Study on the Evaluation Criterions and Methods

for the Supermarket Food Suppliers Based on IAHP

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Abstract

By investigating classified management of suppliers of supermarkets, this paper establishes the evaluation index system of food suppliers of supermarkets, studies standards of evaluation index, and then implements the synthetical evaluation to 30 suppliers of Suguo supermarket by employing the Analytic Hierarchy Process with interval judgment and interval eigenvalue method , this paper makes some suggestions for Suguo supermarket to manage food suppliers.

Keywords: Supermarkets, Food, Evaluation of suppliers, Interval judgment Analytic hierarchy process, Index system

1. Introduction

Food is the source that human being depends on to survival, and the food safety is the base line of the consummation for people. Pawel Zukowski (2003) pointed out that in the early days of the 21st century, it was more difficult to ensure the quality of the food than other products, and the task was more difficult, and more and more consumers hope not only the food can not bring negative influences for their health, but also the food can provide the nutrition values needed by the flesh such as the mineral composition and vitamins (Cythia M, 2002, P.105-112 & Pawel Zukowski, 2003). At present, the circulation of Chinese food supply includes the supermarket, the farmer's market and some small-sized food retail stores. Since 1990s, the supermarket has been developed quickly, and it is gradually replacing the traditional trade market and becoming the important channel to stock the foods for Chinese residents. One report of All-China Commercial Information Center showed that the food sales in the supermarket will occupy above 90% of the social food sales amount till 2010. As the retail end, it is very important to effectively evaluate the food suppliers, manage the suppliers and form the long-term and stable strategic alliance with them, and provide safe foods for consumers.

According to the investigation, there are many problems existing in the food supplier management of Chinese supermarket, such as the lagged supplier management concept, the simple management measure, and the too subjective supplier evaluation and selection. So it is imperative under the situation to strengthen the supplier management in the supermarket chains. In this article, based on the analysis of the necessity of the supermarket chains supplier management, we studied the classification management mechanism, the evaluation criterion and the evaluation methods for the supermarket food suppliers.

2. Supplier classification management

Because the amount of the supermarket chains suppliers is numerous, we classify and manage the suppliers according to the type of the stocked products. The foods stocked by the supermarket are generally divided into two sorts. The one sort is the food with designed packaging, and we call it as the food type A, and this sort of food possesses the characters that the demand amount is large and the suppliers should form certain scale and be relatively stable, and these foods include milk, edible oil and so on. The other sort is the food without designed packaging, and we call it as the food type B, and this sort of food possesses the characters that the demand amount of the single breed is small and the suppliers are dispersive and unstable, and these foods include vegetable and fruits. According to the characters of these two types of food, we classify and manage the suppliers of the supermarket, and the classification and evaluation program of the supermarket food suppliers is seen in Figure 1. For the suppliers of the food type A, we should strictly use the qualitative and quantitative qualification auditing and locale auditing method to select and evaluate them. First, qualitatively evaluate all suppliers, select the selectable supplier set, and confirm the final suppliers by the qualification auditing and locale auditing method. For the suppliers of the food type B, we can use the qualitative method to select and confirm the suppliers by the qualification auditing and locale auditing evaluation method. Then we input the information of qualified suppliers and the daily representations of suppliers into the supplier database, and audit the

suppliers, which can be taken as the input information to evaluate the supermarket food safety quality management system.

3. The method of IAHP evaluation

3.1 The generation background of IAHP

As a sort of effective and practical decision method to deal with complex decision-making method, AHP (Analysis Hierarchy Process) has be broadly applied in many domains, and its problems existing in the theory and practical application have been improved and developed. When the decision-maker makes the decision by AHP and he can obtain complete information, he can compare the importance of two projects (or the sub-rule) in single rule, and give the exact judgment value under certain standard. But in actual social and economic system, because of the complexity of the system, it is very difficult or even impossible to directly obtain the evaluation of various projects under single rule or the weights of various sub-rules in the hierarchy structure. Therefore, under single rule, the deficiency of the information or the imperfection of the project will make the experts can not certainly judge the relative importance degree of the project, and the interval judgment AHP (IAHP) is generated. In IAHP, the paired comparison adopts the interval standard, and the corresponding judgment matrix can be obtained by the form of the interval judgment matrix.

