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Study of Energy Saving and Emission Reduction based on the OLAP Multi-Indicator Relational Model

Y. S. Shen[1], Z. F. Tan[1], X. L. Shen[2], J. J. Bai[2], Q. Z. Li[2,*] and S. Wang[3]

[1]*Department of Technical Economy and Management, North China Electric Power University, Beijing, 102206, China*
[2]*Department of Control and Computer Engineering, North China Electric Power University, Beijing, 102206, China*
[3]*Faculty of Engineering and Applied Science, University of Regina, Regina, SK S4S 0A2, Canada*

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ABSTRACT. The research related to energy-saving and emission-reduction can be helpful in designing the energy-saving development mode. The conventional methods for energy-saving and emission-reduction usually take a long time to estimate the effects under different modes, and their estimations may have many errors with long-term economic and environmental impacts. The environmental protection and economic development are interrelated with each other; a balanced development has to be taken into account synthetically. Since the relationship between economy and environment is complex, this paper studies the effects of the two indicators, and identifies their key impact on achieving energy-saving and emission-reduction. This paper conducts a thorough study on the economic and environmental developments in Beijing based on the OLAP multi-indicator relational model. The relation quantization function can be obtained and the energy-saving and emission-reduction from the perspective of the quantitative multi-indicator relationship can be studied in this study.

Keywords: energy-saving and emission-reduction, multi-indicator relationship, OLAP, coordinated development

1. Introduction

This study creates a multi-indicator relational model based on the On-Line Analysis Processing (OLAP) technology, and uses an example for analyzing the relationship between environmental pollution and economic development system. The model's application is introduced in detail. The OLAP is an information technology, which can conduct single-level dimensional and multi-level dimensional data analysis.

In recent years, there has been a considerable progress in the study on the energy-saving and emission-reduction technology, which mainly includes three aspects: (i) the comprehensive energy-saving and emission-reduction plan has been published, and the research and promotion of the technology have been programmed macroscopically; (ii) The energy-saving technology based on an industrial platform has begun to take shape; (iii) a government-led and business-oriented pattern has been formed (Zhang et al., 2010). Currently, information technology has become a powerful tool for energy-saving and emission-reduction. Many technologies can help to improve resource utilization (Li et al., 2011), to save energy (Fang et al., 2012), to reduce production costs (Schoots et al., 2008), and to create a systematic energy- saving and emission-reduction project (Ouyang et al., 2011). However, few studies focus on using information technology to achieve a balanced development synthetically. Thus it is important to study the effect of the relationship between economy and environment.

To design and build foundation of the models-research platform, this paper studies the relationship of the two systems and selects the system which can reflect its status. In this study, the system of indicators was developed (Shen et al., 2010). The relational model of the research system was transformed into the relationship between the internal multi-indicators of a set of two indicators. A variety of tools and technologies were applied to build the analysis model, including the statistical analysis of the OLAP technology and mathematical tools. This study created a 3E (Energy- Economic-Environ- ment) decision support platform based on the data warehouse which is comprised of of system indicator data (Liu, 2008). The OLAP technology and mathematical statistics analysis tools were integrated in order to provide a solid foundation of the relationship between the building and the research of the model.

To build the analysis model for the multi-indicator relationship based on the OLAP technology and mathematical statistics, the study mainly uses a combination of qualitative constraints and quantitative precise (Zhang, 2010). Data would be preprocessed first. Then the indicator relationship which has obvious influence relations would be filtered out.

* Corresponding author. Tel.: +86 10 61772480; fax: +86 10 61772480.
E-mail address: liqiangzhi1988@126.com (Z. F. Tan).

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At last the correlation matrix came out (Wang, 2010), which would be used for the preparation of further quantitative precise analysis. Based on the analysis of the effects of statistical methods on the relationship between indicators of the correlation matrix, this study provided an accurate quantitative analysis, chose the mathematical statistics with the smallest error, and used the expression of the matrix function to generate the results.

