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Comprehensive Estimation of the Financial Risk of Iron and Steel Enterprise-Based on Carbon Emission Reduction

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Energy consumption and carbon emission have become a focus for trends in the future development of iron and steel enterprises in China. This paper firstly combines energy consumption, carbon emission and financial risk assessment of iron and steel enterprises in China for studying. The financial risk of iron and steel enterprises is classified into five main risks: 1) profit risk, 2) insolvency risk, 3) operational risk, 4) development risk and 5) the risk of carbon emission. Based on carbon emission cash flow cycle table, this paper constructs the iron and steel enterprises' financial risk assessment system which is relies on subordination degree. The 31 iron and steel listed companies of China are examined to test the applicability of the risk assessment system. The results show that this system can better reveal the situation of financial risks faced by iron and steel enterprises such that the may be better prepared to guard against such financial risks.

Keywords: Energy Consumption,Carbon emission, Iron and Steel Industry, Financial Risk

Introduction

Along with low carbon economy development, countries are paying more attention to the problems of high carbon emission industries in the world. At the 2009 world climate conference in Copenhagen, China announced that the carbon dioxide emissions of its gross domestic product will reduce 40%-45% by 2020. This goal will have great effect on high-energy consumption industries in China, such as thermal power, petrochemical, transportation, construction, and chemical and iron and steel industries. In the meantime, the world climate has changed at an alarming rate, which drives more and more researchers to focus on industrial energy efficiency with carbon emission. Improving energy efficiency has been widely regarded as one of the most cost-effective ways to increase energy security, improve industrial competitiveness and mitigate climate change[1]. Some researchers studied the carbon emission from different industries. Mandal estimated energy efficiency of the Indian cement industry and the results revealed that energy efficiency estimates were biased if only desirable output was considered[2]. Similar conclusions were put forward by Zhang *et al*. which proposed that productivity growth appeared to differ whether undesirable outputs were considered or not[3].With the acceleration of industrialization and urbanization, China has become one of spotlights for increasing industrial efficiency in the world. Therefore, a number of researchers have examined the efficiency and productivity of Chinese industries[4-7]. Wu F *et al*. studied China's industrial energy efficiency and found that the efficiency has annually improved by 5.6% since 1997[8]. They have been the first to consider undesirable outputs such as CO_2 emissions with their modeling framework. Their paper also presented that the improvement of industrial energy efficiency in China was mainly driven by technological improvement. Thus, improving industrial energy efficiency is significantly effective to promote low-carbon development. China's iron and steel industry has become the world's biggest steel producer since 1996. As it is one of the most polluted industries in China, it has caught the attention of academia regarding, the energy consumption and environmental problems of China's iron and steel industry associated by its productivity growth. Although the comprehensive energy consumption per ton by the iron and steel industrial enterprises has declined from 1123kg to 619kg of coal equivalent during this period, there is still a wide gap compared to the developed countries[9]. Wei *et al*. investigated the energy efficiency of iron and steel enterprises in China during 1994-2003 through provincial panel data. They concluded that the energy efficiency in China's iron and steel sector

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increased by 60% from 1994 to 2003, which was mainly attributable to technical progress rather than technical efficiency improvement[10]. Even though, the energy efficiency of iron and steel industrial enterprises in China is still low. However, few research studies the financial risk under the background of low carbon economy of iron and steel enterprise. Moreover, there is lacks of empirical research regarding financial risk. In addition, the relationship between carbon emission and financial risk of China's iron and steel enterprises has not been sufficiently explored. This paper conducts empirical research on the financial risk of China's iron and steel enterprises in terms of low carbon development. The research outcome would not only have practical significance for risk prediction and control, but also contribute to enrich the theoretical study on the financial risk.

