



# Stock Investment Value Study Based on Fuzzy Comprehensive Evaluation

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## Abstract

This paper constructs 3-level evaluation model based on index system for the listed corporations and confirm the weights by the factor analysis, then compute the investment value of listed companies in chlor-alkali industry making use of fuzzy comprehensive evaluation method and illustrate the method. The objective and reasonable basis for making investment decision is provided.

**Keywords:** Fuzzy comprehensive evaluation, Investing value, Mathematica

## 1. Introduction

Considering the characteristics that China's stock market is still in development stage and the actual situation of listed companies, and taking into account available data, we could consider the profitability of listed companies, growth and expand capacity of equity capital to reflect the investment value of listed companies.

Profitability: the earnings per share(EPS), return on equity(ROE), cash flow per share(CFPS) and total assets yield(TAY) could be set up to reflect the profitability of listed companies. EPS means the level of profitability of common stock, which is the most concerned indicators for many investors. Besides using this financial profitability to evaluate the listed companies, majority investors also use price per share of listed companies to conduct horizontal compare, by which decide to how to invest, so the indicator would best reflect the image of a listed company.

Growth indicator: the main business revenue growth rate(MBRGR), the growth rate of total assets(GROTA) and net profit growth rate(NPGR) are established to representative the growth of listed companies. From the perspective of assets, total assets of listed companies is an important indicator to measure the strength of listed companies, so, to a certain extent, the total assets growth rate means the growth of listed companies. MBRGR also plays an important role in the company's growth, indicating the focus direction of growth. Because the accumulation, development and return to investors of listed companies depends largely on the increase in net profit, NPGR is the indicator to measure the growth of listed companies.

Expand capacity of equity capital: the net assets per share(NAPS), accumulation fund per share(AFPS) and undistributed profits fund per share(UPFPS) are used to reflect the expand capacity of listed companies. For good business performance and sustainable development ability of listed companies, expand capacity of its share capital should also be strong. Now, China's listed companies has strong desire to expand, but its performance at least be able to grow with the times that it would make a sustainable power source for the development, so these three indicators were set up to reflect the expand capacity.

## 2. Fuzzy comprehensive evaluation model

Fuzzy comprehensive evaluation is a method that makes use of the concept of fuzzy mathematics and applies the principle of fuzzy relation composition to quantify those factors that boundaries are ambiguous and can not be quantified easily, then evaluates comprehensively according to the class situation the factors are affiliated to the evaluated object. Fuzzy comprehensive evaluation can be divided into single-level one and multi-level one.

Generally, single-level one is used to evaluate the case that there are fewer factors the evaluated object possesses. The evaluation steps is as follows. First, determine the affiliation grade each factor is to every evaluation class, then a fuzzy affiliation matrix is obtained. Second, an affiliation vector that the evaluated object is to the classes can be gotten by the composition operation of the affiliation matrix and the weight vector of each factor. Last, conclusion is obtained using different principles. In this paper, we adopted the module  $M(.,+)$  to calculate. The module not only take into account all factors, but also retain all the information of the single-factor evaluation.

The steps of multi-level evaluation method are as follows. First, the factor set is divided into several sub-factor sets. Second, as for the sub-factor sets, the single-level evaluation method is adopted to obtain some affiliation vectors. Third, combine the vectors to obtain a matrix, then composition operation is performed on it and its immediate higher level

weight vector. The evaluation vector can be obtained until the aforementioned three steps are used to the highest level.

### 3. Example analysis

Select the chlor-alkali industry, 13 companies as samples, which all indicators data of samples come from the stock channel (<http://quote.stock.hexun.com>). Its indicators:  $x_1$ : EPS (yuan),  $x_2$ : ROE(%),  $x_3$ : CFPS (yuan),  $x_4$ : TAY(%),  $x_5$ : MBRGR(%),  $x_6$ : GROTA(%),  $x_7$ : NPG(%),  $x_8$ : NAPS (yuan),  $x_9$ : AFPS (yuan),  $x_{10}$ : UPFPS (yuan).

