OPEN ACCESS
EURASIA Journal of Mathematics Science and Technology Education
ISSN: 1305-8223 (online) 1305-8215 (print)
2017 13(8):5233-5245
DOI: 10.12973/eurasia.2017.00997a

Research on the Differences of Ecological Efficiency of Low-carbon M&A among Enterprises under the Education of Ecological Civilization

Man-Wen Tian
School of Business, Lishui University, Lishui, Zhejiang, China
Shu-Rong Yan
College of medicine and health, Lishui University, Lishui, Zhejiang, China
Hui Peng
School of Economics and Management, Shenyang ligong University, Shenyang, China

Received 12 May 2017 ▪ Revised 25 July 2017 ▪ Accepted 11 August 2017

ABSTRACT
Environmental education has a substantial impact on the behavior and performance of mergers and acquisitions. Low-carbon M&A is a new mode of mergers and acquisitions under the education of ecological civilization. This paper first analyses the improvement of ecological efficiency of low-carbon M&A in different regions and industries in China, but there are significant differences in the improvement of environmental efficiency in different regions and industries. The higher efficiency industries are mainly distributed in the capital-intensive industries, followed by labor-intensive industries, while the resource intensive industries are the lowest. The cleaner production industries are significantly higher than the pollution intensive industries. The main reason is that there are significant industrial differences in environmental education, energy structure and low-carbon technology. Regional environmental efficiency is higher in the Yangtze River Delta, followed by the Pearl River Delta, the Circum-Bohai-Sea Region, the worst. The main reason is that there are regional differences in environmental education investment, resource endowment, government intervention, marketization level, environmental policy and ecological civilization education system. Increasing investment in environmental education is one of the key means of improving ecological performance.

Keywords: environmental education, enterprises low-carbon M&A, evaluation of ecological efficiency

INTRODUCTION

With the rapid development of China's economy and society, the production capacity has been continuously improved and the scale has been continuously expanded, resulting in excessive use of many natural resources and deteriorating ecological environment. In the face of increasingly serious environmental problems, it is urgent to strengthen the ecological civilization education, enhance the awareness of conservatives, environmental protection awareness, ecological consciousness, popularize the knowledge and skills of environmental protection, cultivate environmental protection talents, create a good atmosphere of cherishing the ecological environment, and it is a

Correspondence: Shu-Rong Yan, *College of medicine and health, Lishui University, Lishui, Zhejiang, China.*
yansr628@163.com

State of the literature

- The paradigm of existing literatures is mainly established on the background of extensive mode of economic development which does not conform to the requirements of ecological civilization education.
- There are no literatures about low-carbon M&A in academia. The article will for the first time explore ecological benefits evaluation of low-carbon M&A, make a comparison for different regions and industries.

Contribution of this paper to the literature

- For the first time, this paper puts forward the new model of low-carbon M&A based on environmental protection under the background of ecological civilization education, and designs the ecological efficiency evaluation method of low-carbon M&A.
- The DEA differential evaluation model was first constructed to empirically study the impact of environmental education on the ecological efficiency of low-carbon mergers and acquisitions in different regions and industries in China.

strategic measure of Chinese ecological civilization construction so as to solve environmental problems and achieve sustainable development by means of ecological civilization education.

Transforming economic development mode, speeding up ecological civilization education and constructing "a beautiful China" are strategic objectives of economic development stipulated by the government of China in a new normal circumstance. During the process of promoting ecological civilization education on a large scale, enterprises in different industries and economic zones will carry out economic transition, turning extensive mode of economic development featuring high input, high consumption, high pollution and low technical content to the road of ecological civilization development featuring energy saving, emission reduction, and environmental protection, with increasingly strong energy constraint, growing rigidity of carbon emission reduction, and increasingly intensive protection of ecological environment, and corporate social responsibility and value orientation are being greatly altered. In reality, enterprises are facing rigid national constraint in carbon emission index, and carbon sink becomes a rare resource for many enterprises to sustain operation, so all industries and regional enterprises will actively consider low-carbon factors to improve operational environment in M&A. low-carbon M&A pattern based on low-carbon technical integration and in pursuit of ecological synergistic effect will gradually take shape. However, in the actual operational process, obvious differences exist in environmental education level, capital operation mode, economic structure, industrial competitiveness, energy consumption structure and low-carbon technical level in different industries, so low-carbon technical advancement, economic structure and energy consumption structure are outstanding factors influencing energy efficiency in China, and will further significantly influence the ecological efficiency of low-carbon M&A. Are there any industrial differences in ecological efficiency of low-carbon M&A under the current background of ecological civilization? How do industrial features exert a substantial influence on ecological efficiency of low-carbon M&A? These new projects need to be addressed in the study of low-carbon M&A (TIAN Manwen,2014). Meanwhile, China has obvious regional economic features; great differences exist in economic development level, natural conditions and resource endowment conditions, governmental involvement intensity, marketization level and openness degree, industrial structure, environmental policy and systems etc. Different places in China are stipulating and carrying out different systems of ecological civilization education, which will clearly influence efficiency of low-carbon M&A, so there exist regional differences in ecological efficiency of low-carbon M&A in theory. Are there any obvious regional differences in reality? How do different economic regional features substantially influence ecological efficiency of low-carbon M&A? It is another important project that needs an answer in the study of efficiency of low-carbon M&A.

It is a pity that there has been any complete theoretical system and empirical analysis framework in academia according to existing literatures, but such paradigm is mainly established on the background of extensive mode of economic development which does not conform to the requirements of ecological civilization education.

