Modern Economy, **2013, 4, 66-72**
http://dx.doi.org/10.4236/me.2013.41008 Published Online January 2013 (http://www.scirp.org/journal/me)

On Enterprise Social Responsibility Comprehensive Evaluation Based on Two-Step Fuzzy Evaluation Method

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Received November 17, 2012; revised December 18, 2012; accepted January 12, 2013

ABSTRACT

In order to evaluate the enterprise social responsibility scientifically, this paper constructed an enterprise social responsibility evaluation indexes system composed by five first class indexes (environmental protection, resources utilization, economic benefit, human resources and social contribution and so on) and 18 second indexes. The two-step fuzzy evaluation method was adopted to evaluate comprehensive effect and Wuhan Iron and Steel (Group) Corporation (WISCO) was given for example.

Keywords: Two-Oriented Society; Enterprise Social Responsibility; Two-Step Fuzzy Evaluation Method

1. Introduction

The "Two-oriented society" construction plan was put forward by the National Development and Reform Commission in December of 2007, and "Wuhan city circle" and "Changsha-Zhuzhou-Xiangtan city cluster" were conducted as the reform testing districts. It is of great significance to propel the sustainable development of city cluster as well as the solution of problem accompanying urbanization in the areas of resource and energy, ecological environment, and economic development model.

The "Two-oriented society" construction demands that the enterprise should utilize the limited resources reasonably, efficiently and circularly, at the same time corresponding environmental protection measures should be made to reduce the discharge of wastes pollution, to minimize the damage to the environment and to achieve harmonious coexistence of natural environment and economical society. The essence is that the enterprise should undertake social responsibilities more actively [1]. So, it is significance to scientifically evaluate the social responsibility fulfillment of enterprise.

Nowadays, the social responsibility standards have a broad impact on the society, which include of SA8000 social responsibility standard, the Dow Jones Sustainability Indexes (DJSI), G3 international sustainable development report guide and so on [2]. In our country, the famous ones are the social responsibility standard system of Chinese enterprise (HM3000), the top 100 enterprises social responsibility development indexes issued by the academy Chinese Academy of Social Sciences and the golden bee enterprise social responsibility list [3]. However, all these evaluation systems do not set meticulous regulations to environment and resources responsibility, and the enterprise' qualitative evaluation basis can only be obtained from its incomplete information disclosure, which will induce the fulfillment of enterprise social responsibility can't be measured effectively. This paper mainly focuses on constructing the enterprise social responsibility evaluation indexes system based on "Two-oriented society" by analyzing of the stakeholder theory, HM3000 and SA8000. The two-step fuzzy evaluation method is adopted to evaluate the fulfillment of enterprise social responsibility.

2. The Construction of the Enterprise Social Responsibility Evaluation Indexes System Based on "Two-Oriented Society"

In order to synthetically, comprehensively evaluate the fulfillment of enterprise social responsibility based on "Two-oriented society", resources and environment social responsibility are linked up with economic and social one of enterprise, in accordance with the scientific principle, systematic one, close to "Two-oriented society" one, quantitative one, independence one and comparable one. It will construct the enterprise social responsibility indexes system at two levels. According to the suggestions of eight university professors, six enterprise executives and six experts of government environmental protection department, combined with enterprise business characteristics, the first class indexes include five aspects, such as environmental protection, resources utilization, economic benefit, human resources and social contribu-

tion. And the second class indexes consist of 18 ones, such as harmful gas emissions per ten thousand yuan RMB operating income (see **Table 1**).

3. Two-Step Fuzzy Evaluation Method of Enterprise Social Responsibility

This paper will use the modified analytic hierarchy process (MAHP) to calculate the index weight after the enterprise social responsibility evaluation indexes system has been established. Then, the composite score of enterprise social responsibility was calculated using two-step fuzzy evaluation method.

3.1. Calculating Index Weight Based on the Modified Analytic Hierarchy Process

After enterprise social responsibility evaluation indexes system was determined, it needs to calculate the weight of each index. There are many methods to ascertain the weight, of which analytic hierarchy process is an important one. Analytic hierarchy process is an evaluating method combined qualitative with quantitative analysis, which was put forward in the 1970's by A. L. Saaty [4]. This method decomposes the complex problem into several levels and several factors. Then, it will compare and calculate the factors simply to draw their weights and get the evaluation result. But this method has the defect in texting non consistency judgment matrix, for it needs artificial estimate adjustment and carrying on the multiple times if necessary.