#### 3.1 Factor analysis to determine the weights

The weight of each index is decided by the questionnaire data so that the influence comes from subjective factors can be overcome to some extent. The weight is a measure of the relative importance of the factors value. Generally speaking, the traditional method to determine weight include experts estimated method, frequency statistics, and analytic hierarchy process. In order to avoid the impact of human factors, we could use factor analysis to determine weight. We would achieve weight set by running factor analysis module in mathematica.

Step1: Because of the difference of original data dimension, first of all, we adopted the standardization, and run the module `standa[data_]`;

Step2: Program the factor analysis module `fac[data_]`, and analysis the profitability factor using the module, then we could get the factor loading matrix as shown in Table 2.

We can see from Table 2 that EPS, ROE, CFPS, TAY return on the load factor for 0.986,0.953 0.093 0.980 separately, that is  $u_1=0.986u_{11}+0.952u_{12}+0.093u_{13}+0.980u_{14}$ . Factor loading matrix means the correlation between variables and factors, so the larger the load, the more closely relationship between variables and factors, that is, the greater its contribution, the greater the weight. Take normalized treatment for (0.986,0.952,0.093,0.980), we could get the 2<sup>nd</sup>-level weight set  $A_1=(0.327,0.316,0.032,0.325)$ . Similarly, the weight set of growth factor has been obtained  $A_2=(0.368,0.522,0.110)$ , and the weight set of expand capacity factor is  $A_3=(0.417,0.507,0.076)$ .

Step3: Running factor analysis module `fac[data_]` on the profit factor, growth factor and expand capacity factor, we got the 1<sup>st</sup>-level weight set  $A$  of comprehensive evaluation, such as Table 3 shown.

#### 3.2 Conduct attribute function

According to the fact, judgement set  $V$  is built up.  $V$  can be expressed as poor, general and better, so the corresponding vector we can be represented with I, II, III. So the stock could be divided into three grades. The higher the index value of stock, the higher the level of stock, and the lower the index value, the lower the level. According to the principles, we would take the maximum value, median value and minimum value, respectively, as the three level classification standard, as shown in Table 4.

Through refer to an abundance of documents, we selected partial large trapezoidal distribution. According to the actual situation, we could conduct three types of attribute functions as follows:

$$I: \begin{cases} 0, & x < b \\ \frac{x-b}{a-b}, & b \leq x < a \\ 1, & x = a \end{cases}; \quad II: \begin{cases} 1, & x = b \\ \frac{x-c}{b-c}, & c \leq x < b \\ 1 - \frac{x-b}{a-b}, & b < x \leq a \end{cases}; \quad III: \begin{cases} 0, & x > b \\ 1 - \frac{x-c}{b-c}, & c < x \leq b \\ 1, & x = c \end{cases}$$

Where a,b,c are the data of Table 4, and  $a \in \max$ ,  $b \in \text{median}$ ,  $c \in \min$ .

So, we could obtain the attribute:  $\mu_I(x)$ ,  $\mu_{II}(x)$ ,  $\mu_{III}(x)$ . Thus, we got fuzzy evaluation matrix of 2nd-level indicators. Table 5 is the fuzzy evaluation matrix of 2nd-level indicators of Jinlu Group. In the paper, we have omitted 2nd-level fuzzy evaluation matrix of all other stocks.

#### 3.3 The 1<sup>st</sup>-level fuzzy comprehensive evaluation

Use the model  $M(\cdot,+)$  to evaluate the investment value of listed companies.