Under the backdrop of ecological civilization education, fundamental changes have taken place in corporate environmental responsibilities and value orientations, corporate environmental responsibilities have become a heated topic for current government, enterprises and residents, so profound changes will take place in corporate M&A motivation, mode and efficiency evaluation system, which need a set of suitable empirical analysis framework to meet the requirements of ecological civilization education. How to break the restriction that only emphasized economic efficiency evaluation of M&A, establish a new standard for evaluation of low-carbon M&A efficiency from the strategic height of ecological civilization education, bring resources consumption, environmental damage and ecological benefits into ecological efficiency evaluation system of low-carbon M&A, and review and objectively evaluate ecological efficiency of low-carbon M&A becomes a new project of M&A efficiency evaluation in ecological civilization education. However, there are no literatures in low-carbon M&A in academia. The article will for the first time explore ecological benefits evaluation of low-carbon M&A, make a comparison for different regions and industries, and construct EDA model for the first time from the perspectives of resources consumption, environmental damage, low-carbon technology and environmental management etc. which will be used to further study low-carbon M&A models and ecological efficiency evaluation in ecological civilization education. In so doing, it will open up new fields in M&A efficiency studies in theory, and promote a new development of M&A efficiency theory, with a significant theoretical value; it can guide enterprises to draw up the optimum low-carbon M&A strategy to enhance M&A ecological benefits and advance ecological civilization education level, and fill the gap in study of M&A field, with an important practical application value.

METHODS

New Concept of Low-Carbon M&A Model under Ecological Civilization Education

Under the background of ecological civilization education, great changes have taken place in connotation of corporate M&A, enterprises are facing increasingly serious carbon emission and energy constraint, and low-carbon M&A based on low-carbon technical integration, in pursuit of ecological synergistic effect and promoting ecological civilization education will become a new model of M&A market and gradually become the mainstream. Low-carbon M&A is a new kind of M&A model in low-carbon economic transition, whose core thought and value standard are demonstrated in complying with the requirements of ecological civilization and low-carbon economic development, advancing low-carbon green development and promoting energy production and consumption revolution. Green technical advancement featuring energy saving, carbon emission reduction and using production factors to its utmost works as the principal lien of ecological civilization education to effectively reduce energy input and carbon emission by integration of low-carbon M&A of enterprises, or M&A with ecological civilization education as its orientation are increasingly centered in industries and enterprises with more energy saving, less carbon emission and faster technical advancement, with a constant increase of value and ecological benefits of both sides, to realize improvement of resource allocation and Pareto Optimality. Therefore, low-carbon M&A from the perspective of ecological civilization education endows M&A with new connotation, and profound changes will take place in M&A motivation and model, which will enormously promote development of low-carbon economy and the process of ecological civilization education. Therefore, low-carbon M&A model and efficiency evaluation from the perspective becomes a heated new project in academia (Tian Manwen, 2014; Wang Peng, 2017).

Construction of Ecological Efficiency DEA Model

Up to now, the most typical DEA models mainly include CCR model and BCC model (Ma Zhanxin, 2010; Liu Zhenling, 2017). Based on DEA rationale, by means of a comprehensive analysis of input and output data, we can obtain the quantity index of comprehensive valid of every DMU, rate all DMU in order, determine whether all DMU are DEA valid, and point out the reasons of other DMU non-DEA inefficiency, improvement orientation and degree. Suppose the model has n decision units, every decision unit has m kinds of input (refers to "resource "consumption of the decision unit) and s kinds of output (refers to economic output after decision unit consumes resources), X_{ij} and Y_{rj} respectively stand for i input and r output in j decision unit DMUj, v_i is weight coefficient of i input index, and u_r is weight coefficient of i output index (Ma Yufang, et al., 2012), shown as:

$x_j = (x_{1j}, x_{2j}, \dots, x_{mj},)^T$; $y_j = (y_{1j}, y_{2j}, \dots, y_{sj},)^T$; $v = (v_1, v_2, \dots, v_m,)^T$; $u = (u_1, u_2, \dots, u_s,)^T$;

of which $i = 1, 2, \dots, m$; $r = 1, 2, \dots, s$; $j = 1, 2, \dots, n$. For weight coefficient $\in E^m$, $\omega = tv$ and $u \in E^s$, u = tu, efficiency evaluation index of decision unit j is: $h_j = \sum_{r=1}^{s} u_r y_{rj} \Big/ \sum_{i=1}^{m} v_i x_{ij}$. We select proper weight coefficient v and u, and get $h_j \le 1, j = 1, 2, \dots, n$. When we evaluate efficiency of j_0(1≤j_0≤n) decision unit, we take weight coefficient v and u as variables, with efficiency index of j_0 decision unit as an object, with efficiency index $h_j \le 1, j = 1, 2, \dots, n$ of all decision units as a constraint, and get following linear programming CCR model：

$$(P_{C^2R}) = \begin{cases} \max u^T y_{j_0} = v_p, \\ \text{s.t.}\ \omega^T x_j - u^T y_j \ge 0, j = 1, 2, \dots, n, \\ \omega^T x_{j_0} = 1, \\ \omega \ge 0, u \ge 0. \end{cases} \tag{1}$$

If linear programming (*PCCR*) has the optimal solution ω^0, and u^{0}satisfies $V_P = u^{0T} y_{j0} = 1$, decision unit j_0 will be weak DEA valid. If the optimal solution contains $\omega^0 > 0$, and u^0>0 satisfies $V_P = u^{0T} y_{j0} = 1$, decision unit j_0 will be DEA valid (*CCR*).

It is not easy to judge whether a decision unit is valid in actual application. To make application of CCR model easier and more practical, we introduce non-Archimedean to construction a mathematic model of judging DEA validity. We make ε as non-Archimedean less than any positive number and more than 0, and get following CCR model (WANG Keliang, et al., 2011):

$$(P_\varepsilon) = \begin{cases} \max u^T y_0 = v_{p_\varepsilon}, \\ s.t. \omega^T x_j - u^T y_j \ge 0, j = 1, 2, \dots, n, \\ \omega^T x_0 = 1, \\ \omega \ge \varepsilon \hat{e}, u \ge \varepsilon e. \end{cases}$$

whose dual problem is:

$$(D_\varepsilon) = \begin{cases} \min[\theta - \varepsilon(\hat{e}^T s^- + e^T s^+)] = v_{D_\varepsilon}, \\ s.t. \sum_{j=1}^{n} x_j \lambda_j + s^- = \theta x_0, \\ \sum_{j=1}^{n} y_j \lambda_j - s^+ = y_0, \\ \lambda_j \ge 0, s^- \ge 0, s^+ \ge 0, j = 1,2, \dots, n. \end{cases} \tag{2}$$

of which is $e^T = (1, 1, \dots, 1)$ m vector quantity, $e^T = (1, 1, \dots, 1)$ is p vector quantity; slack variable $(s_1^+, s_2^+, \dots, s_m^+)$; $S^- = (s_1^-, s_2^-, \dots, s_m^-)$, θ stands for relative number DMUj, the total value of efficiency, and $0 \le \theta \le 1$.