In order to overcome this problem, a modified method of analytical hierarchy process is adopted. Its main characteristics are to introduce the quasi-optimal matrix, which can meet the consistency naturally and doesn't

Table 1. Enterprise social responsibility evaluation indexes system.

First class indexes	Second class indexes	Meaning
Environmental protection B_1	Harmful gas emissions per ten thousand yuan RMB operating income B_{11}	Harmful gas emissions per year/Operating income per year (ten thousand yuan RMB)
	COD emissions per ten thousand yuan operating income B_{12}	COD emissions per year/Operating income per year (ten thousand yuan RMB)
	Solid waste emissions per ten thousand yuan RMB operating income B_{13}	Solid waste emissions/Ten thousand yuan RMB operating income
	Wastewater emissions per ten thousand yuan RMB operating income B_{14}	Wastewater emissions per year/Operating income per year (ten thousand yuan RMB)
	Total expenditure accounts for the proportion of profits per year B_{15}	Environmental protection aggregate expenditure per year/Operating profit per year (ten thousand yuan RMB)
Resource utilization B_2	Comprehensive energy consumption per ten thousand yuan RMB operating income B_{21}	Comprehensive energy consumption (including coal, oil, electricity etc.)/Operating income per year (ten thousand yuan RMB)
	New water consumption per ten thousand yuan RMB operating income B_{22}	New water consumption per year/Operating income per year (ten thousand yuan RMB)
	Mineral resources consumption per ten thousand yuan RMB operating income B_{23}	Mineral resources per year/Operating income per year (ten thousand yuan RMB)
	Recycle rate of industrial solid waste B_{24}	(Recycle rate of industrial solid waste per year/total emissions of industrial three wastes per year) × 100%
	Recycle rate of industrial wastewater B_{25}	(Recycle rate of industrial wastewater per year/Total waste per year) × 100%
Economic benefit B_3	Return on equity B_{31}	After-tax profits per year/net asset
	Sales increasing ratio B_{32}	[(Current operating income − operating income last year)/ Operating income last year] × 100%
	Capital value-retaining and value-increasing rate B_{33}	(Final total owners' equity/Initial total owners' equity) × 100%t
Human resources B_4	Annual staff and workers' training fees accounted for the proportion of profit after tax B_{41}	Annual staff and workers' training fees/Annual profit after tax
	Annual increasing rate of average wages and welfare of staff B_{42}	[(Current wages and welfare of staff and workers − wages and welfare of staff last year)/Total of wages and welfare of staff last year] × 100%
	Worker safety accident rate B_{43}	(The number of industrial injury workers/Average number of listed workers) × 1000
Social contribution B_5	Contribution rate to society B_{51}	[(Expenses of average wages and welfare of staff + interest expenses of net amount + various taxes + net profit)/Average total assets] × 100%
	Donation rate to society B_{52}	Annual external donation/Annual profit after tax

need consistent test [5,6]. The process of the modified analytic hierarchy process is as follows:

Firstly, it will construct judgment matrix, the method is the same of the one of analytic hierarchy process. Let the judgment matrix be *A*, then, *A* can be represented as in (1).

$$A=\left(a_{ij}\right)_{\times n}, a_{ij}=1/a_{ji}, a_{ii}=1, i\neq j, i, j=1,2,\cdots,n \quad (1)$$

Secondly, it will calculate the anti-symmetric matrix of judgment matrix *A*, and let it be *L*, it can be obtained by (2).

$$L=\left(l_{ij}\right)_{\times n}, l_{ij=}\ln\left(a_{ij}\right), i\neq j, i, j=1,2,\cdots,n \quad (2)$$

Thirdly, it will construct quasi-optimal matrix of this judgment matrix *A*, let it be *M*, it can be shown as in (3).

$$\begin{aligned} M&=\left(m_{ij}\right)_{n\times n}=\mathrm{e}^{f_{ij}},\\ f_{ij}&=\sum_{k=1}^{n}\left(l_{ik}-l_{jk}\right)/n, i, j=1,2,\cdots,n \end{aligned} \quad (3)$$

The end, it will calculate eigenvector of *M* by square root method. Let the eigenvector be *W*. And the component of *W* (let to be W_i) is the weight of corresponding index, it can be gotten by (4).