3.2 The algorithm of IAHP

In 1987, Saaty and Vargas defined the interval judgment matrix, and put forward the simulated algorithm to seek the weight vector of the interval judgment matrix (Saaty, 1987, P.107-117), and E.S. Rosenbloom put forward the Monte-Carlo simulation method in 1996 (E.S. Rosenbloom, 1996, P.371-378), and David Hauser (1996) put forward the Cauchy distribution method (David Hauser, 1996, P.27-37), and many domestic experts and scholars extended the algorithm judging the weight vector of the dot judgment matrix to the domain of the interval judgment matrix, for example, Wei Cuiping et al (1996) put forward the interval gradient eigenvector method (IGEM) according to decision-makers' different grasps for the judgment interval in the interval judgment matrix (Wei, 1996, P.25-30), and Wei Yiqiang et al (1994) put forward the interval eigenvector method (IEM) (Wei, 1994, P.16-22).

According to the basic idea generated by the algorithm, we divide the interval judgment matrix compositor algorithm into the approximate algorithm and the optimization algorithm to study, and the approximate algorithm of the interval judgment compositor mainly includes the simulation algorithm, the interval eigenvector method, the interval number gradient character vector method, the improved interval number gradient character vector method, the coherence approach method, the optimal transfer matrix method and the Cauchy distribution method. And the optimization method of the interval judgment matrix compositor mainly includes the linear programming method, the convex cone model method, the interval number least square method, and the interval number generalized least warp method and the interval number χ^2 method. Through studying the algorithms proposed by foreign and domestic scholars, we think IEM is sort of concise and practical algorithm (Li, 2004).

For the coherence interval judgment matrix,

$$A = (a_{ij})_{n \times n} = \begin{bmatrix} 1 & [a_{12}^-, a_{12}^+] & \cdots & [a_{1n}^-, a_{1n}^+] \\ [a_{21}^-, a_{21}^+] & 1 & \cdots & [a_{2n}^-, a_{2n}^+] \\ \vdots & \vdots & \ddots & \vdots \\ [a_{n1}^-, a_{n1}^+] & [a_{n2}^-, a_{n2}^+] & \cdots & 1 \end{bmatrix} = [A^-, A^+]$$

Where, $a_{ji}^- = 1/a_{ij}^+, a_{ji}^+ = 1/a_{ij}^-$ and $A^- = (a_{ij}^-)_{n \times n}, A^+ = (a_{ij}^+)_{n \times n}$.

The concrete computation approaches of IEM include three steps.

First, respectively compute the standardized character vectors x^-, x^+ with the positive weight corresponded by the maximum character roots of A^-, A^+.

Second, by the formula $k = \sqrt{\sum\limits_{j=1}^{n} \dfrac{1}{\sum\limits_{i=1}^{n} a_{ij}^+}}$ $m = \sqrt{\sum\limits_{j=1}^{n} \dfrac{1}{\sum\limits_{i=1}^{n} a_{ij}^-}}$ to compute the values of k, m.

Third, seek the weight vector, $w = [kx^-, mx^+]$.

4. The evaluation index system and evaluation criterions for food suppliers

4.1 The evaluation index system for food suppliers

Comprehensively considering nine indexes such as qualified rate of the product, consumer withdrawal rate, price

representation, delivery time, delivery quality, delivery safety, market share, service quality and mark traceability, we establish the supermarket food supplier evaluation index system from five aspects including the quality level, the price level, the delivery ability, the market competition ability and the service level (seen in Table 1).

According to the principles such as the science character, the maneuverability and the system character, we adopt the method combining the qualitative analysis with the quantitative analysis to constitute detailed evaluation standards aiming at various evaluation projects.

4.2 The evaluation criterions for food suppliers

4.2.1 The quality level

From Table 1, we can use the qualified rate of the product and the consumer withdrawal rate to evaluate the quality of the food supplied by the suppliers, and the product qualified rate means the spot check qualified rate of the stock test, and its score can be denoted by the formula.

$$Q_{C_1} = (1 - \frac{n}{N}) \times 100$$

Where, n is the disqualified batch and N is the total batch of the stock.

The score of the consumer withdrawal rate Q_{C_2} can be denoted by the following formula.

$$Q_{C_2} = (1 - r) \times 100$$

Where, r is the consumer withdrawal rate.

4.2.2 The price level

According to the price representations of the suppliers, we can evaluate the price level of supplier.

If the supplied product price is stable and drops little, the score of the price representation Q_{C_3} is 90 points, and if the price is stable persistently, Q_{C_3} is 80 points, and if the price is basically stable the price fluctuates little with the price of the farm products, Q_{C_3} is 70 points, and if the price is not stable and it is largely influenced by the market price, Q_{C_3} is 60 points, and the price is not stable and not reasonable, Q_{C_3} is 0 points.

