

OPTIMAL MARKETING CHANNEL AND STRATEGY IN SOCIAL COMMERCE

XU CHEN¹, YINGLIANG WU^{1,2,*}  AND RUJIE ZHONG³

Abstract. This paper aims to explore the optimal marketing channel of e-commerce enterprises with various consumer base size and product added-value in social commerce. By characterizing the consumer utility, we construct decision-making models of e-commerce enterprises under the traditional e-commerce platform (TECP) and two kinds of social commerce marketing channels involving “e-commerce platform + social” (ECPS) and “social media + business” (SMB). Then, we obtain the optimal strategy of e-commerce enterprises for each channel by using the Karush–Kuhn–Tucker (KKT) conditions, and verify the effectiveness of the corollaries by numerical simulation. Results find that social commerce marketing channels (ECPS and SMB) are not necessarily better than TECP. For e-commerce enterprises with low consumer base size and low product added-value, the TECP channel offers the largest profit. Besides, SMB is the preferred marketing channel for most e-commerce enterprises.

Mathematics Subject Classification. 90B60, 90C30.

Received August 4, 2021. Accepted April 17, 2022.

1. INTRODUCTION

In the new round of digital transformation, social commerce (SC) is one of the most popular frontier issues in business change and digital commerce, which is regarded to drive future business and economic prosperity [3, 10]. In 2018, the scale of China’s social commerce industry reached 626.85 billion yuan, with a yearly growth of 255.8%. The proportion of social commerce in China’s overall online shopping market in 2018 increased to 7.8%, from only 0.1% in 2015 [12]. Social commerce refers to the business activities based on social network service platforms or tools. It is a new e-commerce model reflecting the social value derived from network socialization [35]. The main marketing channels in social commerce are the “e-commerce platform + social” (ECPS) channel and the “social media + business” (SMB) channel. For example, “Pinduoduo”¹, the largest platform of ECPS channel, integrates social attributes on the basis of the e-commerce platform [42]. Its revenue has increased by 67% to 12.193 billion yuan in the second quarter of 2020 [26]. In this channel, consumers need to share the bargaining links with their friends to get preferential prices; Besides, “WeChat business” is one of

Keywords. Social commerce, marketing channel, decision-making model, KKT conditions, nonlinear programming.

¹ Department of Electronic Business, South China University of Technology, Guangzhou Higher Education Mega Center, Guangzhou 510006, P.R. China.

² Institute of Digital Business and Intelligent Logistics, South China University of Technology, Guangzhou Higher Education Mega Center, Guangzhou 510006, P.R. China.

³ School of Informatics, University of Edinburgh, Edinburgh EH8 9LE, UK.

*Corresponding author: bmylwu@scut.edu.cn

¹<https://www.pinduoduo.com/>.

the representatives of the SMB channel, which combines e-commerce transactions on the basis of social media (WeChat). Its transaction scale of China's WeChat market has exceeded 2 trillion yuan, and the number of practitioners has reached 60 million in 2019 [13]. In this channel, consumers can buy products through WeChat friends' recommendations [20].

The rise of social commerce marketing has contributed to a tripartite win-win situation among consumers, platforms or social media, and e-commerce enterprises. For consumers, they can get higher bargaining power through their social attributes to reduce the purchase cost; For platforms or social media, they can win the fixed fee or flow benefits as the intermediary role; For e-commerce enterprises, in addition to traditional e-commerce platforms (*e.g.*, Taobao² and Jingdong³, two top 3 largest e-commerce platforms in China with sales of 3202 billion yuan and 2600 billion yuan respectively in 2020 [8]), new marketing options are added to obtain higher profits and scale.

Previous scholars have fully studied the multi-channel selection strategy of e-commerce enterprises in the traditional e-commerce context [39]. But few studies focus on the context of social commerce. Among them, most research involves the ECPS channel and only considers once forwarding of the consumer [4, 40, 41]. However, the ECPS channel is the initial model of social commerce marketing, while the SMB channel derived from broader social media requires more focus [16]. In addition, consumers in social commerce only forwarding once seem to deviate from real life. Typically, one consumer can forward to a few friends, who can continue forwarding if interested. To fill these gaps, we assume that one consumer who received the bargaining link can continue forwarding. We develop three decision-making models and analyze the optimal strategies of e-commerce enterprises in different marketing channels: (1) traditional e-commerce platform (TECP); (2) e-commerce platform with social attributes (ECPS); (3) social media with business functions (SMB). In addition, we interpret the advantages and disadvantages of marketing channel selection from the perspective of marketing coverage, which fixes the singleness problem of maximum-profit decision-making. We aim to solve the following research questions:

- (1) Which marketing channel should e-commerce enterprises with limited cost choose to obtain the maximum profit?
- (2) Must the social commerce marketing channels (ECPS and SMB) be better than the traditional e-commerce platform (TECP)?
- (3) What are the factors in social commerce marketing that significantly affect the profitability of e-commerce enterprises?

The rest of this paper is organized as follows: Section 2 summarizes the relevant literature of enterprise decision-making in social commerce and social commerce marketing channels. Section 3 models the decision-making of e-commerce enterprises in three marketing channels. Section 4 makes a multi-dimensional comparative analysis of the e-commerce enterprises' decision-making. Section 5 analyzes the reliability of the corollaries by numerical simulation. Theoretical contributions and practical implications are presented in Section 6.

2. LITERATURE REVIEW

The literature of this study mainly consists of two parts: enterprise decision-making in social commerce and social commerce marketing channels.

2.1. Enterprise decision-making in social commerce

Previous studies have paid much attention to consumer decision-making in social commerce, such as consumer decision-making styles [6], consumer avoidance [19, 32], decision factors of choosing the market [22]. A small number of scholars focus on the research of enterprises decision-making in social commerce, involving

²<https://www.taobao.com/>.

³<https://www.jd.com/>.

the profitability and sustainable development of enterprises. In the multi-channel competition, the choice difference of social media platforms affects the enterprises' profitability through consumers' perceived quality of products [34]. Information sharing in social commerce improves consumer trust in the platform enterprises to significantly reduce consumers' perceived privacy risk, conducive to the sustainable development of platform enterprises in emerging markets [2].

Besides, the research topics of enterprises decision-making in social commerce mainly concentrate on price strategy, service strategy, competition strategy, marketing strategy and closure strategy. Specifically, in terms of price strategy, Jiang *et al.* [14] discuss the impact of social network structure, sales strategy differences and price adjustment frequency on the e-commerce enterprises' profit, to reveal the price dispersion under different sales strategies. In terms of marketing strategy, Zhu *et al.* [43] construct a hierarchical graph to predict the user interest in social commerce to optimize the social marketing decision-making of e-commerce enterprises; Sabaityte *et al.* [29] construct a decision-tree model to identify the preferences of different types of e-consumers for e-marketing communication modes, to adjust the marketing strategy of e-commerce enterprises. In terms of competition strategy, Chen *et al.* [7] construct the evaluation model of the social commerce ecosystem and niches to evaluate the competitiveness and sustainability of four types of social commerce enterprises. In terms of closure strategy, Trivella *et al.* [33] improve the shutdown decision of enterprises by introducing the social preference to reduce the possibility of regrettable social consequences.

2.2. Social commerce marketing channels

Different social commerce structures (community and forum, rating and comment, recommendation) and relationship factors significantly impact consumers' willingness to participate in social commerce [31, 38]. Therefore, based on the typical social commerce platforms formed by the differentiated structures and the strength of social ties, this study identifies and summarizes two different social commerce marketing channels, *i.e.*, "e-commerce platform + social" (ECPS) and "social media + business" (SMB).

2.2.1. ECPS marketing channel

ECPS channel relies on e-commerce platform and integrates social attributes, which is the basic mode of social commerce marketing. The most typical and widely studied model is social group buying (SGB).

