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Triple-bottom-line performance evaluation on China's iron and steel enterprises under the background of low carbon economy

Dajun Ye

Department of Civil Engineering, Sichuan College of Architectural Technology, No.4, West Jialingjiang Road, Deyang, China

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ABSTRACT

On the basis of triple-bottom-line performance evaluation, the system of indicator and the model of evaluating are established in this paper on the performance of Iron and Steel Enterprises. With the sample of 10 listed data between 2009 and 2011 of China's Iron and Steel Enterprises, this paper also conducts an empirical study on tripe performance evaluation and sets out each one's overall performance to carry out a synthetic evaluation on China's Iron and Steel Enterprises under low carbon economy.

Key words: Low Carbon; Iron and Steel Enterprises of China; Triple-Bottom-Line Performance; Empirical Research

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INTRODUCTION

Performance evaluation of an enterprise remains a complex system which conducts comprehensive evaluation of enterprise's overall business and operational efficiency. It concerns not only an enterprise's current situation but also future development, which means that scientific evaluation is of great significance for enterprises' survival and development. Ed Freeman et al.(1984) proposed stakeholder theory, whose core idea is that an enterprise is a combination of mutual contact with stakeholders (including shareholders, employees, customers, suppliers, creditors, governments and communities) accordingly the enterprise performance evaluation should analyze the interest satisfaction between all stakeholders; "triple bottom line" (TBL) theory that indicates companies in pursuit of their own development process, should achieve economic, social and environmental " triple bottom line " basic requirements[1]; " triple-bottom-line performance " theory that the enterprise performance is divided into economic, environmental and social performance, and the evaluation is based on the former responsibilities, covering all aspects of the enterprise operating, is a comprehensive enterprise performance evaluation of scientific method[2].Triple-bottom-line performance accounting provides the frameworkand tool for considering economic, environmental,and social implications of decisions,products,operations, or future plans and is thereforehelpful in improving the fundamental functionsof organizations and lasting stability [3]. The triplebottomline concept suggeststhatfirmsnotonlyneedto engage in socially and environmentally responsible behavior,butalso, that positive financial gains can be made in the process[4]. Iron and Steel Enterprises are not only a big unit of GDP, but also a major pollutant emission. In the context of the development of low carbon economy, those enterprises must achieve the goals of economic development, ecological survival, and social welfare [5]. As a result, the evaluation on performance of the enterprises cannot simply consider economic factors, but on basis of ecological, economic, social, triple-bottom-line performance.

The advantages of triple-bottom-line performance evaluation method for Iron and Steel Enterprises are: (1) avorable for making the real evaluation on the enterprise operation to identify problems. (2) Favorable for reinforcing Ecological awareness in the enterprise and their employees to achieve green GDP growth. (3) Favorable for consciously practicing economic, social and environmental responsibilities, and enhancing marketing competitiveness and social influence of Iron and Steel Enterprises.Meanwhile because of large number of selected

factors and of hard-determined indicators' quantification, the triple-bottom-line performance evaluation can only be used for large mature enterprises.

INDICATION SYSTEM OF TRIPLE-BOTTOM-LINE PERFORMANCE EVALUATION ON IRON AND STEEL ENTERPRISES

In order to comprehensively, objectively and impartially evaluate the performance of Iron and Steel Enterprises, based on the principles of scientific, practical and comparable, this article separately construct indicators of economic performance, ecological performance and social performance considering reports on finance, social responsibility, sustainable development and other content of Iron and Steel Enterprises[6][7], and the selected indicators are quantitative.

