

## Research Article

### Evaluation on Indicator System of Food Economic Project Evaluation based on Combination Weight and TOPSIS

Aiying Shang, Weihua Li, Huijuan Sun, Xiumin Zhao and Zhigang Zheng  
Xingtai University, Xingtai, Hebei 054001, China

**Abstract:** This study takes the drawback that the project performance has great influence on food enterprise performance into consideration, through the introduction of financial indicators, indicators of internal processes, learning and development indicators, to build a new comprehensive performance evaluation index system for food economic projects. Based on this, performance indicators data of food economic project is collected and then further processed, which lays the foundation for determining indicators weights.

**Keywords:** Comprehensive performance, evaluation methods, food enterprise, index system, TOPSIS

#### INTRODUCTION

The evaluation of Food economic Project is adaptation of socialism food economic market development, is consolidation of investing and financing reform and is meaningful to the realization of scientific project decision-making, enhancing the overall benefit of the project and implementing the strategic target of sustainable development of our country (Herman, 2008; Fu and Xu, 2008). With the development of investment system reform and the establishment of restrictive mechanism venture, the input-output of investment project and the successful rate of investment decision-making will be further emphasized in a variety of investors, the dissertation makes a detailed and systematic study of the theory and method of food economic project evaluation, which aims to services supervision and evaluation of our domestic Food economic Project with elements in both theory and technology and the system is valuable in practice (Zavadskasn *et al.*, 2014). Traditional indicators of performance evaluation system involves mostly just in quality, schedule and environmental goals of the project, that is to say, it only considers the level of performance that only a few large projects in progress goals, without taking into account of the impact on the overall performance level caused by the staff involved in the project and project management level of internal management of the project, which cannot meet the requirements for the performance evaluation (Wang and Lai, 2008).

#### MATERIALS AND METHODS

##### Processing of indicators data:

**Unification method:** According to the indicator system established in this study, the indicators including income satisfaction of staff, capital utilization, administration innovation, management quality, staffs' learning attitude, perfect degree of incentive mechanism, timeliness of material, equipment and food economic units, completion of food economic schedule plan, complete food economic data, reduction rate of project cost, contract compliance rate, resolution rate of technical problem, passing rate of project quality, the quality qualification rate of raw materials and equipment, environmental assessment level are benefit indicators; budget and final accounts deviation rate, environmental protection input cost indicators (Ngacho and Das, 2014).

Cost indicators are transferred into benefit indicators in this study (Sun and Luo, 2008). The transfer formula is shown as:

$$x^* = M - x$$

where,  $M$  is the set upper bound of  $x$ .

**Non-dimensional method:** When evaluating the project performance level, different dimensions of different indicators makes it hard for the comprehensive evaluation (Wen and Ren, 2011). Then, non-dimensional method is applied to unify the indicators dimensions, where efficacy coefficient is introduced in this study (Lv, 2009). The formula of efficacy coefficient is shown below:

$$x_{ij}^* = c + \frac{x_{ij} - m_j}{M_j - m_j} \times d$$

where,  $M_j$ ,  $m_j$  respectively represent maximum and minimum values of each indicator;  $c$  and  $d$  are known constants, which make the numbers for transformation translate and zoom. The  $c$  and  $d$  are respectively valued 60 and 40 in this study.

**Eigenvalue method:** Eigenvalue method is used for determining indicators weights by establishing evaluation matrixes and comparing evaluation indicators. Firstly, evaluation matrix  $A$  is established and the eigenvector of matrix  $A$  can be calculated by the following formula  $(A-\lambda E)x = 0$ , where  $\lambda$  is the root of equation  $|A-\lambda E| = 0$  and then the indicators weights sequencing can be obtained. The eigenvector corresponding to the maximum eigenvalue of matrix  $A$  is the weight vector wanted. However, this method needs examining consistency. Consistency indicator  $CI$  can be calculated with the following formula  $CI = (\lambda_{max} - m)/(m-1)$ , where  $m$  represents the matrix order. The average random consistency  $RI$  meets demands of the Table 1.