In the case of publishing retail prices and considering consumers' heterogeneous preferences, whether e-commerce enterprises provide SGB options and which option combination is the best are the primary research issues to be considered [23]. Secondly, the optimal decisions of SGB have also been widely studied, such as the optimal price and order quantity [5, 42]. For example, Wu and Zhu [36] discuss the optimal decision of enterprises considering the joint strategy of service quality and price under the SGB; Deng *et al.* [9] propose an analytical model for the optimal price and maximum transaction size of sellers with limited capacity on the SGB platform. They believe that even if the transportation capacity is tight, the deep discount is also beneficial; Zhu *et al.* [44] propose an SGB pricing method with continuous price, which encourages consumers to reflect their preferences truthfully through compensatory payment to reduce consumers' false reports as much as possible.

Different from the fixed price-quantity table and static pricing [24], Ong *et al.* [25] focus on the dynamic changes of SGB enterprises' profitability with the time-continuous model. In addition to considering enterprise profitability, some scholars also investigate sustainable development factors such as supervision and fairness. For example, Jiang *et al.* [15] explore the impact of enterprises' honesty strategy on building a healthy SGB environment under government supervision; He *et al.* [11] discuss the optimal SGB strategy for different enterprises with fairness concerns in the supply chain. Besides, because social cost inhibits consumers' recommending motivation on social networks [4], it negatively impacts the ECPS marketing channel [37]. Therefore, based on the previous SGB models, we focus on the social cost and design a forwarding-bargaining model with multiple iterations to study the ECPS channel.

TABLE 1. Comparison of some related research and this study.

Related research	Method	Offline channel	TECP	SC channels	
				ECPS	SMB
Zhang <i>et al.</i> [42]	M		✓	✓	
Zhang and Xu [40]	M		✓	✓	
Zhang and Xu [41]	M			✓	
Wu <i>et al.</i> [37]	M	✓		✓	
Cao and Li [4]	M			✓	
Kim N. and Kim W. [16]	E				✓
This study	M		✓	✓	✓

Notes. (1) “E” and “M” represent the empirical analysis and the mathematical model, respectively. (2) “✓” means “covered”.

2.2.2. SMB marketing channel

Social media has broadened the social width of consumers, and the relationship network in the online community has been fully studied [30]. With the help of consumers’ high stickiness to social media, business models that embed business attributes into social media (*e.g.*, WeChat Mini Program, clickbait promotion, etc.) give full play to the role of guanxi and have a positive impact on consumers’ purchase intention and loyalty [21, 27]. Social media carries users’ social desire and business desire, and users will be affected by the suggestions and shopping lists of social friends during picking products [17]. On the other hand, the tie strength reflected by the different friend types is positively correlated with the trust, which further affects the purchase decision in the network [20]. Specifically, it has a significant impact on consumers’ purchase intention after being recommended, and the impact from friends with stronger ties is more positive [28].

The diversified development of social media has spawned the new business models of social commerce, such as Facebook commerce [1, 18] and WeChat business [21, 27]. In SMB marketing, social influence generated by social referral significantly promotes social commerce sales, but this influence is different among various social media [16]. Instead of focusing on Facebook commerce with relatively weak ties as the previous research, this paper selects the particular agent model of WeChat business with strong ties to study the impact of SMB marketing on e-commerce enterprise profitability.

Throughout the research on the influence of marketing channels on enterprise profitability in social commerce (as shown in Tab. 1), most of them involve one single marketing channel and focus on ECPS. The research on enterprise decision-making in the SMB channel is fewer and mainly uses empirical analysis rather than mathematical models. This paper provides a comprehensive comparison of three marketing channels consisting of TECP, ECPS and SMB.

3. MARKETING DECISION MODELS OF E-COMMERCE ENTERPRISES

In this section, we first describe the research problem and introduce the notations used in the following models, then discuss the decision-making of e-commerce enterprises in the three marketing channels (TECP, ECPS and SMB) one by one and analyze their optimal strategies.

3.1. Problem description and notations

When an e-commerce enterprise enters a new market, it needs to choose one marketing channel. We present three marketing channels, namely, traditional e-commerce platform (TECP), “e-commerce platform + social” (ECPS) and “social media + business” (SMB), as shown in Figure 1. Specifically, the e-commerce enterprise can promote products relying on the search function of the platform, iterative forwarding behavior of consumers and recommendation of agents, respectively. Therefore, in different models, the decision variables of the enterprise

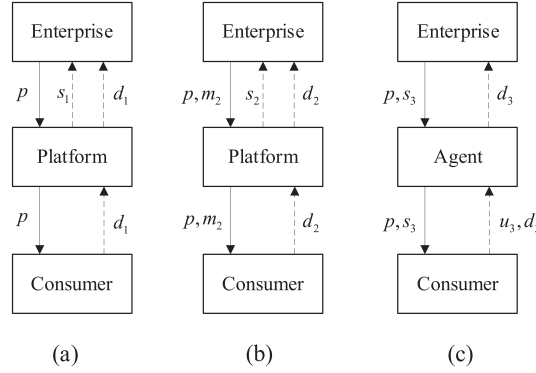


FIGURE 1. Structures of marketing channels. (a) TECP. (b) ECPS. (c) SMB.

are various due to the channel characteristics and marketing scenarios. The consumers will purchase if they can get a non-negative surplus, and each consumer can only buy the product once at most. The e-commerce enterprise will choose a certain marketing channel where it can get the maximum profit. Related notations and assumptions used in the models are shown in Table 2.

3.2. Decision-making model in TECP channel

We first introduce the strategy of e-commerce enterprises when they choose to enter the traditional e-commerce platform (*e.g.*, Taobao and Jingdong). Consumers' expected utility of products is

$$\pi_1 = \theta q - p \quad (3.1)$$

where θ is the consumer perception to unit product quality and p is the product price. Consumers' perception of product quality is different, and we assume that θ obeys the uniform distribution of $[0, 1]$ in this paper. When $\pi_1 \geq 0$, consumers will choose to purchase, so we can get the consumer purchase proportion $d_1 = \frac{q-p}{q}$. To ensure the existence of the proportion, the condition $0 \leq d_1 \leq 1$ should be met. Assume that all consumers on the platform can receive product information when the enterprise selecting TECP channel, then $C_1 = N_1$. Let c be the product cost, and s_1 represents the fixed fee that traditional e-commerce platform charges enterprises for each sold product, then the profit of the e-commerce enterprise can be computed.

$$R_1 = N_1 \left(\frac{q-p}{q} \right) (p - c - s_1). \quad (3.2)$$

The profit optimization problem can be solved by computing the partial derivative of equation (3.2) with respect to p and letting it be 0.

$$p^* = \frac{q + c + s_1}{2}, R_1^* = \frac{N_1(q - c - s_1)^2}{4q}. \quad (3.3)$$

Proposition 3.1. When e-commerce enterprises choose TECP channel to sell products, the optimal price is $p^* = \frac{q+c+s_1}{2}$, the maximum profit is $R_1^* = \frac{N_1(q-c-s_1)^2}{4q}$.

Corollary 3.2. In TECP channel, the optimal price p^* rises with the increase of q , c and s_1 and the maximum profit R_1^* is not related to the consumer base size n .

With the increase of product quality q , the bargaining power of e-commerce enterprises improves, and the product price p rises accordingly; With the rise of the product cost c and fixed fee s_1 , e-commerce enterprises

TABLE 2. Notations and definitions.