Experimental Section

The connotation of iron and steel enterprises financial risk

At present, the study of iron and steel enterprises financial risk research system has not been formed. Most of the literature focuses on the definition of financial risk, characteristics and preventive measures of the iron and steel enterprises. Besides, current research also discusses management policies of iron and steel enterprises to reduce finical risk. However, most of the recent studies in this field lack a macroscopic perspective. Firstly, there is little research on iron and steel enterprises in foreign countries and mainly in the aspects of corporate governance structure and capital structure research. These researches laid a good dimensional research foundation for studying the iron and steel enterprises' financial risk. Liu D Q and Keijiro O studied 61 iron and steel enterprises from 1984 to 1992 and 108 iron and steel enterprises from1995 to 1999 respectively, and concluded that the production efficiency and equity reform of iron and steel enterprises has a positive correlation relationship with the development of iron and steel enterprises[11]. Caneghem took Arcelor Mittal Gent as an example and came to a conclusion that the production and profits of iron and steel enterprises can co-exist with the reduction of emissions[12]. Secondly, most of the iron and steel enterprises' financial risk research literature focuses on the risk brought by funds movement. Di Z G draw a conclusion that the debt structure adjustment and reasonable use of hedging the futures market can prevent some financial risk[13]. The iron and steel enterprises should complete internal control systems to strengthen risk awareness. Zhang H L and Zhang H took China's Xuanhua iron and steel company as an example to study the foreign exchange risk. This company adopted different financial instruments for managing foreign exchange risk which made great achievements[14]. Zhao Y N *et al.* put forward constructing the risk evaluation and early warning indexes system to assess the risk degree of large-scale iron and steel enterprises in China[15]. Lai D *et al.* presented that the key link of iron and steel enterprises financial risk control should be analyzed from the following six perspectives: management system, institutional guarantee, prevention and control, audit supervision, early-warning and feedback and performance evaluation six[16]. Tan L J *et al.* expounded on RMB appreciation influences the pros and cons of iron and steel enterprises. And the paper gave some solutions from the aspects of sales, investment and financing[17]. Xu X X analyzed the reasons of the iron and steel enterprises anti-dumping investigation, which presented that the enterprises should cope with a pricing strategy to do a reset in order to avoid risk[18]. However, there are few thorough research studies that have analyzed the iron and steel enterprises' risk in combination from the perspective of low carbon economy. Therefore, this paper, combining with the background of low carbon, proposes that the connotation of the iron and steel enterprises' financial risk mainly refers to financial imbalances that are brought by the uncertainty of capital movement. Such risk can result in operational problems, such as financial difficulty, debt burden, etc. The main characteristics of financial imbalances are shortage of funds, to make ends meet, and even profits diving into negative territory. Funding carbon emission or investing in other items of carbon emission could induce financial risk. This situation can be directly reflected through the changes of corporate profits. Thus we could regulate capital and prevent risk timely through analyzing investment of enterprise carbon emission and other aspects of the cash flow as well as specific use of these funds. Thus it can be seen that profit information for the iron and steel enterprise financial risks provides a more reliable basis under the perspective of carbon emission. To this end, we can effectively evaluate and analyze the risk of an enterprise in combination with the profits of the enterprise.