4.2.3 The delivery ability

The delivery ability is composed by three indexes such as the delivery time, the delivery quantity and the delivery safety, and the score of the delivery time Q_{C_4} can be computed by the following formula.

$$Q_{C_4} = (1 - \frac{m_1}{M_1}) \times 100$$

Where, m_1 is the delivery batch before or after the schedule, and M_1 is the total batch of the delivery.

The score of the delivery quantity Q_{C_5} can be denoted by the following formula.

$$Q_{C_5} = (1 - \frac{m_2}{M_2}) \times 100$$

Where, m_2 the quantity of the deficient goods, and M_2 is the total quantity of the delivery.

In the delivery process, it is the important measure to ensure the nutritious components and the safety of the foods by strictly defending the foods according to the characters of the foods and the requirement of the refrigeration chain, so the score of the delivery safety Q_{C_6} can be divided into two sorts. One sort is to defend the foods strictly according to the contract, and Q_{C_6} is 100 points, and the another sort is the necessary defense without the requirements of the contract, and Q_{C_6} is 0 points.

4.2.4 The market competition ability

We use the market occupation rate to reflect the market competition ability of the product, and because the regional character exists in the food consumption, the market occupation rate means the market share of the product in the region, and the score Q_{C_7} can be denoted as

$$Q_{C_7} = \frac{p}{P} \times 100 \cdot$$

Where, p is the market share of the product, and P is the maximum market share of the same sort of product.

4.2.5 The service ability

Two indexes including the service quality and the mark traceability can be used to evaluate the suppliers' service ability,

and the service quality is a comprehensive index which can be denoted by the hundred percent of the five-class conversion. The service quality is very good, the score of the service quality Q_{C_8} is 100 points, and the service quality is better, Q_{C_8} is 80 points, and the service quality is common, Q_{C_8} is 60 points, and the service quality is bad, Q_{C_8} is 40 points, and the service is very bad, Q_{C_8} is 20 points.

The mark traceability is mainly used to measure the traceability of the foods supplied the suppliers, and whether the supplier system is perfect and possesses good traceability is related with the start of the food withdrawal program and consumers' safety and health when the unsafe goods or the potential unsafe goods enter into the sales and consumption stage. The score of this index of supplier can be divided into following sorts. First, the mark traceability in the good production process is very strong, and the good materials can be traced to the producing area, so the score Q_{C_9} is 100 points. Second, the mark traceability in the good production process is strong, and the good materials can be traced to the upper supplier, so the score Q_{C_9} is 80 points. Third, the mark traceability in the good production process is strong, so the score Q_{C_9} is 60 points. Fourth, the mark traceability in the good production process is common, so the score Q_{C_9} is 40 points. Fifth, the mark traceability in the good production process is bad, so the score Q_{C_9} is 20 points. Sixth, the mark traceability in the good production process is very bad, so the score Q_{C_9} is 0 point.

5. The application of IAHP in the comprehensive evaluation of supermarket food suppliers

5.1 To establish the hierarchical structure

According to the evaluation index system in Table 1 and the dominant and dominated relation among factors, the hierarchy structure is established (seen in Figure 2). From Figure 2, there are four layers, i.e. the objective layer, the rule layer, and sub-rule layer and the project layer.

5.2 To establish the interval judgment matrix by paired comparison

According to the 1~9 proportion scale proposed by Saaty (1980), we respectively compare the factors dominated by the total objective and various rules in pair, and establish the interval judgment matrix (seen in Table 2 to Table 5).

5.3 To compute the weight interval of the interval judgment matrix

We adopt the interval eigenvector method (IEM) to compute the weight intervals of the judgment matrix compositor in pair (seen in Table 2 to Table 5).

5.4 To compute the combined weights among various factors

In Table 2 to Table 5, the local compositor weight interval vectors of factors in various layers, we use the combined weight formula of various-layer factors in Wu Yuhua's article (Wu, 1995, P.700-705) to obtain the total weight interval vector (seen in Table 6).

5.5 Case analysis and advices

According to the evaluation criterions of various indexes for the suppliers, we evaluated 30 qualified food suppliers in SUGUO Supermarket, and obtained Table 7.