	Notations	Descriptions
Basics	p	Product price
	c	Product cost
	q	Product quality
	θ	Consumer perception to unit product quality, obeying the uniform distribution of $[0, 1]$
	n	Consumer base size of e-commerce enterprises
	N	Total number of potential consumers
TECP	s_1	The fixed fee that traditional e-commerce platform charges enterprises for each sold product
	d_1	Consumer purchase proportion in the TECP channel
	D_1	Number of consumers on the TECP
	C_1	Number of consumers covered on the TECP, to whom the products information is disseminated
	N_1	Total number of potential consumers on the TECP, $N_1 < N$
	R_1	Enterprise profit on the TECP
ECPS	m_2	Forwarding number set by the e-commerce enterprise
	t_2	Forwarding cost of each forwarding consumer, obeying the uniform distribution of $[0, 2T_2]$
	T_2	Average forwarding cost in society
	s_2	The fixed fee that social commerce platform charges enterprises for each sold product
	d_2	Consumer forwarding-purchasing proportion in the ECPS channel
	D_2	Number of consumers in the ECPS channel
	C_2	Number of consumers covered in the ECPS channel
	R_2	Enterprise profit in the ECPS channel
SMB	α_3	Trust index of potential consumers to agent consumers
	m_3	Number of social contacts of each agent consumer
	t_3	Agent cost of each agent consumer, obeying the uniform distribution of $[0, 2T_3]$
	T_3	Average agent cost in society
	u_3	Flow benefits brought by each purchase through agent consumers' recommendation
	s_3	The fixed fee that enterprises need to pay agent consumers for each sold product
	d_3	Consumer purchase proportion in the SMB channel
	d'_3	Consumer agent proportion, the proportion of agent consumers in consumer base size in the SMB channel
	D_3	Number of consumers in the SMB channel
	C_3	Number of consumers covered in the SMB channel
	R_3	Enterprise profit in the SMB channel

will raise the product price p to ensure the profit space. Besides, when e-commerce enterprises choose to settle in the TECP, they will depend on the platform's search function rather than the consumer base size n for promotion. Therefore, the decision-making of e-commerce enterprises is not related to n . For those e-commerce enterprises with low n , the TECP channel could be a good choice.

3.3. Decision-making model in ECPS channel

This sub-section describes the strategy of e-commerce enterprises when they settle in social commerce platforms (*e.g.*, Pinduoduo). In this case, only after consumers forward product links and make m_2 friends "click to bargain" can they buy the product. The cost for consumers to forward and make one friend "click to bargain" is t_2 , describing its social difficulty. Therefore, consumers' expected utility of products is

$$\pi_2 = \theta q - p - m_2 t_2. \quad (3.4)$$

With $\pi_2 \geq 0$, we can obtain the consumer forwarding-purchasing proportion $d_2 = \frac{q-p-m_2 t_2}{q}$. To ensure the existence of the proportion, the condition $0 \leq d_2 \leq 1$ should be met.

We refer to those willing to forward links to m_2 friends and purchase the product as *forwarding consumers*. In the social commerce platform, the links can be forwarded round by round, and the link receivers of the current round will become potential forwarding consumers for the next round. Let n and N be the consumers base size of the enterprise and the total number of potential consumers. After L round forwarding, the number of consumers who receive the links will be

$$C_2(L) = n + nd_2m_2 + n(d_2m_2)^2 + \cdots + n(d_2m_2)^L = n \frac{1 - (d_2m_2)^{L+1}}{1 - d_2m_2}. \quad (3.5)$$

Let s_2 be the fixed fee that the social commerce platform charges e-commerce enterprises for each sold product. When $d_2m_2 \geq 1$ and $L \rightarrow \infty$, $n(L) = N$, the decision-making of e-commerce enterprises is expressed as the equation (3.6).

$$\begin{cases} p^*, m_2^* = \operatorname{argmax}_{p, m_2} N d_2(p - c - s_2) \\ \text{s.t. } d_2m_2 \geq 1, 0 < d_2 < 1, m_2 \geq 0. \end{cases} \quad (3.6)$$

When $d_2m_2 < 1$ and $L \rightarrow \infty$, $n(L) = \min\left(\frac{n}{1-d_2m_2}, N\right)$, the decision-making of e-commerce enterprises is expressed as the equation (3.7).

$$\begin{cases} p^*, m_2^* = \operatorname{argmax}_{p, m_2} \left(\min\left(N, \frac{n}{1-d_2m_2}\right) d_2(p - c - s_2) \right) \\ \text{s.t. } d_2m_2 < 1, 0 < d_2 < 1, m_2 \geq 0. \end{cases} \quad (3.7)$$

By applying the KKT conditions, the following proposition can be obtained.

Proposition 3.3.

$$\text{When } (q - c - s_2)^2 < 4qt_2, m_2^* = 0, p^* = \frac{q + c + s_2}{2}, R_2^* = \frac{n(q - c - s_2)^2}{4q} \quad (3.8)$$

$$\begin{aligned} \text{When } (q - c - s_2)^2 \geq 4qt_2, m_2^* &= \frac{2q(N - n)}{N(q - c - s_2)}, p^* = \frac{q + c + s_2}{2} - \frac{2qt_2(N - n)}{N(q - c - s_2)}, \\ R_2^* &= \frac{N(q - c - s_2)^2}{4q} - (N - n)t_2. \end{aligned} \quad (3.9)$$

We use condition A to denote $(q - c - s_2)^2 \geq 4qt_2$ for the following corollaries.

Corollary 3.4. *In ECPS channel, if and only if condition A holds, e-commerce enterprises will enter the forwarding mode (i.e., $m_2^* > 0$). Otherwise, even if e-commerce enterprises choose ECPS channel, the optimal forwarding number is zero.*

We define $q - c$ as the product added-value, that is, products' extra value through produced and processed. When the product added-value is lower, e-commerce enterprises' profit space is narrow, and thus the pricing range is limited. In this case, if e-commerce enterprises increase the forwarding number m_2 to cover more consumers, but can not reduce the price to ensure consumers' purchase intention, then the growth of the number of consumers covered cannot offset the loss of the forwarding-purchasing proportion, and therefore they will not choose the forwarding mode. In contrast, when the product added-value is higher, e-commerce enterprises' profit space is wide, and the pricing range is large. In this case, e-commerce enterprises can increase the forwarding number m_2 and reduce the price to ensure the continuity of the forwarding process and bring more profits.

Corollary 3.5. *For the e-commerce enterprises that cannot meet condition A, the decision logic is similar to that of the TECP channel. In this case, the optimal price p^* rises with the increase of q , c and s_2 , and the maximum profit R_2^* is not related to N (Eq. (3.8)); The e-commerce enterprises meeting the condition A will choose to reduce the price significantly and set m_2 to just cover all potential consumers (Eq. (3.9)).*

It is worth noting that the first items of the optimal price p^* and the maximum profit R_2^* in equation (3.9) are similar to those in the TECP channel (Eq. (3.3)); The second items are the sum of the unit forwarding costs that e-commerce enterprises need to pay to enter the forwarding mode. Therefore, it can be clearly seen where the ECPS channel is different from the TECP channel.

3.4. Decision-making model in SMB channel

This sub-section discusses the strategy of e-commerce enterprises when they draw support from social media (e.g., WeChat) to sell products. We refer to each consumer who is willing to recommend and sell products on social media as an agent consumer. The trust index of potential consumers to agent consumers is α_3 . Consumers' expected utility of products is

$$\pi_3 = \alpha_3 q + (1 - \alpha_3)\theta q - p. \quad (3.10)$$

With $\pi_3 \geq 0$, we can obtain the consumer purchase proportion $d_3 = \frac{q-p}{(1-\alpha_3)q}$. To ensure the existence of the proportion, the condition $0 \leq d_3 \leq 1$ should be met.

Assume agent consumers can obtain flow benefits u_3 if the consumers are attracted to their recommendations and buy products through social media. These flow benefits denote that extra benefits from potential future transactions. The fixed fee that e-commerce enterprises need to pay agent consumers for each sold product is s_3 . Therefore, the expected utility of each agent consumer can be calculated.

$$\pi'_3 = m_3(u_3 + s_3) \frac{q-p}{(1-\alpha_3)q} - t_3 \quad (3.11)$$

where m_3 denotes the number of social contacts of each agent consumer. The agent cost of each agent consumer is t_3 , obeying the uniform distribution of $[0, 2T_3]$, where T_3 is the average agent cost in society. When $\pi'_3 \geq 0$ (i.e., $t_3 \leq \frac{m_3(u_3+s_3)(q-p)}{(1-\alpha_3)q}$), agent consumers choose to recommend and sell products on social media, the agent proportion of initial consumers in SMB channel is $d'_3 = \frac{m_3(u_3+s_3)(q-p)}{2(1-\alpha_3)qT_3}$. Since the agent proportion does not exceed 1, then $d'_3 = \min\left(\frac{m_3(u_3+s_3)(q-p)}{2(1-\alpha_3)qT_3}, 1\right)$. Besides, to ensure the existence of agent consumers, condition $d'_3 \geq 0$ should be held. In this case, the number of consumers covered in SMB channel C_3 is theoretically nd'_3m_3 . However, limited to the total number of potential consumers N , $C_3 = \min(nd'_3m_3, N)$.

