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A MULTI-CHANNEL ASSESSMENT MODEL CONSTRUCTED BASED ON TRANSACTION COST COMPLEXITY: NEWLY LISTED BEAUTY COSMETICS CASE

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Abstract

This study focuses on the process of model construction, and based on the transaction cost theory, establishes a model according to the impact of transaction cost factors on consumers' decision making regarding purchase behavior. Through the analytic network process (ANP), this study compares the mutual effects of transaction cost factors on consumers' behavior, and obtains the weights of the transaction cost factors of the different phases of consumer decision making. In order to elaborate the application of this model, this study treats new products of beauty cosmetics with integrated online and offline channels, and consumption styles as examples, and demonstrates that the most effective channels are stores. The results of this study can serve as a criterion for dealers to establish the most effective measure to enhance transactions. The application extended from this model can be used with other products. Knowing the items included in the transaction costs of both the buyer and the seller, the cost values of various items of both parties can be estimated.

Keywords: transaction cost, decision-making, analytic network processes, channel assessment

Introduction

In recent years, scientific and technological progress and the rise of the Internet have led to significant changes in business models and trading behaviors. When distributors want to sell their products to consumers, distributors will face the issue of transaction costs, such as how to communicate the information of the product, the form of the transaction, and how to deliver the products. Due to technological advances, transaction costs have become complicated. In practice, e-commerce applications have the greatest impact on business operations, and when coupled with the distribution type of "home delivery service," the most complex logistics problem in e-commerce has been solved, which makes the factors affecting transactions more diverse.

According to the principles of opening market economies, most industries have a low barrier to entry, meaning businesses can sell products through a network platform, and competition becomes increasingly fierce. Due to consumer-oriented market policies and high consumer awareness, during product sales promotions, how to more easily communicate product information to consumers to facilitate the purchase or use of products has become one of the most important issues to businesses.

Distributors often take measures to enhance transaction efficiency, for example, setting up shops, home delivery, website exposition, online transaction service, building parking lots and nurseries around shops, or directly absorbing part of the consumers' transaction expenditures, which reduces consumer transaction costs to convert potential consumers into consumers with actual demand. Hence, how distributors make decisions regarding transaction cost investment level has become an issue worth exploring, as it affects the transaction cost expenditures of consumers, and whether consumers will purchase products.

With the current emphasis on the use of Internet technology, many distributors have invested resources in the development of Internet marketing. However, while distributors adoption of multiple channels remains one of the optimal strategies, distributors still face the problem of how many re-

sources should be invested and how to distribute these resources in different types of sales channels.

Therefore, it is necessary to identify the optimal means and methods to promote the efficiency of a transaction. However, literature review found that, past studies failed to provide effective solution methods or modes, thus, promoting exploration regarding the concept of the problem proposed in this study. This study conducts literature review of various concepts, including consumer decision-making procedures, transaction cost theory development, and distributor channel decision-making, and establishes the concept of this study using the analysis contents, as illustrated in the following.

Literature Review

Transaction Cost Economics (TCE)

As early as 200 years ago, Adam Smith pointed out that "the real price of any goods (payment) is all the effort and labor required to obtain the goods" (Kotler, 2003). Coase (1937) was the first person to introduce the concept of transaction cost into the analysis of manufacturers and markets (Williamson, 2010). According to Coase, in the economic system of the professional division of labor and exchange, price operation will produce ex-ante costs (e.g., searching for information, contract negotiation, and signing costs) and ex-post costs (the cost of supervision of contract execution). The ex-ante cost and ex-post cost are collectively known as transaction costs.

Coase found that manufacturers often replace the market to complete the economic coordination function, which can effectively save transaction costs. Williamson (1975) expanded the initial framework of Coase and published articles relating to transactions and transaction costs (Williamson, 1981, 1983), and transaction costs began to be taken seriously.

Regarding the measure of transaction costs, Liang and Huang (1998) defined transaction cost as the cost generated by deal-related activities during the transaction process, and classified the transaction costs of consumer purchasing behavior decision-making processes into: (1) pre-purchasing evaluation behavior stage: search cost, comparison cost, negotiation cost, and testing cost; (2) purchasing behavior stage: order cost and

payment cost; (3) post-purchasing behavior stage: shipping cost.