The random consistency rate  $CR$  can be calculated with formula  $CR = CI/RI$ . When  $CR$  is lower than 0.10, the judgment matrix has satisfied consistency; or the judgment matrix need adjusting, until it has satisfied consistency.

**Entropy weight method:** Entropy weight method is used to determine the indicators weights based on information load of each indicator (Qu and Fang, 2014). Here establishes matrix  $R = (x_{ij})_{m \times n}$ , in which  $x_{ij}$  represents the  $i$ th indicator attribute corresponding to  $j$ th item. The detailed procedure of the entropy weight method is given below:

**Contribution degree:**

$$p_{ij} = x_{ij} / \sum_{i=1}^n x_{ij}$$

where,  $p_{ij}$  represents the contribution degree of the  $j$ th item corresponding to  $i$ th indicator attribute.

**Entropy:** Entropy  $e_i$  is the total contribution of all the items to  $i$ th indicator:

$$e_i = -k \sum_{j=1}^n p_{ij} \ln p_{ij}$$

Where, constant  $k$  can be calculated by formula  $k = 1/\ln n$ .

**Difference coefficient:**  $g_i$  represents contribution difference of each item corresponding to the  $i$ th indicator:

$$g_i = 1 - e_i$$

**Indicators weights:** The entropy weight of the  $j$ th indicator can be obtained by the following formula:

$$w_i = \frac{g_i}{\sum_{i=1}^m g_i}$$

**Combination weight method:** In order to avoid the influence of experts' subjective preferences in subjective weight and uncontrolled weighting result in objective weight, the combination weight is applied to determine the indicators weights (Song and Yang, 2004). The weight vector by eigenvalue method is shown as  $w' = (w'_1, w'_2, \dots, w'_n)^T$  and the weight vector by entropy weight method is shown as  $w'' = (w''_1, w''_2, \dots, w''_n)^T$ . Then the combination weight of each indicator can be calculated with the following formula:

$$w = k_1 * w' + k_2 * w''$$

where,  $k_1 + k_2 = 1$  and  $k_1, k_2 > 0$ .

**TOPSIS:** TOPSIS is originated in discrimination problems of multivariate statistical analysis (Luo and Peng, 2011). The detailed procedures of TOPSIS are shown below:

**Standard decision matrix:** Based on the indicators data after processing in Table 1 to 5, the standard decision matrix  $T = (t_{ij})_{m \times n}$  can be established.

**Weighted decision matrix:** Based on the indicators combination weight vector  $W = (w_1, w_2, \dots, w_m)$ , the weighted decision matrix can be obtained by the following formula:

$$X = WT = \begin{bmatrix} w_1 t_{11} & w_2 t_{12} & \dots & w_n t_{1n} \\ w_1 t_{21} & w_2 t_{22} & \dots & w_n t_{2n} \\ \dots & \dots & \dots & \dots \\ w_1 t_{m1} & w_2 t_{m2} & \dots & w_n t_{mn} \end{bmatrix}$$

where,  $w_j$  is the weight of the  $j$ th indicator and  $\sum_{j=1}^n w_j = 1$ .

**Positive and negative ideal points:** In the weighted decision matrix, the positive ideal point  $x^+$  is a vector composed of maximum number of each column; the

Table 1: Average random consistency RI

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

negative ideal point  $x^-$  is a vector composed of minimum number of each column, that is,  $x^+$  and  $x^-$  meet the requirements below:

$$x^+ = (x_1^+, x_2^+, \dots, x_m^+), x_j^+ = \max \{x_{ij}\}, j = 1, 2, \dots, m$$

$$x^- = (x_1^-, x_2^-, \dots, x_m^-), x_j^- = \min \{x_{ij}\}, j = 1, 2, \dots, m$$

**Distances with positive and negative ideal solutions:** The n-dimension Euclidean distances between evaluated object and positive, negative ideal points are shown by  $Y_i^+$  and  $Y_i^-$ , which are calculated with the following formulas:

$$y_i^+ = \sqrt{\sum_{j=1}^m (x_{ij} - x_j^+)^2}, \quad i=1, 2, \dots, n$$

$$y_i^- = \sqrt{\sum_{j=1}^m (x_{ij} - x_j^-)^2}, \quad i=1, 2, \dots, n$$

**Similarities with positive ideal point:** Similarities with positive ideal point can be obtained by the following formula:

$$C_i = \frac{y_i^-}{y_i^+ + y_i^-}$$

It is obvious that the larger  $C_i$  is, the longer distance between evaluated object and negative ideal solution and shorter distance between evaluated object and positive ideal solutions are. Then, rank the similarities of all the objects and select the best evaluated object.