Before evaluating comprehensively, the first thing should be done is to 1<sup>st</sup>-level fuzzy evaluation, which its evaluation set is  $B_i = A_i \circ R_i = (b_1, b_2, b_3)$ . For example, for Jinlu Group, we could obtain:

(1) profitability: from 3.1, we can see the weight  $A_1=(0.327,0.316,0.032,0.325)$ , so the comprehensive evaluation for profitability as follow:

$$B_1 = A_1 \circ R_1 = (0.327,0.316,0.032,0.325) \circ \begin{bmatrix} 0.784 & 0.216 & 0 \\ 0 & 1 & 0 \\ 0.368 & 0.632 & 0 \\ 0.197 & 0.803 & 0 \end{bmatrix} = (0.332,0.668,0)$$

(2) the growth of capability: from 3.1, we known  $A_2=(0.368,0.522,0.110)$ , so the comprehensive evaluation for the growth of capability as follow:

$$B_2 = A_2 \circ R_2 = (0.368,0.522,0.110) \circ \begin{bmatrix} 0.389 & 0.611 & 0 \\ 0.151 & 0.849 & 0 \\ 0.210 & 0.790 & 0 \end{bmatrix} = (0.245,0.775,0)$$

(3) expand capability: from  $A_3=(0.417,0.507,0.076)$ , we got the comprehensive evaluation for the expand capacity as follow:

$$B_3 = A_3 \circ R_3 = (0.417,0.507,0.076) \circ \begin{bmatrix} 0.325 & 0.675 & 0 \\ 0.903 & 0.097 & 0 \\ 0 & 1 & 0 \end{bmatrix} = (0.593,0.407,0)$$

Therefore, the 1<sup>st</sup>-level fuzzy comprehensive evaluation of Jinlu Group could be obtained as Table 6.

The other 12 stocks' 1<sup>st</sup>-level fuzzy comprehensive evaluation sets have the same structures as Table 6, from which we can see clearly the attribute of the stock's 1<sup>st</sup>-level indicators. In this paper, evaluate the investment value of stocks, mainly from the perspective of many different stocks to comprehensive study.

### 3.4 The 2<sup>nd</sup>-level fuzzy comprehensive evaluation

The 2<sup>nd</sup>-level fuzzy comprehensive evaluation matrix is  $R=[B_1, B_2, B_3]^T$ , that is, as shown in Table 6. Then, according to the formula  $B = A \circ R = (b_1, b_2, b_3)$ , we could obtain 2<sup>nd</sup>-level evaluation set, and finally evaluation results.

For example, for Jinlu Group, the comprehensive evaluation of investment value is:

$$B = A \circ R = (0.097,0.456,0.447) \circ \begin{bmatrix} 0.332 & 0.668 & 0 \\ 0.245 & 0.775 & 0 \\ 0.593 & 0.407 & 0 \end{bmatrix} = (0.253,0.747,0)$$

Based on the maximum attribute principle, Jinlu Group shares belong to the second category.

We got all 2<sup>nd</sup>-level fuzzy comprehensive evaluation results in Table 7.

From Table 7, we can see the stock could be divided into three categories:

Category 1:  $I = \{y_{12}, y_{13}\}$ ;

Category 2:  $II = \{y_1, y_3, y_4, y_5, y_7, y_8, y_9, y_{10}, y_{11}\}$ ;

Category 3:  $III = \{y_2, y_6\}$ .

### 3.5 Results analysis

In analysis the various types of samples, using average of indicators:

$$\bar{x}_i = \frac{1}{n} \sum x_{ij}$$

which denote the average of the  $i$  indicator. Where  $i=1,2,3$ , and  $n$  denote the number of sample points.

From Table 8, we can see:

The first category clearly belongs to the low-growth, low-expansion, low performance shares. In particular, the MBRGR, GROTA, NPGR, and NAPS are relatively low, especially ROE is very low, which compared with other types have significant differences. This shows that the companies almost have no growth. Negative UPFPS shows that the category almost has no power source of sustainable development, so the category has limited investment value.

The second category stock is good return, higher growth, and better expand capacity stock. Higher NAPS and AFPS indicate better expansion capability, and useful space for development. This type of companies has good business performance, sustainable development capability, so it could be invested.