Degeratu et al. (2000) pointed out that an appropriate exposition method can reduce the search cost of consumers. O'Connor and O'Keefe (1997) found that real time online interactions can reduce the negotiation cost of the transaction process. Dutta et al. (1998) suggested that the interactivity of the Internet can reduce unnecessary costs. Papows et al. (1999) found that the interactivity of a network can reduce information asymmetry. Moutaz and Reinhold (1999) studied the most appropriate terms of payment in the cases of different transaction costs. Some studies found that transaction trust is one of the factors considered by consumers (Teo and Yu, 2005; Güth et al., 2007). Hence, a higher safety level of payment can result in better personal data privacy, and thus, consumer transaction costs will be lower. Sitzia and Zizzo (2011) indicated that product complexity will affect the competitiveness of the retail market, and the reason may be that consumers must spend more time to understand the product, meaning that, for some products, demonstration and explanation is important.

The time cost during the transaction process is only discussed superficially in the above literature, thus, the measurement of time cost lacks feasibility, and the waiting time cost differences of consumers for goods (i.e. the time cost varies from consumer to consumer) are not mentioned. Studies on how the abovementioned waiting time cost affects consumer demand have been widely discussed in the inventory field, and relevant models have been developed (Chen and Chen, 2010; Chung, 2011; Yu, 2010). Therefore, this study considers the factor of the waiting time cost among the transaction cost factors to address actual situations regarding consumer purchasing behavior.

Consumer Behavior

Contemporary consumers are faced with numerous products in the markets of different brands, prices, and terms of payment. How do consumers engage in selection and purchasing behaviors? Kim and Park (1997) and Bell et al. (1998) discussed the problem of selecting stores by consumers. Farag et al. (2007) discussed consumer choice regarding online shopping and non-

online shopping. Chen (2017) pointed out the correlation between the consumers' choices of shopping information websites and transaction costs.

Some studies suggested that consumers will evaluate which distributor can provide them with the most valued (or least valued) products (Chiang and Dholakia, 2003; Konuş et al., 2014; Hu and Jasper, 2015). Some academics discussed the applications of transaction costs in marketing fields (Chen et al., 2006; Stump and Heide, 1996). However, the above studies have not discussed the impact of different compositions of transaction cost factors on consumer purchasing behaviors. In addition, regarding product attributes, most studies focused on discussions of actual products, while services (intangible products) are rarely discussed.

However, from the psychological dimension of consumer purchasing behaviors, services can be regarded as a reduction in transaction costs, for example, the courtesy of honor at the moment of purchasing (Bilgihan and Bujisic, 2015), or the satisfaction of a haircut. Such things have not been considered in the transaction cost theory, marketing studies, or analysis of transaction cost factors at the present stage, which is possibly due to a lack of methods to measure transaction cost price.

This study develops a model for specific discussion of the above factors affecting consumer transaction cost. Based on the transaction cost measurement method, as proposed by Chang and Chen (2008a), this study directly investigates the transaction costs of consumers at different purchase decision-making stages in order to reflect the individual time costs of consumers, especially services, which could even have negative cost items. Therefore, some consumers are willing to pay higher pre-purchasing and purchasing costs, as well as higher post-purchasing costs.

Channel Decision-making

According to Schoenbachler and Gordon (2002), if distributors use virtual channels (network) as the only channel, the investment level of newly developed consumers will be twice that of the distributors adopting multiple channels. Nicholson et al. (2002) pointed out that most distributors will sell products by the multi-channel

method; however, the selection of the channel by consumers will result in changes in the composition of the consumer transaction cost (Hann and Terwiesch, 2003). Regarding the selection of multiple channels, as faced by consumers, there is no feasible application model regarding how the composition of transaction cost would affect consumer behavior. Therefore, although distributors may assess product demand by different means, it remains difficult for them to make multi-channel decisions (Chen and Hausman, 2000; Jedidi et al., 1996; Chen, 2017; Pu et al, 2017).

Regarding the transaction cost exchange between distributors and consumers, distributors often take various measures to enhance transaction efficiency (Chircu and Mahajan, 2006; Konana et al., 2002). If the manufacturer invests in the transaction environment with an additional 1 unit amount, the transaction cost expenditure of the consumer group can be reduced by 1 unit amount or more, and the manufacturer's investment in the transaction environment will be effective.

The effect is determined by the selling price level, which may benefit the other party, but not cause damage to itself (benefit the manufacturer, but not damage the consumer, or benefit the consumer, but not damage the manufacturer), or it may benefit both parties (benefit the manufacturer and the consumer). There are many cases of increases in the above-mentioned transaction efficiency, such as allowing consumers to easily contact or search for product information, and conveniently purchase products. The manufacturer can establish an official website to display product information and usage benefits, and the consumers can rapidly find product information through search engines using keywords or the information platform (e.g., built-in information), in order to reduce the search cost.

