Chapter 5
Study of Electronic Commerce Maturity of Nantong Home-Textile Enterprises Based on AHP and Fuzzy Theory

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Abstract This article advances the evaluation index system of e-commerce maturity of Nantong home-textile enterprises. The index system covers four dimensions: attention degree to e-commerce of home-textile enterprises, e-commerce operations, e-commerce security, e-commerce revenue. This article first adopts AHP and fuzzy evaluation theory, and calculates various levels of the index weights, then using fuzzy method to determine the evaluation mathematical models of the various index; finally evaluate e-commerce maturity of Nantong home-textile enterprises.

Keywords The analytic hierarchy process · Fuzzy evaluation · Nantong home-textile · E-commerce maturity

5.1 Introduction

Textile industry is a veteran pillar industry in Nantong [1]. There are only more than 450 home-textile enterprises to expand sale channel via e-commerce in Haimen Dieshiqiao, and more than 60 home-textile enterprises establish department of e-commerce marketing or subsidiary company. In Dieshiqiao international home-textile City, there are nearly 4,000 stores to develop their business through e-commerce network of online trading, the online consumption sum more than 20 %. The development of e-commerce is the key factor of continuing existence in Nantong home-textile enterprises [2, 3]. Therefore, evaluation of Nantong textile enterprises in e-commerce maturity is extremely urgent, on the basis of previous studies, the author has constructed evaluation index system in Nantong home-

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textile enterprises in e-commerce maturity, using the analytic hierarchy process (AHP) and 1–9 scale to determine the weights of the various index, and establishing fuzzy evaluation model, finally validating this method to evaluate Nantong textile enterprises in the implementation of e-commerce maturity of rationality and reliability through the Nantong textile enterprises instance [4, 5].

5.2 The Building of E-commerce Maturity Index System in Nantong Home-Textile Enterprises

5.2.1 Theoretical Background

Chen ZhuPu early put forward the evaluation index system of the enterprise e-commerce maturity via referencing to the CII e-commerce index system by the National Information Evaluation Center [6]. And he stressed the basis of the e-commerce operational processes and evaluated the enterprise via the five aspects: e-commerce infrastructure, the inner and external environment in the e-commerce, e-commerce operation process, e-commerce security and e-commerce revenue.

Nantong home-textile enterprises have carried out e-commerce nearly 10 years, but most enterprises are relying on third-party platform for the implementation of e-commerce, and expand the enterprise's own sales. So a lot of literature on the infrastructure of e-commerce index system lacks practical value, this paper emphasis more on the importance of enterprise e-commerce and actual operating results.

5.2.2 Index System Design

Nantong textile enterprise e-commerce applications rely more on third-party e-commerce platform to expand business sales, on the basis of summing up the literature and combined with Nantong textile enterprises e-commerce implementation, so author designs the four index system about the attention degree of the enterprises e-commerce, e-commerce operations, e-commerce security, e-commerce revenue on Nantong home-textile enterprises in e-commerce maturity index system [7, 8]. The index system of e-commerce maturity in Nantong home-textile enterprises is as shown in Table 5.1.

5.3 Based on AHP and Fuzzy Comprehensive Evaluation Algorithm

The AHP is a structured technique for organizing and analyzing complex decisions. Based on mathematics and psychology, it was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular

Table 5.1 The index system of the e-commerce maturity in Nantong home-textile enterprises

Elements	Index	Index explanation
The attention degree of the enterprises e-commerce U1	Website maintenance U11	The implementation of the ongoing maintenance of e-commerce website in home-textile enterprises
	Professionals U12	The implementation of e-commerce with the appropriate professionals in home-textile enterprises
	Staff training mechanisms U13	E-commerce training to employees on a regular basis in
	E-commerce investment proportion U14	Willing to invest the cost of e-commerce in home-textile enterprises
E-commerce operations U2	Online product publicity U21	Propaganda of the implementation of e-commerce for textile products and corporate image
	Online transaction U22	Complete product transactions by electronic payment in home-textile enterprises
	Internet marketing strategies U23	Continue to implement and improve online marketing strategies in home-textile enterprises
	Profit model innovation U24	Continue to realize the innovative e-commerce profit model in home-textile enterprises
	Customization services U25	E-commerce implementation to promote the textile enterprise customization services
E-commerce security U3	Network security degree U31	Website network security in home-textile enterprises
	Online payment security U32	Online payment security in home-textile enterprises
	Viruses situation U33	Website virus defense capabilities in home-textile enterprises
E-commerce revenue U4	Network sales share U41	E-commerce sales accounted for a share of sales of the home-textile enterprises
	Customer satisfaction degree U42	E-commerce implementation to enhance the satisfaction of the end consumer groups to home-textile enterprises
	Decrease of marketing costs U43	E-commerce implementation to reduce the marketing costs of the traditional marketing model
	Improvement of Work efficiency U44	E-commerce implementation to improve the work efficiency of the textile enterprises