$$W_i=\frac{\sqrt[n]{M_i}}{\sum_{i=1}^{n}M_i}\left(i=1,2,\cdots,n\right) \quad (4)$$

3.2. Two-Step Fuzzy Evaluation Method

Fuzzy evaluation method is a decision-making one for some objective under fuzzy environment, which considers the influence of many factors and can solve the problem of indexes system better. It can reduce the influence of the artificial factor to the smallest extent, and has the advantage over reflecting the nature of problem. The enterprise social responsibility evaluation indexes system is divided into three levels in this paper based on "Two-oriented society", so, two-step fuzzy evaluation method was adopted.

3.2.1. Elements

1) Factors set

The factor set of enterprise social responsibility evaluation indexes system consists of the first class indexes set and the second class indexes set, as are showed in **Table 1**. The first class indexes set is $B = (B_1, B_2, B_3, B_4, B_5)$, and B_1, B_2, B_3, B_4, B_5 represent five first class indexes in the **Table 1**. $B_i = (B_{i1}, B_{i2},\cdots, B_{im})$, $i = 1, 2,\cdots, 5$. $B_{i1}, B_{i2},\cdots, B_{im}$ are the second indexes corresponding with the first class index B_i, which can also be seen in **Table 1**.

2) Weight set

The weight set of enterprise social responsibility evaluation indexes system includes the first class indexes weight set (let be W_B) and the second class indexes weight set (let be $W_i = (i = 1, 2,\cdots, 5)$). Let $W_B = (w_{B1}, w_{B2}, \cdots, w_{B5})$, $W_i = (w_{i1}, w_{i2},\cdots, w_{im})$. W_B and W_i are both determined by modified analytic hierarchy process.

3) Comment set

Let $V=\left(V_1,V_2,\cdots,V_5\right)$ to be a comment set, which stands by five grades, such as excellent, good, medium, poor and very poor.

3.2.2. Fuzzy Relation from Membership Matrix to Comment Set

Membership matrix *R* is constructed to determine the fuzzy relation from *B* to *V*. $R=\left(R_1,R_2,\cdots,R_5\right)^{\mathrm{T}}$, and R_i is shown as in (5).

$$R_i=\begin{bmatrix} r_{i11} & r_{i12} & r_{i13} & r_{i14} & r_{i15}\\ r_{i21} & r_{i22} & r_{i23} & r_{i24} & r_{i25}\\ \cdots & \cdots & \cdots & \cdots & \cdots\\ r_{im1} & r_{im2} & r_{im3} & r_{im4} & r_{im5} \end{bmatrix} \quad (5)$$

In the equation, $R_i\left(i=1,2,\cdots,5\right)$ is the membership matrix of the ith first class index, and *m* is its index number, while $r_{ilj}\left(i=1,2,\cdots,5; j=1,2,\cdots,5\right)$ represent the membership degree of grade $j\left(j=1,2,\cdots,5\right)$ corresponding its lth second index. The value of r_{imj} is divided into positive index (the bigger, the better) and reverse index (the smaller, the better) according to its property. They are calculated as follows:

1) The calculation of membership degree of positive index

Positive indexes are ranked in the order from big to small, the bigger the index value, the better the membership, which indicates the enterprise complete well. The calculation of membership degree of positive index is as follows:

Firstly, if the actual value of the lth second index X_{il} is greater than its corresponding "excellent" grade standard value, then the membership to "excellent" is 1, and the ones to the other four is 0. That is, if $X_{il}>V_{il}$, then $r_{il1}=1, r_{il2}=r_{il3}=r_{il4}=r_{il5}=0$

Secondly, if the actual value of the lth second index X_{il} is between the jth grade and the $(j+1)th$ one, that is, $V_{il(j+1)}\le X_{il}\le V_{ilj}$, then the membership to $(j+1)th$ grade is shown as in (6).

$$r_{il(j+1)}=\frac{V_{ilj}-X_{il}}{V_{ilj}-V_{il(j+1)}}, j=0,1,2,3,4 \quad (6)$$

The membership to the jth grade is shown as in (7).

$$r_{imj}=1-r_{im(j+1)}, j=0,1,2,3,4 \quad (7)$$

The membership to other three grades is 0.