Tyagi (2004) validated that, the increasing level of investment in transaction costs by distributors can reduce consumer transaction costs when purchasing products. According to Chang and Chen (2008a), distrib-utors' transaction cost investment and consumers' transaction cost expenditures are not zero-sums (distributors transaction cost

investment is lower than the overall transaction cost expenditure). Although Chang and Chen expanded the demand function to the conventional EOQ model (Chang and Chen, 2008b), they failed to further explain how distributors can enhance transaction efficiency or how to determine the optimal cost investment level.

According to the report of the Research and Markets (2018), the global beauty care cosmetics industry reached $716.6 billion USD by 2025, and will grow at a compound annual growth rate (CAGR) of 5.9% from 2018 to 2025. The Ministry of Economic Affairs (2017) suggested that the market scale of beauty care products in Taiwan in 2017 was over $200 billion NTD. In recent years, the fashion of appearance has expanded the market potentials of beauty cosmetics, and more age groups start to use beauty cosmetics with continuously expanding product classes. In particular, there are multiple choices of sales channels for beauty cosmetics, which can be roughly divided into “shop”, “open shelf”, “direct sales”, “drug store”, “beauty salon”, “franchised store”, “online shopping”, and “TV shopping”. Based on the product search method, terms of payment, and the length of time to product delivery, this study divides the channels of beauty cosmetics into outlet channels (including chain stores or retailers), point-of-distribution (i.e. store or Internet purchase, but sent to home, work, or a nearby convenience store), and home delivery.

Based on the transaction cost theory, this study specifically discusses the impact of transaction cost factors on consumer purchasing behaviors at the pre-purchasing, purchasing, and post-purchasing stages of the decision-making process. Considering the interdependence and feedback relationships between transaction cost factors of various decision making perspectives, this study uses ANP to compare the interactive effects between transaction cost factors, in order to learn about the weights of various transaction cost factors and the weights of transaction costs at various decision making stages. With new beauty cosmetics as an example, this study determines the channel that can best promote transaction efficiency for distributors launching new products to the market. The find-

ings of this study can provide reference for product distributors or distributors. The specific model construction and operational procedures are shown, as follows.

Model Construction and Analysis

This model uses combined transaction cost economics and the ANP method, and is intended to establish a composition model of the weight of transaction cost factors in the case of different channels. The construction process can be divided into two parts: the first part is to understand how transaction cost factors, according to the consumer perspective, can affect the consumer selection behavior; the second part discusses the interactive relationships of transaction cost factors and ANP application processes through detailed operational steps, as shown in Table 1.

The Impact of Transaction Cost Factors

Through literature review, this study develops the transaction cost factors from the perspective of consumer decision making, and uses SPSS 20.0 for factor analysis and AMOS 17.0 for SEM (Structural Equation Models) analysis, and found that, the SEM model satisfies fitness conditions, and transaction cost factors in various decision-making dimensions can significantly affect consumers' purchasing behaviors (Chen and Yao, 2012). Based on the above findings, this study establishes the evaluation criteria and sub-criteria for the impact of transaction cost factors in various dimensions on consumer purchasing behavior (see Table 1).

Analytic Network Processes (ANP)

The purpose of this study is to provide a resource distribution decision making model to discuss the interactive relationships between transaction cost factors, and provide the optimal transaction cost investment level in cases of different channels. Faced with such uncertainties, as well as the decision-making problem of multiple evaluation criteria, AHP is the one of the most suitable solution methods (Saaty, 1990; Chin et al., 2008; Ngai and Chan, 2005). As an extension of AHP, ANP integrates the feedback mechanism in the hierarchical structure of the decision-making model to

Table 1. Evaluation Stage and Criteria

Stage	Criteria		Definition
P1	C1a	Easy access to product information	The product information that consumer can access, and the time to obtain access to such information
	C1b	Sufficient information exposure	Consumers access details and range of information related to a product in a single contact
	C1c	Trial use	Allow consumers to use and experience the product
	C1d	Demonstration and explanation	Description of the product regarding when to use, how to use, and applicable situations
P2	C2a	Purchasing threshold limit	The least amount of purchasing cost the consumer should pay for each purchase of a product
	C2b	Personal privacy leakage prevention	Reduce consumer concerns regarding personal information leakage or misuse
	C2c	Simplify the filling of certificates	Upon consumer payment, certificate or identity should be checked
	C2d	Provide diverse terms of payment	Cash, ATM transfer, credit card, cash on delivery
	C2e	Privileges	Honor perception at consumption
P3	C3a	Order transparency	After product order, consumers can use the telephone or online shopping to monitor product delivery status in real time
	C3b	Delivery progress notification	The manufacturers may, via message or E-mail, actively communicate delivery information or expected time of arrival of the product
	C3c	Enhanced delivery speed	The time waiting for a product can affect consumer satisfaction and repurchase intention
	C3d	Lengthened product appreciation period	The effective appreciation period is the time for the consumer to confirm whether the product is correct and flawless
	C3e	Simplified refunding procedure	The procedure for a refund is complex, and the method of product refunding