application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

5.3.1 Establishing the Hierarchical Structure Model

Stratified by the factors included in the problem, first the overall goal should be considered the highest level; then we consider the various measures and criteria taken to achieve the overall goal is the middle layer; finally the various options of solving the problem should be considered the lowest level. Various factors should be considered on the appropriate level. Factor sets are collection of various criterion of the associated evaluation object elements, usually set U, U = {U1, U2,…, Un}.

The e-commerce maturity factor of Nantong home-textile enterprises divided into two levels according to Table 5.1, you can create top-level factor sets: U = {U1, U2, U3, U4}. The second level single factor set as follows: U1 = {u11, u12, u13, u14}; U2 = {u21, u22, u23, u24, u25}; U3 = {u31, u32 Bases the, u33}; U4 = {u41, u42, u43, u44}.

5.3.2 Estimating the Normalized Priority Weights of Decision Criteria

Importance of each factor is usually not the same, in order to reflect the differences of the various factors importance we give each factor (Ui) to the priority weights wi. By the weights of the collection known as the factor weight sets, W = (w1, w2,…, wn).

Before the constructor of matrix of dimension *N*, we use the 1–9 scale method listed in the relative importance of the ratio of the various index, as shown in Table 5.2.

Accordingly to compare the same level element in multi-level model and establish the following form of the orthogonal judgment matrix:

$$A - B_i = \begin{pmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{m1} & \cdots & b_{\mathrm{nn}} \end{pmatrix}. \tag{5.1}$$

In the formula, $b_{ij} > 0$, $b_{ij} = 1/b_{ji}$, $b_{ii} = 1$, b_{ij} means importance scale about element B_i and the elements B_j.

There are two methods of calculating judgment matrix, the geometric mean method and standardize the column average.

More commonly used specification column average method to estimate the normalized priority weights in this paper. Suppose largest characteristic root of judgment matrix $A - B_i$ is $\lambda_{\max}$, the normalized priority weights vector of decision criteria W_i and $\lambda_{\max}$ is calculated:

$$W_i = \sum_{j=1}^{n} b_{ij} \Big/ \sum_{j=1}^{n} \sum_{i=1}^{n} b_{ij} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, n) \tag{5.2}$$

Table 5.2 1–9 scale method

Value	Scale explanation
1	Two elements are compared, both are equally important
2	The two elements compared, the first element is slightly important than the latter
5	The two elements compared, the first element is important than the latter
7	The two elements compared, the first element is very important than the latter
9	The two elements compared, the first element is extremely important than the latter
2, 4, 6, 8	Between these two levels compromise the scale
$1/b_{ij}$	The anti-comparison of two elements

$$\lambda_{\max} = \frac{1}{n}\sum_{j=1}^{n}\frac{\sum_{i=1}^{n} b_{ij}\omega_i}{\omega_j} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, n). \tag{5.3}$$

5.3.3 Consistency Test

When we test consistency for each paired judgment matrix to calculate the maximum characteristic root $\lambda_{\max}$ and the corresponding weights W_i. From the theoretical analysis: If the matrix A is consistent pairwise comparison matrix, where

$$\alpha_{ij}\alpha_{jk} = \alpha_{ik}(a \le i, j, k \le n). \tag{5.4}$$

But it is almost impossible to construct pairwise comparison matrix. Therefore, there is good consistency to the pairwise comparison matrix. Exactly the same stringent requirements paired comparison matrix, the absolute value of the maximum characteristic root should be equal to the order of the matrix. In order to improve the scientific nature of the actual decision making, we usually take consistency test. The inspection process is divided into the following three steps:

Step 1. Calculating the consistency index CI.

$$S = W \cdot R \tag{5.5}$$

Step 2. Average random consistency index RI.

