Research on Synthetic Evaluation Model for Enterprise Integration Development

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Abstract: With the development of digital economy, multi-business integration has become the development strategy of many enterprises. Multi-business integration of telecom enterprises refers to the provision of telecom products and services covering multiple fields of CHBG to customers in a "package" form. Under this development trend, the synthetic evaluation of integrated development level has become a very meaningful topic in enterprise management. In this paper, an evaluation model of subjective and objective fusion for enterprise integration development is constructed. Firstly, an AOE evaluation factor system is proposed based on the development requirements. Then, the first level index evaluation method based on AHP is designed, and the second level index evaluation method based on entropy weight method, CRITIC method and fuzzy synthetic evaluation method is designed. Finally, a synthetic evaluation model of subjective and objective fusion is constructed to fully integrate the experience of experts and the information of the statistical data. In terms of application, through the investigation data and sampling data of some provincial companies of China mobile, the model was applied to obtain the evaluation results of the enterprise in three aspects: integration capability, integration operation and integration effectiveness. The empirical analysis results show that integration development can promote customer value and loyalty. Full integration customers (C+H+B) have the highest value increase rate of 92% and the highest loyalty increase rate of 68%. In conclusion, the evaluation model can effectively assist the scientific decision-making in the management and operation process of enterprise integration development.

Keywords: Multi-Business Integration, Synthetic Evaluation Model, Subjective and Objective Fusion, AHP, Entropy Weight Method, CRITIC, Fuzzy Synthetic Evaluation.

1 INTRODUCTION

With the development of the digital economy, the integration of multi-business has become the development strategic of many enterprises, which can promote the efficient allocation of new elements such as technology and data, and realize the aggregation and sharing of resources and elements [1,2]. Multi-business integration for telecom enterprises refers to the provision of telecom products and services covering multiple areas of CHBG to customers in the form of a "package"

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combination, which is a business model that implements sales, billing, and service by product portfolio.

Under this development trend, the synthetic evaluation of integration development level has become an important topic. Evaluation is an important prerequisite for scientific decision. Therefore, it is necessary to construct an evaluation model for the level of enterprise integration development, so as to achieve the goals of goal guidance, quantitative evaluation and comprehensive scoring. First, achieve the goal of direction guidance. By dismantling and quantifying the integration development goals, it points out the direction for the company's development. Second, realize quantitative assessment. Through the quantitative evaluation of the current development status of integration, the current development progress can be presented. Third, calculate the overall scores. Based on the comprehensive scoring results, the subsidiaries are compared horizontally to help them identify the problems encountered in the integration development.

Scholars at home and abroad have carried out a series of studies on comprehensive evaluation. In the 70s and 80s of the 20th century, a variety of widely used evaluation methods appeared, such as analytic hierarchy method [3], data envelopment analysis method [4], and TOPSIS method. In the 80s of the 20th century, many new evaluation ideas and theories of gray system theory [5], artificial neural network technology [6], and information theory were continuously integrated with traditional methods, and new evaluation methods and models were born. After the 90s of the 20th century, the combination of evaluation methods has become a hot spot in the field of evaluation, and methods such as fuzzy artificial neural network system, AHP-entropy [7], AHP-fuzzy evaluation method [8] have been produced, which have enriched the research results of synthetic evaluation methods. In terms of enterprise evaluation studies, Yufang Sun proposed a synthetic evaluation method based on analytic hierarchy and fuzzy evaluation method for the telecom operators' services [9]. Xiaotong Pang used entropy-weight TOPSIS to evaluate the triple-network fusion [10]. Li Anmin researched the operation mode and evaluation system of Chinese telecom operators, and constructed a model of the impact factors of technology, market and value creation system [11].

Based on the above research, this paper constructs a subjective and objective fusion evaluation model for the development of enterprise integration, which has the advantage of fully integrating expert experience and data measurement results. Finally, the model application and empirical analysis are carried out through the survey and sampling data of some provincial companies, which verifies the scientificity and feasibility of the model.