Notes: P1 is the Pre-purchasing stage; P2 is the Purchasing stage; P3 is the Post-purchasing stage

present the dependence of criteria at various levels. The ANP method hypotheses and operational steps are shown, as follows.

3.3 ANP Hypotheses

Proposed by Thomas L. Saaty (1996), ANP is an extension of the basic hypothesis of AHP (Saaty and Vargas, 2000), which is illustrated, as follows:

1. A system can be decomposed into a few classes or components to form a hierarchical network structure.
2. The elements of each hierarchy of the hierarchical structure can have no independence.
3. The elements of each hierarchy can use some or all the factors of the upper hierarchy as the criteria for evaluation.
4. When evaluating the elements, the absolute value scale can be converted into a ratio scale.
5. After pair wise comparison of the elements of various hierarchies, they can be processed by a positive reciprocal matrix.
6. The element preference relationship and strength relationship should satisfy transitivity.
7. As full transitivity is difficult, we must further test the level of consistency.
8. The superiority of elements can be calculated using the weighting principle.

ANP Analysis Step

Step 1. Establish the network structure. By using the evaluation stages and criteria, establish a relationship network of transaction cost factors (see Figure 1).

Step 2. Establish a pair wise comparison matrix. By using the ratio scale as the measurement scale, conduct pair wise comparisons of various evaluation factors. According to the suggestions of Saaty (1980), divide it into nine scales, as defined in Table 2.

If there are m evaluation criteria in decision making, it requires $C(m,2)=m(m-1)/2$ times of pair wise comparisons in order to obtain the pair wise comparison matrix A, as follows:

$$A=\begin{bmatrix} 1 & a_{12} & a_{13} & \cdots & a_{1m} \\ a_{21} & 1 & a_{23} & \cdots & a_{2m} \\ a_{31} & a_{32} & 1 & \cdots & a_{3m} \\ \cdots & \cdots & \cdots & 1 & \cdots \\ a_{m1} & a_{m2} & a_{m3} & \cdots & 1 \end{bmatrix}$$

where $a_{ji}={}^{1}/_{a_{ij}}$, $i,j=1,2,\ldots,m$.