Therefore, the profit of e-commerce enterprises is

$$R_3(p, s_3) = \min(nd'_3m_3, N) \frac{q-p}{(1-\alpha_3)q} (p - c - s_3). \quad (3.12)$$

The decision-making of e-commerce enterprises is expressed as the following constraint problem.

$$\begin{cases} p^*, s_3^* = \underset{p, s_3}{\operatorname{argmax}} \left(\min(nd'_3m_3, N) \frac{q-p}{(1-\alpha_3)q} (p - c - s_3) \right) \\ \text{s.t. } d_3 \geq 0, 0 \leq d'_3 \leq 1. \end{cases} \quad (3.13)$$

By applying the KKT conditions, the following propositions and corollaries can be obtained.

Proposition 3.6.

$$p^* = \frac{q + c - u_3}{2}. \quad (3.14)$$

Corollary 3.7. *In SMB channel, the optimal price strategy remains unchanged, and its optimal price p^* is always lower than that in the TECP channel. p^* rises as the increase of q and c , and falls as the increase of u_3 .*

In SMB channel, the decrease of price can bring double effects: increasing the agent proportion and purchase proportion, while the decrease of fixed fee can only increase the agent proportion. Therefore, e-commerce

enterprises prioritize ensuring that the price stops at the equilibrium point of agent proportion, purchase proportion and unit profit (Eq. (3.14)). In this case, as the product quality q increases, the bargaining power of e-commerce enterprises enhances, and the optimal price p^* rises; With the rise of product cost c , the profit space of e-commerce enterprises narrows, and p^* rises; As the flow benefit u_3 increases, the agent willingness of agent consumers is enhanced. In this case, the increase of agent proportion rises due to the decrease of price, so the equilibrium point of p^* should be lower.

Proposition 3.8. *The optimal fixed fee s_3^* only stops at the bottleneck of agent proportion d'_3 , the bottleneck of number of consumers covered C_3 and the equilibrium point between C_3 and unit profit.*

It can be noticed that the decrease of fixed fee s_3 can cause increases in agent proportion d'_3 and the number of consumers covered C_3 . However, there is a situation when the fixed fee continues to decline, but d'_3 or C_3 no longer rise, referred to as “encountering bottleneck”. In SMB channel, there are two bottlenecks of d'_3 (i.e., $d'_3 = 1$) and C_3 (i.e., $C_3 = N$). When the decrease of s_3 encounters the bottlenecks of d'_3 or C_3 , C_3 reaches the upper bound. In this case, reducing s_3 will only increase the unit profit, then s_3 will stay at the bottleneck. Besides, if there is no bottleneck in the rising process, s_3 will reach the equilibrium point between C_3 and unit profit and stay.

Proposition 3.9.

$$\begin{aligned} \text{When } \frac{4(1-\alpha_3)qT_3}{m_3(q-c+u_3)} - u_3 \leq \min\left(\frac{q-c-3u_3}{4}, \frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3\right), \\ s_3^* = \frac{4(1-\alpha_3)qT_3}{m_3(q-c+u_3)} - u_3, \quad R_3^* = \frac{nm_3}{(1-\alpha_3)q} \left(\frac{q-c+u_3}{2}\right)^2 - 2nT_3 \end{aligned} \quad (3.15)$$

$$\begin{aligned} \text{When } \frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3 \leq \min\left(\frac{q-c-3u_3}{4}, \frac{4(1-\alpha_3)qT_3}{m_3(q-c+u_3)} - u_3\right), \\ s_3^* = \frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3, \quad R_3^* = \frac{N}{(1-\alpha_3)q} \left(\frac{q-c+u_3}{2}\right)^2 - \frac{2T_3N^2}{nm_3^2} \end{aligned} \quad (3.16)$$

$$\begin{aligned} \text{When } \frac{q-c-3u_3}{4} \leq \min\left(\frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3, \frac{4(1-\alpha_3)qT_3}{m_3(q-c+u_3)} - u_3\right), \\ s_3^* = \frac{q-c-3u_3}{4}, \quad R_3^* = \frac{nm_3^2(q-c+u_3)^4}{128(1-\alpha_3)^2q^2T_3}. \end{aligned} \quad (3.17)$$

Corollary 3.10. *For e-commerce enterprises with high product added-value $q-c$, the fixed fee s_3 stays at the bottleneck of agent proportion d'_3 (Eq. (3.15)); For e-commerce enterprises with a large consumer base size n , s_3 stays at the bottleneck of the number of consumers covered C_3 (Eq. (3.16)). For e-commerce enterprises with low $q-c$ and n , s_3 stays at the equilibrium point between C_3 and unit profit (Eq. (3.17)).*

Corollary 3.11. *In SMB channel, the optimal fixed fee s_3^* falls with the increase of the flow benefit u_3 . When the product added-value $q-c$ is small, s_3^* falls with the decrease of $q-c$.*

When the flow benefit u_3 is large enough or the product added-value $q-c$ is small, the optimal fixed fee s_3^* is even negative. In this case, consumers' purchasing can bring greater flow gain for agent consumers. Therefore, agent consumers are even willing to accept negative fixed fee to obtain agent qualification. On the other hand, when $q-c$ is small, e-commerce enterprises can expand their price space by using the utility of agent consumers. When u_3 or $q-c$ increases, the agent consumers' willingness increases, then the enterprise will reduce the fixed fee s_3 .

The optimal decision of e-commerce enterprises in the three marketing channels is summarized in Table 3.

TABLE 3. E-commerce enterprise's optimal decisions in three marketing channels.

	TECP	ECPS	SMB
Condition	$(q - c - s_2)^2 < 4qt_2$	$(q - c - s_2)^2 \geq 4qt_2$	$\frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3 \leq$ $\min\left(\frac{q-c-3u_3}{4}, \frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3\right)$
p^*	$p^* = \frac{q+c+s_1}{2}$	$p^* = \frac{q+c+s_2}{2}$	$\min\left(\frac{4(1-\alpha_3)qT_3N}{nm_3^2(q-c+u_3)} - u_3, \frac{q-c-3u_3}{4}\right)$ $p^* = \frac{q+c-u_3}{2}$
R^*	$R_1^* = \frac{N_1(q-c-s_1)^2}{4q}$	$R_2^* = \frac{n(q-c-s_2)^2}{4q}$	$R_3^* = \frac{N}{(1-\alpha_3)q} \left(\frac{q-c+u_3}{2}\right)^2$ $R_3^* = \frac{nm_3^2(q-c+u_3)^4}{128(1-\alpha_3)^2q^2T_3}$
m^*	$m_2^* = 0$	$m_2^* = \frac{2q(N-n)}{N(q-c-s_2)}$	—
s^*	—	—	$s_3^* = \frac{q-c-3u_3}{4}$
d^*	$d_1^* = \frac{q-c-s_1}{2q}$	$d_2^* = \frac{q-c-2s_2}{2q}$	$d_3^* = \frac{q-c+u}{2(1-\alpha_3)q}$
D^*	$D_1^* = N_1 \frac{q-c-s_1}{2q}$	$D_2^* = n \frac{q-c-2s_2}{2q}$	$D_3^* = \frac{N(q-c+u_3)}{2(1-\alpha_3)q}$ $D_3^* = \frac{nm_3^2(q-c+u_3)^3}{32(1-\alpha_3)^2q^2T_3}$

4. DISCUSSION

Since these three marketing channels involve equilibrium in too many situations, we cannot directly compare them to obtain the optimal model. Therefore, we make a comparative analysis from the two perspectives of product added-value $q - c$ and upper limit of number of consumers covered C .