The third type stock belongs to high-yield, high-growth stocks. However, the lower NAPS and the lower AFPS indicate that its expansion capability is relatively low, and the market is relatively saturated, which means the market has entered a mature stage.

### 3.6 Select potential stocks ways

In addition, we can make ranks for the investment value of each category. There are two ways to select potential stocks:

(1) the largest attribute principle

According to the principle, the potential of the stock is the largest component of the comprehensive evaluation vector  $B$ .

(2) mathematical expectation

It could be established the expectation  $E(x)$  of stock through set up a value  $p_j$  for each component of comprehensive evaluation vector  $B$ . In this paper,  $V$  can be expressed as better, general, poor, so the corresponding  $p_1, p_2, p_3$  value we can be represented with 0.7, 0.4, 0.1. Using the formula  $E(x) = \sum P_j b_j$ , we could get the expectation of stock. The value range between 0~1, and the greater the expectation, the greater the investment value.

Generally speaking, the first method is available to judge the investment potential of a particular stock: better, general, poor. When there are a number of shares, the second method is used to calculate expectations of these stocks, that is the investment value, which may choose the greatest investment value stock.

Select the second category shares to analysis.

From Table 7, we can see that all attribute of stocks, such as Jinlu Group  $B=(0.253, 0.747, 0)$ . Adopted expectation method, we get the stock expectation:  $P=0.7 \times 0.253 + 0.4 \times 0.747 + 0.1 \times 0 = 0.476$ .

Similarly, we could obtain expectations of all other stocks, as shown in Table 9.

From Table 9, we can see that in the second category stock, the highest fuzzy comprehensive evaluation expectation is sanyou chemical, which has profitability and good growth, and its equity has the expansion space. Its profitability, growth capacity and expand capacity, compared with last year reached 97.64(industry average of 41.41), 95.91(industry average of 40.63), 71.45(industry average of 41.41), which fully illustrate this point.

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Table 1. Original data

Stocks name	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	$x_6$	$x_7$	$x_8$	$x_9$	$x_{10}$
Jinlu Group	0.13	6.78	0.22	2.94	-13.23	13.59	0.69	1.95	0.12	0.68
Yinglite	0.71	26.38	2.29	2.61	38.48	211.06	17.05	2.68	0.23	1.26
Shangdong Haihua	0.42	9.18	0.50	4.05	2.60	15.81	4.07	4.33	1.62	1.38
Daqing Huake	0.14	4.01	0.31	3.48	15.95	46.06	4.24	3.50	1.91	0.34
Sino-Thai Chemical	0.93	9.27	1.67	5.23	45.23	71.02	99.85	8.77	5.54	1.84
National shares	0.51	21.25	-0.14	6.18	113.96	116.63	37.26	2.38	0.02	1.17
Haideli	0.89	25.18	0.83	9.97	20.56	67.19	30.46	3.51	0.53	1.62
Taihua share	0.13	4.87	0.51	1.89	64.55	40.44	9.81	2.66	1.05	0.50
Yaxing Chemical	0.06	1.88	0.43	0.74	11.73	-38.77	11.67	3.39	2.11	0.11
Tianli Gaoxin	0.09	2.60	0.39	0.96	15.21	109.54	23.74	3.06	1.73	0.18
Sanyou Chemical	0.55	20.12	0.52	7.50	47.47	110.12	8.55	2.95	0.69	1.06
Chlor-Alkali Chemical	0.05	1.92	0.32	0.83	35.08	-128.91	-2.76	2.51	1.52	-0.02
ST Chemical	2.68	-2026.45	-0.08	40.85	-66.39	-169.46	-33.66	-0.13	0.69	-2.01

