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Study on the Model of Low-Carbon Sustainable Development of Chemical Enterprises

Juan Tang

Hunan Mechanical and Electrical Polyetchnic, Changsha 410105, China
23114128@qq.com

This paper conducts an in-depth study on the analysis model of low-carbon sustainable development in the production process of small and medium-sized chemical companies in China. First, this paper defines the concept of sustainable development, reasonably describes main methods and the model, clarifies the characteristics and existing problems of the small and medium-sized chemical companies at the current stage, establishes correlators of the important concepts used in the research, applies the dissipative structure theory to screen some financial indicators of sustainable development ability, and carries out an actual investigation to conduct in-depth analysis. The results show that: China's small and medium-sized chemical companies have not yet reached a sustainable development status; the main factors constraining the sustainable development of chemical companies are corporate profitability deviations, the companies have low enthusiasm in capital operation and poor corporate internal management mechanisms; by argument, this paper gives main approaches for the development of small and medium-sized chemical companies, ensuring the companies are competitive enough.

1. Introduction

The chemical industry plays a decisive role in the development of the country's economy and relates to the lifeblood of the country’s economic development (Vezenov et al., 1997). There are numerous small and medium-sized companies in the chemical industry in China, accounting for 96% of the total number of enterprises, and their contributed output value in the economic development exceeds 91%. However, there are many problems in the development of small and medium-sized chemical companies in China, such as low technology level, poor management level, old-fashioned development mode, and large amount of pollutants (Soukoulis and Wegener, 2011). These problems have seriously hampered the sustainable development of China's small and medium-sized chemical companies.

In September 2017, the *13th Five-Year Plan for Growth of Small and Medium-Sized Enterprises* published by the Ministry of Industry and Information Technology of China made an important summary of the development of Small and Medium-Sized Enterprises (SMEs) in China. According to the statistical data in the Plan, China's small and medium-sized chemical companies have exceeded 12 million, accounting for more than 97% of China's enterprises. These companies contributed 54.5% of GDP, 53.2% of taxes, and 66.6% of exports (Kruglov et al., 1992). The economy in our country has recently undergone structural adjustments and the economic growth has slowed down. Therefore, it is urgent to find new economic growth points (Ohayon and Soize, 2012). The chemical industry is related to the national economy and the people's livelihood. It is the top priority for China's economic development. Therefore, it is necessary to continuously strengthen the development of chemical companies, expand development modes, and find new economic growth points (Feistl et al., 2014). However, under this background, the development mode of China's small and medium-sized chemical companies still has not changed, it still follows the previous development mode. It is difficult to break through the bottleneck, and the serious pollution is restricting the development of China's economy (Feistl et al., 2014). The development of chemical companies is difficult and the development costs are increasing (Pohlmann and Tributsch, 1993). These problems have seriously affected the sustainable development of China's SMEs. Governments at all levels and scientific research institutes continue their efforts to find a new way that is conducive to the development of enterprises.

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The paper first clearly defines the scale of small and medium-sized chemical companies, conducts in-depth research on various issues encountered in the low-carbon sustainable development of China's small and medium-sized chemical companies, and adopts the dissipative structure theory to build a model for evaluating the sustainability of small and medium-sized chemical companies. After that, this paper takes the Brusselator as the analysis criteria, combines with a number of listed small and medium-sized chemical companies to conduct case studies, and then verifies the rationality of the model, provides solutions to a series of existing problems, and puts forward specific recommendations and measures to ensure the low-carbon sustainable development of China's chemical companies.

2. Construction of evaluation indicator system

2.1 Selection methods for financial indicators

Combining with the basic methods of extenics principles, we can identify the matter-elements of sustainable development abilities and concretize the chemical companies' low-carbon sustainable development abilities (Chabrier and Baraffe, 2000).
The target matter-element is:

$$R = (N_x, C_x, v(c_x)) \tag{1}$$

In the formula:
R – target matter-element;
N_x – company to-be-evaluated x (x=1,2, 3, ..., n);
C_x – basic indicator that influences the company's sustainable development ability;
$V(C_x)$ –degree of influence of a financial indicator on the development of a company.
Specific steps of extension identification are as follows:
The first step, the determination of the matter-element model, orders:

$$R_0 = (N, C, V_0) = \begin{bmatrix} N_0 & c_1 & V_{01} \\ & c_2 & V_{02} \\ & \vdots & \vdots \\ & c_n, & V_{0n} \end{bmatrix} = \begin{bmatrix} N_0 & c_1 & \langle a_{01}, b_{01} \rangle \\ & c_2 & \langle a_{02}, b_{02} \rangle \\ & \vdots & \vdots \\ & c_n, & \langle a_{0n}, b_{0n} \rangle \end{bmatrix} \tag{2}$$