4.1. How $q - c$ affects marketing decisions

Through observing equations (3.3), (3.8), (3.9), (3.15)–(3.17), we find that product added-value $q - c$ is common in high power terms, which significantly affects the maximum profit of e-commerce enterprises. When the $q - c$ is large enough, the other low power terms of $q - c$ can be ignored temporarily. The sum of the low power terms of $q - c$ can be represented by ε . Therefore, the maximum profits of e-commerce enterprises in the three marketing channels are as follows.

- (1) In the TECP channel, the maximum profits of e-commerce enterprises $R_1^* = \frac{N_1(q-c-s_1)^2}{4q} = \frac{N_1}{4q}(q-c)^2 + \varepsilon$.
- (2) In the ECPS channel, e-commerce enterprises tend to choose forwarding mode as the increase of $q - c$. In this case, the maximum profits of e-commerce enterprises $R_2^* = \frac{N(q-c-s_2)^2}{4q} - (N-n)t_2 = \frac{N}{4q}(q-c)^2 + \varepsilon$.
- (3) In the SMB channel, the maximum profits of e-commerce enterprises will be limited by the agent proportion d'_3 or the number of consumers covered C_3 as the increase of $q - c$. In this case, the maximum profits of e-commerce enterprises $R_3^* = \frac{N}{(1-\alpha_3)q} \left(\frac{q-c+u_3}{2} \right)^2 - \frac{2T_3N^2}{nm_3^2} = \frac{N}{4(1-\alpha_3)q}(q-c)^2 + \varepsilon$ or $R_3^* = \frac{nm_3}{(1-\alpha_3)q} \left(\frac{q-c+u_3}{2} \right)^2 - 2nT_3 = \frac{nm_3}{4(1-\alpha_3)q}(q-c)^2 + \varepsilon$. Similarly, $R_3^* = \min\left(\frac{N}{4(1-\alpha_3)q}, \frac{nm_3}{4(1-\alpha_3)q}\right)(q-c)^2 + \varepsilon$.

By comparing the maximum profits after simplifying negligible items in the three marketing channels, we can draw the following corollaries.

Corollary 4.1. *For e-commerce enterprises with high product added-value $q - c$, the maximum profit of the TECP must be lower than that of the ECPS since $N > N_1$. When $N > \min\left(\frac{N}{1-\alpha_3}, \frac{nm_3}{1-\alpha_3}\right)$, ECPS is the optimal choice; Otherwise, SMB is the optimal choice.*

Corollary 4.2. *For e-commerce enterprises with extremely low product added-value $q - c$, SMB is the optimal choice.*

When the product added-value $q - c$ is very low (even $q - c < s$), only in the SMB channel can the e-commerce enterprises have profit space. Because there is the possibility that the agent cost of the agent consumer is 0, namely, if the e-commerce enterprise sets s_3 very low or even negative, there are still agent consumers willing to join in.

In addition, when the product added-value $q - c$ is medium, the maximum profit of e-commerce enterprises in various marketing channels will be related to too many parameters. Then, it will not be able to compare the profit of these marketing channels with their simplified formulas.

4.2. Upper limit of C in three marketing channels

- (1) In the TECP channel, the upper limit of the number of consumers covered C_1 is the total number of potential consumers N_1 , and $N_1 < N$;
- (2) There are forwarding iterations in the promotion of the ECPS channel. After L rounds, the number of consumers covered $C_2 = n \frac{1-(d_2m_2)^{L+1}}{1-d_2m_2}$. The reasonable settings of price p and forwarding number m_2 can make C_2 reach an arbitrarily large value;
- (3) In the SMB channel, when the agent proportion $d'_3 = 1$, the number of consumers covered C_3 will reach the upper limit (i.e., $C_3 = nm_3$). When the total number of potential consumers N is extremely large than the consumer base size n , it will hard to cover all potential consumers, even if all consumers are willing to act as agents ($d'_3 = 1$).

TABLE 4. Basic setting for parameters.

Channel	Parameter
TECP	$N_1 = 50\,000$
	$s_1 = 5$
ECPS	$N = 100\,000$
	$s_2 = 5$
	$t_2 = 3$
SMB	$N = 100\,000$
	$\alpha_3 = 0.5$
	$m_3 = 300$
	$t_3 = 500$
	$u_3 = 3$

By comparing the information dissemination effects in three marketing channels, we can draw the following corollary.

Corollary 4.3. *From the perspective of marketing coverage, when the consumer base size n of e-commerce enterprises is small, and the total number of potential consumers N is extremely large, only the ECPS channel can cover all potential consumers, while TECP and SMB channels cannot.*

5. NUMERICAL SIMULATION ANALYSIS

In this section, we use python programming to explore the optimal decision and profit of the e-commerce enterprise when choosing different marketing channels in social commerce. First, we verify the correctness of the above propositions and corollaries through two-dimensional numerical simulation. Next, we explore the trend changes of the optimal model under the joint influence of multiple variables through the three-dimensional numerical simulation.

5.1. Two-dimensional numerical simulation

By changing the parameter range for numerical simulation, the impacts of product quality q , product cost c and the consumer base size n on enterprise decision-making are analyzed intuitively. The basic setting for parameters of each marketing channel is shown in Table 4.

(1) Set $q = 28$, $c = 20$, $n \in [0, 300]$, as shown in Figure 2.

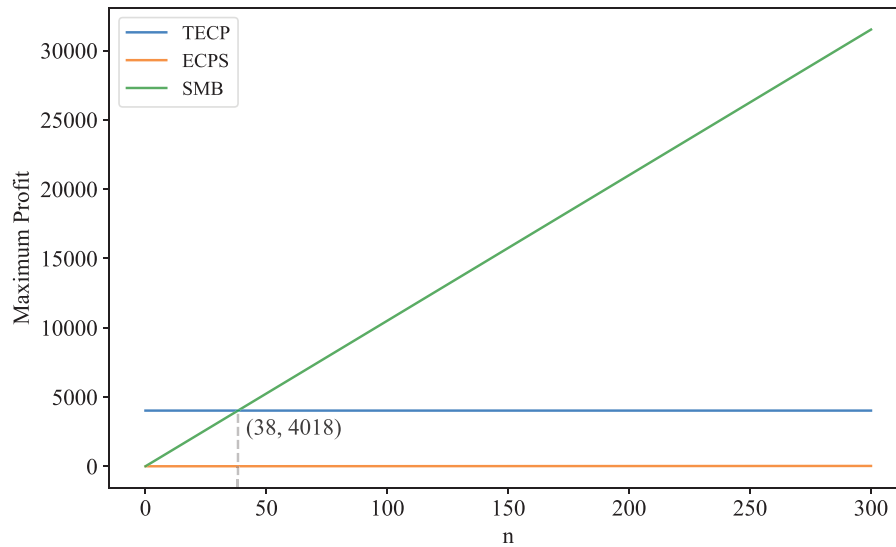
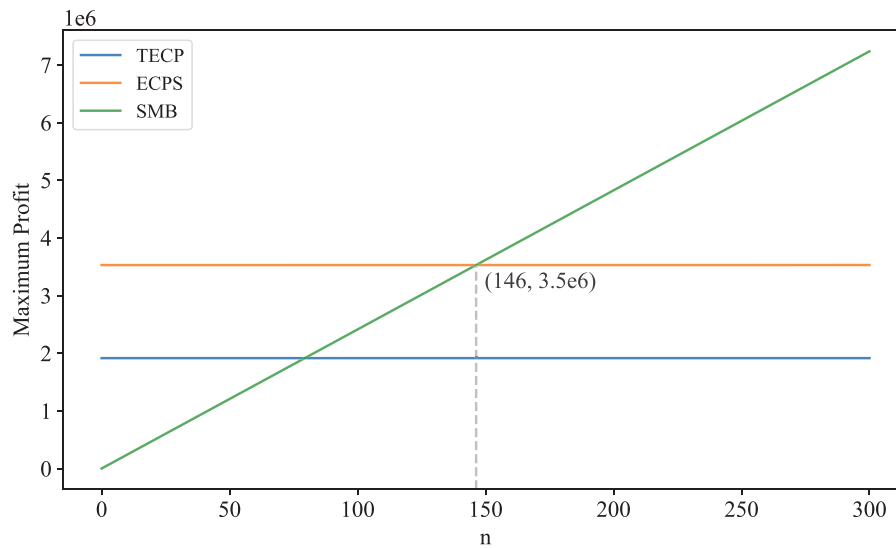
From Figure 2, the maximum profit of the e-commerce enterprise is independent of n in the TECP channel (Cor. 3.2). In the ECPS channel, when $q - c$ is small, enterprises will not choose the forwarding mode (Cor. 3.4), and its maximum profit has nothing to do with n . In the SMB channel, the maximum profit increases with the rise of n (Cor. 3.10).