Table 2. Profit factor loading matrix

	EPS	ROE	CFPS	TAY
load	0.986	0.952	0.093	0.980

Table 3. The weight set of evaluation index

$a_1$				$a_2$			$a_3$		
0.097				0.456			0.447		
$a_{11}$	$a_{12}$	$a_{13}$	$a_{14}$	$a_{21}$	$a_{22}$	$a_{23}$	$a_{31}$	$a_{32}$	$a_{33}$
0.327	0.316	0.032	0.325	0.368	0.522	0.110	0.417	0.507	0.076

Table 4. Classification standard of stock

	grade indicator	I (max)	II (median)	III (min)
		profitability	EPS	2.68
ROE	26.38		6.78	-2026.45
CFPS	2.29		0.43	-0.14
TAY	40.85		3.48	0.74
growth indicator	MBRGR	113.96	20.56	-66.39
	GROTA	211.06	46.06	-169.46
	NPG	99.85	9.81	-33.66
Expand capacity of equity capital	NAPS	8.77	2.95	-0.13
	AFPS	5.54	1.05	0.02
	UPFPS	1.84	0.68	-2.01

Table 5. Jinlu Group's fuzzy evaluation matrix of 2nd-level indicators

	attribute indicators	$\mu_I(x)$	$\mu_{II}(x)$	$\mu_{III}(x)$
		profitability	EPS	0.784
ROE	0		1	0
CFPS	0.368		0.632	0
TAY	0.197		0.803	0
growth indicator	MBRGR	0.389	0.611	0
	GROTA	0.151	0.849	0
	NPG	0.210	0.790	0
Expand capacity of equity capital	NAPS	0.325	0.675	0
	AFPS	0.903	0.097	0
	UPFPS	0	1	0

Table 6. Jinlu Group's 1st-level fuzzy comprehensive evaluation

	$\mu_I(x)$	$\mu_{II}(x)$	$\mu_{III}(x)$
profitability $B_1$	0.332	0.668	0
growth of capability $B_2$	0.245	0.775	0
expand capability $B_3$	0.593	0.407	0

Table 7. 2<sup>nd</sup>-level fuzzy comprehensive evaluation set

variable	Stocks name	Attribute structure			results
		Attribute for I	Attribute for II	Attribute for III	
$y_1$	Jinlu Group	0.253	0.747	0	II
$y_2$	Yinglite	0.010	0.409	0.581	III
$y_3$	Shangdong Haihua	0.147	0.848	0.004	II
$y_4$	Daqing Huake	0.055	0.945	0	II
$y_5$	Sino-Thai Chemical	0	0.727	0.273	II
$y_6$	National shares	0.003	0.407	0.590	III
$y_7$	Haideli	0	0.875	0.125	II
$y_8$	Taihua share	0.055	0.788	0.157	II
$y_9$	Yaxing Chemical	0.282	0.716	0.002	II
$y_{10}$	Tianli Gaoxin	0.078	0.725	0.197	II
$y_{11}$	Sanyou Chemical	0.003	0.692	0.305	II
$y_{12}$	Chlor-Alkali Chemical	0.4743	0.4741	0.0516	I
$y_{13}$	ST Chemical	0.936	0.0003	0.063	I

Table 8. The average of sample indicators

class	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	$x_6$	$x_7$	$x_8$	$x_9$	$x_{10}$
I	1.365	-1012.27	0.12	20.84	-15.655	-149.185	-18.21	1.19	1.105	-1.015
II	0.371	9.321	0.578	4.084	23.341	48.333	21.453	3.791	1.7	0.857
III	0.61	23.815	1.075	4.395	76.22	163.845	27.155	2.53	0.125	1.215

Table 9. investment value of listed companies in alkali industry

Stocks name	Sanyou Chemical	Sino-Thai Chemical	Haideli	Tianli Gaoxin	Taihua share	Daqing Huake	Shangdong Haihua	Jinlu Group	Yaxing Chemical
expectation	0.491	0.482	0.437	0.436	0.430	0.383	0.357	0.324	0.316
sort	1	2	3	4	5	6	7	8	9