2 EVALUATION FACTOR SYSTEM CONSTRUCTION

2.1 Principles for the Construction of Factor System

Based on the requirements of enterprise integration development planning, an evaluation factor system is designed. The factor system is the basis for reflecting the level of integration development, which should meet the principles of consistency, adequacy, systematicness, feasibility, comparability, dynamism and predictability.

- Consistency: Ensure that indicators reflect the strategic direction of integration development and are consistent with the planning goals
- Adequacy: Multiple perspectives of process and results should be included, covering the construction process, operation level, implementation effect, etc.
- Systematic: There is a hierarchical logical relationship between the indicators, from top to bottom, from macro to micro. The systematic structure that supports structured dismantling can assist in the problem location in the process of integration development.
- Feasibility: Indicators in the evaluation system should be clearly defined, measurable and make full use of available statistics
- Comparability: Design relative values and uniform measurement schemes to achieve horizontal and vertical comparisons of different metrics.
- Dynamic: Establish a dynamic adjustment mechanism for indicators to meet market changes.
- Predictability: Choose indicators with long-term effectiveness and business foresight to meet forecasting and decision-making needs.

2.2 Influencing Factor Model

Following the above factor system principles, a factor model consisting of three dimensions: integration capability evaluation, integration operation evaluation and integration effect evaluation is constructed, namely the AOE model.

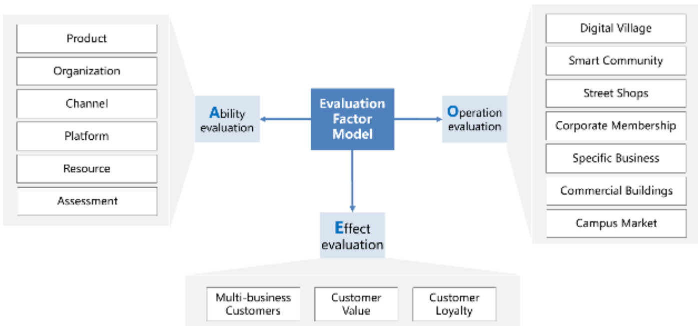

Figure 1. AOE model for influecing facor system

The ability dimension reflects the progress of enterprises in building integrated products, organizations, contact points, platforms, resources, and assessment. The operation dimension reflects the operation status of typical converged business scenarios of enterprises. The effect dimension reflects the development effect in terms of customer scale, value, and loyalty.

Dimension	Sub-dimensions	Evaluation Indicators	Decomposed Metrics			
Ability Evaluation	Product	Product integration completion rate	demand	products	manifest	
	Organization	Organization reform completion rate	Integrated team	Operational mechanism	Training and assessment	
	Channel	Channel convergence completion rate	One-screen display	One-order processing	All-in-one service	
	Platform	Platform building completion rate	Operational platform	Standard specifications	Interface capability	
	Resource	Resource management completion ratio	Internal resources	Collaborative resources	Marketing resources	
	Assessment	Assessment design completion ratio	Assessment indicators	Benefits Distribution		
Operation Evaluation	Digital Village	Digital village completion ratio	Standard village	APP customers	CH customers	BG customers
	Smart Community	Smart community completion ratio	Standard community	APP customers	CH customers	BG customers
	Street Shops	Street shops completion ratio	Wired broadband			
	Corporate Membership	Corporate membership completion ratio	Enterprise customers	Enterprise Convergence Pack		
	Specific Business	Specific business completion ratio	Specific market products			
	Commercial Buildings	Commercial buildings completion ratio	Gold Building	Network coverage	Enterprise private line	
	Campus Market	Campus market completion ratio	Electronic student ID			
Effect Evaluation	Multi-business Customers	Muti-business customers penetration ratio	Partially converged customers	All converged customers		
	Customer Value	Customer value increasing ratio	ARPU of Partially converged customers	ARPU of all converged customers		
	Customer Loyalty	Customer loyalty increasing ratio	Loyalty of Partially converged customers	Loyalty of all converged customers		

Figure 2. Evaluation indicator system based on AOE model

The evaluation indicator system should have a dynamic iterative mechanism, including indicator entry, indicator exit, and indicator replacement.