1. Indicator system of economic performance

Table.1Indicators of economic performance evaluation

Level 1	Level 2	Level 3	Equation or description
Economic performance A1	Profit ability B1	Rate of sales profit C1	=Total profit/ Revenue*100%
		The weighted average return on net assets C2	=Net profit attributable to ordinary shares/Average balance of net assets*100%
		Return on assets C3	=(Total profits+Interest expense)/Average total assets*100%
		Basic earnings per share C4	=(After tax profits-Preferred stock dividend)/The average share of the outstanding stock*100%
	Solvency ability B2	Debt to total assets ratio C5	=Total liabilities/Total assets*100%
		Multiples of interest earned C6	=(Net profit+Interestexpenses+Income Tax Expense)/Interest expenses*100%
		The quick ratio C7	=Quick assets/Current liabilities*100%
		Cash flow and debt ratio C8	=Year of net operating cash flow/Current liabilities at the end of the year*100%
	Development ability B3	The growth rate of sales revenue C9	=（The annual revenue-The previous year revenue）/The previous year revenue*100%
		The increasing rate of assets C10	=（Total assets at the end of the year-Total assets at the beginning of the year）/Total assets at the beginning of the year *100%
		Technology investment ratio C11	=Total spending on technology this year/The annual revenue*100%
		Capital increment rate C12	=The owner's equity at the end of the year/The owner's equity at the beginning of this year*100%
	Operating ability B4	Assets turnover ratio C13	=Revenue /Average total assets*100%
		Current assets turnover ratio C14	=Revenue /The average total current assets*100%
		Receivables turnover ratio C15	=Revenue /Average total receivables*100%
		Cash recovery of assets C16	=Net operating cash flow/The average total current assets*100%

2. Indicator system of ecological performance

Table.2 Indicators of ecological performance evaluation

Level 1	Level 2	Level 3	Equation or description
Ecological performance A2	Environmental impactand control B5	$C0_2$ emissions of steel, per ton C17	= $C0_2$ emissions /Crude steel output
		SO_2 emissions of steel, per ton C18	= SO_2 emissions /Crude steel output
		Environmental protection investment ratio C19	=Environmental protection investment / Total value of output
	Resource consumption B6	Fresh water consumption of steel, per tonC20	=Fresh water consumption / crude steel output
		Comprehensive energy consumption of steel, per ton C21	=Energy consumption / Crude steel output

3. Indicator system of social performance

Table.3 Indicators of social performance evaluation

Level 1	Level 2	Level 3	Equation or description
Social performance A3	Labor employment B7	Annual growth rate of employees C22	=(Total employees this year -Employees the previous year)/Employees the previous year*100%
		Growth rate of wages and benefits C23	=(Average wages and benefits this year -Average wages and benefits the previous year)/Average wages and benefits the previous year*100%
	Social contribution B8	Actual payment rate of tax C24	=Tax payment this year /The annual revenue*100%
		Rate of social donation to revenue C25	=Donation /Revenue *100%

EVALUATION MODEL ON IRON AND STEEL ENTERPRISE ' TRIPLE-BOTTOM-LINE PERFORMANCE

1. Static comprehensive Evaluation on Iron and Steel Enterprises' triple-bottom-line performance

Triple-bottom-line performance is defined as S, and Economic performance,Ecological performance,Social performance, as A1, A2, and A3. Respectively, that is, S=A1+A2+A3, whose static comprehensive evaluation model[8][9]is:

Firstly, to define the original value of each indicator, as considering quantification in indicator selecting, the value of selected ones can be computed.

Secondly, the non-dimension of indicator's original value. The method chosen integrates both advantages of linear non-dimension treatment method and "solutions non-dimension treatment evaluation of nonlinear"[10], whose raw data controlling the variable is limited in [0, 1], and the non-dimension relationships:
Forward indicator

$$V_{ij} = \frac{u_{ij} - u_{\min.j}}{u_{\max.j} - u_{\min.j}} \quad (1)$$

Reverse indicator

$$V_{ij} = \frac{u_{\max.j} - u_{ij}}{u_{\max.j} - u_{\min.j}} \quad (2)$$

Therein, i=1,2……,n(i, subsystems; n, the number of indicators); j=l,2……,n(j, hypo-subsystems;n, the number of indicators). $U_{\max.j}$ is the industry's maximum values of the indicator; $U_{\min.j}$, the minimum.