In the above model, suppose optimal solution of linear programming is $\lambda^0, s^{-0}, s^{+0}, \theta^0$. If $\theta^0 = 1$, and $s^{-0} = 0$, $s^{+0} = 0$, decision unit is DEA valid, and technology and scale reach a valid status, it demonstrates that efficiency of resources allocation becomes optimal, input factors are the best combination, output scale is at its best, and resources are fully used. If $\theta^0 = 1$, and at least there is one s_i^{0-} more than 0 or s_r^{0+} more than 0, decision unit is weak DEA valid, which means that technical efficiency and scale efficiency do not achieve the optimal efficiency at the same time. Specifically speaking, s_i^{0-} more than 0 means that s_i^{0-} resources are not fully employed in i resource input while s_r^{0+} more than 0 shows that there exist s_r^{0+} insufficiency between r output scale and the biggest scale, and output scale is not up to optimal efficiency (Yang Hongjuan, Guo Binbin,2010). On the contrary, if θ<0, decision unit DMUj is not DEA valid, which shows that technical efficiency and scale efficiency of resources allocation are not optimal, namely efficiency of resources allocation is low.

Data Processing and Variables Setting

According to features of low-carbon M&A, we select 17 industries and three economic zones, Yangtze River Delta, Pearl River Delta and Circum-Bohai Sea, and take low-carbon listed companies in 2010 as samples, selecting 2009-2013 financial data and data in energy consumption and environmental pollution. These data come from CSMAR database of Shenzhen GTA, of which data in energy consumption and environmental pollution come from Environmental Report, Yearly Report, Corporate Social Responsibility Report and Sustainable Development Report released by listed companies, see http://www.cninfo.com.cn and websites of other companies.

When ecological efficiency of low-carbon M&A is studied from the perspective of ecological civilization education, the first question confronting us is how to measure ecological benefits and low-carbon economic development. According to the connotation of low-carbon economy in pursuit of low energy consumption, low carbon emission and low pollution as well as advocating green technical advancement, in reference to the practice of Yue Shujing, we adopt DEA (Data Envelopment Analysis)-based green TFP(Total Factor Productivity) index including energy consumption and carbon emission factors(Yue shujing, 2011). This is the object that evaluation of ecological benefits pursues, so ecological benefits evaluation DEA model is constructed, in accordance with index system of ecological benefits evaluation, in combination with the principle of comprehensiveness, representativeness, scientificity and availability.

(1) Input index. The selected input indexes are energy consumption and carbon emission as well as input of capital and labor. There are no official statistical data of energy consumption and carbon emission of listed companies in China, so we obtain the data by inquiring all kinds of relevant reports released by listed companies and making comprehensive sorting. For energy consumption, we adopt yearly consumption in coal, crude oil and gas of listed companies as main energy input, represented by the number of 10 thousand standard coals consumed by listed company every year. We use the consumption amount of coal, crude oil and gas to multiply corresponding carbon emission coefficient to evaluate carbon emission of all companies. Capital input is represented by yearly investment total of listed companies, and replaced by total operation cost in view of availability of data. Calculation of labor input can be represented by the ratio of yearly average employees in every 10 thousand people. However, it is rare for listed companies to disclose the yearly number of employees, and employees have a direct influence on corporate scale and total asset, in view of availability of data, we adopt total asset as input index to investigate improvement on efficiency of resources allocation after M&A of listed companies.

(2) Output index. Output index of ecological benefits mainly reflect economic value of low-carbon products or services after listed companies carried out M&A, so it is to select total benefits and income of major businesses disclosed by listed companies as output index.

The article, based above DEA model, makes an analysis of low-carbon M&A samples in terms of their comprehensive scores of M&A performances in the years before and after M&A, takes into consideration various factors influencing performance of the year M&A was carried out, disregards low-carbon performance change of that year to get a clear picture of measurement of M&A performances, compares mean values of ecological benefits two years before M&A and three years after M&A to construct DEA difference evaluation model for performance evaluation of low-carbon M&A, and further explores improvement on ecological efficiency resulting from low-carbon M&A, with certain originality.

RESULTS

Comparison of Ecological Efficiencies of Low-Carbon M&A in Different Industries

According to obvious differences and features of different industries in resources, capital and labor factor intensity, we group low-carbon samples into resource-intensive, labor-intensive and capital intensive (including technology-intensive) categories. Meanwhile, we take into account major features of industrial enterprises with

Table 1. Classification of industries with different factors intensity and intensity of industrial pollution discharge

industries of different factor intensity			intensity of industrial pollution discharge	
capital-intensive	**labor-intensive**	**resource-intensive**	**pollution-intensive**	**clean production industry**
Steel	textile and garment	coal	steel	information equipment
nonferrous metals	light manufacture	agrotechny	nonferrous	textile and garment
chemical industry	commercial trade	electricity	chemical industry	light manufacture
Building materials		Food and beverage	building materials	commercial trade
mechanical equipment			electron	real estate
real estate			mechanical equipment	electrical equipment
Electronics			coal	agrotechny
Pharmaceutical			electricity	food and beverage
information equipment				pharmaceutical

Note: materials come from calculation of 2005-2013 average industrial pollution discharge

