θ, which suggests that a decrease in the agency fee is also beneficial in deterring the manufacturer from implementing the encroachment strategy. And when θ reduced to a certain level (e.g., $F_3 < 0$ when $\theta < \theta_1'$), the manufacturer can obtain higher revenue from the e-tailer's low agency fee without encroachment, so there is no need to increase profit by encroachment anymore.

Proposition 5. *When the agency fee is moderate, the manufacturer's encroachment strategy prevents store brands from entering the market; when the agency fee is low or high, the encroachment strategy is an ineffective threat to the e-tailer.*

As shown in Figure 6, when the agency fee is moderate ($\theta \in (\theta_2, \min(\theta_3, 0.5)]$), if the manufacturer's cost of encroachment is intermediate and the cost of store brand introduction is not too high ($F_5 < F < F_6$, $G < G_1$), these two fixed costs are not the only drivers of these companies' decisions. F_5 are the thresholds at which a manufacturer can establish a direct sales channel without a store brand, $F > F_5 \Leftrightarrow \pi_m^{dNR*} < \pi_m^{nNA*}$. Thus, without the threat of store brand, manufacturer will not encroach. If the manufacturer does not have a direct channel, e-tailer will introduce store brand (nSA) and the introduction of store brand will result in a much higher loss of profits for the manufacturer. Therefore, the manufacturer will establish a direct channel to prevent the entry of store brand (dNR). This suggests that the manufacturer's encroachment strategy is a mechanism for manufacturer to prevent e-tailer from introducing store brands. However, when $\theta \in (0, \min(\theta_2, 0.5)]$ or $\theta \in (\theta_3, 0.5)$, the manufacturer's encroachment strategy fails to prevent store brand from entering the market. As in region $F_3 < F < F_4$ in Figure 5(a) (or $F_7 < F < F_8$ in Figure 7(a)), if manufacturer does not encroach, e-tailer will not introduce store brand; if manufacturer encroaches, e-tailer will introduce store brand; this is because the loss of profit to e-tailer caused by the encroachment is greater than the cost of introducing a store brand.

Proposition 6. *Manufacturer's direct-only channel structure could prevent e-tailer from introducing store brand.*

Interestingly, under certain conditions, a manufacturer's channel structure strategy can also prevent store brand from entering the market. As shown in Proposition 2, Figure 5(a) and (c), when the agency fee is small ($\theta \in (0, \min(\theta_2, 0.5)]$), if the direct channel disadvantage is small ($\alpha > \alpha'$) and the quality of the store brand is not too high, the manufacturer's choice of a direct-only channel structure prevents the e-tailer from introducing store brand. This is because the cost interval for store brand introduction is smaller in the direct-only channel structure ($G_4 < G_5$), when the cost of store brand introduction is at a medium level ($G \in (G_4, G_5]$), e-tailer does not introduce store brand when the manufacturer chooses the direct-only channel structure (sN), and store brand are introduced in the dual-channel structure (dSA), so the manufacturer, in order to avoid the loss of profit that store brand would cause for him, chooses the direct-only channel structure to prevent the entry of store brand.

5 Conclusions

By constructing a supply chain system consisting of a manufacturer and an e-tailer, this paper explores the interaction between the manufacturer's encroachment, sales modes and the e-tailer's store brand strategy, and obtains the following main conclusions: First, when manufacturer does not encroach, e-tailer is more likely to introduce store brand at moderate levels of agency fees, whereas when manufacturer encroaches and chooses a dual-channel structure, e-tailer is more likely to introduce store brand at lower or higher levels of agency fees. In addition, a moderate increase in the quality of the store brand facilitates the e-tailer's the introduction strategy, but a higher quality may have the opposite effect. Second, when the agency fee is at a low level, a manufacturer's direct-only channel structure can prevent store brand from entering the market if the direct channel disadvantage is small; manufacturer's encroachment strategy can also prevent e-tailer from introducing store brand when the agency fee is at a moderate level. Third, increasing consumer preference for the direct channel favors the manufacturer's encroachment strategy, whereas e-tailers can deter encroachment by increasing the quality of store brand or lowering the agency fee.

Our study also has some limitations. In this paper, we assume that the quality of store brand is less than that of manufacturer's products, while with the continuous development of store brands, high-quality and premium store brands have appeared, therefore, in the future, we can consider the situation that the quality of store brand is higher than manufacturer's products. In addition, we assume that there is no information occlusion between manufacturer and e-tailer, but in real life there will be information asymmetry, so this is also a direction that can be studied in the future.

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