The focus of energy-saving and emission-reduction is the economy effect on both energy and environment (Liu et al., 2012a). In this paper, the effects relationship between economy and environment in Beijing was used as an example to make a detailed introduction of the model application. According to the selection principle of the metadata indicators, a indicator system was chosen to quantify the effect of economic development on energy consumption (Shaligram, 2007).

2. OLAP Multi-Indicator Relational Model

To study the relationship between economy and environment, this paper builds two sets of indicators to describe the economic and environmental systems and analyzes their relationships. Firstly, according to the OLAP technology, this paper studies the impact of all indicators of the economic system set on each indicator of the environmental system set. Secondly, the qualitative analysis on the impact relationship is given in this study. Then, this paper provides the impact relational curves, preprocesses the data, and gives the correlation matrix between the indicators. Finally, this paper uses the statistical method to analyze the indicator value, and provides the quantitative relationship matrix functions (Bouwman, 1983). The specific process is shown in Figure 1.

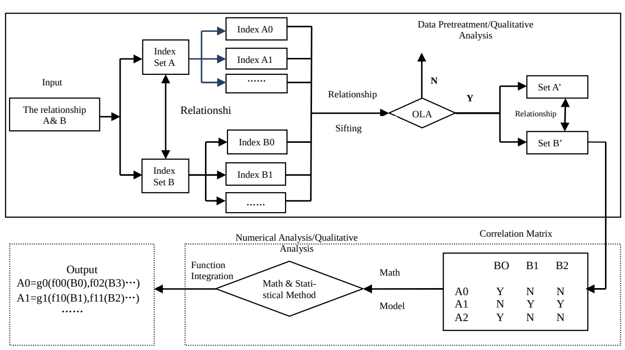

Figure 1. The analysis process chart of multi-indicator relationship.

2.1. Basis of Model Development

To build the OLAP multi-indicator relational model, a variety of tools and techniques were used, including the OLAP technology and mathematical analysis tools such as SPSS (Yin and Liu, 2003) and MATLAB. To study the relationship between economy and environment, this study builds 3E decision support platform which is comprised of 3E data warehouse, various data analysis tools (Wang et al., 2009c), and 3E application study.

2.1.1. Introduction of 3E Decision Support Platform

In this paper, the guiding ideology of building 3E decision support platform includes the focus of the 3E sustainable development (You et al., 2011), the integration of Beijing and China Major cities' 3E indicator data in ten years (Wang et al., 2009b), the OLAP analysis tools, common computing analysis tools, the latest achievement of scientific research, as well as policies and regulations in the recent years. Figure 2 describes the framework of the 3E decision support platform (Wang and Shen, 2009).

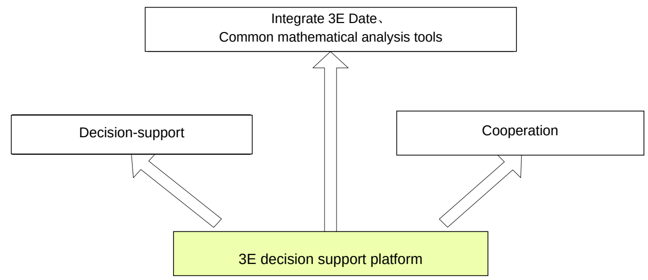

Figure 2. The framework of the 3E decision support platform.

This paper provides a definition for the specific functions of the 3E decision support platform, including the mathematical computation software, the comparative analysis (Liu et al., 2012b), the OLAP analysis, the prediction and warning (Wang et al., 2009a), and the applied research (Wang et al., 2011a). The specific structure functions of the 3E decision support platform are shown in Figure 3.

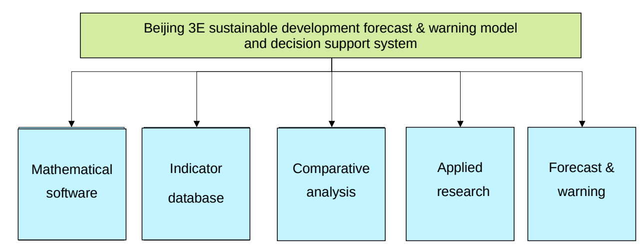

Figure 3. The specific structure functions of 3E decision support platform.