Thirdly, if the actual value of the *lth* second index X_{il} is less than its corresponding "very poor" grade standard value, then the membership to "very poor" for is 1, and the ones to others are 0. That is, when $X_{il} < V_{il}$,

$$r_{il5} = 1; r_{il1} = r_{il2} = r_{il3} = r_{il4} = 0$$

2) The calculation of membership degree of reverse index

Reverse indexes are ranked in the order from small to big, the smaller the index value, the better the membership. The calculation of membership degree of reverse index is similar to positive ones.

3.3. Hierarchical Fuzzy Evaluation Method

The enterprise social responsibility indexes evaluation system based on "Two-oriented society" is divided into three layers, such as the target layer, the first class index layer and the second class one. So, it can be evaluated by two-step fuzzy evaluating method. The first step is the evaluation of second class index layer to the first class one, and the second step is the first class index layer to the target layer.

The fuzzy evaluation matrix of second class index layer to the first class one is

$$C = \{C_1, C_2, \cdots, C_5\}^{\mathrm{T}}$$

$C_i\ (i = 1, 2, \cdots, 5)$ is shown as in (8).

$$C_i = W_i \circ R_i = (C_{i1}, C_{i2}, \cdots, C_{im}) \tag{8}$$

The fuzzy evaluation of the first class index layer to the target layer is *S*, *S* can be obtained by (9).

$$S = W_B \circ C = (S_1, S_2, S_3, S_4, S_5) \tag{9}$$

In (2.9), $S_j, j = 1, 2, \cdots, 5$ is the comprehensive performance of the membership degree to the *jth* grade. If

$$\sum_{j=1}^{5} S_j \neq 1$$

normalization process will be necessary. Let the new matrix after normalization process is $P = (P_1, P_2, P_3, P_4, P_5)$. P_i (i = 1, 2, 3, 4, 5) is shown as in (10).

$$P_i = S_i \Big/ \sum_{i=1}^{5} S_i \tag{10}$$

According to the maximum membership degree principle, $\max_{1 \le j \le 5} \{P_j\}$ is chosen to refer as evaluation result of the *ith* first class index.

4. Case Study

In order to expound how to use the two-steps fuzzy synthesize evaluation method to estimate the enterprise social responsibility, an example is given. It will take Wuhan Iron and Steel (Group) Corp. (WISCO) for example.

4.1. Data Source

The data mainly come from the social responsibility report in 2008 and the annual report in 2007 of WISCO. The secondary indexes were calculated as **Table 2**.

4.2. The Evaluation Standard Value

The evaluation standard value for each second index is shown in **Table 3** according to the published standards and the actual situation.

4.3. The Weights of Indexes System

By virtue of survey results of eight university professors, six enterprise executives and six experts of government environmental protection department, the judgment matrix of the first class indexes and the second class ones are shown as (11)-(16). *A* is the judgment matrix of the first class index *B*, $B = (B_1, B_2, B_3, B_4, B_5)$, and A_i (i = 1, 2,···, 5) is the judgment matrix of B_i, B_i = (B_{i1}, B_{i2},···, B_{im}).

$$A = \begin{bmatrix} 1 & 3 & 1 & 2 & 5 \\ 1/3 & 1 & 1 & 2 & 6 \\ 1 & 1 & 1 & 2 & 4 \\ 1/2 & 1/2 & 1/2 & 1 & 1 \\ 1/5 & 1/6 & 1/4 & 1 & 1 \end{bmatrix} \tag{11}$$

$$A_1 = \begin{bmatrix} 1 & 3 & 3 & 3 & 2 \\ 1/3 & 1 & 3 & 1/2 & 3 \\ 1/3 & 1/3 & 1 & 1/2 & 1 \\ 1/3 & 2 & 2 & 1 & 1 \\ 1/2 & 1/3 & 1 & 1 & 1 \end{bmatrix} \tag{12}$$

$$A_2 = \begin{bmatrix} 1 & 3 & 1/2 & 3 & 3 \\ 1/3 & 1 & 1/3 & 1/2 & 2 \\ 2 & 3 & 1 & 3 & 3 \\ 1/3 & 2 & 1/3 & 1 & 3 \\ 1/3 & 1/2 & 1/3 & 1/3 & 1 \end{bmatrix} \tag{13}$$

$$A_3 = \begin{bmatrix} 1 & 4 & 1/3 \\ 1/4 & 1 & 1/6 \\ 3 & 6 & 1 \end{bmatrix} \tag{14}$$

$$A_4 = \begin{bmatrix} 1 & 3 & 1/2 \\ 1/3 & 1 & 1/5 \\ 2 & 5 & 1 \end{bmatrix} \tag{15}$$

$$A_5 = \begin{bmatrix} 1 & 1/3 \\ 3 & 1 \end{bmatrix} \tag{16}$$

Table 2. The actual value of social responsibility indexes of WISCO.