**RESULTS AND DISCUSSION**

**Indicators data processing:** When conducting unification of indicators data,  $M_{51}$  and  $M_{81}$  are respectively valued 1.40 million and 100%. Then based on the unification result, the efficacy coefficient method is applied to unify the indicators dimensions. The processing result is shown in Table 2.

**Determining the indicators weights:** **Indicators weights by eigenvalue method:** According to the eigenvalue method, the indicators scores tables of

Table 2: Processing result of indicators data

Indicators	Unification			Non-dimensions		
	P1	P2	P3	P1	P2	P3
B <sub>11</sub>	76	87	84	60	100	89.0909
B <sub>12</sub>	31	40	26	74.2857	100	60
B <sub>21</sub>	3.8	4.3	3.2	81.8182	100	60
B <sub>22</sub>	3.1	3.4	4.2	60	70.9091	100
B <sub>31</sub>	2.1	3.3	4	60	85.2632	100
B <sub>32</sub>	3.8	4.2	3.6	73.3333	100	60
B <sub>41</sub>	90	87	72	100	93.3333	60
B <sub>42</sub>	81	89	76	75.3846	100	60
B <sub>43</sub>	87	85	79	100	90	60
B <sub>51</sub>	82	91	84	60	100	68.8889
B <sub>52</sub>	75	86	88	60	93.8462	100
B <sub>61</sub>	80	91	84	60	100	74.5455
B <sub>62</sub>	90	95	87	75	100	60
B <sub>71</sub>	95	92	90	100	76	60
B <sub>72</sub>	93	97	85	86.6667	100	60
B <sub>81</sub>	0.16	0.43	0.05	71.5790	100	60
B <sub>82</sub>	0.72	0.88	0.9	60	95.5556	100

Table 3: Indicator weights of layer O-A

O-A	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	A <sub>4</sub>	A <sub>5</sub>	A <sub>6</sub>	A <sub>7</sub>	A <sub>8</sub>	Weight
A <sub>1</sub>	1	1.5	0.8	0.8	0.5	0.4	0.6	0.8	0.0902
A <sub>2</sub>	0.6667	1	0.7	0.6	0.4	0.5	0.8	0.9	0.0813
A <sub>3</sub>	1.25	1.4286	1	1.25	1	1.5	2	1.25	0.1585
A <sub>4</sub>	1.25	1.6667	0.8	1	0.8	1.25	1.5	0.5	0.1249
A <sub>5</sub>	2	2.5	1	1.25	1	1.5	1.25	1	0.1653
A <sub>6</sub>	2.5	2	0.6667	0.8	0.6667	1	0.8	0.5	0.1164
A <sub>7</sub>	1.6667	1.25	0.5	0.6667	0.8	1.25	1	0.8	0.1129
A <sub>8</sub>	1.25	1.1111	0.8	2	1	2	1.25	1	0.1505

Table 4: Indicators weights of layer A1-B

A <sub>1</sub>	B <sub>11</sub>	B <sub>12</sub>	Weight	$\lambda_{max}$	Test
B <sub>11</sub>	1	0.8	0.4444	2	CI = 0; satisfied
B <sub>12</sub>	1.25	1	0.5556		

Table 5: Indicators weights of layer A2-B

A <sub>2</sub>	B <sub>21</sub>	B <sub>22</sub>	Weight	$\lambda_{max}$	Test
B <sub>21</sub>	1	0.85	0.4595	2	CI = 0; satisfied
B <sub>22</sub>	1.1764	1	0.5405		