Thirdly, calculation of static comprehensive performance values in each subsystem or minor ones. The values are calculated and determined by the catastrophe progression method on each of the subsystems non-dimension indicator: subsystems' sequence and its inclusion relations are determined according to their hierarchical structure, within which if an indicator is only decomposed into 2 sub indicators, the system can be regarded as the cusp catastrophe one, such as indicator A2, A3, B6, B7, and B8. The model of these indicators is $f(x) = x^4 + ax^2 + bx$,andthe normalized one could be expressed as:

$$x_a = \sqrt{a'}, x_b = \sqrt[3]{b'} \quad (3)$$

In the case of an indicator decomposed into 3 sub indicators, the system is regarded as the dovetail catastrophe, like indicator B5, whose model is $f(x) = x^5 + ax^3 + bx^2 + cx$, and the normalized one:

$$x_a = \sqrt{a'}, x_b = \sqrt[3]{b'}, x_c = \sqrt[4]{c'} \quad (4)$$

In the case of 4 sub-indicators, the system is regarded as the butterfly catastrophe, such as A1, B1, B2, B3, and B4, whose modelis $f(x) = x^6 + ax^4 + bx^3 + cx^2 + dx$, and the normalized one:

$$x_a = \sqrt{a'}, x_b = \sqrt[3]{b'}, x_c = \sqrt[4]{c'}, x_d = \sqrt[5]{d'} \quad (5)$$

Fourthly, calculation of the static comprehensive triple-bottom-line performance value X in Iron and Steel Enterprises. The value is obtained by the number of subsystems decomposed triple-bottom-line performance S according to the catastrophe progression method.

2. Static coordination of triple-bottom-line performance of Iron and Steel Enterprises

Static coordination means equiponderant state of triple-bottom-line performance at a specific point or in a period of time. According to three-dimensional vectors analysis, static coordinative degree can be anglicized on the basis of the angle and orientation between vector of overall performance and the one of triple-bottom-line performance. Angle shows the magnitude of the enterprise business's the actual effect of strategies in the economic, environmental and social, as well as of the overall performance, and indicates the matching relationship between them. The relationship between enterprise's overall triple-bottom-line performance and its vector value P is available by the following functional expression:

$$P(t) = \sqrt{A_1^2(t) + A_2^2(t) + A_3^2(t)} \quad (6)$$

Computational equation on static coordination degree:

$$H_i = \prod_{i=1}^{3} \cos\theta_i \Big/ 3^{-3/2} = \frac{A_1 \times A_2 \times A_3}{P^2(t)} \Big/ 3^{-3/2} \quad (7)$$

3. Dynamic coordination of triple-bottom-line performance of Iron and Steel Enterprises

Dynamic coordination means the development of orderly oriented triple-bottom-line performance, including the level of performance development and the one of static coordination improvement. Therefore, the variation of overall performance and static coordination can comprehensively reflect dynamic coordination. Its equation is:

$$D_i = \sqrt{[P(t) - P(t-\Delta t) + 1] \times [H(t) - H(t-\Delta t) + 1]} \quad (8)$$

In equation (8), D represents dynamic coordination. If $D > 1$, it explains that the performance level and the static coordination tend to be improved in general; If $D = 1$, generally stable; If $D < 1$, regress on the whole.

d. Comprehensive evaluation model of performance of Iron and Steel Enterprises

Based on the static performance comprehensive evaluation, the integrated model forms by adjustment using the static coordination and dynamic coordination:

$$F_i = X_{A_i} \times H_i \times D_i \quad (9)$$

The F_i is the comprehensive performance of the i-th enterprise, whose magnitude determines its sorting position.