Where, c_1, c_2, ... c_n are n different features of N_0, and V_{01}, V_{02}, ... V_{0n} are ranges of values taken by N_0 for c_1, c_2, ... c_n, respectively, namely the classical domain. And there is $V_{01}=<a_{0i}, V_{0i}>$ (i=1,2...n).
Orders:

$$R_p = (N, C, V_p) = \begin{bmatrix} N & c_1 & V_{p1} \\ & c_2 & V_{p2} \\ & \vdots & \vdots \\ & c_n, & V_{pn} \end{bmatrix} = \begin{bmatrix} N & c_1 & \langle a_{p1}, b_{p1} \rangle \\ & c_2 & \langle a_{p2}, b_{p2} \rangle \\ & \vdots & \vdots \\ & c_n, & \langle a_{pn}, b_{pn} \rangle \end{bmatrix} \tag{3}$$

Where, V_{01}, V_{02}, ... V_{0n} are the ranges of the values taken by c_1, c_2, ... c_n, respectively, namely the joint domain of N.
Marks as:

$$R = \langle a_{pi}, b_{pi} \rangle (i = 1,2 \cdots n) \tag{4}$$

For the object N to be identified, the measurement result is represented by the following matter-element:

$$R_0 = (N, C, V) = \begin{bmatrix} N & c_1 & V_1 \\ & c_2 & V_2 \\ & \vdots & \vdots \\ & c_n , & V_n \end{bmatrix} \tag{5}$$

The second step, based on the definition of distance, establishes the correlation function and calculates the value of the correlation function. The correlation function value is calculated according to the following correlation function:

$$K_i = (V_i) = \begin{cases} \dfrac{-\rho(V_i, V_{0i})}{|V_{0i}|}, V_i \in V_{0i}, \quad 且\rho(V_i, V_{\rho i}) =, V_i \in V_{0i}, \quad 且\rho(V_i, V_{0i}) \\ \dfrac{\rho(V_i, V_{0i})}{\rho(V_i, V_{\rho i}) - \rho(V_i, V_{0i})}, \quad V_i \notin V_{0i} \end{cases} \tag{6}$$

2.2 Selection of financial indicators of chemical companies

The paper builds an evaluation model for the sustainable development ability of small and medium-sized chemical companies in China. Therefore, this paper mainly selects chemical companies listed in the domestic chemical stocks of the Shanghai and Shenzhen stock markets as research groups, and determines the primary indicators of the research samples (Klein et al. 2001).

Table 1: Research sample summary table

Code	Name	Code	Name
SH600747	Sopo	SH600726	Jacques ST
SH600635	Three love rich	SH600359	Swords stock
SH600377	Joint-stock shares	SH600470	Le Tong shares
SH600092	ST Ming Department	SH600221	Rainbow refinement
SH600265	De Federation group	SH600289	Medium - nuclear titanium white
SZ002653	Zan Yu ST	SZ002654	Annada

2.3 Selection of non-financial indicators of chemical companies

In the selection of non-financial indicators, the paper has found 32 subjects to conduct interviews. The level of education and age of the subjects are shown in Table 2 (Sharma and Ruckenstein, 1986).

Table 2: Survey and age distribution table for interviewees

Educational background distribution				
Education	Undergraduate	Master	Doctor	
Number of people	15	10	7	
Percentage	47	31%	22%	
Age distribution				
Age	20~30	30~40	40~50	50~60
Number of people	3	10	13	6
Percentage	9%	31%	41%	19%

Table 3: Non financial indicators for sustainable development capacity

HSE management ability	Level of safety management
	Technical personnel ratio
	Environmental friendliness
R & D capability	Undergraduate and above staff ratio
	Ratio of R & D input to operating income
Social responsibility	Absorb the number of employment
	Corporate reputation

Chemical companies need to have a high level of science and technology. The R&D ability in the enterprise is crucial to the development of the company. At the same time, most small and medium-sized chemical companies are limited by the size of the industry, and it is difficult for them to implement diversified production. In product production, they often concentrate their strength on the breakthrough of a single aspect and expect to occupy a relatively larger market share. All enterprise exists in the society, which is a large group, and this requires that these companies must have a sense of community and mission. It is no exception for small and medium-sized chemical companies. While developing, they will inevitably take responsibilities for social development and contribute to social progress as well.