Second class indexes code	Actual value code	Unit	Actual value
B_{11}	X_{11}	Kilogram/ten thousand yuan RMB	2.3573
B_{12}	X_{12}	Kilogram/ten thousand yuan RMB	0.1164
B_{13}	X_{13}	ton/ten thousand yuan RMB	0.7304
B_{14}	X_{14}	ton/ten thousand yuan RMB	2.3275
B_{15}	X_{15}	%	5.3
B_{21}	X_{21}	%	10.08
B_{22}	X_{22}	ton/ten thousand yuan RMB	7.5792
B_{23}	X_{23}	ton/ten thousand yuan RMB	1.61
B_{24}	X_{24}	%	22.67
B_{25}	X_{25}	%	97
B_{31}	X_{31}	%	14.37
B_{32}	X_{32}	%	17.97
B_{33}	X_{33}	%	8.88
B_{41}	X_{41}	class	102
B_{42}	X_{42}	%	20.2
B_{43}	X_{43}	%	0.5
B_{51}	X_{51}	%	19.86
B_{52}	X_{52}	%	0.47

Table 3. The evaluation standard value of second indexes.

Second class indexes code	Unit and standard value code	Evaluation level				
		Excellence	Good	Medium	Poor	Very poor
B_{11}	Kilogram/ten thousand yuan RMB, V_{11}	<2.0	2.0 - 2.5	2.5 - 3	3 - 3.5	>3.5
B_{12}	Kilogram/ten thousand yuan RMB, V_{12}	<0.1	0.1 - 0.2	0.2 - 0.3	0.3 - 0.4	>0.4
B_{13}	ton/ten thousand yuan RMB, V_{13}	<0.3	0.3 - 0.5	0.5 - 0.7	0.7 - 0.9	>0.9
B_{14}	ton/ten thousand yuan RMB, V_{14}	<0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2	>2.0
B_{15}	%, V_{15}	>5	4 - 5	3 - 4	2 - 3	<2.0
B_{21}	%, V_{21}	>10	8 - 10	6 - 8	4 - 6	<4.0
B_{22}	ton/ten thousand yuan RMB, V_{22}	<5	5 - 7	7 - 9	9 - 11	>11
B_{23}	ton/ten thousand yuan RMB, V_{23}	<0.5	0.5 - 1.0	1.0 - 1.5	1.5 - 2.0	>2.0
B_{24}	%, V_{24}	>20	15 - 20	10 - 15	5 - 10	<5.0
B_{25}	%, V_{25}	>80	60 - 80	40 - 60	20 - 40	<20
B_{31}	%, V_{31}	>30	20 - 30	10 - 20	5 - 10	<5.0
B_{32}	%, V_{32}	>20	15 - 20	10 - 15	5 - 10	<5.0
B_{33}	%, V_{33}	>20	15 - 20	10 - 15	5 - 10	<5.0
B_{41}	Class, V_{41}	>50	40 - 50	30 - 40	20 - 30	<20
B_{42}	%, V_{42}	>20	15 - 20	10 - 15	5 - 10	<5.0
B_{43}	%, V_{43}	<0.3	0.3 - 0.4	0.4 - 0.5	0.5 - 0.6	>0.6
B_{51}	%, V_{51}	>20	15 - 20	10 - 15	5 - 10	<5.0
B_{52}	%, V_{52}	3	2 - 3	1 - 2	0.5 - 1	>0.5

The weight sets of he first class indexes and the second class ones are obtained by modified analytic hierarchy process, which are shown as in (17) and (18).