Table 2. Calculation of ecological efficiency of low-carbon M&A in different industries

industrial mean value	2008	2009	2010	2011	2012	2013
steel	0.844	0.794	0.884	0.837	0.816	0.826
coal	0.876	0.893	0.907	0.857	0.813	0.868
nonferrous metals	0.778	0.786	0.790	0.805	0.777	0.816
chemical industry	0.774	0.728	0.792	0.797	0.745	0.852
electricity	0.617	0.650	0.757	0.689	0.745	0.786
pharmaceutical	0.877	0.929	0.914	0.844	0.916	0.934
information equipment	0.839	0.893	0.906	0.877	0.857	0.856
commercial trade	0.703	0.800	0.732	0.732	0.791	0.851
industrial entirety	0.750	0.787	0.848	0.804	0.798	0.847

high pollution emission, and divide them into pollution-intensive industry and clean production industry according to intensity of industrial pollution discharge (Tian Manwen,2009; Lin Jingwen, 2017), shown as **Table 1**.

Ecological efficiency of low-carbon M&A lies in investigating whether carbon emission has been controlled after M&A, energy saving and carbon emission reduction have been greatly improved, and environmental efficiency has been enhanced, so we select DEA model with the smallest carbon emission in DEA models. We make use of MAXDEA6.3 software to conduct data envelopment analysis of low-carbon M&A data in 17 industries, whose partial results shown as **Table 2**.

It can be seen from **Table 2** that ecological efficiency of low-carbon M&A in 17 industries as a whole has improved to some degree, total industrial average performance After M&A reaches 0.816333, a great increase compared with 0.7685 before M&A. However, technical efficiency, pure technical efficiency and scale efficiency are not high on the whole in ecological efficiency of various industries. This shows that in the transition of ecological civilization education, Chinese industries are all actively carrying out low-carbon M&A policy, trying to turn economic development mode to intensive development mode, but such transition is not complete in current stage, its transitional process is very difficult and long, and most industries still depend on extensive development mode featuring typical high input, high consumption and high pollution. We still have a long way to improve ecological efficiency in the long run. Great differences of ecological efficiency exist among industries, and for above-mentioned three kinds of factor intensive industries, industry with high efficiency is located in capital intensive

Table 3. DEA difference evaluation model for performance evaluation of low-carbon M&A in different industries

mean value of DEA difference evaluation	S_{2011}-S_{2009}	S_{2011}-S_{2008}	S_{2012}-S_{2009}	S_{2012}-S_{2008}	S_{2013}-S_{2009}	S_{2013}-S_{2008}	S_1-S_2	N_1-N_2	sample
steel	0.044	-0.007	0.022	-0.028	0.032	-0.018	0.007	0.000	7
coal	-0.035	-0.019	-0.080	-0.063	-0.025	-0.009	-0.039	-0.500	4
nonferrous metals	0.018	0.027	-0.009	0.000	0.030	0.039	0.018	0.000	7
chemical industry	0.070	0.023	0.018	-0.029	0.125	0.078	0.047	-0.333	5
building materials	0.069	0.105	-0.058	-0.022	0.040	0.075	0.035	0.333	4
mechanical equipment	-0.033	-0.052	-0.050	-0.069	0.030	0.011	-0.027	-0.167	6
agrotechny	0.033	0.173	0.023	0.164	0.123	0.263	0.130	0.000	3
textile and garment	0.130	0.278	0.126	0.274	0.148	0.295	0.208	0.667	3
real estate	0.061	0.108	0.102	0.149	0.049	0.096	0.094	0.500	6
appliances	0.053	0.033	0.138	0.118	0.156	0.136	0.106	1.167	3
electron	0.055	0.047	0.070	0.062	0.052	0.044	0.055	0.167	3
electricity	0.039	0.072	0.096	0.128	0.137	0.169	0.107	0.667	6
light manufacture	-0.027	-0.024	-0.081	-0.077	0.098	0.102	-0.001	-0.167	3
pharmaceutical	-0.085	-0.033	-0.013	0.039	0.005	0.057	-0.005	-0.833	3
information equipment	-0.016	0.038	-0.035	0.019	-0.037	0.017	-0.002	0.333	6
food and beverage	-0.020	0.116	-0.075	0.062	0.008	0.144	0.039	0.500	3
commercial trade	-0.068	0.029	-0.009	0.088	0.051	0.148	0.040	-0.167	5
industrial entirety	0.017	0.054	0.011	0.048	0.060	0.097	0.048	0.127	77

Note: 1) S stands for DEA score value of ecological performance of low-carbon M&A; 2) S2011-S2009 stands for DEA score difference of the related two years; 3）S1-S2 and N1-N2 represent difference evaluation value of DEA score value and valid number of increment mean value respectively 3 years after M&A and 2 years before M&A.

industry (such as pharmaceutical and information industry) with large industrial scale and high technical barrier, the second labor intensive industry (such as commercial trade), the lowest resource-intensive industry (such as electricity and coal). This is mainly because capital intensive industry has actively enhanced efficiency of capital operation in low-carbon transition to propel industrial transition and upgrading, so ecological efficiency has been greatly improved. However, resource intensive industry such as electricity and coal has focused on extensive development mode in current ecological civilization education transition, with low efficiency of capital operation, leading to enormous consumption of natural resources, serious resource waste and wide environmental damage, so its improvement on ecological efficiency is transient. By further analysis of pollution discharge industry, it can be seen that on the whole clean production industry(such as information equipment, commercial trade and pharmaceutical)improves better in ecological efficiency of low-carbon M&A than pollution intensive industry(such as nonferrous metals, chemical industry and coal), which demonstrates that pollution intensive industry has low industrial concentration in current ecological civilization education, neglects integration of low-carbon technology talents and organization, whose industrial agglomeration effect is not reflected, with insufficient capacity of energy saving and carbon emission reduction, high resources waste and serious environmental pollution, so ecological civilization education are faced with serious situation.