3. Analysis of enterprise sustainable development ability

3.1 Analysis model of enterprise development ability based on dissipative structure theory

According to the dissipative structure theory, open development is a precondition for achieving system ordering and a prerequisite for the formation, maintenance and development of the entire dissipative structure system (Miehls et al., 2009). Through the open development and the introduction of negative entropy flow from the outside, the internal positive entropy is offset and the system is transformed into a higher order form (Chen et al 1994). Combining this model to select statistical data (Li et al., 1999), the obtained data processing results are shown in Table 4.

Table 4: Dissipative structure model for sustainable development capacity of small and medium sized chemical enterprises

Positive entropy	Enterprise structure entropy	Speed ratio	Negative entropy	Direct environmental entropy	net asset value per share
		Asset liability ratio			Technical personnel ratio
		Equity Turnover			Undergraduate and above staff ratio
	Intrinsic ability entropy	Net profit of total assets		Indirect environmental entropy	Level of safety management
		Growth rate of main business income			Corporate reputation
	Enterprise growth entropy	Total asset growth rate			
		Net profit growth rate			

In this paper, we choose the interval entropy method to determine the weight, and the calculation steps of the interval entropy method are as follows:

$$X_{ij} = \frac{x_{\max} - x_i}{x_{\max} - x_{\min}} \tag{7}$$

$$X_{ij} = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \tag{8}$$

Where, x_{ij} is the normalized value, it is the normalized value of x_i, x_{min} is the minimum value of this indicator data, and x_{max} is the maximum value of this indicator data.

(1) According to the positive entropy indicator, the proportion of each indicator in Table 4 is calculated as:

$$f_{aij} = \frac{x_{\max} - x_i}{\sum_{j=1}^{33} x_{ij}} (i = 1,2 \cdots 13)$$

(2) Set H_j as the entropy value of the j-th positive entropy indicator, there is:

$$H_{ai} = -k\sum_{j=1}^{33} f_{aij} \times \ln f_{aij}$$

$$k = \frac{1}{\ln 33}$$

(3) The weight of the j-th negative entropy indicator is:

$$w_{bj} = \frac{1/(1-H_{bj})}{\sum_{j=1}^{33} 1/(1-H_{bj})}$$

According to the above steps, the entropy values of each indicator and the calculation results of the weights are shown as Table 5.

Table 5: Entropy value and weight table

index			Entropy	weight
Positive entropy 0.88742	Enterprise structure entropy	Motion ratio	0.77637	0.27651
		Asset liability ratio	0.96145	0.04148
	Intrinsic ability entropy	Net profit of total assets	0.97062	0.03621
		Growth rate of main business income	0.97338	0.03276
		Earnings per share	0.96303	0.04553
	Enterprise growth entropy	Net cash flow of per share investment activity	0.97577	0.16438
Negative entropy 1.53504	Direct environmental entropy	Technical personnel ratio	1.55006	0.12932
		Undergraduate and above staff ratio	1.49591	0.11661
	Indirect environmental entropy	Level of safety management	1.57771	0.13583
		Corporate reputation	1.48048	0.12851

Based on the above information, we can see that China's small and medium-sized chemical companies have not yet reached a sustainable development status. Summarizing all kinds of situations, we can know that, the core issues that have caused slow low-carbon sustainable development of China's small and medium-sized chemical companies include following aspects: SMEs generally have poor corporate profits, most of them are slow in develop speed, underwent free develop, or separated from the capital market, they invested less in research and development of innovative products, did not pay enough attention to the introduction of talents, their lack of environmental protection awareness led to great pollution, and their corporate credibility was low. The conclusions obtained from the research results of this paper have certain reference value for the development of small and medium-sized chemical companies. The obtained results reflected the greater applicability of the evaluation model adopted by the research, and reflected the actual situation faced by the companies.

Combined with the research conclusions of this paper, for various types of subjective and objective factors that affect the low-carbon sustainable development of China's small and medium-sized chemical companies, companies should improve their profitability, improve their growth speed, actively and steadily make use of the capital market, and enhance their R&D abilities, pay attention to human resources, increase investment in environmental protection, and improve corporate reputation, etc., so as to achieve low-carbon sustainable development of enterprises.