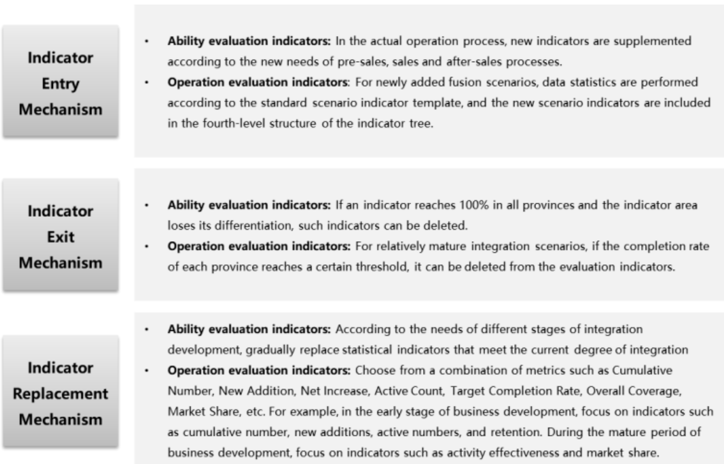

Figure 3. Dynamic iteration mechanism of evaluation indicator system

3 SYNTHETIC EVALUATION MODEL

The evaluation model is constructed by subjective and objective fusion methods, and the expert experience and data measurement results are fully integrated. Based on subjective experience driven, the model can effectively meet the needs of converged development goals. At the same time, based on the data measurement results, the scientificity of the model can be improved.

3.1 Subjective Evaluation Method

AHP analytic hierarchy is a decision-making weight research method that combines qualitative and quantitative to solve multi-factor complex problems. Based on the experience of decision makers, this method determines the relative importance of each measurement element, and calculates the weight of each element based on statistical methods.

Step 1: Scale determination and judgment matrix construction. In this scheme, the 1-5 degree scale method is used to obtain the judgment matrix A through expert scoring.

Step 2: Feature vectors and weights calculation. The columns of the judgment matrix are summed and normalized to obtain the B matrix. The rows are summed to obtain the feature vector C matrix, and then the C matrix is normalized to obtain the weights.

$$b_{ij} = a_{ij} / \sum_i a_{ij},\ \ c_i = \sum_j b_{ij} \tag{1}$$

Step 3: Consistency test analysis. The consistency analysis is carried out by calculating the maximum feature root, CI value, RI value, and CR value to avoid the logic error of the judgment matrix. If the CR value is less than 0.1, it means that the consistency test has passed.

Step 4: Analysis and weight fine-tuning. After the consistency test passes, the final applied weight result is determined by fine-tuned processing.

$$\lambda_{max} = \sum_{\mathrm{i}} \frac{\mathrm{aW_i}}{\mathrm{nW_i}},\ CI = \frac{\lambda_{max} - n}{n-1}, CR = \frac{CI}{RI} \tag{2}$$

3.2 Objective Evaluation - Entropy Weight Method

Entropy is a physical unit of measurement. Higher entropy indicates more chaotic data, less information carried, smaller utility values, and therefore smaller weights. The entropy method is a research method that combines the information value provided by the entropy value to determine the weight, avoiding the bias caused by human factors. Compared with the subjective assignment method, the entropy method has higher accuracy and stronger objectivity, which can better explain the results obtained.