Meanwhile, we take into consideration various factors influencing performance of the year M&A was carried out, disregards low-carbon performance change of that year to get a clear picture of measurement of M&A performances, compares mean values of ecological benefits two years before M&A and three years after M&A to construct DEA difference evaluation model for performance evaluation of low-carbon M&A, with the results shown as **Table 3**.

Table 3 more clearly shows, in addition to the influence of complicated factors in the M&A year, there has been a yearly increase of mean value of DEA difference score for various industries before and after M&A, with the highest 0.097 evaluation performance of industrial entirety, M&A mean performance 0.048, 0.127 valid number of increment mean value before M&A and after M&A, which shows implementation of low-carbon M&A has enhanced the capacity of various industries in energy saving and carbon emission reduction on the whole, and ecological efficiency has improved. However, there exists obvious difference in ecological efficiency of industries

and number of DEA valid increment, ecological efficiency of steel, nonferrous metals, chemical industry, building materials and mechanical equipment improves greatly in the short term but gradually decreases later, and it is not obvious for other industries; on average, some industries such as information equipment, food and beverage, building materials, textile and garment, real estate, appliances, electron and electricity are making gradual progress in the number of DEA valid, of which appliances, textile and garment, real estate and food and beverage increase with the fastest speed while steel, nonferrous metals, chemical industry and agricultural products increase with the least speed even minus speed. This shows that, under the background of ecological civilization education, Chinese manufacturing industry has low energy efficiency, with great potential in carbon emission reduction, and energy waste and environmental pollution are still very serious. Pharmaceutical, commercial trade, information industry and textile and garment are comparatively stable in ecological efficiency, with an increase in energy saving and carbon emission reduction as well as fast industrial transition and upgrading (ZHOU Chun-ying et al., 2013). Clean production industry makes an especially great improvement in ecological efficiency while pollution intensive industry keeps it low, so it is a focus of ecological civilization education to speed up ecological transition of pollution intensive industry in future.

Comparison of Difference in Ecological Efficiency of Low-Carbon M&A in Different Economic Regions

Ecological civilization education is an overwhelming trend in future economic construction of China. All regions of China are stipulating practical and strict ecological civilization education system. Enterprises are the main force of ecological civilization education, and enterprises of the whole country are starting to implement low-carbon economic transition. To study the difference in ecological efficiency of low-carbon M&A in different regions, we for the first time divide the whole country into three economic regions according to their features: Yangtze River Delta, Pearl River Delta and Circum-Bohai-Sea Region. Yangtze River Delta includes Shanghai, Zhejiang province and Jiangsu province, Pearl River mainly refers to Guangdong province, and Circum-Bohai-Sea Region includes Beijing, Tianjin, Hebei, Shandong and Liaoning (Tian Manwen, 2009).

Ecological efficiency of low-carbon M&A lies in investigating whether carbon emission has been controlled after M&A, energy saving and carbon emission reduction have been greatly improved, and environmental efficiency has been enhanced, so we select DEA model with the smallest carbon emission in DEA models. We make use of MAXDEA6.3 software to conduct data envelopment analysis of low-carbon M&A data in 3 regions, whose partial results shown as **Table 4**.

Data in **Table 4** shows that ecological efficiency of low-carbon M&A in the three regions keeps a wavelike rise on the whole, ecological M&A performances of most listed companies have risen to some degree, but there is a low improvement in the total ecological performance, and ecological efficiency of M&A needs to be improved. This demonstrates, under the dominance of ecological civilization education, all regions of China are forcefully stipulating and implementing policy of ecological civilization education, which urges most listed companies to keep up with the times and actively implement low-carbon M&A strategy to improve ecological environment. However, from the effect of current low-carbon M&A, all economic regions of China just start low-carbon M&A and ecological civilization education, improvement on ecological performance just takes shape but has a long way, low-carbon economic transition shoulder heavy responsibilities, and ecological civilization education will be a arduous long-term process. By an analysis of different regions, we can find out that there exist obvious differences in ecological M&A performance in the three regions, Yangtze River Delta the highest, Pearl River Delta the second, Circum-Bohai-Sea Region the worst. Circum-Bohai-Sea Region makes the fastest development while Pearl River Delta keeps a downtrend from the perspective of growth speed. We further compare ecological efficiency improvement of low-carbon M&A in the three regions from the perspective of DEA valid and distribution of performance mean value, shown as **Table 5**.

Table 4. Calculation of ecological efficiency of low-carbon M&A in three regions

DMU	2008	2009	2010	2011	2012	2013	Registered region	Three regions
000717	0.842	0.857	0.833	0.805	0.712	0.836	Jiangsu	Yangtze River Delta
002062	0.708	0.813	0.756	0.675	0.779	0.764	Zhejiang	Yangtze River Delta
002075	0.396	0.177	0.837	0.801	0.730	0.810	Jiangsu	Yangtze River Delta
002122	0.737	0.808	0.883	0.718	0.715	1.000	Zhejiang	Yangtze River Delta
600019	1.000	1.000	1.000	1.000	1.000	1.000	Shanghai	Yangtze River Delta
600261	0.553	0.625	0.724	0.620	0.633	0.715	Zhejiang	Yangtze River Delta
600822	0.939	0.923	0.905	0.947	0.918	0.890	Shanghai	Yangtze River Delta
000060	0.980	0.851	0.823	0.867	0.780	0.838	Shenzhen	Pearl River Delta
000063	1.000	0.972	0.929	1.000	0.858	0.833	Shenzhen	Pearl River Delta
000534	0.751	0.713	0.939	1.000	1.000	0.893	Guangdong	Pearl River Delta
000651	1.000	0.994	0.943	1.000	1.000	1.000	Zhuhai	Pearl River Delta
000893	0.488	0.798	0.730	0.656	0.703	0.817	Guangdong	Pearl River Delta
002141	0.525	0.605	0.781	0.598	0.631	0.674	Guangdong	Pearl River Delta
002233	0.624	0.713	0.866	0.729	0.659	0.983	Guangdong	Pearl River Delta
000680	0.821	0.819	0.860	0.796	0.718	0.763	Shandong	Circum-Bohai-Sea Region
000692	0.508	0.627	0.641	0.642	0.625	0.685	Liaoning	Circum-Bohai-Sea Region
000758	0.727	0.763	0.733	0.834	0.795	0.837	Beijing	Circum-Bohai-Sea Region
000958	0.415	0.295	0.752	0.482	0.514	0.625	Hebei	Circum-Bohai-Sea Region
600231	0.863	0.846	0.830	0.774	0.713	0.799	Liaoning	Circum-Bohai-Sea Region
600409	0.705	0.706	0.734	0.761	0.729	0.847	Hebei	Circum-Bohai-Sea Region
600807	0.672	0.358	0.790	0.845	0.777	0.741	Shandong	Circum-Bohai-Sea Region