4. Conclusion

The paper first sorted out current corporate sustainable development ability evaluation systems, and then analyzed low-carbon sustainable development of small and medium-sized chemical companies based on the dissipative structure theory and used quantitative analysis methods such as extension technology, entropy method, and Brusselator. Three conclusions are mainly obtained as follows:

(1) The paper adopted the extension technology to screen the key financial indicators, and then constructed the evaluation standard model of low-carbon sustainable development ability of small and medium-sized chemical companies through the dissipative structure theory. A comparative analysis of the data of a number

of small and medium-sized chemical companies listed on the Shanghai and Shenzhen stock markets was conducted. Finally, through the analysis results, it pointed out that the overall development level of China's small and medium-sized chemical companies has not yet reached the standard of low-carbon sustainable development.

(2) During the analysis of the empirical test, this paper found that the comprehensive performance of small and medium-sized chemical companies in China is not ideal enough in eight evaluation indicators. These indicators have become obstacles to the development of SMEs in China, mainly including the following aspects: poor profitability, low capital operation speed, poor management, and lack of development motivation.

(3) In response to the factors constraining the sustainable development of China's small and medium-sized chemical companies, this paper has proposed solutions to promote the low-carbon sustainable development of China's SMEs, mainly including the following seven aspects: improve corporate profitability, accelerate corporate growth, make use of capital market bonus to promote development, increase R&D investment, actively introduce talents, reduce corporate emissions, enhance quality and emphasize business integrity, so as to achieve the goal of low-carbon sustainable development of the company.

References

Chabrier G., Baraffe I., 2000, Theory of low-mass stars and substellar objects, Annual Review of Astronomy and Astrophysics, 38(1), 337-377, DOI: 10.1146/annurev.astro.38.1.337

Chen L.Y., Goldenfeld N., Oono Y., 1994, Renormalization group theory and variational calculations for propagating fronts, Phys Rev E Stat Phys Plasmas Fluids Relat Interdiscip Topics, 49(5), 4502-4511, DOI: 10.1103/physreve.49.4502

Feistl T., Bebi P., Teich M., Bühler Y., Christen M., Thuro K., 2014, Observations and modeling of the braking effect of forests on small and medium avalanches, Journal of Glaciology, 60(219), 124-138, DOI: 10.3189/2014jog13j055

Klein A.H.D.F., Menezes J.T.D., 2001, Beach morphodynamics and profile sequence for a headland bay coast, Journal of Coastal Research, 17(4), 812-835, DOI: 10.4095/128168

Kobayashi C., Umeda H., Nomoto K., Tominaga N., Ohkubo T., 2006, Galactic chemical evolution: carbon through zinc, Astrophysical Journal, 653(2), 1145, DOI: 10.1086/508914

Kruglov V.I., Logvin Y.A., Volkov V.M., 1992, The theory of spiral laser beams in nonlinear media, Optica Acta International Journal of Optics, 39(11), 2277-2291, DOI: 10.1080/09500349214552301

Miehls A.L.J., Mason D.M., Frank K.A., Krause A.E., Peacor S.D., Taylor W.W., 2009, Invasive species impacts on ecosystem structure and function: a comparison of oneida lake, new york, usa, before and after zebra mussel invasion, Ecological Modelling, 220(22), 3194-3209, DOI: 10.1016/j.ecolmodel.2009.07.020

Ohayon R., Soize C., 2012, Advanced computational dissipative structural acoustics and fluid-structure interaction in low-and medium-frequency domains. reduced-order models and uncertainty quantification, International Journal of Aeronautical & Space Sciences, 13(2), 127-153, DOI: 10.5139/ijass.2012.13.2.127

Pohlmann L., Tributsch H., 1993, Hypothesis explaining the activated complex in primary photosynthetic electron transfer as a dissipative structure, Journal of Physical Chemistry, 97(43), 11318-11323. DOI: 10.1021/j100145a033

Sharma A., Ruckenstein E., 1986, An analytical nonlinear theory of thin film rupture and its application to wetting films, Journal of Colloid & Interface Science, 113(2), 456-479, DOI: /10.1016/0021-9797(86)90181-5

Soukoulis C.M., Wegener M., 2011, Past achievements and future challenges in the development of three-dimensional photonic metamaterials, Nature Photonics, 5(9), 523-530, DOI: 10.1038/nphoton.2011.154

Vezenov D.V., Noy A., And L.F.R., Lieber C.M., 1997, Force titrations and ionization state sensitive imaging of functional groups in aqueous solutions by chemical force microscopy, Journal of the American Chemical Society, 119(119), 2006-2015, DOI: 10.1021/ja963375m

Yi Z., Micha D.A., Sund J., 1999, Density matrix theory and calculations of nonlinear yields of co photodesorbed from cu(001) by light pulses, Journal of Chemical Physics, 110(21), 10562-10575, DOI: 10.1063/1.478988