Evaluation on Enterprises' Service Flexible Capability Based on Reverse Supply Chain

Xu Chang#1, Li Jiujin#2, Yang Donghong#3

#*Institute of Petroleum Economics and Management, Northeast Petroleum University, Daqing Heilongjang, China.*

1xuchangup@126.com

2dqlijiujin@126.com

3dqyangdonghong@126.com

Abstract — **Due to the characteristics such as complexity and uncertainty etc., there are many difficulties during the performing of reverse supply chain. In order to effectively play the role of reverse supply chain, obtain lasting economic, ecological and social benefits, this paper introduces the concept of service flexible capability, and contributes an evaluation index system of it for enterprises. Due to fuzziness of the indicators, combined with AHP, this paper takes a real enterprise for example, evaluates the enterprise's service flexible capability by fuzzy comprehensive evaluation method. According to the evaluation process and evaluation results, the enterprise's service flexible capability can be mastered better.**

Keywords — *Reverse supply chain, Fuzzy comprehensive evaluation method, Service flexible capability*

1. Necessity of Evaluation on Enterprises' Service Flexible Capability Based on Reverse Supply Chain

The mode of modern market economy has been shifted from product economy to service economy. In the 21st century, the important magic weapon for the market competition to win is not competing on price, but the service competition. With the progress of high technology, consumers' demand for services is higher and higher, and the market competition is fierce increasingly too. On the same service product, because of the invisibility of service product, both customers and service providers produce different quantity and feelings, which vary from people to people——that creates a service of instability, which directly affects the customer perception of service quality satisfaction, affects the degree of customer value creation, and even endangers the enterprises to maintain competitive advantage. Aimed at this situation, many well-known enterprises have put forward the importance of service flexible management, they pointed out that if service flexible capability shaping and flexible capacity arrangement can be taken effectively in the process of service production and operation, enterprises and customers can receive better benefits.

Reverse supply chain is a concept which is paid more attention in recent years, many enterprises have devoted to the improvement for reverse supply chain efficiency. Due to the obvious differences between the traditional forward supply chain and the reverse supply chain, management of the latter is not easy. So, the service flexible capability can be introduced to reduce the uncertainty in the reverse supply chain management, improve enterprises' service capability, so as to improve customers' satisfaction. Therefore, it is necessary to assess the current levels of enterprises' service flexible capability based on reverse supply chain.

2. Construction of Evaluation Index System of Enterprises' Service Flexible Capability Based on Reverse Supply Chain

On the basis of previous studies, this paper argues that, from the perspective of reverse supply chain, the enterprise' service flexible capability is reflected in three aspects: flexible strategic capability, flexible management capability and flexible operational capability [1]. As the first-level indicators, the three aspects are reflected further in secondary indicators. We can get the evaluation index system as follows:

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

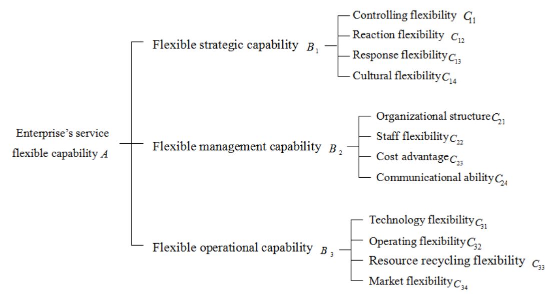

Figure 1. Evaluation index system of enterprises' service flexible capability based on reverse supply chain

3. Building Fuzzy Comprehensive Evaluation Model of Enterprises' Service Flexible Capability Based on Reverse Supply Chain

3.1 Determination of the evaluation factor set

$F = \{f_1, f_2, ..., f_n\}$, And f_i represents a level of all the factors.

3.2 Determination of the weights of each evaluation indicator

In order to comprehensively consider the qualitative and quantitative factors, this paper uses the Analytic Hierarchy Process (AHP) to determine the weight of each indicator [2] [3]. Among them，The AHP structure model is showed as Figure 1，and the specific steps are as follows:

3.2.1 Construction of the judgment matrix

For the analytic multi-hierarchy model, experts are asked to make qualitative description separately for the importance of each evaluation indicator, which is quantified by exact figures. Saaty's 1-9 scaling method is referred to make indexes quantitative[4][5].