Step 1: Indicator forwardization and data standardization. Convert all indicators into postitive indicators and carry out forward processing of indicators. Then the data standardization process is used to balance the errors caused by the differences between indexes or dimensionality.

$$z_{ij} = \frac{x_{ij} - min(x_{1j}, x_{2j}, \ldots, x_{nj})}{max(x_{1j}, x_{2j}, \ldots, x_{nj}) - min(x_{1j}, x_{2j}, \ldots, x_{nj})} \tag{3}$$

Step 2: Indicator information entropy calculation. Calculate the probability matrix p of the indicators, and then calculate the information entropy e of each indicator.

$$p_{ij} = \frac{z_{ij}}{\sum_{i=1}^{n} z_{ij}}\,,\ \ e_j = -\frac{1}{ln(n)} \sum_{i=1}^{n} p_{ij} ln(p_{ij}) \tag{4}$$

Step 3: Information utility and weight calculation. The information utility value is obtained through information entropy, and then the weight is obtained through normalization.

$$d_j = 1 - e_j\,,\ \ w_j = \frac{d_j}{\sum_{j=1}^{m} d_j} \tag{5}$$

3.3 Objective Evaluation - CRITIC Weighting Method

The CRITIC weighting method is an objective weighting method based on data volatility, and its advantage lies in the comprehensive measurement of volatility and conflict, while taking into account the variability of indicators and the correlation of indicators. This method can use the objective properties of data for scientific evaluation.

Step 1: Indicator forwardization and data standardization. All indicators are converted into positive indicators and dimensionless.

Step 2: Indicator volatility and conflict. Volatility S is expressed in terms of standard deviation, and larger standard deviations indicate greater volatility and higher weights. Conflicting R is expressed using the correlation coefficient, and the larger the correlation coefficient value between indicators, the less conflicting and the lower the weight.

$$S_j = \sqrt{\frac{\sum_{i=1}^{m} (z_{ij} - \overline{z_j})^2}{n-1}},\ \ R_j = \sum_{i=1}^{m} (1 - r_{ij}) \tag{6}$$

Step 3: Indicator information content and weight. The information content C is expressed by the product of volatility and conflict, and the weight is obtained by normalizing the amount of information.

$$C_j = S_j * R_j\,,\ \ w_j = \frac{c_j}{\sum_{j=1}^{m} c_j} \tag{7}$$

3.4 Objective Evaluation - Fuzzy Synthetic Evaluation

Fuzzy synthetic evaluation method is a comprehensive evaluation method based on fuzzy mathematics, which transforms qualitative evaluation into quantitative evaluation according to the affiliation theory of fuzzy mathematics. The model can make an overall evaluation of the objects affected by multiple factors. This method has the characteristics of clear results and strong systematic, which can better solve vague and difficult to quantify problems, and is suitable for solving various non-deterministic problems.

Step 1: Synthetic evaluation factor set and evaluation set. Factor set U is a set of various indicators that affect the evaluation object. Evaluation set V is a set of various possible outcomes for the evaluation object.

$$U = (u_1, u_2, \ldots, u_m), \quad V = (v_1, v_2, \ldots, v_n) \tag{8}$$

Step 2: Fuzzy synthetic evaluation matrix and factor weight vector. Through the membership degree r from the factor set to the evaluation set, the fuzzy synthetic evaluation matrix is obtained. The weight A of each factor is used to form a set of weights.

$$\mathrm{R} = (\mathrm{r_{ij}})_{\mathrm{m}*} = \begin{bmatrix} \mathrm{r_{11}} & \cdots & \mathrm{r_{1n}} \\ \vdots & \ddots & \vdots \\ \mathrm{r_{m1}} & \cdots & \mathrm{r_{mn}} \end{bmatrix} \tag{9}$$

$$A = (a_1, a_2, \ldots, a_m) \tag{10}$$

Step 3: Fuzzy vector and synthetic evaluation model. Change the fuzzy vector A on U to the fuzzy vector B on V by fuzzy change. The column vector is C with respect to the parameter specified for each class v. The system score S is the matrix product of the fuzzy vector B and the parameter column vector C.

$$\mathrm{B = A * R, C = (c_1, c_{2,} \ldots c_n)^T, S = B * C} \tag{11}$$

3.5 Subjective And Objective Fusion Evaluation Model

On the one hand, the evaluation model obtains the dimension weights through the AHP method based on expert scoring. On the other hand, based on the real data collected by enterprises, an integrated evaluation method including entropy weight method, CRITIC method and fuzzy synthetic evaluation method is designed to obtain the indicator weights. Finally, the subjective evaluation results and objective evaluation results are combined to obtain the comprehensive evaluation weight results.