Table 6: Indicators weights of layer A3-B

A <sub>3</sub>	B <sub>31</sub>	B <sub>32</sub>	Weight	$\lambda_{max}$	Test
B <sub>31</sub>	1	1.2	0.5455	2	CI = 0; satisfied
B <sub>32</sub>	0.8333	1	0.4545		

Table 7: Indicators weights of layer A4-B

A <sub>4</sub>	B <sub>41</sub>	B <sub>42</sub>	B <sub>43</sub>	Weight	$\lambda_{max}$	Test
B <sub>41</sub>	1	1.5	2	0.4568	3.0101	CI = 0.0051; CR = 0.0871; satisfied
B <sub>42</sub>	0.6667	1	1.8	0.3366		
B <sub>43</sub>	0.5	0.5556	1	0.2067		

Table 8: Indicators weights of layer A5-B

A <sub>5</sub>	B <sub>51</sub>	B <sub>52</sub>	Weight	$\lambda_{max}$	Test
B <sub>51</sub>	1	0.7	0.4118	2	CI = 0; satisfied
B <sub>52</sub>	1.4286	1	0.5882		

Table 9: Indicators weights of layer A6-B

A <sub>6</sub>	B <sub>61</sub>	B <sub>62</sub>	Weight	$\lambda_{max}$	Test
B <sub>61</sub>	1	1.2931	0.5639	2	CI = 0; satisfied
B <sub>62</sub>	0.7733	1	0.4361		

Table 10: Indicators weights of layer A7-B

A <sub>7</sub>	B <sub>71</sub>	B <sub>72</sub>	Weight	$\lambda_{max}$	Test
B <sub>71</sub>	1	0.86	0.4624	2	CI = 0; satisfied
B <sub>72</sub>	1.1627	1	0.5376		

Table 11: Indicators weights of layer A8-B

A <sub>8</sub>	B <sub>81</sub>	B <sub>82</sub>	Weight	$\lambda_{max}$	Test
B <sub>81</sub>	1	0.6667	0.4000	2	CI = 0; satisfied
B <sub>82</sub>	1.5	1	0.6000		

Table 12: Indicators weights corresponding to the first class

First class	Second class	Third class
Indicator system of food economic project performance evaluation (O)	(A <sub>1</sub> ) 0.0902	(B <sub>11</sub> ) 0.0401 (B <sub>12</sub> ) 0.0501
	(A <sub>2</sub> ) 0.0813	(B <sub>21</sub> ) 0.0374 (B <sub>22</sub> ) 0.0439
	(A <sub>3</sub> ) 0.1585	(B <sub>31</sub> ) 0.0865 (B <sub>32</sub> ) 0.0720
	(A <sub>4</sub> ) 0.1249	(B <sub>41</sub> ) 0.0571 (B <sub>42</sub> ) 0.0420 (B <sub>43</sub> ) 0.0258
	(A <sub>5</sub> ) 0.1653	(B <sub>51</sub> ) 0.0681 (B <sub>52</sub> ) 0.0972
	(A <sub>6</sub> ) 0.1164	(B <sub>61</sub> ) 0.0656 (B <sub>62</sub> ) 0.0508
	(A <sub>7</sub> ) 0.1129	(B <sub>71</sub> ) 0.0522 (B <sub>72</sub> ) 0.0607
	(A <sub>8</sub> ) 0.1505	(B <sub>81</sub> ) 0.0602 (B <sub>82</sub> ) 0.0903

relative importance and weighting result are shown from Table 3 to 11. And the weight of each indicator relative to the first class indicator is calculated, as Table 12 shows.

The maximum eigenvalue  $\lambda_{max}$  of judgment matrix is 8.2641, the value of Consistency indicator  $CI=0.0377$ , the value of random consistency  $RI=0.0267$  and the matrix has satisfied consistency.

**Indicators weights by entropy weight method:** Based on the indicator system and indicator data from three projects, the entropy weight method is

applied to determine indicators weights, as Table 13 shows.

**Indicators combination weights:** The weights of subjective and objective weight methods for the combination weight are calculated by lagrange algorithm and the result shown in Table 14.