THE EMPIRICAL APPLICATION ON TRIPLE-BOTTOM-LINE PERFORMANCE EVALUATION OF IRON AND STEEL ENTERPRISES

1. Samples and data resource

The data selected in this paper is released from reports of 10 listed companies during 2009-2011 on annual finance, social responsibility, and sustainable development. In order to ensure the representativeness and scientificness of samples, the 10 Iron and Steel Enterprises are distributed in north China (Shougang Group), east (Baosteel Co.,Ltd., Masteel Group), northeast (Angang steel Corp.), south(SGIS Songshan Co.,Ltd.), northwest(Xining special steel Co., Ltd., Baotou steel Group), central(Wuhan iron and steel Corp.), southwest(Chongqing iron and steel Co., Ltd., Liuzhou iron and steel company,Ltd.), amongst are 4 mega enterprises(Baosteel, Shougang, Wuhan iron and steel, Angang),4 large enterprises(Masteel, Liuzhou iron and steel, Chongqing iron and steel, Baotou steel), and 2 average scale enterprises(SGIS, Xining special steel).

2. Data pre-processing

According to the equation(1)and(2), a total of 66 samples, the parameter values of specific corresponding indicators of the 10 listed companies between 2009 and 2011, namely 66 x 10 data are processed in non-dimension. Due to the

finite space, the non-dimension values ofBaosteel in 2009 are the only ones listed.(the following calculation is based on the example of Baosteel's data in 2009)

Table.4Data on non-dimension processed enterprise performance evaluation indicators of Baosteel in 2009

Indicators of level C	Processed data	Indicators of level C	Processed data
C1 Rate of sales profit	1.0000	C14 Current assets turnover ratio	0.3168
C2 The weighted average return on net assets	0.7875	C15 Receivables turnover ratio	0.4470
C3 Return on assets	0.8681	C16 Cash recovery of assets	0.6710
C4 Basic earnings per share	0.7596	C17 CO2emissions of steel, per ton	0.9934
C5 Debt to total assets ratio	0.7147	C18 SO2 emissions of steel, per ton	0.6972
C6 Multiples of interest earned	0.0280	C19 Environmental protection investment ratio	0.7358
C7 The quick ratio	0.4407	C20 Fresh water consumption of steel, per ton	0.5040
C8 Cash flow and debt ratio	0.8923	C21 Comprehensive energy consumption of steel, per ton	0.9043
C9 The growth rate of sales revenue	0.6275	C22 Annual growth rate of employees	0.7475
C10 The increasing rate of assets	0.2899	C23 Growth rate of wages and benefits	0.0538
C11 Technology investment ratio	0.0040	C24 Actual payment rate of tax	0.3563
C12 Capital increment rate	0.3493	C25 Rate of social donation to revenue	0.3445
C13 Assets turnover ratio	0.1647		

3. The computational process of triple-bottom-line performance of Iron and Steel Enterprises

Firstly, according to the equation (4), (5), (6), and values of Level 2 indicators(B1, B2, B3, B4, B5, B6, B7,and B8) are calculated separately, such as the calculation model of B2. Because of B2's 4 subordinate indicators(C5, C6, C7andC8), as stated previously, the butterfly catastrophe, the indicator of solvency of Baosteel in 2009 is:

$$X_{B2} = \frac{X_{C5}^{1/2} + X_{C6}^{1/3} + X_{C7}^{1/4} + X_{C8}^{1/5}}{4}$$
$$= \frac{\sqrt{0.7147} + \sqrt[3]{0.0280} + \sqrt[4]{0.4407} + \sqrt[5]{0.8923}}{4}$$
$$= 0.7353$$

Secondly, continuously according to the equations (4), (5), and (6), values of the level, indicators, namely the economic performance A1, ecological performanceA2, social performance A3,are calculated out based on the Level 2 indicators, and according which the value of comprehensive performance evaluation X is worked out.