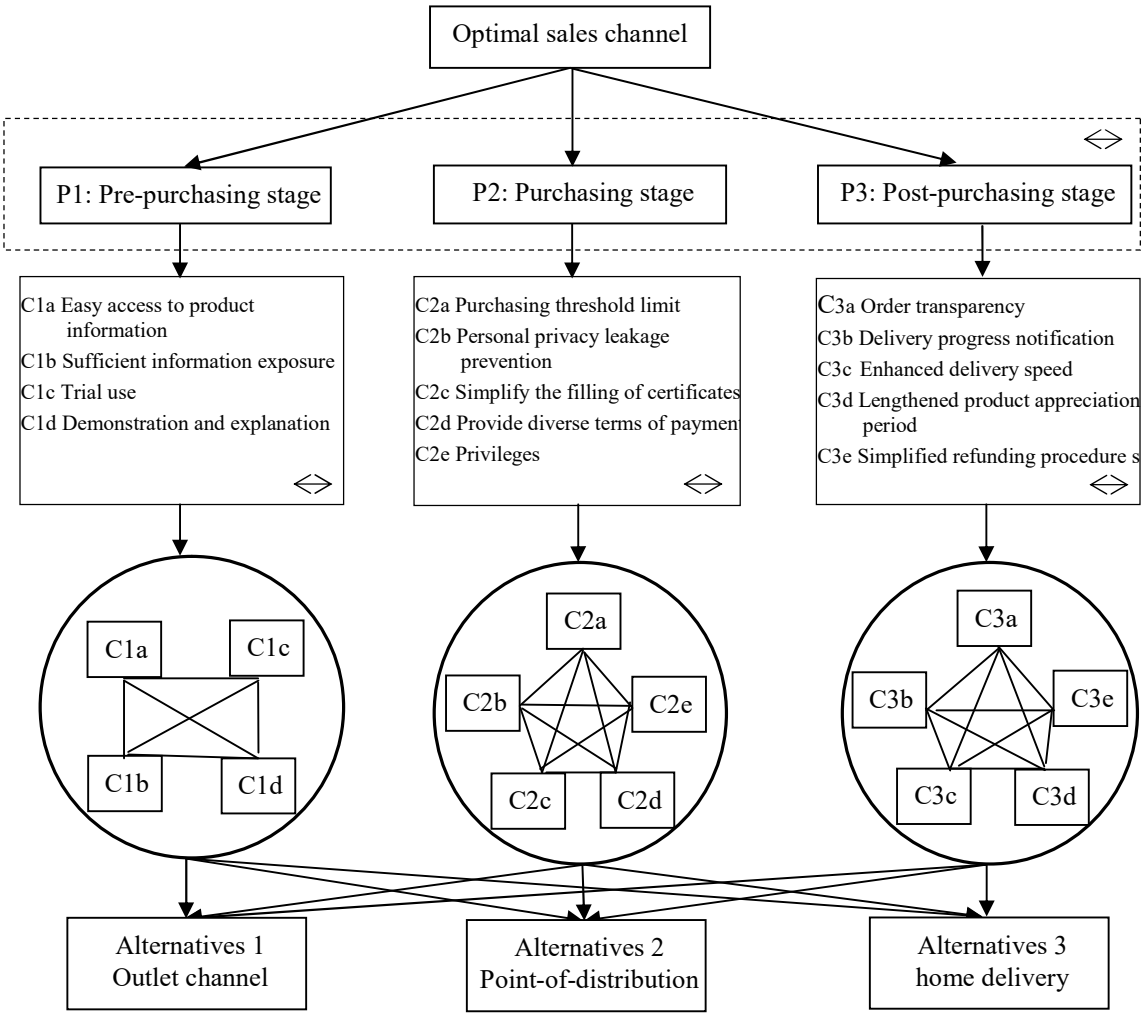
Step 3. Integrate the preferences of R experts using the geometric mean method.

Step 4. Determine the maximum Eigen value and the eigenvector. Satty proposed using the row vector average standardization method in computation, as its accuracy rate is better, and the equation is:

$$w_i' = \frac{1}{n} \cdot \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \; i,j = 1,2,\ldots,n \qquad (1)$$

Step 5. Compute *C.I.* (Consistency index), if *C.I.*≤0.1, the standard of judgment consistency is satisfied.

Step 6. Obtain *R.I.* (random index) according to Table 3.



(Note: ⇔ indicates that the criteria of the group have internal interdependence)

Figure 1. Sales channel decision making framework

Table 2. The Ratio Scale

Intensity of importance on an absolute scale	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment strongly favor one activity over another
5	Essential or Strong importance	Experience and judgment strongly favor one activity over another
7	Very Strong importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals	If activity *i* has one of the above numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i*	

Table 3. Random Index

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57

Step 7. Compute *C.R.* (Consistency ratio) according to the following equation:

$$C.R. = \frac{C.I.}{R.I.} \quad (2)$$

If *C.R.*<0.1, it indicates that the consistency level is satisfactory.

Step 8. Calculate weights according to the supermatrix.

Step 9. Summarize evaluation factor weights and determine the optimal method of promoting transaction efficiency.

Empirical Analysis

In order to explain the application method of the model, this study treats the beauty cosmetics of multi-channels as an example. From the viewpoint of marketing or CRM, good

consumer impressions of products are promoted by the PR or business department, the academic research on consumer behaviors, and the first reaction of the retail department personnel to the consumer, and will influence the transaction cost of the consumers. An expert survey was conducted with four experts from PR and business departments, two experts in marketing research, and four experts from a retail department. According to the method in Step 2 of 3.4, this study constructs a pairwise comparison matrix, and according to Step 7, calculates the consistency ratio (*C.R.)* of the pairwise matrixes, and ensures the C.R. of pairwise matrixes are good ($C.R. < 1$). This study then conducts ANP calculations on the data obtained by Super Decisions.