$$\begin{aligned} W_B &= \left(W_{B_1} \quad W_{B_2} \quad W_{B_3} \quad W_{B_4} \quad W_{B_5}\right) \\ &= \left(0.3373 \quad 0.2254 \quad 0.2590 \quad 0.1127 \quad 0.0656\right) \\ W_1 &= \left(W_{11} \quad W_{12} \quad W_{13} \quad W_{14} \quad W_{15}\right) \\ &= \left(0.3949 \quad 0.1929 \quad 0.0996 \quad 0.1884 \quad 0.1243\right) \end{aligned} \tag{17}$$

$$\begin{aligned} W_2 &= \left(W_{21} \quad W_{22} \quad W_{23} \quad W_{24} \quad W_{25}\right) \\ &= \left(0.2843 \quad 0.1088 \quad 0.3751 \quad 0.1558 \quad 0.0761\right) \\ W_3 &= \left(W_{31} \quad W_{32} \quad W_{33}\right) = \left(0.2706 \quad 0.0852 \quad 0.6442\right) \\ W_4 &= \left(W_{41} \quad W_{42} \quad W_{43}\right) = \left(0.3090 \quad 0.1095 \quad 0.5816\right) \\ W_5 &= \left(W_{51} \quad W_{52}\right) = \left(0.2500 \quad 0.7500\right) \end{aligned} \tag{18}$$

4.4. The Results

Membership degrees to the second class indexes are calculated as shown in **Table 4**. And the evaluation result of first class indexes is shown in **Table 5**, according to the two-step fuzzy evaluation method.

1) The fulfillment of the second class indexes of WISCO

From **Table 4**, what can be seen that the fulfillment of the second class indexes of WISCO in 2008 was well. "Total expenditure accounts for the proportion of profits per year", "Comprehensive energy consumption per ten thousand yuan RMB operating income", "Recycle rate of industrial wastewater" and "Annual staff and workers' training classes" are "excellence". "COD emissions per ten thousand yuan RMB operating income" and "Recycle rate of industrial solid waste" are also very well. The fulfillment of "Wastewater emissions per ten thousand yuan RMB operating income", "Capital value-retaining and value-increasing rate" and "Donation rate to society" are not good enough.

2) The fulfillment of the first class indexes

It can be seen from **Table 5** that the fulfillment of "En-

Table 4 The membership degree of the second class indexes.

The second class indexes code	Fuzzy evaluation matrix code	Membership degree				
		Excellence	Good	Medium	Poor	Very poor
B_{11}	C_{11}	0.29	0.71	0	0	0
B_{12}	C_{12}	0.8	0.2	0	0	0
B_{13}	C_{13}	0	0	0.85	0.15	0
B_{14}	C_{14}	0	0	0	0.34	0.66
B_{15}	C_{15}	1	0	0	0	0
B_{21}	C_{21}	1	0	0	0	0
B_{22}	C_{22}	0	0.71	0.29	0	0
B_{23}	C_{23}	0	0	0.78	0.22	0
B_{24}	C_{24}	0.53	0.47	0	0	0
B_{25}	C_{25}	1	0	0	0	0
B_{31}	C_{31}	0	0	0.87	0.13	0
B_{32}	C_{32}	0	0.59	0.41	0	0
B_{33}	C_{33}	0	0	0	0.78	0.22
B_{41}	C_{41}	1	0	0	0	0
B_{42}	C_{42}	0.04	0.96	0	0	0
B_{43}	C_{43}	0	0	1	0	0
B_{51}	C_{51}	0	0.97	0.03	0	0
B_{52}	C_{52}	0	0	0	0.06	0.94

Table 5. The evaluation result of the first class indexes.

The first class indexes	Environmental protection	Resources utilization	Economic benefit	Human resource	Social contribution
Comprehensive score	0.1478	0.1665	0.2021	0.2186	0.2650
Result	Excellence	Excellence	Poor	Medium	Very poor

vironmental protection" and "Resources utilization" are excellence, "Economic benefit" is poor, "Human resource" is medium and "Social contribution" is very poor for WISCO in 2008, according to the maximum membership degree principle.

In a word, this paper constructed a set of enterprise social responsibility evaluation indexes system based on "Two-oriented society", which included of environmental protection, resources utilization, economic benefit, human resources and social contribution. And more second indexes were designed to reflect the characteristics of environmental protection and resources utilization, which can prominent the theme of "Two-oriented society". In the part of case analysis, WISCO was taken for example, and two-step fuzzy evaluation method was used to evaluate the social responsibility performance of in 2008.

5. Acknowledgements

This research is supported by NSSF of China (Grant No. 09BJY015).

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