Table 5. DEA valid and distribution of performance mean value of ecological efficiency of low-carbon M&A

Performance	2008	2009	2010	2011	2012	2013	Sample/ Number
Circum-Bohai-Sea Region low-carbon M&A performance mean value	0.716	0.792	0.839	0.793	0.781	0.827	20
Circum-Bohai-Sea Region DEA valid number	3	2	2	1	1	1	20
Pearl River Delta low-carbon performance mean value	0.836	0.824	0.866	0.847	0.830	0.851	16
Pearl River Delta DEA valid number	7	1	1	1	1	1	16
Yangtze River Delta low-carbon performance mean value	0.779	0.783	0.872	0.833	0.847	0.865	24
Yangtze DEA valid number	3	2	2	2	2	2	24

Table 5 shows the result of ecological performance mean value of low-carbon M&A of listed companies in different regions. Data shows, there exists structural differences in ecological efficiency in the three regions, ecological efficiency of Yangtze River Delta is 0.833,0.847 and 0.865 in three successive years after M&A, clearly better than 0.779 and 0.783 2 years before M&A, with a big improvement range, and M&A samples number with leading edge of production surpasses those in Pearl River Delta and Circum-Bohai-Sea Region after M&A, which demonstrates that Yangtze River Delta has the highest ecological performance of low-carbon M&A, ecological efficiency in Pear River in the second place, Circum-Bohai-River the worst, whose mean value of ecological performance after M&A are 0.793, 0.781 and 0.827 respectively, much lower than Yangtze River Delta and Pearl River Delta.

Meanwhile, we take into consideration various factors influencing performance of the year M&A was carried out, disregards low-carbon performance change of that year to get a clear picture of measurement of M&A performances, compares mean values of ecological benefits two years before M&A and three years after M&A to construct DEA difference evaluation model for an analysis of performance evaluation of low-carbon M&A in different regions, with the results shown as **Table 6**.

Table 6. DEA difference evaluation model for performance evaluation of low-carbon M&A in the three regions

Performance	S_{2011}-S_{2009}	S_{2011}-S_{2008}	S_{2012}-S_{2009}	S_{2012}-S_{2008}	S_{2013}-S_{2009}	S_{2013}-S_{2008}	S_1-S_2	Sample
Circum-Bohai-Sea Region difference evaluation mean value	0.001	0.077	-0.012	0.065	0.035	0.111	0.046	20
Circum-Bohai-Sea Region DEA valid additions	-1	-2	-1	-2	-1	-2	-1.5	20
Pearl River Delta difference evaluation mean value	0.023	0.011	0.006	-0.006	0.027	0.015	0.013	16
Pearl River Delta DEA valid additions	0	-6	0	-6	0	-6	-3	16
Yangtze River Delta DEA valid additions	0.050	0.055	0.064	0.068	0.082	0.086	0.068	24
Yangtze River Delta DEA valid additions	0	-1	0	-1	0	-1	0	24

Note: 1) S stands for DEA score value of ecological performance of low-carbon M&A; 2) S2011-S2009 stands for DEA score difference of the related two years; 3) S1-S2 represents difference evaluation value of DEA score value 3 years after M&A and 2 years before M&A.

Table 6 shows the result of ecological performance DEA difference evaluation of low-carbon M&A of listed companies in different regions. The analytical results more clearly show, regardless of influence of the complicated factors in the M&A year, there is improvement in DEA difference score before and after M&A in the three regions, with comparatively stable ecological performance after M&A, which indicates that low-carbon M&A is beneficial to improvement of ecological efficiency in the three regions on the whole, with the strengthened capacity of energy saving and carbon emission reduction. However, there exists differences in ecological efficiency in the three regions, mean value of DEA difference evaluation of one year before M&A and one year after M&A in Yangtze River Delta, Pearl River Delta and Circum-Bohai-Sea Region is 0.50,0.023 and 0.001 while mean value of DEA difference evaluation of two years before M&A and three years after M&A in Yangtze River Delta, Pearl River Delta and Circum-Bohai-Sea Region is 0.068,0.013 and 0.046, which demonstrates that Yangtze River Delta has the highest ecological performance of low-carbon M&A, ecological efficiency in Pear River in the second place and in a downturn, Circum-Bohai-Sea the worst but in a fast increase.

DISCUSSION

Obvious differences of ecological efficiency mainly lie in the unique geographic position and resources endowment of different economic regions, especially in obvious regional differences in governmental involvement, marketization level and openness degree, industrial structure and policy system etc., which leads to regional differences in performance and M&A efficiency of listed companies.