From the relevant literature we can find the RI of comparison matrix A, RI is called the average random consistency index, and it is only relative the order n of matrix, when n = {1, 2,…, 9}, where RI = {0, 0, 0.58, 0.9, 1.12, 1.24, 1.32, 1.41, 1.45}, as shown in Table 5.3.

Step 3. Calculating the consistency ratio CR.

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{5.6}$$

If CR < 0.1, we consider the judgment matrix which has good consistency, otherwise we must adjust the value of the judgment matrix.

Table 5.3 Average random consistency index RI

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

5.3.4 Building and Solving the Fuzzy Evaluation Algorithm

Step 1. Building the evaluation sets.

We can give five elements of the evaluation set when evaluation index is to be quantitative analysis, such as {very high, high, generally, low, very low}, {very good, good, generally, poor, very poor} {[90–100], [80–89], [70–79], [60–69], [40–59]}, there are five results of e-commerce maturity evaluation in Nantong home-textile enterprises, it is very good, good, generally, poor, and very poor, set V = {V1, V2, V3, V4, V5,} = {very good, good, generally, poor, very poor}.

Step 2. Constructing fuzzy relation matrix and fuzzy evaluation matrix.

According to the evaluation set of objectives to be evaluated by the expert group, we can get the evaluation results of each factor evaluation and fuzzy matrix. N evaluation of the factors set composed of a total evaluation matrix R. Then via the weight vector W and the relationship matrix R, the fuzzy evaluation matrix S can be constructed:

$$S = W \cdot R. \tag{5.7}$$

5.4 Case Study of the Nantong Home-Textile Enterprises

On the basis of theoretical studies and combined with the previous analysis, we can get a fuzzy comprehensive evaluation of the hierarchical model of e-commerce maturity index system in Nantong home-textile enterprises, as shown in Table 5.4.

According to the hierarchical model theory of e-commerce maturity evaluation in Nantong home-textile enterprises, we can establish judgment matrix A − B, as shown in Table 5.5.

We can establish the judgment matrix of the B layer element and C layer element, according to the Eq. (5.1), (5.2), we can get:

$$\mathrm{WB} = (0.301,\ 0.417,\ 0.097,\ 0.185)$$

$$\lambda_{\max} = 4.099$$

Accordingly Eq. (5.3) can be calculated: CI = (4.099 − 4)/(4 − 1) = 0.033, look up Table 5.3, when n = 4, where RI = 0.9, according to Eq. (5.4), CR = 0.033/0.9 = 0.037 < 0.1, we consider the judgment matrix has satisfied consistency, the weight is acceptable. Similarly we can calculate the weight of the

Table 5.4 Fuzzy comprehensive evaluation of the hierarchical model of e-commerce maturity index system in Nantong home-textile enterprises

The target of e-commerce maturity index system in Nantong home-textile enterprises A
The attention degree of the enterprises e-commerce B1
Website maintenance C11
Professionals C12
Staff training mechanisms C13
E-commerce investment proportion C14
E-commerce operations B2
Online product publicity C21
Online transaction C22
Internet marketing strategies C23
Profit model innovation C24
Customization services C25
E-commerce security B3
Network security degree C31
Online payment security C32
Viruses situation C33
E-commerce revenue B4
Network sales share C41
Customer satisfaction degree C42
Decrease of marketing costs C43
Improvement of work efficiency C44

Table 5.5 Judgment matrix A − Bi

$A–B_i$	B_1	B_2	B_3	B_4
B_1	1	1/2	3	2
B_2	2	1	4	2
B_3	1/3	1/4	1	1/2
B_4	1/2	1/2	2	1

C layer of each element relative to the B shown in Table 5.6. According to Table 5.6 we can get the combined weight of the 16 evaluation results.

$$W = (0.028, 0.134, 0.087, 0.051, 0.121, 0.072, 0.158, 0.042, 0.025, 0.016, 0.051, 0.030, 0.079, 0.039, 0.048, 0.018)$$

The 16 evaluation factors of e-commerce maturity in Nantong home-textile enterprises can be composed of the factors set U, and the evaluation results have five kinds, such as very good, good, generally, poor, very poor. According to expert evaluation data we can obtain the following evaluation results matrix R, shown in Table 5.7.

