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Research on Evaluation of E-commerce Implementation Effect for Small and Middle-Sized Enterprises

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Abstract

Taking the Chinese SMEs as examples, this paper uses the Balanced Scorecard, the D&M model and the financial evaluation model to construct the evaluation index system for the E-commerce implementation performance of small and medium-sized enterprises centering on the financial dimension, customer dimension and organizational dimension, and further explore the E-commerce implementation effect using the structural equation model, factor analysis, and comprehensive fuzzy evaluation. Research results on one hand contribute to further promot theroetical fild of the e-commerce of small and medium-sized enterprises, and on the other hand, aiming at the practice of small and medium-sized enterprises, the researches provide theoretical support and concrete technical means for the evaluation of the effect of e-commerce of small and medium-sized enterprises. Meanwhile, this paper provides specific and feasible decision-making basis for the management and implementation of e-commerce to numerous small and medium-sized enterprises.

Key words

Small and Medium-Sized Enterprises, E-Commerce, Implementation Effect Evaluation, SEM, Comprehensive Fuzzy Evaluation.

1. Introduction

Since the reform and opening-up of China, the small and medium-sized enterprises have been developing and growing, and have gradually become one of the important forces to promote

China’s economic and social development. They have made great contributions in promoting China’s national economic growth and solving the problem of labor and employment. As of 2016, SMEs accounted for 99% of the total number of registered enterprises, and the value of their products and services accounted for more than 60% of the total GDP. They paid more than 50% of the country’s taxes, and crated jobs for 80% of China’ cities and towns. But in recent years, due to the slowdown in domestic economy, structural adjustment and downturn of the international economy, small and medium enterprises are facing such problems as market shrinking, customer loss, impeded exports, rising production and operating costs, insufficient cash flow, and difficult financing. Many small and medium-sized enterprises are falling into the plight of survival, and even at the edge of bankruptcy. The traditional development path of small and medium-sized enterprises featured by low cost, low technology, low yield, and low value-added directly restricts their input-output benefits. E-commerce, as a brand-new means of operation of enterprises, has become an important way for small and medium enterprises to break the bottleneck of development and make innovation. Breaking the time and physical region constraints, E-commerce creates an opportunity to equally compete with large enterprises. On the one hand, E-commerce coordinates and unifies the whole activities of enterprises, standardizes the workflow of affairs treatment, reduces the operating costs, and improves the personnel, funds and equipment utilization efficiency and on the other hand, it opens up a new prospect for the small and medium-sized enterprises in terms of new market opportunities. However, not all small and medium-sized enterprises implementing E-commerce can get a good return. Many small and medium enterprises don’t achieve remarkable results after implementing E-commerce, and even a few enterprises are caught in crisis after investing a lot of money. Therefore, it has become an important task to be urgently researched and solved to make scientific and effective evaluation on the effect of E-commerce implementation in small and medium-sized enterprises and analyze the problems of these enterprises in developing E-commerce, so as to improve the operating efficiency of their e-commerce, effectively use the corporate investment and increase their economic benefits.

Taking Chinese small and medium-sized enterprises as examples, this paper discusses the evaluation index system and evaluation methods for the e-commerce implementation effect, and takes an enterprise as an example to carry out the empirical analysis. Research results show that on one hand, the theoretical system of the e-commerce of small and medium-sized enterprises is further improved and on the other hand, aiming at the practice of small and medium-sized enterprises, the researches provide theoretical support and concrete technical means for the evaluation of the effect of e-commerce of small and medium-sized enterprises to the enterprises and related departments. Meanwhile, this paper provides specific and feasible decision-making basis for the management and implementation of technologies to numerous small and medium-sized enterprises.

2. Evaluation System of E-commerce Implementation Effect

Delong & Mclean [1] presents the classic D&M model for evaluating the success or failure of e-commerce implementation. The model evaluates from such six elements as system quality, information quality, system use, customer satisfaction, personal impact and organizational impact. In the Online Business Application Experience of Small and Medium-sized Enterprises, Australian Sensis takes return on investment, utilization level, i.e. the extent of the e-commerce function, the impact on organizational performance and users' satisfaction degree as the criteria to estimate whether the e-commerce implementation in small and medium-sized enterprises is successful or not. Elahi [2] builds an evaluation index system that includes technical dimensions, organizational dimensions, and inter-organizational dimensions through analyzing the data from 27 sample companies in Iran. Chinese scholars also conducted related researches. Wang [3] designed the performance evaluation index for enterprises implementing e-commerce from such four perspectives as finance, customers, internal business procedures, learning and growth, based on the framework of balanced score card (BSC). Feng Ying [4] combines the D&M model with the Balanced Score Card (BSC) to evaluate the implementation effect of e-commerce from the financial effect, competition effect, service effect and the internal dimension of the enterprise using projection pursuit method. The index system is shown below. Wang Xiaojuan [5] used the method of financial evaluation to build e-commerce implementation evaluation indicators. She combined the enterprise's profitability indicators with its operation capacity indicators, which include current ratio, asset-liability ratio, inventory turnover rate, accounts receivable turnover rate, earnings per share, net profit margin, main profit growth rate, net profit growth rate, etc. Cai Rongjiang [6] proposed the evaluation system for E-commerce enterprise performance based on EVA. Zhao Jing et al [7] established an e-commerce performance evaluation model suitable for the dynamic evaluation from such four perspectives as strategic construction, resource analysis, capacity assessment and performance measurement. Wang Li-ping [8] pointed out that the resources of SMEs are relatively scarce. After the development of e-commerce, the effective use of resources is the key. To measure their effective use, we shall start from the aspects of human resources, financial resources, and material resources and establish scientific measurement standards from such aspects as resources, capacity, customer and management.