By comparing the each two indicators among all indicators, the judgment matrix is constructed as A, $A = (a_{ij})_{n\times n}$.

3.2.2 Single-level ranking and consistency test

3.2.2.1 Single-Level Ranking

According to the judgment matrix, we can get the sort weights of the indicators in the analytic multi-hierarchy model, thus get the eigenvector normalized W . Then, we can get the maximum eigenvalue $\lambda_{\max}$, and W can be obtained as follows:

(1) Each list of matrix elements can be standardized, and $\bar{a}_{ij}$ for each element:

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{k=1}^{n} a_{kj}} \quad (i, j = 1,2,\cdots,n) \qquad (1)$$

(2) We get the summation of elements in each row of the judgment matrix standardized:

$$\bar{W}_i = \sum_{j=1}^{n} \bar{a}_{ij} \quad (i = 1,2,\cdots,n) \qquad (2)$$

So, $\bar{W} = (\bar{W}_1, \bar{W}_2, \cdots, \bar{W}_n)^T$

$$W_i = \frac{\bar{W}_i}{\sum_{i=1}^{n} \bar{W}_i} (i = 1,2,\cdots,n) \qquad (3)$$

The vector $W = (W_1, W_2, W_3, \cdots, W_n)^T$ is the eigenvector calculated, that is the Single-level sort weights. The maximum eigenvalue $\lambda_{\max}$ is:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i} \qquad (4)$$

3.2.2.2 Consistency Test

The target of consistency test is

$$CI = \frac{\lambda_{\max} - n}{n-1} \qquad (5)$$

The smaller CI is, the higher the degree of the judgment matrix consistency becomes. If CI=0, the judgment matrix achieve consistent completely[6]. But in the process of building the judgment matrix, inconsistent judgment of thinking is just one of the reasons to influence the consistency of judgment matrix. With Saaty's 1-9 scaling method as the result of factors comparison is also cause the consistency deviating from the judgment matrix. Therefore, only according to CI to set the acceptable standard of inconsistency is clearly inappropriate. In order to get the critical value for consistency checking for different orders of judgment matrix, it is necessary to eliminate the influence of the matrix order[7].

We introduce the corresponding average target of random consistency RI which is shown in Finger 2.

Rank	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Finger 2. The average random target of consistency test

The consistency hypothesis is

$$CR = \frac{CI}{RI} \qquad (6)$$

Normally, for the judgment matrix which orders is more than three, If $CR < 0.10$, the consistency of the judgment matrix is acceptable, Otherwise, if $CR > 0.10$, the judgment matrix deviation degree of consistency is too big, the judgment matrix must be adjusted to achieve satisfactory consistency.

3.2.3 Calculation for synthetic weights and consistency test

3.2.3.1 Calculation for synthetic weights

Assume that the analytic multi-hierarchy model includes target layer A, criterion layer B and index layer C. The corresponding weight of target layer A to criterion layer B is $W^1, W^{(1)} = (W_1^{(1)}, W_2^{(1)}, W_3^{(1)}, \cdots, W_k^{(1)})^T$.

In the same way, the corresponding weight of the criterion layer B to index layer C is $W_j^{(2)} = (W_{1j}^{(2)}, W_{2j}^{(2)}, W_{3j}^{(2)}, \cdots, W_{nj}^{(2)})^T$ $(j = 1,2,\cdots,k)$, Then, the corresponding weight of index layer C to target layer A can be calculated(finger 3):

H.B / H.C	B_1	B_2	…	B_k	Sort of level Ranking
	W_1	W_2	…	W_k	W
C_1	W_{11}	W_{12}	…	W_{1k}	$W_i = \sum_{j=1}^{k} W_j^{(1)} * W_{ij}^{(2)}$ $(i = 1,2,\cdots n)$
C_2	W_{21}	W_{22}	…	W_{2k}	
⋮	⋮	⋮		⋮	
C_n	W_{n1}	W_{n2}	…	W_{nk}	

Finger 3. Synthetic weights

3.2.3.2 Consistency Test

$$CR = \frac{\sum_{j=1}^{m} CI_j a_j}{\sum_{j=1}^{m} RI_j a_j} \qquad (7)$$

The same as the previous analysis, if $CR < 0.10$, the consistency of the judgment matrix is acceptable. Otherwise, if $CR > 0.10$, the judgment matrix deviation degree of consistency is too big, the judgment matrix must be adjusted to achieve satisfactory consistency, and the corresponding weights of the indexes is $W = (W_1, W_2, W_3, \cdots, W_n)^T$.