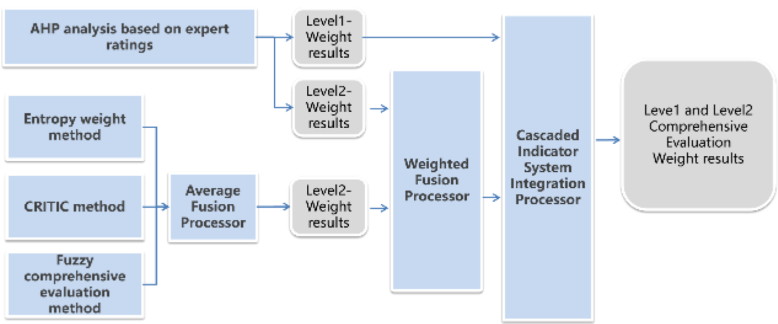

Figure 4. Subjective and objective synthetic evaluation process

4 EXPERIMENTAL RESULTS

4.1 Subjective Evaluation Experimental Results

Based on expert scoring and AHP method, the importance of the three dimensions of AOE model is compared and the comprehensive weight calculation is carried out. The result of the experiment is that the capability weight is 30%, the operation weight is 50%, and the effectiveness weight is 20%.

TABLE I. AHP JUDGMENT MATRIX

Dimensions	Ability	Operation	Effect
Ability	1	0.5	2
Operation	2	1	2
Effect	0.5	0.5	1

TABLE II. AHP ANALYSIS RESULTS

Item	Eigenvector	Weight	Maximum Eigenvalue	CI
Ability	0.936	31.19%	3.054	0.027
Operation	1.471	49.05%		
Effect	0.593	19.76%		

TABLE III. CONSISTENCY TEST RESULTS

Maximum Root	CI	RI	CR	Consistency Test
3.054	0.027	0.52	0.052	pass

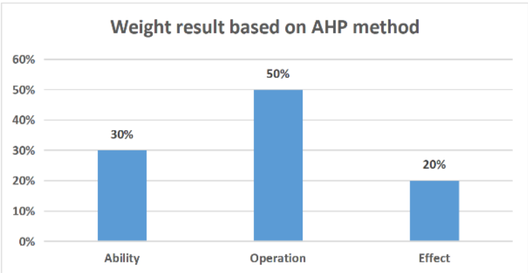

Figure 5. Three evaluation dimensions weight results based on AHP

The expert scoring method based on the weighted evaluation method is used to score the secondary indicators in the AOE model, and the results are shown in the subscript.

TABLE IV. EXPERT SCORING EVALUATION RESULTS

Dimension	Key indicators	Weight
Ability evaluation	Product	10%
	Organization	15%
	Channel	15%
	Platform	20%
	Resource	20%
	Assessment	20%
Operation evaluation	Digital Village	20%
	Smart Community	20%
	Street Shops	15%
	Corporate Membership	15%
	Specific Business	15%
	Commercial Buildings	10%
	Campus Market	10%
Effect evaluation	Multi-business Customers	40%
	Customer Value	30%
	Customer Loyalty	30%

4.2 Entropy Weight Method Experimental Results

Based on the entropy weight method, the weights of each indicators are calculated, and the weight coefficients of each indicators in the three dimensions are shown in the following table.