In the study of the evaluation of the e-commerce implementation effect, foreign scholars tend to take e-commerce as a kind of information technology (information system) to make evaluation, and seldom take the impact of e-commerce on enterprise management and sales as the evaluation index. In addition, the research results may not be suitable for small and medium-sized enterprises in China.

2.1 Evaluation Indexes for Small and Medium-Sized Enterprises

Different from large enterprises, small and medium enterprises have limited funds and personnel investment, so in the study of e-commerce implementation effect, whether the invested resources are effectively used is very critical. Based on the characteristics of small and medium-sized enterprises, and referring to the Balanced Score Card (BSC), D&M model and financial evaluation model, the evaluation indictors system for assessing the e-commerce implementation performance of small and medium-sized enterprises is established in consideration of the characteristics of e-commerce as an information system and its economic characteristics as a business mode and analysis is made from such three dimension s as finance, customer and organization. (1) The financial dimension includes the proportion of increased sales volume achieved through e-commerce in the total sales volume, the proportion of sales profit achieved through e-commerce in the total sales profit and the income gained after the cost saving since the adoption of e-commerce, which includes the deduction of inventory cost, document processing cost, purchase cost and trading cost, the shortened time for capital turnover and the degree of shortening of the inventory turnover rate; (2) the customer dimension includes the enhancement of satisfaction with service, payment, logistic distribution, website information content service, etc. and the improvement of the business information collection and handling capacity during the cooperation process; (3) the organizational dimensions, include the degree of improvement of corporate image, management level, the level of information, staff's quality, etc. The specific index system is shown in Table 1 below:

Tab.1. E-commerce effect evaluation indexes for small and medium-sized enterprises

E-commerce Implementation Output Analysis		
Dimensions	Output Analysis Indicator	
Financial Dimension	B1	proportion of increased sales volume achieved through e-commerce in the total sales volume

	B2	proportion of sales profit achieved through e-commerce in the total sales profit
	B3	income gained after the cost saving since the adoption of e-commerce (deduction of inventory cost, document processing cost, purchase cost and trading cost)
	B4	shortened time for capital turnover
	B5	degree of shortening of the inventory turnover rate
Customer Dimension	B6	number of newly added clients / trading partners
	B7	client/trading partner service improvement level
	B8	enhancement of client's/trading partner's satisfaction with the payment
	B9	enhancement of client's/trading partner's satisfaction with the logistics distribution
	B10	enhancement of client's/trading partner's satisfaction with the website information content
	B11	degree of business information collection and processing power
Organizational Dimension	B12	degree of enterprise image (brand) improvement
	B13	degree of management level improvement
	B14	degree of level of informatization

2.2 Mathematics Methods for Evaluating E-commerce Effect

On the basis of constructing the evaluation index of the e-commerce implementation effect for small and medium-sized enterprise, this paper evaluates the e-commerce implementation effect of the small and medium-sized enterprises combing EFA factor analysis, structural equation model and comprehensive fuzzy evaluation and analyzes the advantages and disadvantages in the current e-commerce implementation, providing reference to the next stage of e-commerce implementation measures.

1. EFA factor analysis and Cronbach's alpha coefficient

The factor analysis groups the variables according to the variable correlation size and seek common factors through transformation and constructing model to simplify the complicated indicators and ensure the completeness of information. Verify the creditability and reliability of the evaluation indexes through factor analysis.

The mathematical model is as follows:

Let there are k variables, x_1, x_2, …, x_k and let $\mu_k=0$, $\sigma=1$. Now express each original variable with the linear combination of $m(m<k)$ factors, f_1, f_2, …, f_m. a_{ij} (i=1, 2, …, m; j=1, 2, …, k) is called the factor loading, represents the load of the i_{th} variable in the j_{th} factor. ε_j (j=1, 2, …, k) is called the residual term, i.e.

$$\begin{cases} X_1 = a_{11} f_1 + a_{12} f_2 + ... + a_{1m} f_m + \varepsilon_1 \\ X_2 = a_{21} f_1 + a_{22} f_2 + ... + a_{2m} f_m + \varepsilon_2 \\ \qquad \cdots\cdots \\ X_k = a_{k1} f_1 + a_{k2} f_2 + ... + a_{km} f_m + \varepsilon_k \end{cases} \tag{1}$$

Before the factor analysis, it is necessary to check whether the sample data are suitable for factor analysis, which is carried out mainly through two kinds of methods. One method is the Bartlett test of sphericity which takes the correlation coefficient matrix of the original variables as starting point. The null hypothesis is that the correlation coefficient is the unit matrix, i.e. to examine whether the correlation coefficients are significantly different and are greater than 0. The other method is KMO test, which is an index used to compare the correlation coefficient and partial correlation coefficient between variables. The calculation formula is as follows:

$$KMO = \frac{\sum\sum_{i \neq j} r_{ij}^2}{\sum\sum_{i \neq j} {}_{ij}^2 + \sum\sum_{i \neq j} p_{ij}^2} \tag{2}$$

r_{ij} is the simple correlation coefficient between the variable xi and other variable x_j. p_{ij} is the partial correlation coefficient of the variables xi and xj after they control the rest variables. KMO is within the range of [0,1]. The closer it is to 1, the more common factors there will be among the variables and the better the factor analysis effect will be. Generally speaking, as long as KMO>0.7, it is acceptable(E.Abrahamson,1993) [9].