According the scores of various indexes and the weight of each index, we use the following formula to obtain the comprehensive evaluation of 30 suppliers (seen in Table 7).

$$Q_j = \sum_{i=1}^{9} Q_{C_i j} \times w_i$$

Where, Q_j is the comprehensive score of the j'th supplier, $Q_{C_i j}$ is the score of the i'th index of the j'th supplier, and w_i is the weight of the i'th index in the index system.

According to the comprehensive evaluation result of the suppliers, the supermarket should establish the long-term and stable cooperation relation with the suppliers with higher score, and supervise and urge the suppliers with lower score to improve the product quality and perfect the traceability system. According to the two-eight principle, the supermarket should further check the qualifications of those six suppliers with lower scores, and delete them from the qualified supplier index necessarily.

References

Cythia M. Stewart. (2002). Food safety: new concepts for the new millennium. *Innovative Food Science & Emerging Technologies,* No. 3, P. 105-112.

David Hauser & Pandu Tadikamalla. (1996). The analytic hierarchy process in an uncertain environment: A simulation approach. *European Journal of Operational Research,* No. 91, P. 27-37.

E.S. Rosenbloom. (1996). A probabilistic interpretation of the final rankings in AHP. *European Journal of Operational Research,* No. 96, P. 371-378.

Li, Xiaoping. (2004). Study on the AHP Theory and Application Based on the Interval Judgment. *Thesis of Nanjing University of Science and Technology,* June of 2004.

Pawel Zukowski. (2003). Modeling of the Integrated System of Food Products' Quality Assurance in an Agricultural and Industrial Complex. *Proceedings of the 5th IEEE International Symposium on Assembly and Task Planning.* Besancon, France. July 10, 2003.

Saaty T.L. & Vargas L.G. (1987). Uncertainty and rank order in the Analytic Hierarchy Process. *European Journal of Operational Research,* No. 32, P. 107-117.

Wei, Cuiping & Hou, Chengjun. (1996). Several New Compositor Methods in Uncertain AHP and Their Comparisons. *Journal of Qufu Normal University,* No. 22(2), P. 25-30.

Wei, Yiqiang, Liu, Jinsheng, & Wang, Xuzhu. (1994). The Coherence Concept and Weight of the Judgment Matrix in Uncertain AHP. *Systems Engineering Theory & Practice,* No. 4, P. 16-22.

Wu, Yuhua et al. (1995). Interval Analytic Hierarchy Process (IAHP). *Journal of Tianjin University,* No. 28(5), P. 700-705.

Table 1. The evaluation index system of supermarket supplier

First class index	Second class index	Third class index
Supplier comprehensive performance level A	Quality level B_1	Qualified rate of the product C_1
		Consumer withdrawal rate C_2
	Price level B_2	Price representation C_3
	Delivery level B_3	Delivery time C_4
		Delivery quality C_5
		Delivery safety C_6
	Market competition ability B_4	Market share C_7
	Service ability B_5	Service quality C_8
		Mark traceability C_9

Table 2. The interval judgment matrix and weight intervals under the total objective supplier comprehensive performance level

A	B1	B2	B3	B4	B5	Weight interval
B1	[1,1]	[2,4]	[1,2]	[2,3]	[1,2]	[0.2730,0.3538]
B2	[1/4,1/2]	[1,1]	[1/2,1]	[1,1]	[1/3,1/2]	[0.1122,0.1275]
B3	[1/2,1]	[1,2]	[1,1]	[1,2]	[1,2]	[0.1815,0.2523]
B4	[1/3,1/2]	[1,1]	[1/2,1]	[1,1]	[1/2,1]	[0.1254,0.1458]
B5	[1/2,1]	[2,3]	[1/2,1]	[1,2]	[1,1]	[0.1868,0.2356]

Table 3. The interval judgment matrix and weight intervals under the criterion of quality level

B1	C1	C2	Weight interval
C1	[1,1]	[3,4]	[0.7563,0.7952]
C2	[1/4,1/3]	[1,1]	[0.2183,0.2295]

Table 4. The interval judgment matrix and weight intervals under the criterion of delivery level

B3	C4	C5	C6	Weight interval
C4	[1,1]	[1,2]	[1/3,1/2]	[0.2173,0.2657]
C5	[1/2,1]	[1,1]	[1/4,1/3]	[0.1572,0.1848]
C6	[2,3]	[3,4]	[1,1]	[0.5681,0.6066]

Table 5. The interval judgment matrix and weight intervals under the criterion of service level

B5	C8	C9	Weight interval
C8	[1,1]	[1,2]	[0.5347,0.6327]
C9	[1/2,1/1]	[1,1]	[0.3781,0.4474]