Specifically, Yangtze River Delta plays an important role in China. Since inception of opening policy, it has become a region with the strongest economy, the biggest urban agglomeration range and highest openness degree, an important international window to Asian Pacific region, and the most important advanced manufacturing base in the world. It has a huge industrial scale, advanced market economy and convenient transportation, is the biggest economic circle and base for production of export goods in China, with over 20% GDP contribution in China, much higher than average GDP growth level. It is also the developed economic region with the fast economic growth speed and the greatest potential in China. International capital and private capital fast accumulated here is not only growingly big in scale but equipped with its unique forceful dynamics to propel the economic development with a fast speed in the region. As an important center of national economic development, Yangtze River Delta has a better resources endowment, developed economy, especially with high marketization degree, loose policy environment, superior complete system, lower governmental involvement, higher economic development level on the whole, which has become a national window to the outside world, a pilot region to deepen economic reform and a model of national economic development. Therefore, with unique natural advantages and cultural environment, Yangtza River Delta has attracted a lot of enterprises, and listed companies

here can easily give play to advantages in resources and system to conduct M&A, and realize scale effect, spatial agglomeration effect and industrial synergistic effect, which greatly promotes enhancement of M&A performance and improvement on ecological environment. As a result, Yangtze River Delta has become a compact district of low-carbon M&A and a pilot region of ecological environment, taking the lead in improvement on ecological performance.

Pearl River Delta is a coast economic development zone with the earliest opening policy, a window of opening and reform in China, and plays a demonstration effect in economic growth and reform in China, with a significant strategic orientation and profound influence in national economic and social development. The region, with rich scientific resources, becomes the biggest new high-tech center in China. With sustainable economic growth, advanced market economy, outstanding export-oriented economy, intensive resources in capital, technology and talents etc, and preferable policy, together with unique endowment, close to Hong Kong and Macao, radiation to Southeast Asia, as home town of overseas Chinese all over the world, Pearl River Delta becomes a world well-known production base for manufacturing, processing and export, and enterprise clusters and industrial clusters with a world influence take shape in the region. Therefore, Pearl River Delta becomes an active region in M&A, for its preferable policy, loose system, superior resources endowment, high marketization degree, developed economy, and less governmental involvement have attracted a great amount of enterprises to come for low-carbon M&A, to seek integration of low-carbon resources and low-carbon technology and synergistic effect of low-carbon technology, with a good spatial agglomeration effect and ecological environmental effect. However, enterprises in Pearl River Delta have a huge scale and quantity, with a deep marketization degree, mostly adopting extensive development mode, featuring high input, high consumption and high pollution. Under the guidance of low-carbon economic transition and ecological civilization education, enterprises there are under great pressure in low-carbon transition, with huge potential in energy saving and carbon emission reduction and unremarkable ecological efficiency, so there is a long way to go for ecological environmental protection.

Circum-Bohai-Sea Region is located in the heartland of Northeast Asia economic circle, an economic region composed of three economic sub-regions, including Jingjinji Circle, Shandong Peninsula Circle and Liaoning Peninsula Circle. With good cultural environment, strong scientific strength, advantages in talents and resources, various resources such as ocean, minerals, oil, coal and tourism, intensive transportation network, and solid industrial foundation, Circum-Bohai-Sea Region is the biggest industrial nesting zone, production base for heavy industry and chemical industry, and important agricultural base in China. Compared with other regions, Circum-Bohai-Sea Region with outstanding comparative advantages in resources and market has attracted a flood of capitals at home and abroad. With close horizontal integration and complementary advantages, Circum-Bohai-Sea Region becomes an important engine and the third "growth pole" of fast economic development in northern part of China, with municipalities Beijing and Tianjin as the center, coastal open cities such as Dalian, Qingdao, Yantai and Weihai as the sector, and provincial capitals such as Shenyang, Jinan, Taiyuan, Shijiazhuang and Hohhot as the regional pivot, and integrates politics, economy, culture, international exchange and export-oriented, and multifunction to form a dense urban community, playing the role of gathering, radiation, service and demonstration, promoting the concentrated development of feature economy and export-oriented economy in the region, listed by the State Council as one of the key opening development regions. Circum-Bohai-Sea Region becomes an active region in M&A, for its preferable policy, loose system, superior resources endowment, and uprising market economy, have attracted a great amount of enterprises to come for low-carbon M&A, to seek integration of low-carbon resources, give play to resources advantages, realize scale effect, industrial agglomeration effect, and ecological synergistic effect. Therefore, Circum-Bohai-Sea Region has a later-mover advantage for fast growth, though with low ecological efficiency.

However, compared with Yangtze River Delta and Pearl River Delta with relatively mature development, Circum-Bohai-Sea Region has obvious disadvantages in economic development level, marketization degree and governmental involvement, restraining the play of synergistic effect of M&A. Nankai University Circum-Bohai-Sea economic project group draws the basic conclusion: Circum-Bohai-Sea Region has backward operation environment, stronger administrative involvement and weaker capacity of allocation market resources, which leads to the gap in system innovation from Yangtze River Delta and Pearl River Delta. Circum-Bohai-Sea Region has

unreasonable industrial structure and a lot of excellent enterprises, but large-scaled enterprises account for overhigh proportion while there are less mediate and small-sized enterprises, lack of vitality; Circum-Bohai-Sea Region has a proportion of state-owned enterprises higher than that of Yangtze River Delta and Pearl River Delta as well as national average level. Strong local awareness of administrative regional interest bodies and serious barriers of different regions lead to high cost of regional economic coordination, low marketization degree, and unsmooth mobility of factors such as capital, talents and technology. Under such circumstances, Circum-Bohai-Sea Region will surely be restricted by existing conditions to enhance low-carbon M&A efficiency, with unremarkable improvement on ecological efficiency of low-carbon M&A, so we still have a long way to go in this respect. However, Circum-Bohai-Sea Region is facing the fastest development opportunity period in history. With the quickening economic development, further enhancement of marketization level, weakening governmental involvement, and constantly improving policy and system, Circum-Bohai-Sea Region will become an active region for marketization M&A, with fundamental improvement of ecological efficiency as its inexorable trend.