The steps to conduct validity test of the indicator system using exploratory factors are as follows:

i. Using the principal component analysis method to extract the common factor, and the factor shaft adopts the orthogonal shaft. The mathematical definition of the communality hi2 of the variable xi is:

$$h_i^2 = \sum_{j=1}^{k} a_{ij}^2 \tag{3}$$

Formula 3 indicates that the communality of the variable x_i is the quadratic sum of the elements in the i_{th} row in the factor loading matrix A. The closer the communality h_i^2 is to 1, the larger the part of the variance of variable xi can be explained by various factors.

ii. Compare the distribution of different number of factors and it is appropriate to make the amount of variability explained by the extracted common factors reach over 60% （the Accumulated Variance Contribution Rate reaches over 60%. The mathematical definition of the variance contribution S_j^2 of the factor f_i is

$$S_j^2 = \sum_{i=1}^{p} a_{ij}^2 \tag{4}$$

Formula 4 indicates that the variance contribution of the factor f_i is the quadratic sum of the elements in the j_{th} column in the factor loading matrix A.

iii. If the factor's load capacity is larger than 0.5, indicating that the construction validity of the measurement index is adopted. The factor loading a_{ij}<=1 and $|a_{ij}|$->1, indicating relatively strong relevance between the factor f_i and the variable x_i.

The Cronbach's α is used to measure the internal consistency of the index scale and its mathematical definitions are as follows:

$$\alpha = \frac{k\overline{r}}{1 + (k - 1)\overline{r}} \tag{5}$$

Where K is the number of the evaluated projects and $\overline{r}$ stands for the average of the correlation coefficient of k projects.

2. Structural Equation Model for Examining the Validity and Looking for Weights

The structural equation model SEM is a kind of statistical method that uses a linear equation system to represent the relationship between observable indicator and latent variable, and the relationship between latent variables. The complete structural equation model consists of a measurement model and a structural model (the measurement model describes the relationship between latent variables and observable indicators, which is intrinsically the confirmatory factor analysis (CFA). The confirmatory factor analysis is adopted to identify the relationship between the observable indicators and latent variables, and whether the index variables can effectively serve as the observable indicator of the latent variable. The purpose is to confirm the scale factor structure or the model of a set of variables. The structural model validation is to test the relationship between the latent variables, the coefficient of each path and the statistical significance. The structural equation model can be represented through three matrix equations. The specific expressions are:

$$x = \Lambda_x \xi + \delta \tag{6}$$

$$y = \Lambda_x \eta + \varepsilon \tag{7}$$

$$\eta = B\eta + \Gamma\varepsilon + \xi \tag{8}$$

Formula (6) and Formula (7) are the measurement model parts, which respectively define the relationship between the implicit endogenous variable η and the dominant endogenous variable y, and the relationship between the implicit exogenous variable ξ and the explicit exogenous variable. A_x refers to the relationship between the exogenous indicator and the exogenous latent variable. It is the factor load matrix of the exogenous indicator on the exogenous latent variable. A_y refers to the relationship between the endogenous indicator and the endogenous latent variable. It is the factor load matrix of the endogenous indicator on the endogenous latent variable. δ represents the error term of exogenous indicator and ε denotes the error term of the endogenous index. Formula (8) is the structural model part, which specifies the causal relationship between the implicit exogenous variable and the implicit endogenous variable assumed in the research model. B represents the effect coefficient matrix of the implicit endogenous variable on the implicit endogenous variable, Γ denotes the effect coefficient matrix of the implicit exogenous variable on the implicit endogenous variable, and ξ denotes the vector quantity of the residual term, which reflects the part of η which cannot be explained in the equation.

The model sample is shown as follows:

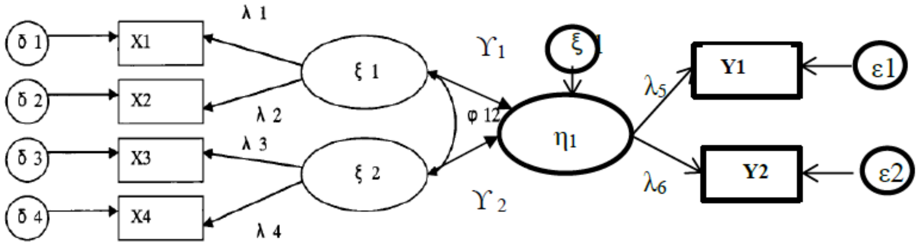

Fig.1. SEM model diagram

An Example of Systems of linear differential equations for the above general structural equation model measurement model (measurement model & structure model) is shown:

$$\begin{cases} X_1 = \lambda_1 + \xi_1 + \delta_1 \\ X_2 = \lambda_2 + \xi_2 + \delta_2 \\ X_3 = \lambda_3 + \xi_3 + \delta_3 \\ X_4 = \lambda_4 + \xi_4 + \delta_4 \\ \eta_1 = \Upsilon_1 \xi_1 + \xi_1 \end{cases}$$