In general, when $q - c$ is small and n is lower than 38, e-commerce enterprises choosing the TECP channel can get the maximum profit; when $q - c$ is small and n is greater than 38, the SMB channel is the best choice.

(2) Set $q = 200$, $c = 20$, $n \in [0, 300]$, as shown in Figure 3.

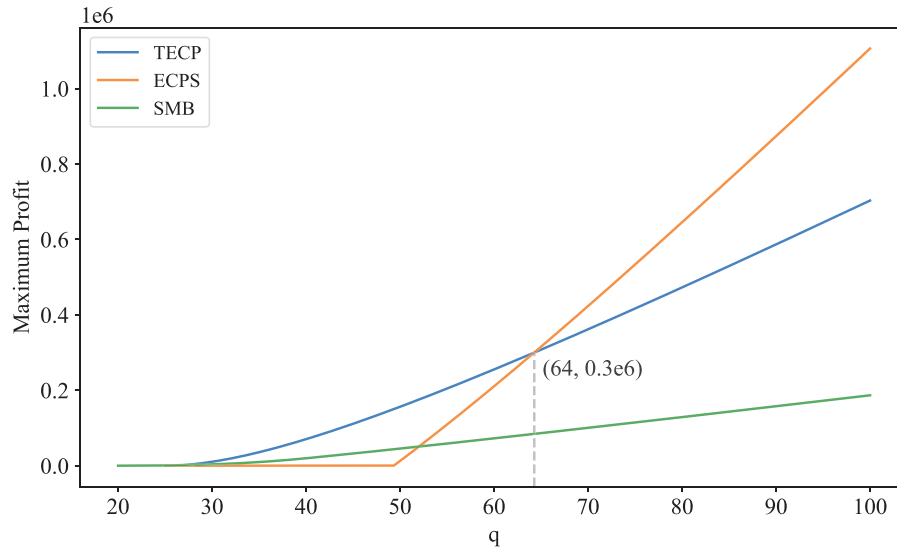
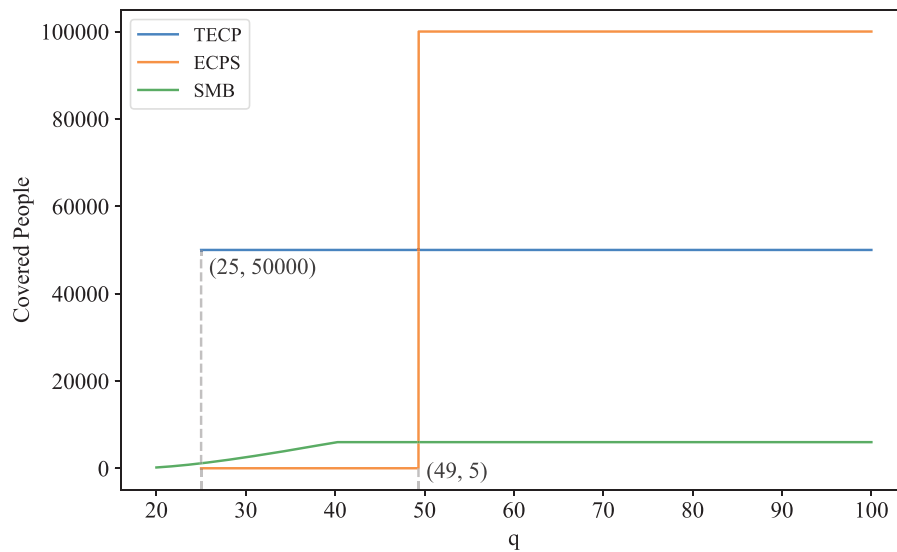
Figure 3 supplements the situation when $q - c$ is large. In this case, when $n < 146$, the ECPS channel offers the largest profit; When $n > 146$, the SMB channel surpasses others (Cor. 4.1).

(3) Set $n = 20$, $c = 20$, $q \in [20, 100]$, as shown in Figures 4 and 5.

FIGURE 2. The impact of n on the R (low-quality products).FIGURE 3. The impact of n on the R (high-quality products).

From Figure 4, when n and q are both small, the TECP channel surpasses others, and it can directly help the enterprises obtain a large number of consumers. When q increases to 64, the ECPS channel is the best choice for e-commerce enterprises with high $q - c$. Due to the small n , the SMB channel is limited by the agent proportion d'_3 . Even those e-commerce enterprises with high $q - c$ cannot cover a large number of consumers (Cor. 4.3).

As shown in Figure 5, when $q < 25$, the enterprises choosing the SMB channel have the maximum number of consumers covered C . That is because only the SMB channel has a positive profit, while other channels would not carry out selling; When $25 < q < 49$, C in the TECP channel is the largest; When $q = 49$, the ECPS

FIGURE 4. The impact of q on the R .FIGURE 5. The impact of q on the C .

channel transfers from non-forwarding mode to forwarding mode, and C rises sharply to the total number of potential consumers N . In this case, the ECPS channel surpasses others.

5.2. Three-dimensional numerical simulation

The marketing channel selections of the above e-commerce enterprises under different values of q , c and n ($n \in [10, 1200]$, $c \in [0, 1000]$ and $q \in [0, 1000]$) are integrated into a three-dimensional graph (Fig. 6), where the blue, orange and green dots represent that e-commerce enterprises can obtain the maximum profit when they

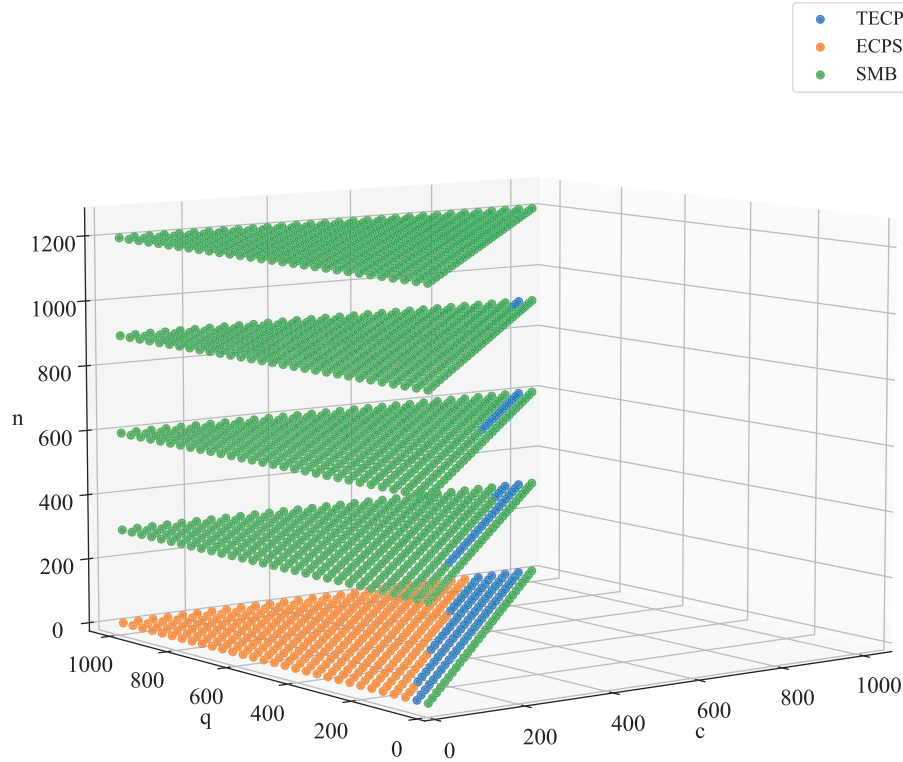


FIGURE 6. Three-dimensional graph of channel selection.

choose the channels of TECP, ECPS and SMB, respectively. From Figure 6, We find that the three-dimensional graph is divided into three parts according to the product added-value $q - c$.