Sample selection and data sources

This paper selects 31 iron and steel listed companies as research samples from CSMAR database. The time span is from 2003 to 2012. In this paper, the data are from the 21 listed companies' annual reports. The traditional internal cost calculation system of iron and steel enterprises' carbon emission mainly emphasizes that all resource costs of the production process are included in the final finished goods. It did not bring waste and defective products into the cost accounting. However, the waste and defective products often have practical value. For example, scrap steel could as raw material for production rejoin circulation material flow. To calculate the internal carbon emission cost, the internal material and energy flow of the enterprises should be regarded as the center of the cost analysis. By accounting for the flow of finished goods and the carbonaceous material in the manufacturing process, we can quantify the factors of all cost and track the quantitative changes of resources, the material flow volume and value information. Referring to the material flow cost calculation of Germany, Japan and the United States and the thoughts of process management and material flow analysis, this paper proposes that the internal cost flow calculation methods and procedures are as follows. The first step is to collect and distribute costs through collecting the carbon emission calculation results of unit process flow and classify the quantity center according to the main process of iron and steel enterprises. Secondly, we should calculate the cost including positive products and negative products in the whole process. The positive products are the continuing manufacture products and semi-finished products that can be directly sold or be able to enter the next production process. The positive products costs and indirect costs are called positive manufacturing costs. The unit process carbon emission cost are negative products cost, namely carbon emission cost. Finally, to calculate the carbon emission cost, we should implement the whole production process calculation because carbon cost calculation is interlinked. The positive products of the former link and the new input carbon material and energy cost constitute the full cost of this link. The cost will be shared between positive and negative products according to the ratio. And the positive products of this link will enter into the next production link cost calculation, so until the last working procedure. Although the iron and steel enterprises can make a certain reduction of actual carbon emission and adopt a series of resource-oriented utilization means, the enterprises eventually discharge considerable carbon pollutants to the environment. The traditional cost calculation methods do not consider the additional cost of the damaged environment which comes from the production activities. However, the cost of this part could essentially influence the enterprises' decision-making regarding cost and benefit. In view of the carbon emission of iron and steel enterprises, we define the external damage cost of carbon emission. The cost of external damage calculation based on the environmental impact involves several potential factors and there is no trade market. So it is difficult to monetize the measuring unit loss coefficient. That is to say, it is difficult to determine the external damage cost of environmental impact. With the development of environmental engineering, environmental economics, the environmental accounting and environmental impact assessment, etc. the monetization measuring has achieved a series of new breakthroughs. The Japanese researchers have developed three kinds of pollutants external damage coefficient (LIME, JEPIX and MAC). The researchers of Netherlands developed Eco-indicator 99. And Sweden developed EPS. This paper preliminarily selects 16 representative indicators to measure 32 financial risk of listed companies which are 1) main business profitability, 2) return on assets, 3) asset-liability ratio, 4) ratio of cash to current liabilities, 5) operating profit ratio, 6) shareholders' equity growth ratio, 7) net profit returns ratio, 8) net assets returns ratio, 9) current ratio, 10) quick ratio, 11) asset-liability ratio, 12) total assets turnover, 13) accounts receivable turnover, 14) rate of stock turnover, 15) R&D growth rate of carbon emission and 16) cost growth rate of carbon emission. The authors of this paper summarize these indicators on the basis of research literature and combine the iron and steel enterprises' own development characteristics.

Model Specification

In the traditional evaluation model, the main financial risk assessment approach is to score the risk of the enterprise for ranking on a certain aspect or several given aspects. The obvious defects of the traditional model are unable to do the comprehensive evaluation. This paper uses expanded Bayesian decision model to effectively make up for the shortcomings of traditional evaluation model, combining with fuzzy mathematic theory. The goals is to find the problems in the management and the underlying reasons in iron and steel listed companies and put forward effective countermeasures. As mentioned above, the financial risks of iron and steel enterprises under the background of low carbon emission are mainly composed of profit risk, insolvency risk, operational risk, development risk and carbon emission risk. The purpose of factor analysis is to integrate multiple random variables into several independent common factors (F_1, F_2, F_3,…F_m), to reveal the relationship between the indexes and factors. Its mathematical model representation is as follows.

$$\begin{cases} X_1 = \alpha_{11}F_1 + \alpha_{12}F_2 + \cdots + \alpha_{1m}F_m + \alpha_1\varepsilon_1 \\ X_2 = \alpha_{21}F_1 + \alpha_{22}F_2 + \cdots + \alpha_{2m}F_m + \alpha_2\varepsilon_2 \\ \cdots\cdots \\ X_n = \alpha_{n1}F_1 + \alpha_{n2}F_2 + \cdots + \alpha_{nm}F_m + \alpha_n\varepsilon_p \end{cases} \quad \ldots \quad \ldots (1)$$