In the SEM model, seven model parameter estimation methods are proposed [10-13]: instrumental variable method(IV), two-stage least squares method(TSLS) un-weighted least squares method(ULS), generalized least square method(GLS), generally weighted least square method(GWLS), maximum likelihood method(ML), and diagonally weighted least squares method(DWLS). This study uses the most widely used maximum likelihood method (ML). The functional expression of ML method is as follows:

$$F_{ML} = \log|\Sigma| - \log|s| + tr(s\Sigma^{-1}) - \rho \tag{9}$$

Where ρ is the amount of the measurement variable (p+q) and Σ is the estimated total covariance matrix. When the estimation matrix is fully matching with the observation matrix, the difference between the logarithm value of the matrix Σ and the logarithm value of the matrix S is 0 and $tr(s\Sigma^{-1})$ is $tr(I)$. F_{ML} is a nonlinear function based on the principle of probability, and it is not easy to obtain the parameter solution. Therefore, the iterative procedure is used to obtain the final solution.

After the hypothetical model parameters are estimated, the fitting of the hypothetical model and the actual observation data is determined by the fit index. In this study, the use of the freedom degree ratio in chi-square test, GFI, RMSEA, NFI and CFI five indicators are adopted mainly. Among them:

The export formula of the chi square value is as follows:

$$T = (N \quad 1)F_{\min} \tag{10}$$

GF1 represents the proportion of the variance which can be explained with the hypothetical model in the covariance. Its mathematical formula is as follows:

$$GFI = tr(\hat{\hat{\sigma}} w \hat{\sigma}) \,/\, tr(s'Ws) \tag{11}$$

Where the numerator is the sum of the weighted variances derived from the covariates of the theoretical hypothesis model; the denominator is the weighted variance derived from the covariates obtained through the actual observation of the sample; and W is the weighted matrix.

RMSEA coefficients are not affected by the quantity of the samples and the complexity of the model, but the RMSEA coefficients are rather sensitive to the error model and can penalize complex models. The smaller the indicators are the better. The mathematical formula is as follows:

$$REMSA = \sqrt{\frac{Fo}{df}} = \sqrt{\max \frac{Fm1}{df} \quad \frac{1}{N \quad 1}, 0} \tag{12}$$

Where, Fo=F(Σ_0, Σ_0) is the disparity caused by the approximation.

NFI is the difference quantity between the chi-square value of the hypothesis model and the chi-square value of the null model and its mathematical calculation formula is as follows:

$$NFI = (X^2_{null} - X^2_{text}) \,/\, X^2_{null} \tag{13}$$

Where, X^2_{null} and X^2_{text} stand for the chi-square value represented by the null model and hypothesis model respectively.

CFI reflects the measure of the degree of deviation between the hypothesis model and the independent model without any covariant relationship, considering the dispersion of distribution of the tested model and the chi-square. Its mathematical calculation formula is as follows:

$$CFI = 1 - \widehat{d}_1 / \widehat{d}_n, \widehat{d}_1 = \max(d_1, 0).\ d_n = (d_0, d_1.0).\ d_o = (x_0{}^2 - df_0) / n \quad (14)$$

$\chi 2$ and df_0 represent the chi-square value and the degree of freedom of the null hypothesis.

When evaluating a model, multiple indicators, rather than one of them, should be considered. Some of the indices and characteristics of the fitting degree of the commonly used evaluation models are shown in Table 4

Tab.4. SEM Model Fit Index Criteria [10]

Type	**Fitting Index**	**Reference Standard**	**Notes**
Chi-square test Fitness Indicators	Ration of the degree of freedom of Chi-square ($\chi 2$ /df)	<=3 (Carmines & Micver, 1981)	Applicable to large samples
	Goodness of Fit Index-GFI	>=0.80 (Sefars & Grover, 1993)	The performance is stable when using different models to evaluate
	Adjusted Goodness of Fit Index-AGFI	>=0.80 (Sefars & Grover, 1993)	Adjust GFI when increasing the freedom degree
	Normed Fit Index-NFI	>=0.90	Sensitive to non-normal and small samples and applicable to big samples
	Incremental Fit Index-IFI	>=0.90 (Bollen, 1989)	Superior to NNFI when applying the least square
Alternative Indicators	Comparative Fit Index-CFI	>=0.90 (Bentler, 1990)	Particularly useful for comparing nested models
	Root Mean Square Error of Approximation-RMSEA	<=0.08 (Steiger & Linder, 1980)	Impose punishment when the model is not simple

In this study, the AMOS20.0 software is applied to analyze the measurement model of the SEM model, and confirmatory factor analysis is conducted to the established indicator system, and then the validity of the index system is analyzed, based on which the first-order index weight and the judgment matrix of the effectiveness evaluation are confirmed using the factor loading factor and combining analytic hierarchy process.