On the basis of the calculation, we have conditions to determine the evaluation anking $E = \{e_1, e_2, ..., e_n\}$, form evaluation matrix and receive the fuzzy comprehensive evaluation results S. Here $S = W^T \circ R$, W^T is the weights matrix, and R is the fuzzy evaluation matrix.

4. Example

In order to validate the above analysis, we take a petroleum equipment manufacturing enterprise for an example. This enterprise has 2130 employees, and it is a professional company which is engaged in the esp and screw pump development, manufacturing and marketing. In recent years, considering the company's long-term goals and the environmental sustainable development, the company attaches great importance to the reverse supply chain management, and actively introduces the concept of service flexible management[8]. We use fuzzy comprehensive evaluation method to evaluate the service flexible capability of this company, the steps as follows:

4.1 The factor set of service flexible capability of the enterprise

The first factor set: $A = (B_1, B_2, B_3)$

The second factor set: $B_1 = (C_{11}, C_{12}, C_{13}, C_{14})$, $B_2 = (C_{21}, C_{22}, C_{23}, C_{24})$, $B_3 = (C_{31}, C_{32}, C_{33}, C_{34})$.

4.2 Determine the evaluation ranking

The service flexible capability ranking of the petroleum equipment manufacturing enterprise is $E = (e_1, e_2, e_3)$, and the specific conversion standards and interpretations are as follows:

Table 1. Ranking conversion standards and interpretation of the service flexible capability

Reviews set	Interpretation	100 points standards	Conversion -al point
e_1	Good	Above 80	90
e_2	General	60-80	70
e_3	Weak	Below 60	50

4.3 Determine the weights of the evaluation indicators

Table 2. The judgment matrix of A-B level

A	B_1	B_2	B_3	W
B_1	1	3	5	0.648
B_2	1/3	1	2	0.230
B_3	1/5	1/2	1	0.122

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)i}{nWi} = 3.004$$

$$CI = \frac{\lambda_{\max} - n}{n-1} = 0.002$$

$$CR = \frac{CI}{RI} = 0.003 < 0.10$$

The consistency test is passed, in the same way, we can get:

Table 3. The judgment matrix of B1-C level

B_1	C_{11}	C_{12}	C_{13}	C_{14}	W
C_{11}	1	3	3	4	0.494
C_{12}	1/3	1	1	1/3	0.121
C_{13}	1/3	1	1	1/3	0.121
C_{14}	1/4	3	3	1	0.264

$\lambda_{\max} = 4.250$, $CI = 0.083$, $CR = 0.093 < 0.1$, the consistency test is passed.

Table 4. The judgment matrix of B2-C level

B_2	C_{21}	C_{22}	C_{23}	C_{24}	W
C_{21}	1	4	2	3	0.452
C_{22}	1/4	1	1/3	2	0.133
C_{23}	1/2	3	1	1/3	0.318
C_{24}	1/3	1/2	1/4	1	0.097

$\lambda_{\max} = 4.144$, $CI = 0.048$, $CR = 0.053 < 0.1$, which passes the consistency test.

Table 5. The judgment matrix of B3-C level

B_3	C_{31}	C_{32}	C_{33}	C_{34}	W
C_{31}	1	2	1/5	1/3	0.135
C_{32}	1/2	1	1/3	1/2	0.118
C_{33}	5	3	1	2	0.479
C_{34}	3	2	1/2	1	0.268

$\lambda_{\max} = 4.183$, $CI = 0.061$, $CR = 0.068 < 0.1$,which passes the consistency test.