**The result of TOPSIS:** Weighted judgment matrix can be calculated by the indicators data after processing and indicators combination weights, as the Table 15 shows.

The positive and negative ideal points can be determined by the Table 16:

$$X+ = (4.2209, 5.1148, 3.9634, 4.6146, 8.2644, 7.0415, 5.7437, 4.3959, 2.9756, 6.7663, 9.2595, 6.4689, 5.1699, 5.2836, 6.0113, 6.0312, 8.6743)$$

$$X- = (2.5325, 3.0689, 2.3780, 2.7688, 4.9586, 4.2249, 3.4462, 2.6376, 1.7854, 4.0598, 5.5557, 3.8813, 3.1019, 3.1702, 3.6068, 3.6187, 5.2046)$$

Then, distances with positive, negative ideal points, the similarities with positive ideal point and the sequence of the three projects are shown in Table 16.

According to the Table 16, the score of P2 is the highest. And by the methods applied in this study, the performance levels of three projects are evaluated, in which P2 ranks first, P3 second, P1 third.

Table 13: Indicators weights by entropy weight method

Indicators	P1	P2	P3	$e_i$	$g_i$	$w_i$
B <sub>11</sub>	60	100	80	0.9803	0.0197	0.0570
B <sub>12</sub>	74.2857	100	60	0.9798	0.0202	0.0585
B <sub>21</sub>	100	80	60	0.9809	0.0191	0.0553
B <sub>22</sub>	80	100	60	0.9786	0.0214	0.0619
B <sub>31</sub>	60	86.6667	100	0.9808	0.0192	0.0556
B <sub>32</sub>	80	100	60	0.9795	0.0205	0.0593
B <sub>41</sub>	100	93.3333	60	0.9794	0.0206	0.0598
B <sub>42</sub>	75.3846	100	60	0.9801	0.0199	0.0577
B <sub>43</sub>	100	90	60	0.9802	0.0198	0.0575
B <sub>51</sub>	60	100	68.8889	0.9777	0.0223	0.0646
B <sub>52</sub>	60	80	100	0.9792	0.0208	0.0603
B <sub>61</sub>	60	100	74.5455	0.9799	0.0201	0.0583
B <sub>62</sub>	75	100	60	0.9800	0.0200	0.0580
B <sub>71</sub>	100	76	60	0.9802	0.0198	0.0573
B <sub>72</sub>	80	100	60	0.9807	0.0193	0.0560
B <sub>81</sub>	71.5790	100	60	0.9789	0.0211	0.0611
B <sub>82</sub>	60	80	100	0.9787	0.0213	0.0618

Table 14: Indicators combination weight

Indicators	Weight	Indicators	Weight	Indicators	Weight	Indicators	Weight
B <sub>11</sub>	0.0422	B <sub>32</sub>	0.0704	B <sub>52</sub>	0.0926	B <sub>81</sub>	0.0603
B <sub>12</sub>	0.0511	B <sub>41</sub>	0.0574	B <sub>61</sub>	0.0647	B <sub>82</sub>	0.0867
B <sub>21</sub>	0.0396	B <sub>42</sub>	0.0440	B <sub>62</sub>	0.0517		
B <sub>22</sub>	0.0461	B <sub>43</sub>	0.0298	B <sub>71</sub>	0.0528		
B <sub>31</sub>	0.0826	B <sub>51</sub>	0.0677	B <sub>72</sub>	0.0601		

Table 15: Weighted judgment matrix

Indicators	Weighted judgment matrix		
B <sub>11</sub>	2.5325	4.2209	3.7604
B <sub>12</sub>	3.7996	5.1148	3.0689
B <sub>21</sub>	3.2428	3.9634	2.3780
B <sub>22</sub>	2.7688	3.2722	4.6146
B <sub>31</sub>	4.9586	7.0465	8.2644
B <sub>32</sub>	5.1638	7.0415	4.2249
B <sub>41</sub>	5.7437	5.3608	3.4462
B <sub>42</sub>	3.3139	4.3959	2.6376
B <sub>43</sub>	2.9756	2.6781	1.7854
B <sub>51</sub>	4.0598	6.7663	4.6612
B <sub>52</sub>	5.5557	8.6897	9.2595
B <sub>61</sub>	3.8813	6.4689	4.8223
B <sub>62</sub>	3.8774	5.1699	3.1019
B <sub>71</sub>	5.2836	4.0156	3.1702
B <sub>72</sub>	5.2098	6.0113	3.6068
B <sub>81</sub>	4.3171	6.0312	3.6187
B <sub>82</sub>	5.2046	8.2888	8.6743