Table 4. Relative positions of pairwise matrixes in the supermatrix

	Behavior Stage	Criteria 1	Criteria 2	Criteria 3	Alternatives
Behavior	A	0	0	0	B
Criteria 1	C	D	0	0	0
Criteria 2	E	0	F	0	0
Criteria 3	G	0	0	H	0
Alternatives	0	I	J	K	0

According to the framework of Figure 1, this study constructs supermatrix M_1(see Table 4), arranges the relative positions of the previous pairwise comparison matrixes in the supermatrix (super matrix is a factorization matrix), and identifies the solution of mutual relations among the criteria. Since M_1 is an unweighted primary matrix (see *Appendix A)*, in order to satisfy the column-stochastic principle (column value of matrix must be 1), it should be first weighted which is M_2. For instance, the total column value of Criteria 1 is not 1, and this study considers the relative importance of D and I. Weighted supermatrix M_2 is shown in *Appendix B*. In order to obtain the relative weights of the criteria, this study conducts extremity of the weighted matrix. It is $2k+1$ root by

multiplication between matrixes M_2 and M_2, and the dependent relation will be gradually convergent: $M_2^{2k+1} = M_2^k \cdot M_2$. Thus, the value of each line of matrix M_2^{2k+1} is the same. The extreme matrix is shown in M_3 of *Appendix C*.

Conclusion

The Results of the Analysis

(1) The analysis results suggest that the pre-purchasing stage (0.4473) is most influential on the decision making of the consumer, followed by the post-purchasing stage (0.2992), and the purchasing stage (0.2535) has the lowest influence, as shown in Table 5.

(2) Among the various decision making stages, trial use (0.3430), diverse terms of payment (0.3365), and enhanced delivery speed (0.2565) are the most influential on the purchasing behavior of consumers; while demonstration and explanation (0.1946), purchasing threshold limit (0.1325), and order transparency (0.1445) have the lowest influence, as shown in Table 5.

(3) When new beauty cosmetic products come on the market, multiple trial channels should be developed, and a trial project should be introduced.

This study suggests that it should be 15.34% of the resources invested in the unit; second is the information disclosure and promotion expenditures of new products, which should be 11.96% and 8.77% of the resource invested in the unit (using Table 5), respectively. The companies' disclosure can be based on media, advertising, and online community platforms. Moreover, by searching websites (such as purchase key words) and information platforms (such as placement information), consumers can rapidly find product information, which will lower searching costs.

(4) Companies can construct official websites to present product information, emphasize consumers' use benefits, maintain commitment to consumers' rights, provide guarantees for multiple payment options, and conduct trial periods and goods return and exchange procedures (using Table 5).

(5) The optimal sales channel of distributors to launch new products is the outlet channel (see Table 6). Through outlet channels, channel manager and sales staff can present the product, in-

cluding complete product information, and demo and trial use. As consumers usually spend more time searching for information relating to new products, as well as trial and inquiry costs, the benefits of reducing consumers' pre-purchase costs through outlet channels are the maximum (see Table 5), especially for beauty care product distributors, whether through

Table 5. Decision-making Stages and Transaction Cost Factors Weights

Stage	Weights	Ranking	Criteria	Weights (local)	Ranking (local)	Weights (global)	Ranking (global)
Pre-purchasing	0.4473	1	C1a Easy access to product information	0.1951	3	0.0873	3
			C1b Sufficient information exposure	0.2673	2	0.1196	2
			C1c Trial use	0.3430	1	0.1534	1
			C1d Demonstration and explanation	0.1946	4	0.0870	4
Purchasing	0.2535	3	C2a Purchasing threshold limit	0.1325	5	0.0336	14
			C2b Personal privacy leakage prevention	0.2204	2	0.0559	9
			C2c Simplify the filling of certificates	0.1336	4	0.0339	13
			C2d Provide diverse terms of payment	0.3365	1	0.0853	5
			C2e Privileges	0.1770	3	0.0449	11
Post-purchasing	0.2992	2	C3a Order transparency	0.1445	5	0.0432	12
			C3b Delivery progress notification	0.1827	4	0.0547	10
			C3c Enhanced delivery speed	0.2565	1	0.0767	6
			C3d Lengthened product appreciation period	0.2203	2	0.0659	7
			C3e Simplified refunding procedure	0.1960	3	0.0586	8

Table 6. Weights of Sales Channels

Alterna-	Outlet channel	Point-of-	Home delivery
Weights	0.4932	0.1987	0.3081

advertising, direct mail (DM), or promotional activity.

Contributions

(1) This study developed a model for specific discussion of the impact of transaction cost factors on consumer purchasing behavior from the consumer purchasing decision making perspective. The principal research value is the process of model construction, which can be easily used by managers and distributors.

(2) Product distributors may use the proposed model to analyze the weights of transaction cost factors, and coupled with the demand function considering transaction cost, as proposed by Chang and Chen (2008a), distributors can determine the resource configuration that best enhances transaction efficiency (using the criteria weights in Table 5). In other words, distributors can achieve the optimal distribution of each unit amount of transaction cost investment; hence, it is highly feasible and practical in use.