CONCLUSIONS

Low-carbon M&A is a new M&A model in ecological civilization education, whose ecological efficiency status draws the attention of academia. By establishment of DEA model, the article for the first time in China makes analysis of improvement on ecological efficiency of low-carbon M&A in different regions and industries, with originality. The conclusions are as follows:

(1) Under the background of ecological civilization education, there exist outstanding differences in environmental education level, capital operation, economic structure, industrial competitiveness, energy consumption structure and technical level in different industries, which leads to obvious ecological efficiency of low-carbon M&A in different industries. The empirical analysis indicates, different industries improve but keep low in technical efficiency, pure technical efficiency and scale efficiency on ecological efficiency of low-carbon M&A on the whole. Ecological efficiency is very different among different industries. For three kinds of factor intensive industry, highest low-carbon efficiency is mainly distributed in capital intensive industry with large industrial scale and high technical barriers, the second the labor-intensive industry, the last the resources intensive industry. By an analysis of pollution discharge industry, it can be seen that on the whole clean production industry(such as information equipment, commercial trade and pharmaceutical)improves better in ecological efficiency of low-carbon M&A than pollution intensive industry(such as nonferrous metals, chemical industry and coal), which demonstrates that pollution intensive industry has low industrial concentration, with insufficient capacity of energy saving and carbon emission reduction, high resources waste and serious environmental pollution.

(2) Under the promotion of ecological civilization education, Yangtze River Delta, Pearl River Delta and Circum-Bohai-Sea Region have actively implemented low-carbon M&A policy, and kept a wavelike rise momentum in ecological efficiency of low-carbon M&A on the whole, with most listed companies rising in ecological efficiency of M&A, but in general kept a low level in improvement range of overall ecological efficiency. Meanwhile, we find out from an analysis of different regions that there exist obvious differences in ecological efficiency of M&A in the three regions, Yangtze River Delta the highest, Pearl River Delta the second and Circum-Bohai-Sea Region the worst. It can be seen from growth speed that Circum-Bohai-Sea Region develops fastest, Pearl River Delta in a downturn, and Yangtze River Delta keeping improving. Such differences mainly lie in the unique geographic position and resources endowment of different economic regions, especially in obvious regional differences in governmental involvement, marketization level and openness degree, energy consumption structure, environmental policy and ecological civilization education system etc., which leads to regional differences in performance and M&A efficiency of listed companies.

Under the promotion of ecological civilization education, Yangtze River Delta, Pearl River Delta and Circum-Bohai-Sea Region have actively implemented low-carbon M&A policy, and kept a wavelike rise momentum in ecological efficiency of low-carbon M&A on the whole, with most listed companies rising in ecological efficiency of M&A, but in general kept a low level in improvement range of overall ecological efficiency.

Meanwhile, we find out from an analysis of different regions that there exist obvious differences in ecological efficiency of M&A in the three regions, Yangtze River Delta the highest, Pearl River Delta the second and Circum-Bohai-Sea Region the worst. It can be seen from growth speed that Circum-Bohai-Sea Region develops fastest, Pearl River Delta in a downturn, and Yangtze River Delta keeping improving. Such differences mainly lie in the unique geographic position and resources endowment of different economic regions, especially in obvious regional differences in governmental involvement, marketization level and openness degree, energy consumption structure, environmental policy and ecological civilization education system etc., which leads to regional differences in performance and M&A efficiency of listed companies.

ACKNOWLEDGEMENTS

This work was financially supported by the 2017 National Social Science Foundation Item (17CJY072); the 2016 soft science research project of Science and Technology Bureau of LiShui (2016RKX02; 2016RKX03); The public welfare item of Science and Technology Bureau of LiShui (2013JYZB12); The high-level personnel training project in Lishui (2014RC22); The item of social science research of Lishui (LC201465).

REFERENCES

Chun-Ying, Z., & Hong-Qiang, Y. (2013). Industry Difference of Chinese Energy Consumption Efficiency and Energy Conservation Potential. *Journal of Shanxi Finance and Economics University*, (9), 84-93. doi:10.13781/j.cnki.1007-9556.2013.09.003

Hongjuan, Y., & Binbin, G. (2010). The research of performance evaluation of low carbon supply chain based on DEA. *Economic issues exploring*, (9), 33. doi:1672-8561(2010)09-0473-03

Lin, J.-W. (2017). A Cross-Grade Study Validating the Evolutionary Pathway of Student Mental Models in Electric Circuits. *Eurasia Journal of Mathematics Science and Technology Education, 13*(7), 3099-3137. doi:10.12973/eurasia.2017.00707a

Liu, Z. (2017). *China's strategy for the development of renewable energies*. Energy Sources, Part B: Economics, Planning, and Policy, 1-5. doi:10.1080/15567249.2017.1336813

Ma, Y., Gao, H., & Li, Z. (2012). Study on the evaluation performance of merger and acquisition based on model of DEA. *Friends of Accounting*, (2), 30-33. doi:1639-3658(2012)02-0867-05

Ma, Z. (2010). *Data envelopment analysis model and method*. Beijing: Science Press, 21-31.

Manwen, T. (2009). A Comparative Study of M& A Efficiency Based on Different Economic Region and Different Industries. *Finance and Sciences*, (9), 73-81. doi:1000- 8306(2009) 08- 0073- 09

Manwen, T. (2014). A new model of Low-Carbon M&A under the Background of Ecological Civilization. *Enterprise Economy*, (12), 11-15. doi:1006-5024 (2014) 12-0011-05

Manwen, T. (2014). The Economic Efficiency of Enterprise Low-Carbon Mergers and Acquisitions: An Empirical Study from Ecological Civilization Construction Perspective. *Journal of Lishui University*, (4), 25-31. doi:2095-3801(2014)04-0025-07

Peng, W. (2017). Research on Model of Student Engagement in Online Learning. *Eurasia Journal of Mathematics Science and Technology Education*, *13*(7), 2869-2882. doi:10.12973/eurasia.2017.00723a

Shujing, Y. (2011). Study on Capital Allocation Efficiency in a Low Carbon Economy Development Perspective. *Research on Quantitative and technical economics*, (4), 110-122. doi:10.13653/j.cnki.jqte.2011.04.009

WANG Keliang, YANG Baochen, YANG Li (2011). China's Provincial Energy Efficiency Measurement based on DEA and Directional Distance Function, *Chinese Journal of Management*, (3), 456-463. doi:1672-884X(2011)03-0456-08