Here (X_1, X_2, X_3,…X_n)are sample variables. They are the standardized variables whose mean value is 0 and variance is 1. Factor loading is the correlation coefficient between the *i*th original variable and the *j*th factor variable. Therefore, the greater the absolute value of α_{ij}, the closer relationship between F_i and X_i. (F_1, F_2, F_3,…F_m) are *m* factor variables and *m* is smaller than *n*. ε denotes specific factor, means the original variables that cannot be explained part but factor variables. According to the fuzzy mathematics theory, all kinds of development indexes in economic field could be processed by membership function. Due to the characteristics of the listed company, the range of its economic indicators data is large. Therefore, we assume that the data variation ranges of all economic indicators are real number $X \in (-\infty, +\infty)$. The constructing membership functions are as follows:

Step 1: Constructing membership function

$$A(X) = \mathrm{Rank}(X'_i, X'_j, \cdots X'_n) = \begin{cases} \frac{1}{2} + \frac{1}{\pi} arctag(\sum_{i=0}^{j}(a_{pi} \times ({}^{X_p}/_{\frac{\sum_{j=1}^{n} X_j}{n}})^i)), & X_j, X_p \in [0, +\infty) \\ \frac{1}{2} - \frac{1}{\pi} arctag(\sum_{i=0}^{j}\left(a_{pi} \times \left({}^{X_p}/_{\frac{\sum_{j=1}^{n} X_j}{n}}\right)^i\right)), & X_j, X_p \in (-\infty, 0] \end{cases} \quad \ldots (2)$$

Here. *A(X)* denotes the membership function of financial index *X*. X' denotes standardized data of financial index. X_i denotes the *i*th financial index data. X_p is the data which are under the same financial index. a_{pi} is corresponding *i* order contributing coefficient. Its value range is $i \in [0, l]$. *arctag* denotes arc-tangent function. Rank is order function that refers to the specific index position in the entire time series.

Step 2: Partition probability space and determining Bayesian probability

$$\begin{cases} P(X''_{kl,sl}|X''_{pl,ql}) = \frac{P(X'_{pl,ql}|X'_{kl,sl})P(X''_{kl,sl})}{\sum_{sl=1}^{\tilde{\omega}_{kl}} P(X''_{pl,ql}|X''_{kl,sl})P(X''_{kl,sl})} \\ X'' = \bigcup_{p=1}^{s} X''_p \end{cases} \quad \ldots (3)$$

Here, X'' denotes the whole probability space. X''_p is the probability space which is determined by X. $X''_{p,i}$is the probability subspace of X'_p , $\tilde{\omega}$ is partition number of X'_p. Using the above formulas, we could determine the probability of different membership conditions. Specifically, we could determine iron and steel enterprises' financial risk probability (in accordance with the principle of maximum membership degree) in different indexes situation.

Financial risk aggregative model

On the basis of iron and steel enterprises financial risk probability in constructing different degrees of membership situation, this paper expands the risk assessment model and constructs the overall financial risk models as follows:

$$R = F_p P(p) + F_s P(s) + F_b P(b) + F_g P(g) + F_o P(o) \quad \ldots (4)$$

Here, *R* denotes comprehensive financial risk probability of iron and steel enterprises. *F* is common factor coefficient. P denotes the probability of risk. *p* denotes profit risk. *s* denotes insolvency risk. *b* denotes operational risk. *g* denotes development risk. And *o* denotes carbon emission risk.