The same can be applied for other enterprises, in other years. (Shown in table 5)

Table.5 Values of the 10 enterprises' triple-bottom-line performance between 2009 and 2011

Year	2009				2010				2011			
Evaluationvalue Name	A1	A2	A3	X	A1	A2	A3	X	A1	A2	A3	X
Baosteel	0.9263	0.9554	0.8269	0.9536	0.9344	0.9393	0.8923	0.9703	0.9527	0.9493	0.9011	0.9743
Shougang	0.9004	0.8809	0.7577	0.9335	0.9119	0.9002	0.7694	0.9364	0.8638	0.9036	0.7263	0.9232
Angang	0.8945	0.8483	0.7569	0.9328	0.9107	0.8917	0.8119	0.9492	0.9274	0.9083	0.8961	0.9635
Wuhan iron and steel	0.8947	0.8508	0.7594	0.9335	0.9433	0.8563	0.8232	0.9496	0.9432	0.8719	0.8927	0.9553
Chongqing iron and steel	0.8847	0.7993	0.7917	0.9279	0.8721	0.7838	0.7934	0.9221	0.8968	0.8217	0.8115	0.9366
Baotou steel	0.8067	0.8067	0.7964	0.8788	0.8868	0.8442	0.7973	0.9417	0.8914	0.8416	0.8217	0.9441
Masteel	0.8954	0.8228	0.8534	0.9371	0.9031	0.8631	0.7851	0.9413	0.9209	0.8923	0.7622	0.9308
Liuzhou iron and steel	0.8984	0.7473	0.7655	0.9075	0.9126	0.7602	0.6321	0.8917	0.8992	0.7806	0.7727	0.9207
SGIS	0.8782	0.8261	0.7003	0.9148	0.8866	0.8302	0.7248	0.9227	0.8313	0.8590	0.7225	0.9118
Xining special steel	0.8762	0.7953	0.7768	0.9265	0.9061	0.8633	0.849	0.9519	0.9019	0.8084	0.8237	0.9316

4. The evaluating process of static coordination of triple-bottom-line performance of Iron and Steel Enterprises

Taking the data of Baosteel, annual 2010, as example, the triple-bottom-line performance vector value P is based on formula (6) and data in table 5:

$$P(t)a = \sqrt{A_1^2(t) + A_2^2(t) + A_3^2(t)} = \sqrt{0.9344^2 + 0.9393^2 + 0.8923^2} = 1.5325$$

According to equation (7), static coordination is:

$$H_i = \prod_{i=1}^{3}\cos\theta_i \Big/ 3^{-3/2} = \frac{0.9344\times0.9393\times0.8923}{105325^2} \Big/ 3^{-3/2} = 0.9759$$

The same can be applied for other enterprises, in other years. (Shown in table 6)

Table.6 Values of the 10 enterprises' static coordination between 2009 and 2011

Year	2009		2010		2011	
Evaluation value Name	P(t)	H	P(t)	H	P(t)	H
Baosteel	1.4831	0.9870	1.5325	0.9759	1.6189	0.9981
Shougang	1.4699	0.9832	1.4945	0.9828	1.4454	0.9749
Angang	1.4466	0.9859	1.5111	0.9927	1.5772	0.9904
Wuhan iron and steel	1.4495	0.9863	1.5167	0.9900	1.5967	0.9897
Chongqing iron and steel	1.4311	0.9923	1.4156	0.9930	1.4622	0.9940
Baotou steel	1.2873	0.9453	1.4611	0.9944	1.4758	0.9965
Masteel	1.4856	0.9964	1.4755	0.9900	1.4917	0.9804
Liuzhou iron and steel	1.3965	0.9796	1.3455	0.9355	1.4191	0.9852
SGIS	1.3943	0.9739	1.4144	0.9796	1.3955	0.9831
Xining special steel	1.4155	0.9817	1.5123	0.9877	1.4643	0.9730

5. The evaluating process of dynamic coordination of triple-bottom-line performance of Iron and Steel Enterprises

Dynamic coordination is based on example of Baosteel and data in chart 6.