TABLE V. ABILITY : ENTROPY METHOD RESULTS

Item	Information entropy value	Information utility value	Weight
Product	1	0	0.00%
Organization	0.9933	0.0067	2.14%
Channel	0.9599	0.0401	12.80%
Platform	0.87	0.13	41.46%
Resource	0.9933	0.0067	2.14%
Assessment	0.87	0.13	41.46%

TABLE VI. OPERATION : ENTROPY METHOD RESULTS

Item	Information entropy value	Information utility value	Weight
Digital Village	0.9376	0.0624	9.92%
Smart Community	0.8691	0.1309	20.82%

Street Shops	0.9193	0.0807	12.84%
Corporate Membership	0.9264	0.0736	11.71%
Specific Business	0.9515	0.0485	7.71%
Commercial Buildings	0.9165	0.0835	13.28%
Campus Market	0.8509	0.1491	23.72%

TABLE VII. EFFECT: ENTROPY METHOD RESULTS

Item	**Information entropy value**	**Information utility value**	**Weight**
Multi-business Customers	0.993	0.007	31.70%
Customer Value	0.9876	0.0124	56.61%
Customer Loyalty	0.9974	0.0026	11.69%

4.3 CRITIC Method Experimental Results

Based on the CRITIC method, the weight of each indicator is calculated, and the weight coefficients of each indicator in the three dimensions are obtained as shown in the following table.

TABLE VIII. ABILITY : CRITIC METHOD RESULTS

Item	**Indicator variability**	**Indicator conflict**	**Information content**	**Weight**
Product	0	5	0	0.00%
Organization	0.148	2.372	0.35	8.93%
Channel	0.299	2.122	0.635	16.19%
Platform	0.447	2.372	1.061	27.07%
Resource	0.148	5.507	0.813	20.74%
Assessment	0.447	2.372	1.061	27.07%

TABLE IX. OPERATION: CRITIC METHOD RESULTS

Item	Indicator variability	Indicator conflict	Information content	Weight
Digital Village	0.821	3.992	3.277	12.13%
Smart Community	0.905	4.828	4.371	16.18%
Street Shops	0.692	7.097	4.911	18.18%
Corporate Membership	2.155	5.029	10.839	40.13%
Specific Business	0.27	4.529	1.223	4.53%
Commercial Buildings	0.124	5.398	0.67	2.48%
Campus Market	0.234	7.357	1.719	6.36%

TABLE X. EFFECT: CRITIC METHOD RESULTS

Item	**Indicator variability**	**Indicator conflict**	**Information content**	**Weight**
Multi-business Customers	0.064	1.261	0.081	16.55%
Customer Value	0.185	1.899	0.35	71.39%
Customer Loyalty	0.061	0.971	0.059	12.06%

4.4 Experimental Results of Fuzzy Synthetic Evaluation Method

Based on the fuzzy synthetic evaluation method, the weight of each indicator is calculated, and the weight coefficient of each indicator in the three dimensions is obtained as shown in the following table.

TABLE XI. ABILITY : FUZZY SYNTHETIC EVALUATION RESULTS

Item	**Degree of affiliation**	**Weight**
Product	0.204	20%
Organization	0.182	18%
Channel	0.147	15%
Platform	0.137	14%
Resource	0.192	19%
Assessment	0.137	14%

TABLE XII. OPERATION : FUZZY SYNTHETIC EVALUATION RESULTS

Item	**Degree of affiliation**	**Weight**
Digital Village	0.164	16%
Smart Community	0.119	12%

Street Shops	0.133	13%
Corporate Membership	0.441	44%
Specific Business	0.073	7%
Commercial Buildings	0.028	3%
Campus Market	0.042	4%

TABLE XIII. EFFECT : FUZZY SYNTHETIC EVALUATION RESULTS

Item	Degree of affiliation	Weight
Multi-business Customers	0.185	19%
Customer Value	0.484	48%
Customer Loyalty	0.331	33%

4.5 Experimental Results of Subjective And Objective Fusion Evaluation Method

The weight calculation results of the subjective and objective fusion evaluation method and the scoring rules of each indicator are shown in the following table.