Result Interpretation

We standardized the sample data before analyzing them to make the data comparability. Financial risk assessment indexes can be divided into positive and negative indexes. Positive index refers to large type index, while the negative index refers to small type. Due to their different attributes, these sample data are normalization processing in this paper. We also need to examine whether these 16 indexes have certain linear correlation before factor analysis, which uses Bartlett's test and KMO test. According to formula 1, we obtain the KMO value of this research samples that is 0.648, while the corresponding probability of Bartlett's test is 0(sig. =0) that is less than the significant level 0.05. Therefore, this paper argues that there are significant differences between the correlative coefficient matrix and unit matrix, which illustrate these indexes, have correlation. Thus we could use factor analysis.The quantity of common factor usually submits to the principle that eigenvalue is greater than 1 and principle component contribution rate is greater than 85%. According to the results of KMO test and Bartlett test, we select 13 indicators and 5 common factors to assess the financial risk of iron and steel companies through adjusting financial indicators(as shown in table 1). From table 1, we can see the eigenvalues of the first, second, third, fourth and fifth common factor are 3.615, 3.232, 2.564, 1.137 and 1.021, which are greater than 1. The accumulative contribution rate is 98.531%.According to the above, the object of study we determined is key index data in each quarter from 2003 to 2012. We could find the contributing coefficient of every index according to subordinating degree function we built, and corresponding coefficients of determination in the function and adjusted coefficients of determination were both above 0.96. Thus, we considered that the model above was statistically significant and credible, there out we determined subordination degree model of different indexes. Next, we were going to study the corresponding financial risk making use of the model. Taking net profit index in 2012 for example, we used formulas mentioned above to study the net profit subordination degree. The whole process of empirical study was unfolded according to the model framework mentioned above and no more tautology here. Results based on formula 2 and formula 3 are shown in Appendix A.According to the formula 4, we could calculate the overall financial probability of 32 listed companies from 2003 to 2012. As shown in Appendix B. Now, after working out the respective financial risk of iron and steel enterprises over 2003-2012, we can figure out sequence mean interval of respective yearly financial risk of iron and steel enterprises [0.3, 0.4]. It is generally recognized that sequence mean interval value is an acceptable state of risk. Thus, we regard the interval [0.3, 0.4] as an acceptable risk interval, and then respectively take 0.1 and 0.3 floated upward and downward as division interval between smaller and low risk and bigger and high risk, and critical values of total financial risk of iron and steel enterprises we got are shown in table 2.We need to address three questions in the process of financial risk assessment. Firstly, the financial risk assessment process should reflect what the influence factors of iron and steel enterprises are. Secondly, the financial risk assessment process needs to get the reasons why the risk happens. Thirdly, we

Table 1— The main financial indicators (rotation factor loading matrix, eigenvalue, variance contribution and the cumulative variance contribution rate) of iron and steel enterprises

NO.	Variables	Factor rotating load estimation				
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
1	Main Business Profitability	.814	-.046	.927	.036	-.178
2	ROA	.978	.146	-.025	-.024	.323
3	ROE	.961	.009	.204	.196	.323
4	Current Ratio	-.141	.961	.319	.295	.021
5	Quick Ratio	.236	.923	-.006	-.003	.163
6	Debt Asset Ratio	-.144	.817	-.204	-.256	-.178
7	Total Assets Turnover	.077	.288	.825	.564	-.042
8	Shareholders' Rights Growth Rate	.213	.121	.034	.884	.026
9	Net Profit Rate of Return	.023	.241	.028	.956	.356
10	Accounts Receivable Turnover	-.070	-.286	.074	.236	.853
11	Inventory Turnover	.862	.261	-.030	-.562	.272
12	Carbon Reduction R&D Spending Growth Rate	-.161	.136	.037	.125	.896
13	Carbon Reduction Cost growth rate	-.196	.067	.189	.562	.913
Eigenvalue		3.615	3.232	2.564	1.137	1.021
Variance Contribution		32.568	26.695	22.368	10.236	7.654
The Cumulative Variance Contribution Rate		32.568	59.273	81.641	91.877	98.531
Name of Factors		Profitability Factor	Solvency Factor	Carbon Reduction Ability Factor	Operational Capabilities Factor	Development Capacity Factor