3. Comprehensive Fuzzy Evaluation Method for the Effect of E-Commerce Implementation

Based on fuzzy mathematics and following the principle of composition of fuzzy relationship, the comprehensive fuzzy evaluation method quantifies the factors with obscure boundaries and which are not easy to be quantified to make a comprehensive evaluation of the problem. In the course of the evaluation of the implementation effect of e-commerce in small and medium-sized enterprises, the problem of various driving factors subordinating to different estimation scale are often uncertain and have the characteristics of fuzzy classification, so it is more suitable to solve the problem by means of fuzzy comprehensive evaluation [14].

i. First establish the factor set and the evaluation set. The established factor set is divided into two layers. Factors in the first layer are $U=\{U_1, U_2, U_3\}$ and factors in the second layer are $U_1=\{U_{11}, U_{12}, U_{13}, U_{14}, U_{15}\}$; $U_2=\{U_{21}, U_{22}, U_{23}, U_{24}, U_{25}, U_{26}\}$; $U_3=\{U_{31}, U_{32}, U_{33}\}$. The evaluation set is a set representing the degree of advantages and disadvantages of the evaluation targets, which is marked with $V=\{V_1, V, V_3, V_4\}$, corresponding to such four grades as excellent, good, medium and poor.

ii. Calculate the membership degree. The relevant expert representatives evaluate various secondary indicators. The proportion of the number of people who evaluate each indicator as the evaluation grade in the total number of representatives is called the membership degree of this indicator. The representatives who make financial dimension evaluation and organizational dimension evaluation are composed of senior managers and middle managers of relevant departments. Representatives who make customer dimension evaluation include business managers, relevant department heads and some invited customer representatives.

iii. Create a fuzzy evaluation matrix. The fuzzy judgment matrix is composed of membership degree, and for the case where the evaluation grade number is 4, the judgment matrix is:

$$Ri = \begin{bmatrix} R_{i1} \\ R_{i2} \\ \cdots \\ R_{in} \end{bmatrix} = \begin{bmatrix} r_{i11} & r_{i12} & r_{i13} & r_{i14} \\ r_{r21} & r_{i22} & r_{in3} & r_{i24} \\ & \cdots\cdots & r_{ikj} & \\ r_{in1} & r_{in2} & r_{in3} & r_{in4} \end{bmatrix}$$

Where $0<=r_{ikj}<=1;1<=i<=m$. m is the number of the first grade indexes; $1<=k<=n$. n is the number of the secondary indexes under the i_{th} first grade index. j=1,2,3,4 are corresponding to four evaluation grades. For example, r31 stands for the proportion of the number of people who rates the third index as excellent in the total number of representatives.

iv. First-grade fuzzy comprehensive evaluation. Calculate the single factor evaluation vector (Formula 15), where λi is the weight of each secondary index factor in the i_{th} first grade index. R_i is the fuzzy evaluation matrix of the i first grade index obtained in the previous step.

$$Zi = \lambda i * Ri \ (i = 1, 2, ..., m) \tag{15}$$

v. Secondary fuzzy comprehensive evaluation. The final evaluation vector Z is obtained through the complex expression of the matrix (Formula 16), where λ is the weight of each primary index factor and R is the fuzzy comprehensive evaluation vector Zi of the abovementioned level.

$$Z = \lambda * R \tag{16}$$

vi. Anti-fuzzification treatment. The result of fuzzy comprehensive evaluation is a set of fuzzy vectors, that is, the membership vector of the evaluation object subordinated to each evaluation grade. In order to clearly show the object's estimation scale and its comparison with other objects, the vector shall be refined, or called defuzzification. There are three methods for making fuzzy vector precise, including the maximum degree of membership method, the median method and the gravity method. The maximum degree of membership method only considers the influence of the maximum membership degree and ignores the influence of other membership degree, so it is not precise enough. The median method cannot highlight the role of key factors. Therefore, this study uses the gravity method for anti-fuzzification treatment. Let the four grades be corresponding to four values D=(d1, d2, d3, d4) and figure out the estimation scale using formula 17.

$$B = Z * DT \tag{17}$$

4. Experimental Analysis for the Effect of E-commerce in Small and Medium-sized Enterprises

The empirical research object is the managers of small and medium enterprises, who can better reflect the views and propensity of the decision-making personnel towards e-commerce. A total of 500 questionnaires were distributed, and 400 are returned. The recovery rate of the effective questionnaire is 80%. All subsequent quantitative analysis is conducted using SPSS20.0 and AMOS20.0 procedures.