TABLE XIV. INTEGRATED EVALUATION RESULTS

Dimension	Key indicators	Weight	Scoring rules
Ability evaluation 30%	Product	9%	Score by completion ratio:[0,30,60,100]
	Organization	13%	Score by completion ratio:[0,30,60,100]
	Channel	15%	Score by completion ratio:[0,30,60,100]
	Platform	22%	Score by completion ratio:[0,30,60,100]
	Resource	18%	Score by completion ratio:[0,30,60,100]
	Assessment	22%	Score by completion ratio:[0,50,100]
Operation evaluation 50%	Digital Village	18%	Scoring is linear within 100%
	Smart Community	19%	Scoring is linear within 100%
	Street Shops	4%	Scoring is linear within 100%

	Corporate Membership	20%	Scoring is linear within 100%
	Specific Business	12%	Scoring is linear within 100%
	Commercial Buildings	9%	Scoring is linear within 100%
	Campus Market	10%	Scoring is linear within 100%
Effect evaluation 20%	Multi-business Customers	35%	Scoring is linear within 100%
	Customer Value	39%	Scoring is linear within 100%
	Customer Loyalty	27%	Scoring is linear within 100%

5 MODEL APPLICATION AND EMPIRICAL ANALYSIS

Based on this model, a data table tracking mechanism is established to regularly collect key capacity building progress, integrated operation development data, and fusion effectiveness data in the process of integrated development. It is used to understand the specific situation of each province and each link of integrated development. Through the data table, comprehensive evaluation can be realized, including the scoring of various indicators of provincial companies, the scoring of three dimensions, the comprehensive score of integration, and the ranking. Based on the summary of provinces, the overall progress of integration capacity building, the total progress of integration operation, and the total effectiveness of integration can be comprehensively analyzed.

Provincial corporations	Ability Evaluation							Operation Evaluation								Effect Evaluation				Synthetic Evaluation	
	Product	Organization	Channel	Platform	Resource	Assessment	Ability Score	Digital Village	Smart Community	Street Shops	Corporate Membership	Specific Business	Commercial Buildings	Campus Market	Operation score	Multi-business Customers	Customer Value	Customer Loyalty	Effect score	Synthetic Score	Ranking
A	100%	100%	100%	100%	100%	100%	100	92%	84%	65%	97%	57%	25%	35%	74	48%	92%	68%	67	79	2
B	100%	100%	100%	100%	100%	100%	100	288%	273%	166%	446%	99%	23%	1%	85	31%	107%	58%	60	83	1
C	100%	67%	33%	0%	100%	0%	44	188%	85%	49%	660%	75%	40%	67%	81	40%	78%	64%	59	64	5
D	100%	100%	100%	100%	100%	100%	100	108%	50%	123%	446%	64%	23%	35%	75	36%	57%	56%	48	76	3
E	100%	100%	67%	100%	67%	100%	86	110%	73%	215%	581%	25%	5%	37%	72	35%	86%	53%	56	73	4