Table 16: The result of TOPSIS

Items	$y^+$	$y^-$	$C_i$	Sequence
P1	69.1607	17.4411	0.2014	3
P2	5.6019	79.5978	0.9342	1
P3	52.119	42.8471	0.4512	2

### CONCLUSION

In this study, the project and construction project is described, the relation between project evaluation and project life-cycle and the significance of making evaluation are analyzed, developing process of evaluation is reviewed; On the basis of analysis, generalization and summarization, the theory basis of construction project food economic evaluation, environment evaluation and social evaluation are put forward to make a basis on further study; the concept, basic process, the principle and the basic content of the comprehensive evaluation of construction project are

introduced, then the establishment and standard way of index system in the Multiple Attribute Evaluation (MAE) of construction project are studied; Based on the analysis of subjective weights and objective weights, the subjective and objective synthetic method, which makes up the default of subjective weights or objective weights, is put forward; Through comprehensive and thorough research, the classification of the commonly used evaluation method is carried on and the choice principle of evaluation method is elaborated, which provides the basis for the people to select it correctly; According to the research results of index system of construction project comprehensive evaluation, on the foundation of the introduction of construction evaluation content, the food economic evaluation, the society and the environmental effect evaluation index system are established; In profits from the most recent information related of the domestic and foreign on project evaluation and in the reference of various research results related food enterprise achievements evaluation, a set of index system to evaluate the food enterprise. At last, TOPSIS is applied to comprehensively evaluate the projects performance levels.

### REFERENCES

Fu, Y.H. and Y.L. Xu, 2008. Performance Management [M]. 2nd Edn., Fudan University Press, Shanghai.  
 Herman, A., 2008. Performance Management [M]. China Renmin University Press, Beijing.  
 Luo, X.X. and S.H. Peng, 2011. Research on the vendor evaluation and selection based on AHP and TOPSIS in green supply Chain [J]. Soft Sci., 25(2): 53-56.

- Lv, H.B., 2009. The efficacy coefficient method in the evaluation of food enterprise performance [J]. *InnerMongolia Sci. Technol. Econ.*, 9: 69-71.
- Ngacho, C. and D. Das, 2014. A performance evaluation framework of development projects: An empirical study of constituency development fund food economic projects in Kenya [J]. *Int. J. Proj. Manag.*, 32(3): 492-507.
- Qu, W.J. and X.Y. Fang, 2014. Assessment of black-start modes based on entropy value method and principal component analysis [J]. *Power Syst. Protect. Control*, 42(8): 22-27.
- Song, G.X. and D.L. Yang, 2004. Combination weighting approach based on the decision-maker' preference and consistency of weighting methods [J]. *Syst. Eng. Electron.*, 26(9): 1226-1230.
- Sun, Y.H. and H. Luo, 2008. Performance Appraisal Quantitative Management [M]. People's Posts and Telecommunications Press, Beijing, pp: 524-526.
- Wang, T.J. and Y.B. Lai, 2008. Study on the performance evaluation index system of the highway food economic project [J]. *Highway Traffic Sci. Technol.*, 09: 186-191.
- Wen, H.T. and C.P. Ren, 2011. A new study of non-measurement in evaluation of food enterprise's performance [J]. *Food Econ. Problems*, 6: 61-65.
- Zavadskasn, E.K., T. Vilutiene, Z. Turskis *et al.*, 2014. Multi-criteria analysis of projects' performance in food economic [J]. *Arch. Civ. Mech. Eng.*, 2014: 114-121.