Substituted into equation (8):

$$\begin{aligned} D_i &= \sqrt{[P(t)-P(t-\Delta t)+1]\times[H(t)-H(t-\Delta t)+1]} \\ &= \sqrt{[P(2010)-P(2009)+1]\times[H(2010)-H(2009)+1]} \\ &= \sqrt{[1.5325-1.4831+1]\times[0.9759-0.9870+1]} \\ &= 1.0187 \end{aligned}$$

The same can be applied for other enterprises, in other years. (Shown in table 7)

Table.7 Values of the 10 enterprises 'dynamic coordination between 2009 and 2011

D Value / Name	2010	2011	Year	2010	2011
Baosteel	1.0187	1.0538	Baotou steel	1.1097	1.0084
Shougang	1.0120	0.9713	Masteel	0.9917	1.0032
Angang	1.0352	1.0360	Liuzhou iron and steel	0.9524	1.0616
Wuhan iron and steel	1.0350	1.0391	SGIS	1.0129	0.9922
Chongqing iron and steel	0.9926	1.0235	Xining special steel	1.0504	0.9734

6. The evaluating of comprehensive performance of Iron and Steel Enterprises

According to equation (9)and data above, the value of comprehensive performance of Baosteel in 2010 is:

$$F_i = X_{A_i}\times H_i \times D_i = 0.9703\times0.9759\times1.087 = 0.9646$$

The same can be applied for other enterprises, in other years. (Shown in table 8)

Table.8 Values of the 10 enterprises' comprehensive performance evaluation between 2009 and 2011

F Value / Name	2010	2011	Average value	Year	2010	2011	Average value
Baosteel	0.9646	1.0248	0.9947	Baotou steel	1.0392	0.9487	0.9940
Shougang	0.9313	0.8742	0.9028	Masteel	0.9242	0.9155	0.9199
Angang	0.9754	0.9971	0.9863	Liuzhou iron and steel	0.9245	0.9629	0.9437
Wuhan iron and steel	0.9730	0.9824	0.9777	SGIS	0.9155	0.8894	0.9025
Chongqing iron and steel	0.9088	0.9529	0.9309	Xining special steel	0.9276	0.9005	0.9141

CONCLUSION

(1)The triple-bottom-line performance static comprehensive evaluation shows, that in addition to Baosteel's ecological of the 2010 annual is greater than the economic and social performance, its data in 2009 and 2011, and

other enterprises'in the three year indicates a contrary result, which is that the economic is greater than the other two, for this reason it is unscientific, prone to draw one-sided conclusion to evaluate performance only on the economic in iron and steel enterprise s; and that besides Wuhan's economic performance more than Baosteel's in 2010, the rest of the data are displayed Baosteel ranking first, which we can see Baosteel's inductialleading status in China.

(2)On the static coordination of triple-bottom-line performance, data of the 10 enterprises in each annual generally are between 0.97 to 0.099, which shows a fine static coordination. And that in 2009 annual Masteel ranked the first, so did Baotou steel in 2010 and 2011, shows that large enterprises' static coordination is not necessarily good.

(3)On the dynamic coordination of triple-bottom-line performance, values of Baosteel, An gang, Wuhan iron and steel and Baotou steel in 2010 and 2011 annual are larger than 1, indicating that the four enterprise's dynamic coordination is good, and performance level and the static coordination tend to improve; And in 2010 values of Chongqing iron and steel, Masteel, Liuzhou iron and steel is less than 1 while greater than 1 in 2011, it presents that the static coordination of the three companies tend from the regressing state of 2010 to the improving one of 2011 through adjustments, especially Liuzhou iron and steel; On the contrary, the shift is worth thinking for Shougang, SGIS and Xining special steel in 2012, as in 2010 their dynamic coordination values is more than 1 but less than 1 in 2011.

(4)On the data of comprehensive evaluation, the average value of the 10 enterprises both in 2010 and 2011 is between 0.9 and 1, with ranking of Baosteel, Baotou steel, Angang, Wuhan iron and steel, Liuzhou iron and steel, Chongqing iron and steel, Masteel, Xining Special steel, Shougang, and SGIS. To a certain extent, this reflects development level of China's Iron and Steel Enterprises in the background of low carbon economy. As for Shrugging's low ranking, adjust mental phase of its post-relocation has much to do.

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