Figure 6. Evaluation model application on some provincial corporations

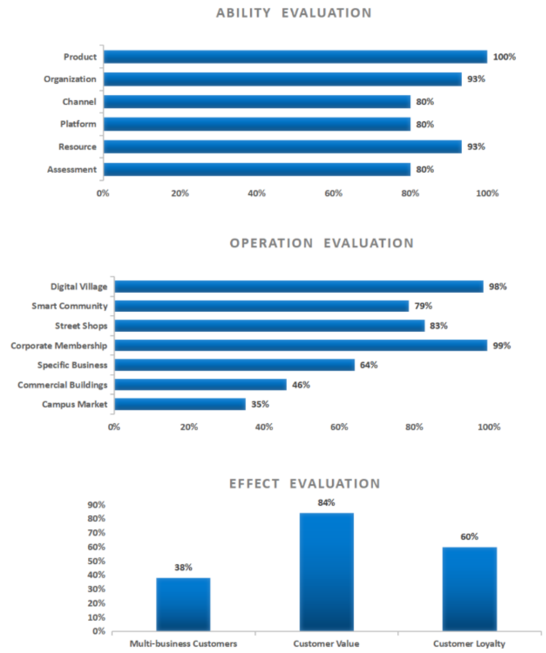

Figure 7. Evaluation results for overall integration development level

The synthetic evaluation conclusion of integration development is as follows. First, integration capacity building is the foundation, and the construction progress is considerable. The development of products is relatively mature, some provincial companies need to be improved in terms of organization and resources, and some provincial companies need to strengthen construction in terms of contacts, platforms and assessments. Second, integration operation has achieved phased results, and some scenarios need to be continuously expanded. Scenarios such as digital villages and smart communities have achieved good operational results driven by the resources of the conference, while scenarios such as campus markets and pendant markets still need to be continuously expanded. Third, the integration effect is significant and the value and loyalty of integrated customers both have been improved. The penetration rate of integrated customers is 30%+, and there is still room for improvement in the scale of integrated customers.

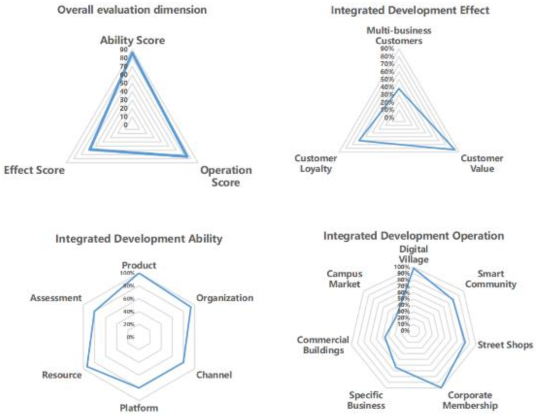

Figure 8. Analysis results for each dimension of integrated development

Empirical analysis results show that customer integration development can promote customer value and loyalty. First, the integration of H and C areas can increase value by 77% and loyalty rate by 48%. Compared with C+B integration, C+H integration is more significant in value enhancement. Second, the integration of B and C can increase value by 29% and loyalty rate by 52%. Compared with C+H integration, C+B integration is more significant in terms of loyalty improvement. Third, C+H+B full integration has the highest value improvement rate of 92% and the highest loyalty promotion rate of 68%, and the development towards full integration has achieved remarkable results.

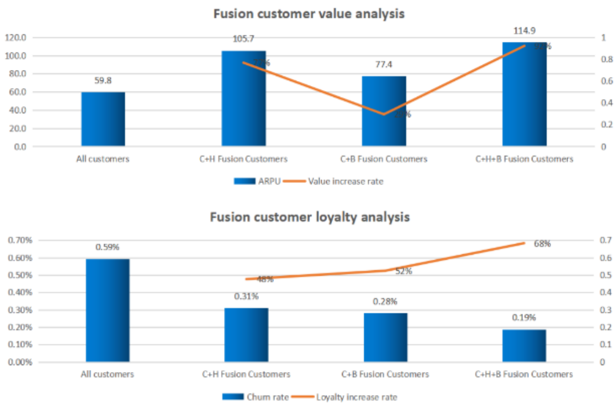

Figure 9. Enterprise integration development Effectiveness analysis

6 CONCLUSIONS

This paper constructs a subjective and objective comprehensive evaluation model for the level of enterprise integration development, which can fully integrate the management experience of experts and the information behind the statistical data. Through empirical analysis, it is proved that the model can effectively reflect the overall progress of enterprise integration development, and at the same time reflect more mature aspects and relatively backward aspects, thus assisting enterprises to analyze problems in the process of integration development. Furthermore, the model achieves regional evaluation by scoring, thus achieving the comparison of the integration development level of enterprises in different regions, and successfully locates the problems in various regions through radar map analysis. To sum up, the evaluation model can effectively assist the scientific decision-making in the management and operation process of enterprise integration development.

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