- (1) When $q - c$ is extremely small, no matter the value of n is, it is the green dot. Namely, e-commerce enterprises can obtain maximum profit from the SMB channel. Since the agent consumers can accept negative fixed fee in this case, the e-commerce enterprises can have profit space only in this channel.
- (2) When $q - c$ is small, most dots are blue. Namely, the TECP channel surpasses others. In this case, e-commerce enterprises can quickly obtain a large number of consumers by choosing the TECP channel. On the other hand, it is difficult for the enterprises to promote in channels of ECPS and SMB. On this basis, if n is also small, ECPS and SMB channels will have lower C than TECP. As n increases to medium, the dots change from blue to green. The reason is that C in the SMB channel gradually exceeds that in the TECP channel.
- (3) When $q - c$ is large and n is small, all dots are orange, meaning that the ECPS channel surpasses others. With forwarding mode conditions satisfied, the ECPS channel can bring full consumer coverage, while the TECP channel cannot. With the increase of n , each channel has reached the maximum number of consumers covered. The maximum of C in the TECP channel is lower. Compared with the ECPS channel, the SMB channel can bring more profit for e-commerce enterprises, which may be led by the trust index.

Therefore, the marketing channel selection strategy of e-commerce enterprises is obtained based on the consumer base size n and product added-value $q - c$, as shown in Figure 7.

From Figure 7, the TECP channel offers the maximum profit for e-commerce enterprises with low or medium n and low $q - c$; The ECPS channel surpasses others for e-commerce enterprises with low n and high $q - c$; The

	n			
High	SMB	SMB	SMB	
Medium	SMB	TECP	SMB	
Low	SMB	TECP	ECPS	
		Extremely Low	Low	High
				q-c

FIGURE 7. Marketing channel selection strategy of e-commerce enterprises.

SMB channel is the preferred choice for most e-commerce enterprises, such as those with high n , extremely low $q - c$, medium n and high $q - c$.

6. CONCLUSIONS AND IMPLICATIONS

6.1. Conclusions

Under the background of the digital economy, “Pinduoduo”, “WeChat business” and other social commerce platforms are popular. In addition to the traditional e-commerce platform (TECP), e-commerce enterprises have new choices of marketing channels as “e-commerce platform + social” (ECPS) and “social media + business” (SMB). This paper constructs the decision-making models, compares and analyzes the optimal decisions and profits of e-commerce enterprises in different marketing channels. Research results show that:

- (1) Consumer base size and product added-value significantly affect the marketing channel selection of e-commerce enterprises.
- (2) Social commerce marketing channels (ECPS and SMB) are not necessarily better than TECP. When e-commerce enterprises have low consumer base size and low product added-value, choosing TECP can bring maximum profits for enterprises.
- (3) SMB is the preferred marketing channel for most e-commerce enterprises, such as enterprises with high consumer base size, extremely low product added-value, medium consumer base size and high product added-value.
- (4) E-commerce enterprises with low consumer base size and high product added-value choose ECPS as the best channel, which can cover the upper limit of potential consumers as soon as possible.

6.2. Theoretical contributions and practical implications

The main theoretical contributions of this paper are as follows.

Firstly, this paper uses the utility function to depict consumers’ choosing behavior in social commerce and establishes the decision-making models of e-commerce enterprises in three marketing channels, which expanding the quantitative analysis models and methods of multi-channel selection research under social commerce marketing.

Secondly, product added-value is introduced into the decision-making models of e-commerce enterprises participating in social commerce, and its influence on the marketing channel selection of e-commerce enterprises is analyzed.

Thirdly, based on selecting the decision elements of maximum profit, this paper analyzes the upper limit of consumers covered in three marketing channels, which provides a new perspective for the study of enterprise's marketing channels selection.

According to the above conclusions, the practical implications are as follows.

Firstly, e-commerce enterprises should choose appropriate marketing channels according to their consumer base size and product added-value to improve their maximum profit and competitiveness. For example, for the e-commerce enterprises with low consumer base size and low product added-value, it cannot meet the development needs when keeping on the TECP channel. With the increase of the consumer base size, they should gradually transfer to the SMB channel. For the e-commerce enterprises with low consumer base size and high product added-value, the optimal marketing channel will change from ECPS to SMB with the increase of the consumer base size.

Secondly, when developing marketing strategies, e-commerce enterprises can not only focus on profitability but also consider non-profit factors such as promotion speed and marketing coverage. For example, the ECPS channel can be promoted to the maximum number of potential consumers as soon as possible, which is the first choice for e-commerce enterprises striving to occupy the market quickly.

Thirdly, the long-term development strategy of e-commerce enterprises should be divided into three stages. In the early stage, when the consumer base size is small, e-commerce enterprises should choose the TECP channel for the primary purpose of survival; In the medium stage, e-commerce enterprises should choose the ECPS channel for growth to occupy the market quickly; In the later stage, e-commerce enterprises should choose the SMB channel, and consolidate the market by covering a large number of consumers.

6.3. Limitations and future research

Although this paper has some innovations in the same type of research, there are still some limitations. For example, it is assumed that the forwarding cost t_2 of the ECPS channel is fixed for the convenience of calculation, and the value of the forwarding number m_2 is continuous. In fact, t_2 may rise with the increase of m_2 , and the value of m_2 is discrete. Besides, this paper focuses on describing the decision-making models of e-commerce enterprises in three marketing channels while does not involve the game between the platform and e-commerce enterprises under platform guidance. Further research will involve more interactions between platforms and enterprises, and analyze their behavior under dynamic game theory.

Acknowledgements. The authors are very grateful to editors and referees for their valuable comments and suggestions that helped to improve the quality of the original work. This work was supported by the National Office for Philosophy and Social Sciences [grant numbers 18BGL110 and 20FGLB034], and the Natural Science Foundation of Guangdong Province [grant number 2020A1515010830].

REFERENCES

- [1] M.A. Ashraf, M.M.D. Alam and L. Alexa, Making decision with an alternative mind-set: predicting entrepreneurial intention toward f-commerce in a cross-country context. *J. Retail. Consum. Serv.* **60** (2021) 102475.
- [2] H. Bugshan and R.W. Attar, Social commerce information sharing and their impact on consumers. *Technol. Forecasting Soc. Change* **153** (2020) 119875.
- [3] A.H. Busalim and A.R.C. Hussin, Understanding social commerce: a systematic literature review and directions for further research. *Int. J. Inf. Manage.* **36** (2016) 1075–1088.
- [4] E. Cao and H. Li, Group buying and consumer referral on a social network. *Electron. Commerce Res.* **20** (2020) 21–52.
- [5] Y.K. Chen, C.T. Chen, F.R. Chiu and J.W. Lian, Applying the bootstrap method to newsvendor model incorporating group buying for optimal price discount and order quantity. *Kybernetes* **46** (2017) 1692–1705.
- [6] Y.J. Chen, Y.M. Chen, Y.-J. Hsu and J.H. Wu, Predicting consumers' decision-making styles by analyzing digital footprints on facebook. *Int. J. Inf. Technol. Decis. Making* **18** (2019) 601–627.