4.1. The Reliability and Validity for the Evaluation Metrics

The research adopts Cronbach's α to measure the internal consistency reliability of the index. The Cronbach's α in the total scale is over 0.8, indicating fairly sound internal consistency reliability. The analysis results are shown in table 5:

Tab.5. Reliability of Evaluation Metrics

First Grade Index	Cronbach's α	Secondary Index	Cronbach's α
Financial Dimension	0.856	proportion of increased sales volume achieved through e-commerce in the total sales volume	0.785
		proportion of sales profit achieved through e-commerce in the total sales profit	0.812
		income gained after the cost saving since the adoption of e-commerce	0.824
		shortened time for capital turnover	0.843
		degree of shortening of the inventory turnover rate	0.829
Customer Dimension	0.851	number of newly added clients / trading partners	0.735
		client/trading partner service improvement level	0.842
		enhancement of client's/trading partner's satisfaction with the payment	0.821
		enhancement of client's/trading partner's satisfaction with the logistics distribution	0.843
		enhancement of client's/trading partner's satisfaction with the website information content	0.809
		degree of business information collection and processing power	0.796
Organizational Dimension	0.932	degree of enterprise and brand image improvement	0.812
		degree of management level improvement	0.824
		degree of level of informatization	0.843

The construct validity analysis of the indicator system is tested by analysis of the exploratory factor and the computing result is as follows: the Bartlett test of Sphericity and KMO fitness test results show that the KMO value is 0.817 and The Bartlett test of Sphericity achieves significant level, which is suitable for factor analysis. The result of EFA factor analysis using SPSS20.0 is shown in following Table 6:

Tab.6. EFA Factor Analysis Results

Indicator	FAC1	FAC2	FAC3
B1	0.87		
B2	0.95		
B3	0.73		
B4	0.79		
B5	0.85		
B6		0.47	
B7		0.85	
B8		0.73	
B9		0.89	
B10		0.85	
B11		0.49	
B12			0.81
B13			0.96
B14			0.75
Accumulated Variance Contribution Rate **70.62%**			

On this basis, this study uses the measurement model (CFA analysis) in the SEM model to test the construction validity of the index. The construction validity can be tested by the fit index and the normalized factor loading coefficient of the model. The fitting level of the model must be acceptable first, and then the construction validity will be tested with the size of the normalized factor loading coefficient. Generally, the index of coincidence of the normalized factor shall be greater than 0.5. The analysis result is shown in Figure 2:

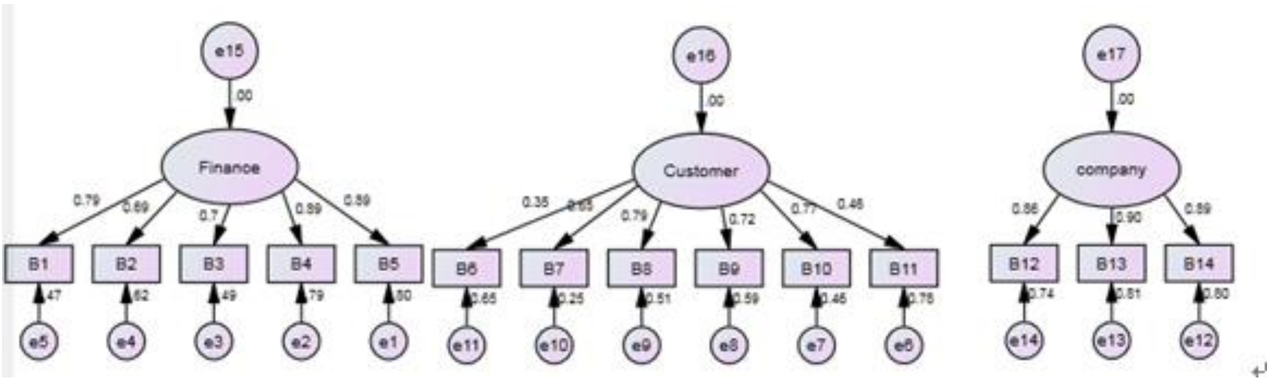

Fig.2. Measurement Model of the Evaluation Indexes

The results of the goodness-of-fit index of the financial dimension measurement model are as follows: RMSEA <0.08; $\chi 2$ / DF <3, and other fitting indices are all above 0.9, and the fitting situation of the whole model is adopted. The normalized factor loading coefficient is 0.89, 0.89, 0.7, 0.69, 0.79. The results of the goodness-of-fit index of the customer dimension measurement model are as follows: RMSEA <0.05; $\chi 2$ / DF <3, and other fitting indices are all above 0.9. The normalized factor loading coefficient is 0.35, 0.65, 0.79, 0.72, 0.77, 0.46. The results of the goodness index of the organization dimension measurement model are as follows: RMSEA <0.05; $\chi 2$ / DF <3,and other fitting indices are all above 0.9. The normalized factor loading coefficient is 0.86, 0.90 and 0.89. Combining with EFA analysis and SEM measurement model analysis, the customer dimension indicators B6 and B11 factor loading are both smaller than 0.6, so they were deleted. The final evaluation index system after the deletion has good reliability and validity.

4.2 The evaluation on E-commerce Implementation Effect

After testing the reliability and construct validity of the index system, this study takes one of the small and medium enterprises as an example, and uses the index system to comprehensively evaluate the effect of e-commerce application. The specific analysis process is as follows:

1. Get the index weight.

In this study, the factor loading coefficient and AHP method are combined to determine the index weight. The basic idea is to express the complex evaluation object as an orderly entity with hierarchical structure. Through the comparison and judgment by people of each evaluation items, the relative important coefficient of each evaluation item is then calculated, which is also known as the weight. The key of the AHP method is to establish a reasonable and consistent judgment matrix. This study uses the commonly used proportional scaling method to quantify the importance of indicators. The method of constructing the judgment matrix is to construct the high-order factor analysis model with SEM, and figure out the normalized load factor of each factor. Then, the difference between the highest value and the minimum value of the normalized loading factor of each factor in each evaluation item is distributed in different sections, each corresponding to a scale value. Taking this as standard, the judgment matrix is established according to the difference between two normalized factor loading coefficients. After the judgment matrix is constructed, the following steps are used to obtain the index weight: ① calculate the n-th root Wi of the continued products of each scale at each row in the judgment matrix ②normalized processing, that is to confirm the weight of each evaluation index using formula 4 ③seek the largest eigenvalue of the matrix, and test the consistency of the judgment matrix.