Table 6. The comprehensive compositor weight intervals, interval medians and adjusted interval medians of various factors

Index	Weight interval	Interval median	Adjusted interval median
C1	[0.2065,0.2813]	0.2439	0.2436
C2	[0.0596,0.0812]	0.0704	0.0703
C3	[0.1122,0.1275]	0.1199	0.1198
C4	[0.0394,0.0670]	0.0532	0.0531
C5	[0.0285,0.0466]	0.0376	0.0376
C6	[0.1031,0.1530]	0.1281	0.1279
C7	[0.1254,0.1458]	0.1356	0.1354
C8	[0.0706,0.1054]	0.0880	0.0879
C9	[0.0999,0.1491]	0.1245	0.1244
Total	-	1.0012	1

Table 7. Various index evaluation values for suppliers

Supplier	Q_{C_1}	Q_{C_2}	Q_{C_3}	Q_{C_4}	Q_{C_5}	Q_{C_6}	Q_{C_7}	Q_{C_8}	Q_{C_9}	Value	Ranking
S1	95.66	99.43	71	87.94	94.47	95.14	78.51	86	85	87.9523	11
S2	95.34	98.49	78	96.85	91.83	98.67	61.38	81	74	85.3449	27
S3	95.35	99.54	74	97.83	93.15	96.03	66.72	79	73	85.1288	28
S4	95.73	99.49	76	96.42	96.42	98.46	67.86	82	77	86.7320	19
S5	95.11	99.83	79	97.25	90.45	98.63	75.02	84	79	88.1996	8
S6	97.22	99.69	76	97.97	93.60	96.99	65.39	96	77	87.7934	13
S7	96.85	99.74	70	91.99	97.54	96.89	80.06	87	70	87.1302	15
S8	95.82	97.38	77	98.55	94.93	98.02	80.43	86	72	88.1577	9
S9	94.89	99.26	75	95.24	93.10	99.09	72.42	81	72	86.1920	22
S10	95.79	99.69	74	92.87	97.68	100	71.30	88	71	86.8236	18
S11	96.13	98.41	70	91.87	92.24	95.51	64.95	90	73	85.0702	30
S12	96.64	99.41	77	97.77	99.98	98.88	69.43	80	73	86.8662	16
S13	94.92	99.59	77	97.17	89.12	96.42	81.01	82	78	88.0708	10