- [7] X. Chen, Y. Wu and R. Zhong, Research on competitiveness of China's social commerce enterprises based on macro- and micro-niche. *Sustainability* **13** (2021) 422.
- [8] China National Commercial Information Center, The scale of China's top 100 retailers exceeded 10 trillion in 2020. Retrieved July 30, 2021, from <https://www.cncic.org/?p=3607> (2021).
- [9] S. Deng, X. Jiang and Y. Li, Optimal price and maximum deal size on group-buying websites for sellers with finite capacity. *Int. J. Prod. Res.* **56** (2018) 1918–1933.
- [10] H. Han, H. Xu and H. Chen, Social commerce: a systematic review and data synthesis. *Electron. Commerce Res. App.* **30** (2018) 38–50.
- [11] N. He, Z.Z. Jiang, M. Sun and Y. Sheng, Group buying of competing retailers with fairness concerns. *J. Syst. Sci. Syst. Eng.* **29** (2020) 655–674.
- [12] iResearch, China's social e-commerce industry research report in 2019. Retrieved July 26, 2021, from <https://www.iresearch.com.cn/Detail/report?id=3402&isfree=0> (2019).
- [13] iResearch, Chinese wechat marketing research in 2020. Retrieved July 30, 2021, from <https://www.iresearch.com.cn/Detail/report?id=3765&isfree=0> (2021).
- [14] G. Jiang, S. Liu, W. Liu and Y. Xu, Agent-based modeling and simulation of the decision behaviors of e-retailers. *Ind. Manage. Data Syst.* **118** (2018) 1094–1113.
- [15] Z.Z. Jiang, N. He, X. Qin, W. Ip, C. Wu and K. Yung, Evolutionary game analysis and regulatory strategies for online group-buying based on system dynamics. *Enterp. Inf. Syst.* **12** (2018) 695–713.
- [16] N. Kim and W. Kim, Do your social media lead you to make social deal purchases? Consumer-generated social referrals for sales via social commerce. *Int. J. Inf. Manage.* **39** (2018) 38–48.
- [17] H.C. Ko, Social desire or commercial desire? The factors driving social sharing and shopping intentions on social commerce platforms. *Electron. Commerce Res. App.* **28** (2018) 1–15.
- [18] L. Leong, N. Jaafar and S. Ainin, Understanding facebook commerce (f-commerce) actual purchase from an artificial neural network perspective. *J. Electron. Commerce Res.* **19** (2018) 75–103.
- [19] X. Li, C. Wang and Y. Zhang, The dilemma of social commerce why customers avoid peer-generated advertisements in mobile social networks. *Int. Res.* **30** (2020) 1059–1080.
- [20] L. Liang and X. Qin, Research on consumers online shopping decision-making and recommendation of commodity based on social media network. *Cluster Comput.* **22** (2019) 6529–6539.
- [21] M.T. Liu, J. Xue and Y. Liu, The mechanism leads to successful clickbait promotion in wechat social media platforms. *Asia Pac. J. Market. Logistics* **33** (2021) 1952–1973.
- [22] B. Lu and S. Zhang, A conjoint approach to understanding online buyers' decisions towards online marketplaces. *J. Theor. Appl. Electron. Commerce Res.* **15** (2020) 69–83.
- [23] G. Ni, L. Luo, Y. Xu, J. Xu and Y. Dong, Optimal decisions on group buying option with a posted retail price and heterogeneous demand. *Electron. Commerce Res. App.* **14** (2015) 23–33.
- [24] G. Ni, Y. Xu, J. Xu and Y. Dong, Optimal decisions for fixed-price group-buying business originated in China: a game theoretic perspective. *Int. J. Prod. Res.* **53** (2015) 2995–3005.
- [25] J.B. Ong, W.K. Ng, A. Vorobev and T.N. Ho, Groupon and groupon now: participating firm's profitability analysis. *Comput. Econ.* **53** (2019) 617–632.
- [26] Pinduoduo, Pinduoduo announces second quarter 2020 unaudited financial results. Retrieved July 30, 2021, from <https://investor.pinduoduo.com/static-files/35ff26e3-ec5a-4167-9384-7f52b11312b6/> (2020).
- [27] Q. Rao and E. Ko, Impulsive purchasing and luxury brand loyalty in WeChat mini program. *Asia Pac. J. Market. Logistics* **33** (2021) 2054–2071.
- [28] V. Raghupathi and J. Fogel, The impact of opinion leadership on purchases through social networking websites. *J. Theor. Appl. Electron. Commerce Res.* **10** (2015) 18–29.
- [29] J. Sabaityte, V. Davidaviciene, J. Strakova and J. Raudeliuniene, Decision tree modelling of e-consumers' preferences for internet marketing communication tools during browsing. *E & M Ekonomie a Manage.* **22** (2019) 206–221.
- [30] Z. Shao and Z. Pan, Building guanxi network in the mobile social platform: a social capital perspective. *Int. J. Inf. Manage.* **44** (2019) 109–120.
- [31] Z. Sheikh, L. Yezheng, Z. Hameed and I.U. Khan, Impact of social commerce constructs and social support on social commerce intentions. *Inf. Technol. People* **32** (2019) 68–93.
- [32] J. Tang and P. Zhang, The impact of atmospheric cues on consumers' approach and avoidance behavioral intentions in social commerce websites. *Comput. Human Behav.* **108** (2020) 105729.
- [33] A. Trivella, S. Nadarajah, S.-E. Fleten, D. Mazieres and D. Pisinger, Managing shutdown decisions in merchant commodity and energy production: a social commerce perspective. *Manuf. Serv. Oper. Manage.* **23** (2021) 311–330.
- [34] E.E. Vazquez, Effect of an e-retailer's product category and social media platform selection on perceived quality of e-retail products. *Electron. Markets* **31** (2021) 139–157.
- [35] Y. Wu and X. Chen, A new cognitive framework for understanding social commerce: a service ecosystem perspective. *J. Serv. Sci. Manage.* **13** (2020) 459–469.
- [36] Y. Wu and L. Zhu, Joint quality and pricing decisions for service online group-buying strategy. *Electron. Commerce Res. App.* **25** (2017) 1–15.
- [37] Y. Wu, D. Li and T. Li, Coordination of traditional and online group-buying channels considering website promotion effort. *Sci. Iran.* **27** (2020) 2069–2092.

- [38] X. Yang, Consumers' decisions in social commerce: the role of Guanxi element. *Asia Pac. J. Market. Logistics* **31** (2019) 759–772.
- [39] G. Yang, L. Zhao and N. Kong, “Order-online-and-pickup-offline” strategy for online direct sale of time-sensitive commodities. *RAIRO: Oper. Res.* **55** (2021) S999–S1011.
- [40] Y. Zhang and B. Xu, Does social group-buying of “buy together” style decrease the quality of platform goods? From the perspective of platform selection for e-commerce enterprises. *Commercial Res.* **61** (2019) 10–17.
- [41] Y. Zhang and B. Xu, Study of group-buying-induced strategies for e-commerce platform based on social group-buying. *Manage. Rev.* **31** (2019) 133–141.
- [42] G. Zhang, J. Shang and P. Yildirim, Optimal pricing for group buying with network effects. *Omega* **63** (2016) 69–82.
- [43] Z. Zhu, Y. Zhou, X. Deng and X. Wang, A graph-oriented model for hierarchical user interest in precision social marketing. *Electron. Commerce Res. App.* **35** (2019) 100845.
- [44] J. Zhu, L. Teng, Z. Zhu and H. Lu, A pricing method of online group-buying for continuous price function. *Neural Comput. App.* **32** (2020) 4453–4461.

Subscribe to Open (S2O)

A fair and sustainable open access model



This journal is currently published in open access under a Subscribe-to-Open model (S2O). S2O is a transformative model that aims to move subscription journals to open access. Open access is the free, immediate, online availability of research articles combined with the rights to use these articles fully in the digital environment. We are thankful to our subscribers and sponsors for making it possible to publish this journal in open access, free of charge for authors.

Please help to maintain this journal in open access!

Check that your library subscribes to the journal, or make a personal donation to the S2O programme, by contacting subscribers@edpsciences.org

More information, including a list of sponsors and a financial transparency report, available at: <https://www.edpsciences.org/en/maths-s2o-programme>