Table 2— Financial Risk Hierarchy table of iron and steel enterprises

Guard Interval	Risk Level	Risk Description
(0.5,1]	Higher Risk	Financial risk is particularly high, if improper measures, may be on the verge of bankruptcy
(0.4,0.5]	High Risk	Financial risk is high, if out of control will lead to a crisis
(0.3,0.4]	Acceptable Risk	Financial risk could be managed and should be taken control measures
(0.2,0.3]	Low Risk	Financial risk is low, but should pay attention to
(0,0.2]	Lower Risk	Good financial situation

should build an adaptability of financial risk assessment system. The following section will instruct respectively.First of all, from the perspective of importance degrees of iron and steel enterprises' financial risk, the most important risks are profit risk, insolvency risk and carbon emission risk. Their contribution degrees of overall financial risk are 32.568%, 26.695% and 22.368% respectively. According to our analysis, it is mainly because in recent years, iron and steel enterprises have intensified emission reduction due to China's national strategy of low carbon economy. However, the short-term economic benefit produced by the investment of carbon emission is fewer, and the progress produced by the input of research mainly benefits from the improvement of ecological effect. Thus, with the investing for science and research of carbon emission, the capital gains of iron and steel enterprises certainly will be reduced, while iron and steel enterprises' financial risk increases. Therefore, the more investment for carbon emission, the greater financial risk the iron and steel enterprises face.Secondly, regarding the reason for the emergence of financial risk of iron and steel enterprises, the emergence is always caused by a variety of factors. Furthermore, the higher risk degree, the greater impact of the factors. According to the results which the authors get, the financial risk of Chinese iron and steel enterprises is mostly normal distribution in interval [0.3, 0.4], and it is serried in the acceptable-risk area (shown in Appendix B). Moreover, seeing from the high financial risk distribution of iron and steel enterprises, it is mainly center on 2007, 2008 and 2009. The reason is that duo to the impact of financial crisis, Chinese iron and steel enterprises hard operated, especially that in condition of excess capacity, the operating profit of Chinese iron and steel enterprises is much fewer than that of foreign enterprises' operating profit. In addition, with respect to fundraising capacity, the funding risk of the iron and steel enterprises' is quite high, and debt paying ability is weaker. As can be seen, reasons for financial risk of enterprises in high risk area are always various.Finally, the empirical analysis shows that the financial risk system proposed by this paper constructed have certain effect to reveal the daily operation, solvency ability and carbon emission ability. At present, China's iron and steel enterprises greatly enhance the carbon emission input and the financial structure makes a certain change. However, according to the current development trend and carbon emission of iron and steel enterprises gradually increasing, enterprise risk ability will also be in the process of enterprise development for a long time. In this paper, the financial risk assessment system of China's iron and steel enterprises based on carbon emission capital circulation provides effective financial risk evaluation methods. To have effective control of financial risk, this assessment system based on carbon emission cash flow could evaluate China's iron and steel enterprises' financial risk overall and carry it out effectively.

Conclusions and Policy Recommendations

Firstly, the financial risk of China's iron and steel listed companies is quite high. The proportion of low risk type and smaller risk companies is less, only 31.25%. Secondly, in terms of the whole iron and steel industry, the industry average profit is low, and the vicious internal competition makes the profit ability and solvency worse. Thirdly, the top priority of the iron and steel industry developing is to increase profit ability and expand profit ratio.

According to the research conclusions, this paper puts forward the following policy recommendations. Firstly, to reduce the financial risk in development, the iron and steel industry should devote to changing the traditional extensional pattern, strengthening technology input, improving technological innovative ability and increasing developing connotation. Secondly, to enhance profitability, the iron and steel industry should further speed up the pace of mergers and acquisitions and improve industry concentration and core competence. Thirdly, in addition to the scientific and technological innovation, iron and steel enterprises need to promptly respond to market changes and to reduce purchasing costs.

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