S14	94.34	99.51	74	98.91	86.30	97.86	68.83	87	72	85.7790	24
S15	94.28	99.46	77	92.68	94.33	98.95	74.66	85	70	86.5955	20
S16	96.58	97.19	80	95.01	90.69	99.1	85.37	84	71	88.8483	3
S17	98.36	99.10	78	98.70	94.38	97.13	67.11	83	66	86.077	23
S18	95.35	98.73	70	92.06	95.99	96.73	68.59	86	71	85.1022	29
S19	95.69	99.35	90	96.10	93.20	97.51	73.24	87	69	88.3027	7
S20	95.05	99.44	91	98.59	96.13	98.49	66.96	90	72	88.4273	6
S21	95.96	99.43	75	92.77	97.21	96.4	73.26	82	67	85.7235	26
S22	95.18	99.31	75	95.47	94.16	97.76	73.47	86	70	86.481	21
S23	96.58	99.55	70	95.43	95.98	99.31	75.58	80	66	85.7651	25
S24	95.54	99.45	72	95.50	100	96.79	66.98	85	82	86.8424	17
S25	94.56	99.37	81	90.54	97.02	98.71	78.82	83	70	87.4809	14
S26	96.43	99.57	73	96.89	93.93	96.65	84.77	84	79	88.9627	2
S27	94.71	99.51	87	93.17	97.48	95.84	71.31	80	79	87.875	12
S28	97.62	98.11	76	96.77	99.32	98.46	76.28	91	78	89.2785	1
S29	96.78	99.12	76	87.56	100	99.93	77.99	92	74	88.6913	5
S30	97.65	99.48	79	98.68	100	95.9	81.63	86	70	88.8308	4
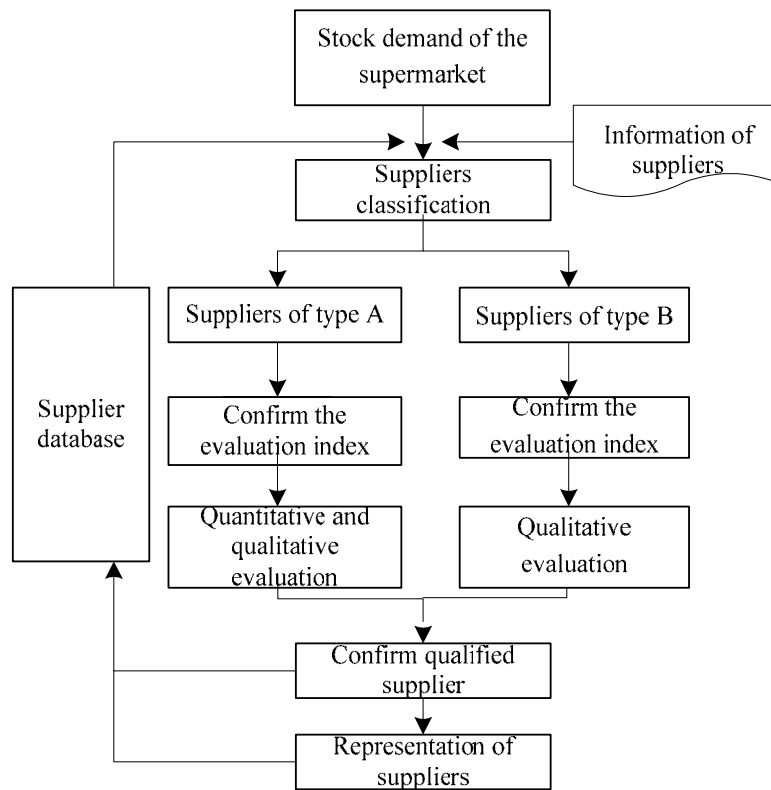
Figure 1. The Classification Evaluation Program of Supermarket Good Suppliers
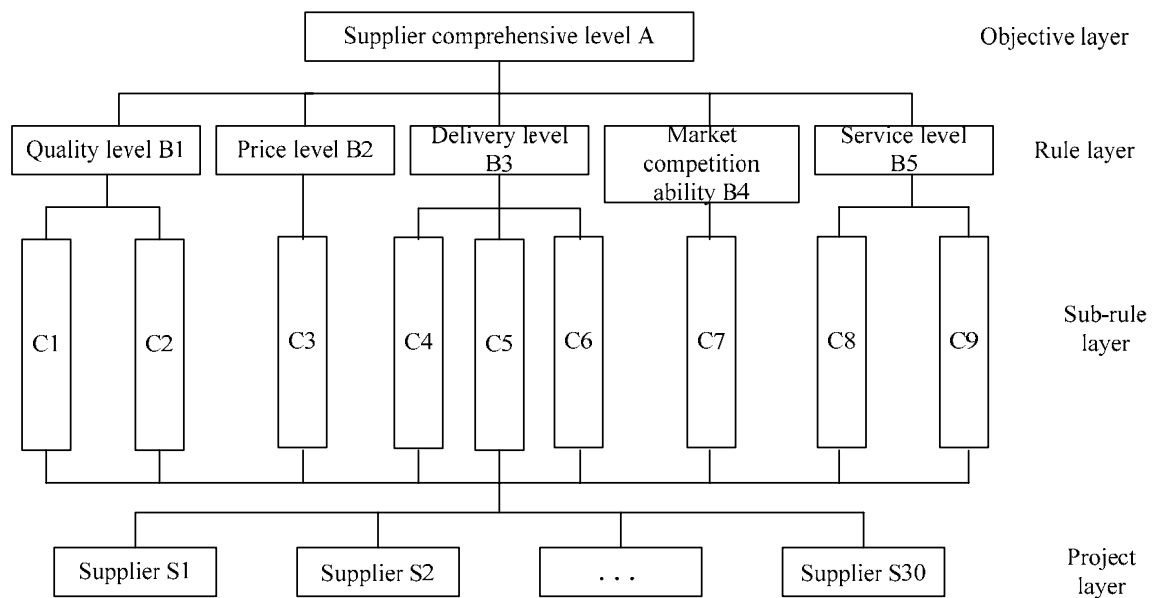
Figure 2. The Hierarchical Structure of the Supplier Comprehensive Evaluation (C_1: Qualified rate of the product, C_2: Consumer withdrawal rate, C_3: Price representation, C_4: Delivery time, C_5: Delivery quality, C_6: Delivery safety, C_7: Market share, C_8: Service quality, C_9: Mark traceability)