Table 5.6 The weights of e-commerce maturity index in Nantong home-textile enterprises

B layer element	Weights	Index	Weights	Combined weights
The attention degree of the enterprises e-commerce U1	0.301	Website maintenance U11	0.093	0.028
		Professionals U12	0.446	0.134
		Staff training mechanisms U13	0.290	0.087
		E-commerce investment proportion U14	0.171	0.051
E-commerce operations U2	0.417	Online product publicity U21	0.290	0.121
		Online transaction U22	0.172	0.072
		Internet marketing strategies U23	0.379	0.158
		Profit model innovation U24	0.100	0.042
		Customization services U25	0.059	0.025
E-commerce security U3	0.097	Network security degree U31	0.162	0.016
		Online payment security U32	0.529	0.051
		Viruses situation U33	0.309	0.030
E-commerce revenue U4	0.185	Network sales share U41	0.427	0.079
		Customer satisfaction degree U42	0.213	0.039
		Decrease of marketing costs U43	0.261	0.048
		Improvement of work efficiency U44	0.099	0.018

Table 5.7 Evaluation results matrix

Index	Very good	Good	Generally	Poor	Very poor
Website maintenance U11	0.2	0.6	0.2	0.1	0
Professionals U12	0.1	0.7	0.1	0.1	0
Staff training mechanisms U13	0.1	0.4	0.3	0.2	0
E-commerce investment proportion U14	0.3	0.3	0.3	0.1	0
Online product publicity U21	0.2	0.6	0.1	0.1	0
Online transaction U22	0.5	0.5	0	0	0
Internet marketing strategies U23	0.2	0.4	0.2	0.2	0
Profit model innovation U24	0.1	0.2	0.4	0.3	0
Customization services U25	0.2	0.6	0.2	0	0
Network security degree U31	0.1	0.8	0.1	0	0
Online payment security U32	0.3	0.6	0	0.1	0
Viruses situation U33	0.5	0.3	0.2	0	0
Network sales share U41	0.2	0.7	0.1	0	0
Customer satisfaction degree U42	0.2	0.5	0.2	0.1	0
Decrease Of Marketing costs U43	0.2	0.5	0.1	0.2	0
Improvement of Work efficiency U44	0.2	0.6	0.1	0.1	0

According to Eq.(5.5) $S = W \cdot R$, where $S = (0.213, 0.518, 0.156, 0.115)$. Based on the maximum degree of membership method, the maximum degree of membership value of Nantong home-textile enterprise e-commerce maturity

evaluation max(s) = 0.518, the e-commerce maturity in Nantong textile enterprises is the second stage of the evaluation grade, that is "good".

5.5 Conclusions

For multi-program evaluation, there is the limitation of the weight in AHP, for example judgment matrix consistency test is difficult to pass. This paper is based on AHP and fuzzy comprehensive evaluation algorithm theory, effectively avoiding the AHP in man-made subjective judgments of the e-commerce maturity evaluation. Case study indicates that the evaluation based on AHP fuzzy comprehensive evaluation algorithm is good in evaluating the e-commerce maturity in Nantong home-textile enterprises.

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References

1. Jin X (2004) Department of commerce in Taiwan. Important international organizations to promote the history and trends of e-commerce. ROC national information infrastructure industry development Association, vol 12(6), pp 74–84
2. Liang X (2011) Based on AHP and fuzzy comprehensive evaluation algorithm and its application. Sci Pap Online 8(3):538–547
3. Yong CZ (2004) A combination of the maturity of the enterprise e-business evaluation. Bus Res 39(12):356–365
4. Tian M, Min L (2004) Maturity ranking of the global e-commerce development in China's revelation. Economist 13(10):94–106
5. Zheng Y, Jingying Y, Qiping J (2001) Measure of e-commerce level. Stat Res 32(12):26–31
6. Song W, Ziqin Y, Lin S-L, Chan S (2002) Weeks Taiwan's industrial e-commerce maturity assessment report. Taiwan ministry of economic affairs, vol 42(10), pp 849–856
7. Huizhen Z, Jin X (2010) Analysis of new rural construction in China's agricultural e-commerce development strategy. Management 23(10):108–109
8. Saaty P, Thomas L (2008) Relative measurement and its generalization in decision making: why pairwise comparisons are central in mathematics for the measurement of intangible factors—the analytic hierarchy/network process. Racsam 12(6):12–22