Calculations for CI , RI and CR :

$$CI = \sum_{j=i}^{4} B_j CI_j = 0.648*0.083+0.230*0.048$$
$$+0.122*0.061=0.073$$

$$RI = \sum_{j=i}^{4} B_j RI_j = 0.648*0.900+0.230*0.900$$
$$+0.122*0.900=0.900$$

$$CR = \frac{\sum_{j=1}^{4} CI_j B_j}{\sum_{j=1}^{4} RI_j B_j} = 0.081 < 0.1$$

The consistency test is passed.

4.4 Determine fuzzy judgment matrixes

$$R_1 = \begin{bmatrix} 0.333 & 0.467 & 0.200 \\ 0.267 & 0.333 & 0.400 \\ 0.167 & 0.533 & 0.300 \\ 0.400 & 0.233 & 0.367 \end{bmatrix}$$

$$R_2 = \begin{bmatrix} 0.467 & 0.333 & 0.200 \\ 0.267 & 0.233 & 0.500 \\ 0.200 & 0.467 & 0.333 \\ 0.333 & 0.434 & 0.233 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.467 & 0.233 & 0.300 \\ 0.367 & 0.257 & 0.376 \\ 0.167 & 0.363 & 0.480 \\ 0.233 & 0.467 & 0.300 \end{bmatrix}$$

4.5 Calculation for fuzzy comprehensive evaluation

Result of Fuzzy comprehensive evaluation is S , Here, $S = W^T \circ R$, W^T is the weights matrix, and R is the fuzzy evaluation matrix:

$$S_1 = W_1^T \circ R_1 = \begin{bmatrix} 0.494 & 0.121 & 0.121 & 0.264 \end{bmatrix} \circ \begin{bmatrix} 0.333 & 0.467 & 0.200 \\ 0.257 & 0.333 & 0.410 \\ 0167 & 0.533 & 0.300 \\ 0.400 & 0.233 & 0.367 \end{bmatrix} = \begin{bmatrix} 0.323 & 0.397 & 0.280 \end{bmatrix}$$

Similarly obtained:

$$S_2 = \begin{bmatrix} 0.343 & 0.372 & 0.285 \end{bmatrix}$$

$$S_3 = [0.249 \quad 0.361 \quad 0.394]$$

$$S = W^T \circ R = [0.648 \quad 0.230 \quad 0.122] \circ \begin{bmatrix} 0.323 & 0.397 & 0.280 \\ 0.343 & 0.372 & 0.285 \\ 0.249 & 0.361 & 0.394 \end{bmatrix} = [0.318 \quad 0.387 \quad 0.295]$$

Result of comprehensive evaluation:

90*0.318+70*0.387+50*0.295=70.489

According to the ranking conversion standards, the petroleum equipment manufacturing enterprise's service flexible capability is general (60-80 points).

In combination with the practical situation of the company, this paper argues that, there is still a gap for the company in capability of flexible control and operation of service. Therefore, the company first should accurately define the target service customers, and clear their needs. At the same time, the company should accurate the positioning of products, make the flexible service cause the resonance of the target customers. To this end, the company also needs a strong background management system, using database to collect and analyze the supply chain upstream and downstream demand. Of course, higher request will be sent for the company's capability to supply chain management.

5. Conclusions

As more and more companies involved in the reverse supply chain management, service flexible capability will be paid more attention. The current service flexible capability of enterprises can be mastered by fuzzy comprehensive evaluation method and AHP. Under the background of cloud computing, interactivity between dynamic environment and enterprises organization reform is reinforced, and a highly flexible dynamic service organization construction is needed to response quickly to the market changes. So how to assess the dynamic service flexible capability is a problem worth considering in the future, and will be the research direction for next researches

Acknowledgments

This work was supported by: 1. the Education Science“12th 5-year Plan”Fund of Heilongjiang Province, China（GBB1211016、GBB1213019; 2. The Science Fund for Young Scholar of Northeast Petroleum University,China（2012QN206）; 3. The Social Science Fund of Daqing City, China (DSGB2013036. Furthermore, we would like to thank Dr. Md.Mamun Habib for critically reviewing the manuscript.

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