(3) The manufacturer can design a new transaction approach to lower the overall transaction cost (including the selling price), which is the sum of the manufacturer's transaction cost and the transaction cost of the consumer group.

If the manufacturer invests in the transaction environment with an additional 1 unit amount, the transaction cost expenditure of the consumer group can be reduced by 1 unit amount or more, and the manufacturer's investment in the transaction environment will be effective. The effect is determined by the selling price level. It may benefit the other party but not cause damage to itself (benefit the manufacturer but not damage the consumer, or benefit the consumer but not damage the manufacturer), or it may benefit both parties (benefit the manufacturer and the consumer). There are many cases of increases in the above-

mentioned transaction efficiency, such as allowing the consumers to easily contact or search for product information and conveniently purchase products.

(4) The proposed model can be applied to actual products, services, and composite commodities in order to satisfy the attributes of most present commodities. The findings of this study can be widely applied.

(5) The findings of this study can be used as reference in the selection and development of sales channels for beauty cosmetics distributors or other distributors, and can be applied to marketing fields, financial fields, and inventory management, and transaction cost analysis.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Data Availability

The data used to support the findings of this study are included within the article.

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Appendix A. Table 7 Uunweighted Supermatrix M_1

	Goal	Stage			Criteria														Alternatives		
		P1	P2	P3	C1a	C1b	C1c	C1d	C2a	C2b	C2c	C2d	C2e	C3a	C3b	C3c	C3d	C3e	A1	A2	A3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
P1	0.6072	0.1468	0.4331	0.5171	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4802	0.6333	0.6546
P2	0.2159	0.3469	0.1415	0.2853	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3051	0.1997	0.1314
P3	0.1768	0.5064	0.4254	0.1976	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2147	0.1670	0.2140
C1a	0.0000	0.2018	0.0000	0.0000	0.1023	0.2203	0.2480	0.1260	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1b	0.0000	0.2682	0.0000	0.0000	0.2853	0.1157	0.3268	0.3478	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1c	0.0000	0.3641	0.0000	0.0000	0.3940	0.4055	0.1393	0.4567	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1d	0.0000	0.1660	0.0000	0.0000	0.2184	0.2584	0.2859	0.0695	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2a	0.0000	0.0000	0.1458	0.0000	0.0000	0.0000	0.0000	0.0000	0.0692	0.1104	0.1335	0.1270	0.1424	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2b	0.0000	0.0000	0.2176	0.0000	0.0000	0.0000	0.0000	0.0000	0.1778	0.1164	0.1895	0.2814	0.3049	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2c	0.0000	0.0000	0.1187	0.0000	0.0000	0.0000	0.0000	0.0000	0.1727	0.1808	0.0765	0.1610	0.1201	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

C2d	0.0000	0.0000	0.3528	0.0000	0.0000	0.0000	0.0000	0.0000	0.4327	0.4574	0.4231	0.1186	0.3714	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2e	0.0000	0.0000	0.1651	0.0000	0.0000	0.0000	0.0000	0.0000	0.1476	0.1350	0.1775	0.3120	0.0612	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C3a	0.0000	0.0000	0.0000	0.1006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0608	0.2287	0.1721	0.1873	0.2675	0.0000	0.0000	0.0000
C3b	0.0000	0.0000	0.0000	0.1914	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2561	0.1083	0.2360	0.1406	0.1307	0.0000	0.0000	0.0000
C3c	0.0000	0.0000	0.0000	0.2693	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2859	0.2843	0.1150	0.2638	0.3210	0.0000	0.0000	0.0000
C3d	0.0000	0.0000	0.0000	0.2381	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1719	0.1687	0.3043	0.1650	0.1654	0.0000	0.0000	0.0000
C3e	0.0000	0.0000	0.0000	0.2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2254	0.2100	0.1724	0.2433	0.1154	0.0000	0.0000	0.0000
A1	0.0000	0.0000	0.0000	0.0000	0.6539	0.6449	0.6937	0.6469	0.1699	0.6626	0.4203	0.3157	0.1982	0.4944	0.4153	0.3331	0.2210	0.3287	0.0000	0.0000	0.0000
A2	0.0000	0.0000	0.0000	0.0000	0.1448	0.1708	0.1367	0.1094	0.1893	0.1617	0.2372	0.3289	0.1425	0.3189	0.3271	0.1810	0.1920	0.3243	0.0000	0.0000	0.0000
A3	0.0000	0.0000	0.0000	0.0000	0.2012	0.1842	0.1696	0.2437	0.6408	0.1757	0.3424	0.3554	0.6593	0.1867	0.2576	0.4858	0.5870	0.3470	0.0000	0.0000	0.0000