$$W_{\bar{i}} = W_i \;/\; \sum_{i=1}^{n} W_i \tag{18}$$

The high-order factor model and analysis result are shown in Figure 3 and Table 7:

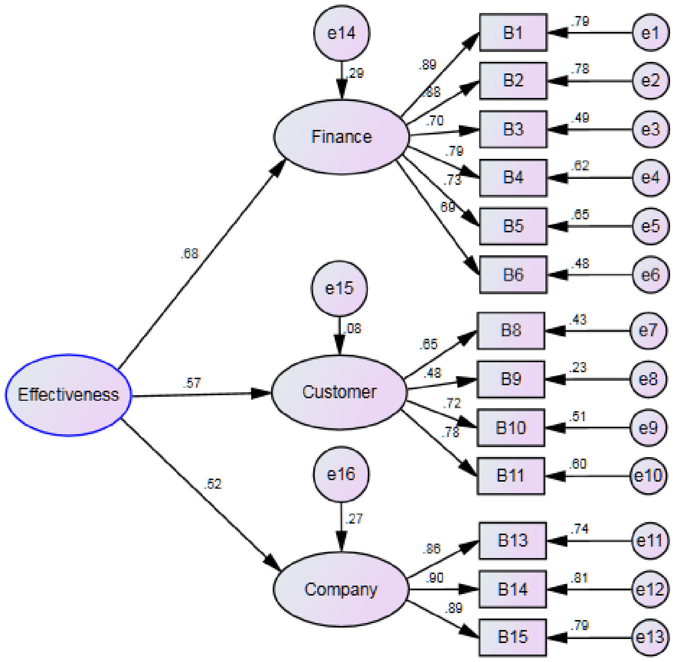

Fig.3. High-order Factor Analysis Result

Tab.7. Goodness-of-fit of SEM Model

Chi-square Degree of Freedom	GFI	RMSEA	NFI	CFI
2.71	0.917	0.075	0.931	0.956

Based on the difference between every two normalized loading coefficients of each indicator, the judgement matrix for the evaluation of the e-commerce effect of small and medium-sized enterprises and the weight of corresponding of secondary indicators are obtained, which are shown in Table 8.

Tab.8. Judgement Matrix of the First-level Indicators

<table>
<tr><th>Indicator Dimensions</th><th>Financial Dimension</th><th>Customer Dimension</th><th>Organizational Dimension</th><th>Calculation Results</th></tr>
<tr><td>Financial Dimension</td><td>1</td><td>7</td><td>9</td><td rowspan="3">$\lambda=\{\lambda_1,\lambda_2,\lambda_3\}=(0.785,0.149,0.066)$, $\lambda_{max}=3.080$, CI=0.040,RI=0.580, CR=0.069<0.1000</td></tr>
<tr><td>Customer Dimension</td><td></td><td>1</td><td>3</td></tr>
<tr><td>Organizational Dimension</td><td></td><td></td><td>1</td></tr>
</table>

Finally, the total weight of each secondary index can be obtained. λ={0.360,0,273,0.025，0.094,0.033,0.019,0.005,0.041,0.083， 0.004,0.043， 0.019}.

2. Fuzzy Comprehensive Evaluation on E-commerce Implementation Effect.

The relevant business representatives and experts will grade each secondary indicator to figure out the degree of membership of each secondary indicator. Then the evaluation vector of each single factor will be obtained through the formula. And the final evaluation vector will be confirmed with the formula. Figure out the evaluation vector of the financial dimension of the e-commerce of this enterprise.

i. Calculate the degree of membership and evaluation vector of each evaluation dimension

The degree of membership of the financial dimension of enterprise's e-commerce is shown in Table 9.

Tab.9. Data of the Degree of Membership of Financial Dimension

Secondary Index	Comprehensive Weight of Secondary Index	Degree of Membership of the Comment			
		Excellent	Good	Medium	Poor
E-commerce added the sales volume	0.459	0.142	0.629	0.229	0
E-commerce increased the client number	0.348	0.600	0.257	0.143	0
E-commerce reduced the trading cost	0.042	0.143	0.457	0.371	0.029
E-commerce enhanced the enterprise reputation	0.120	0.514	0.457	0.029	0
E-commerce enhanced enterprise brand image	0.032	0.314	0.543	0.143	0

The evaluation vector calculation process and results are as follows:

$$Z_1 = \lambda_1 * R_1 = (0.459 \quad 0.348 \quad 0.120 \quad 0.032) * \begin{pmatrix} 0.142 & 0.629 & 0.229 & 0 \\ 0.600 & 0.257 & 0.143 & 0 \\ 0.143 & 0.457 & 0.371 & 0.029 \\ 0.514 & 0.457 & 0.029 & 0 \end{pmatrix}$$

$$= (0.352 \quad 0.469 \quad 0.178 \quad 0.001)$$

The degree of membership of the customer dimension of the enterprise's e-commerce is as shown in Table 10:

Tab.10. Data of the Degree of Membership of the Customer Dimension

Secondary Index	Comprehensive Weight of Secondary Index	Degree of Membership of the Comment			
		Excellent	Good	Medium	Poor
E-commerce improves customer service	0.130	0.171	0.486	0.343	0
Degree of satisfaction of clients with e-commerce payment	0.036	0.371	0.342	0.286	0
Degree of satisfaction of clients with e-commerce logistic speed	0.275	0.314	0.514	0.171	0
Degree of satisfaction of clients with the website information content	0.558	0.400	0.400	0.200	0

The evaluation vector calculation process and results are as follows:

$$Z_2 = \lambda_2 * R_2 = (0.130 \quad 0.036 \quad 0.275 \quad 0.558) * \begin{pmatrix} 0.171 & 0.486 & 0.343 & 0 \\ 0.371 & 0.342 & 0.286 & 0 \\ 0.314 & 0.514 & 0.171 & 0 \\ 0.400 & 0.400 & 0.200 & 0 \end{pmatrix}$$

$$= (0.345 \quad 0.440 \quad 0.214 \quad 0)$$

The calculation of the degree of membership of the organizational dimension is shown in Table 11:

Tab.11. Data of the Degree of Membership of the Organizational Dimension

Secondary Index	Comprehensive Weight of Secondary Index	Degree of Membership of the Comment			
		Excellent	Good	Medium	Poor
E-commerce improves the enterprise's informationalized level	0.055	0.057	0.486	0.429	0.029
E-commerce improves the staff's IT skill	0.655	0.286	0.486	0.229	0
E-commerce improves the staff's labor productivity	0.290	0.229	0.486	0.286	0

The evaluation vector calculation process and results are as follows:

$$Z_3 = \lambda_3 * R_3 = (0.055 \quad 0.655 \quad 0.290) * \begin{pmatrix} 0.057 & 0.486 & 0.429 & 0.029 \\ 0.286 & 0.257 & 0.143 & 0 \\ 0.229 & 0.486 & 0.286 & 0 \end{pmatrix}$$

$$= (0.256 \quad 0.486 \quad 0.256 \quad 0.002)$$

ii. Confirm the final evaluation vector

λ in the following formula is the weight of the first grade index. Z_1~Z_3 is the evaluation vector of the single factor calculated from the previous step. The evaluation vector calculation process and results are as follows:

$$\mathrm{Z} = \lambda * R = (\lambda_1 \quad \lambda_2 \quad \lambda_3) * \begin{pmatrix} Z_1 \\ Z_2 \\ Z_3 \end{pmatrix}$$

$$= (0.785 \quad 0.149 \quad 0.066) * \begin{pmatrix} 0.352 & 0.469 & 0.178 & 0.001 \\ 0.345 & 0.440 & 0.214 & 0 \\ 0.257 & 0.486 & 0.256 & 0.002 \end{pmatrix}$$

$$= (0.345 \quad 0.467 \quad 0.188 \quad 0.001)$$

Through the comprehensive evaluation results, it is obtained that the excellent results account for 34.5%, good results take up 46.7%, medium results take up 18.3% and poor result account for 0.1%. Apply the defuzzification (Formula 17) to figure out the total evaluation grade score of three dimensions.

The calculation results are as follows:

$B_1 = Z_1 * D^T = (0.352\ 0.469\ 0.178\ 0.001) * (10, 7, 5, 2)^T = 7.70$

$B_2 = Z_2 * D^T = (0.345\ 0.440\ 0.214\ 0) * (10, 7, 5, 2)^T = 7.60$

$B_3 = Z_3 * D^T = (0.257\ 0.486\ 0.256\ 0.002) * (10, 7, 5, 2)^T = 7.25$

$B = Z * D^T = (0.345\ 0.467\ 0.189\ 0.001) * (10, 7, 5, 2)^T = 7.66$

From the analysis results, it can be seen that the comprehensive quality of the enterprise’s e-commerce is good, but there is certain gap from excellent, thus its quality needs to be further improved. The effect evaluation of the financial dimension and customer dimension is higher than that of the organization dimension, which shows that the enterprise’s e-commerce is still in the initial stage. The effect of e-commerce is mainly reflected in the aspects of social and economic benefits and customer satisfaction. Its impact on the enterprise’s overall management level needs to be improved.

Conclusion

This paper constructs the evaluation index system for the e-commerce implementation of small and medium-sized enterprises centering on the financial dimension, customer dimension and organizational dimension, makes initial analysis of the reliability and validity of the construct indicator using Cronbach's α and EFA, figures out the factor loading coefficient using comprehensive fuzzy evaluation (CFA) of SEM, seeks the weight of the first grade index and establish the judgement matrix combining Analytic Hierarchy Process (AHP). The analysis results show that the established indicator system confirmed three effect factors of the e-commerce in small and medium-sized enterprises, i.e. the effect and level of the E-commerce implementation of small and medium-sized enterprises can be measured from such three aspects as the direct and indirect income of the enterprise, the customer's satisfaction level and impact on the organization internal.

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