Appendix B. Table 8 Weighted Supermatrix M_2

	Goal	Stage			Criteria														Alternatives		
		P1	P2	P3	C1a	C1b	C1c	C1d	C2a	C2b	C2c	C2d	C2e	C3a	C3b	C3c	C3d	C3e	A1	A2	A3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
P1	0.6072	0.0734	0.2166	0.2585	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4802	0.6333	0.6546
P2	0.2159	0.1734	0.0708	0.1426	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3051	0.1997	0.1314
P3	0.1768	0.2532	0.2127	0.0988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2147	0.1670	0.2140
C1a	0.0000	0.1009	0.0000	0.0000	0.0511	0.1102	0.1240	0.0630	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1b	0.0000	0.1341	0.0000	0.0000	0.1427	0.0578	0.1634	0.1739	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1c	0.0000	0.1820	0.0000	0.0000	0.1970	0.2028	0.0696	0.2283	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C1d	0.0000	0.0830	0.0000	0.0000	0.1092	0.1292	0.1430	0.0348	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2a	0.0000	0.0000	0.0729	0.0000	0.0000	0.0000	0.0000	0.0000	0.0346	0.0552	0.0667	0.0635	0.0712	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2b	0.0000	0.0000	0.1088	0.0000	0.0000	0.0000	0.0000	0.0000	0.0889	0.0582	0.0947	0.1407	0.1524	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2c	0.0000	0.0000	0.0594	0.0000	0.0000	0.0000	0.0000	0.0000	0.0863	0.0904	0.0382	0.0805	0.0601	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

C2d	0.0000	0.0000	0.1764	0.0000	0.0000	0.0000	0.0000	0.0000	0.2163	0.2287	0.2116	0.0593	0.1857	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C2e	0.0000	0.0000	0.0825	0.0000	0.0000	0.0000	0.0000	0.0000	0.0738	0.0675	0.0887	0.1560	0.0306	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
C3a	0.0000	0.0000	0.0000	0.0503	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0304	0.1143	0.0861	0.0936	0.1337	0.0000	0.0000	0.0000
C3b	0.0000	0.0000	0.0000	0.0957	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1280	0.0542	0.1180	0.0703	0.0653	0.0000	0.0000	0.0000
C3c	0.0000	0.0000	0.0000	0.1346	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1429	0.1421	0.0575	0.1319	0.1605	0.0000	0.0000	0.0000
C3d	0.0000	0.0000	0.0000	0.1191	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0859	0.0843	0.1522	0.0825	0.0827	0.0000	0.0000	0.0000
C3e	0.0000	0.0000	0.0000	0.1003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1127	0.1050	0.0862	0.1217	0.0577	0.0000	0.0000	0.0000
A1	0.0000	0.0000	0.0000	0.0000	0.3270	0.3225	0.3469	0.3234	0.0850	0.3313	0.2102	0.1578	0.0991	0.2472	0.2077	0.1666	0.1105	0.1644	0.0000	0.0000	0.0000
A2	0.0000	0.0000	0.0000	0.0000	0.0724	0.0854	0.0683	0.0547	0.0947	0.0808	0.1186	0.1645	0.0712	0.1594	0.1635	0.0905	0.0960	0.1622	0.0000	0.0000	0.0000
A3	0.0000	0.0000	0.0000	0.0000	0.1006	0.0921	0.0848	0.1219	0.3204	0.0878	0.1712	0.1777	0.3297	0.0934	0.1288	0.2429	0.2935	0.1735	0.0000	0.0000	0.0000

Appendix C. Table 9 Limiting Supermatrix M_3

	Goal	Stage			Criteria														Alternatives		
		P1	P2	P3	C1a	C1b	C1c	C1d	C2a	C2b	C2c	C2d	C2e	C3a	C3b	C3c	C3d	C3e	A1	A2	A3
Goal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
P1	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789	0.1789
P2	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014	0.1014
P3	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197
C1a	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349	0.0349
C1b	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478	0.0478
C1c	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614	0.0614
C1d	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348	0.0348
C2a	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134
C2b	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223	0.0223

C2c	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135
C2d	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341	0.0341
C2e	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179
C3a	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173
C3b	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219
C3c	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307
C3d	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264	0.0264
C3e	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235	0.0235
A1	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986	0.0986
A2	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397	0.0397
A3	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616	0.0616