2.1.2. Achievement of OLAP Multi-Indicator Relational Model

The introduction of the indicator relational model in this study is mainly based on the integrated OLAP analysis tool (Yang et al., 2010). This paper uses the OLAP technology to conduct a qualitative analysis on the related indicator, creates SQL-Server Database warehouse (Tony and Mike, 2003), and achieves the pretreatment of the research problem. Moreover, a detailed description of the OLAP technology and the specific implementation process are given which is integrated with the platform. The on-line analysis processing can have level dimensional and multi-level dimensional data analysis (Mike and Tim, 2001). The implementation method of the 3E indicator data relationship can be summarized as the following steps: (i) creating the fact table and the dimension

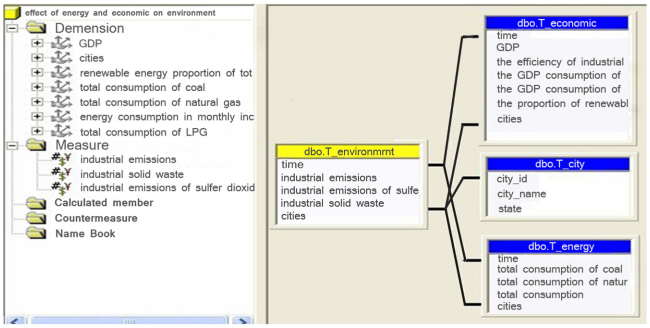

Figure 4. Cubic "the effect of energy and economic on environment" and the map relationship of fact table and dimension table.

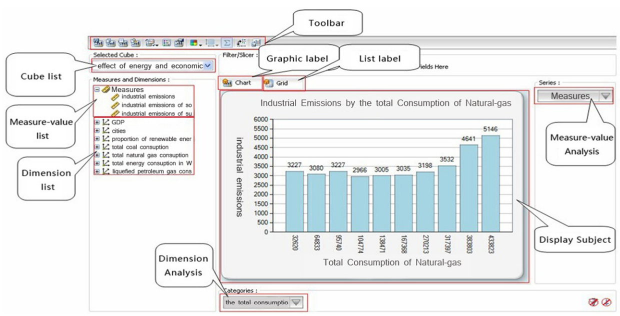

Figure 5. Display of OLAP visualization chart.

table. The fact data represents the numeric data which can be analyzed. It also includes the fact table and the dimension table related to the foreign key. To analyze the relationship of 3E, this study designs the energy, economic and environment as the fact table (Lv et al., 2011), the name of the corresponding indicator is a field and includes the two properties of time and city. For example, to analyze the effect of energy and economy on environment, the environment data is used to analyze the target data, which is called measure value; the data of energy and economic is the condition data used to analyze the target data, which is called dimension. This study creates a fact table related to the environment data and three dimension tables in the database. The built environment table (T-environment), the indicator data of the table is the industrial waste gas emission, SO_2 emission and solid waste emission. The three dimension tables are the economic table (T-economic), the energy dimension table (T-energy) and the city dimension table (T-city). The structure of economic table includes time, city, GDP, per ￥10,000 GDP energy consumption and proportion of the renewable energy of the total energy. The energy dimension table includes time, city, total coal consumption, total liquefied petroleum consumption and total natural gas consumption. The city dimension table includes city logo and city name (Tan et al., 2009); (ii) Creating cube. According to the indicators, total coal consumption, total liquefied petroleum consumption and total natural gas consumption of energy and GDP, 10,000 RMB GDP energy consumption and proportion of the renewable energy of the total energy of the economic may have an effect on the industrial waste gas emission, SO_2 emission and solid waste emission (Wang and Liu, 2011). Thus this study uses the Analysis Services Manager to create six dimensions in the workspace (includng total coal consumption, total liquefied petroleum consumption, total natural gas consumption, GDP, per ￥10,000 GDP energy consumption, and proportion of the renewable energy of the total energy of the economic) and three measure value (including industrial waste gas emission, SO_2 emission and solid waste emission). Thus this study creates the cube cubic "effect of energy and economic on environment" (Ma, 2012), and creates the map between the fact table and the dimension table (Figure 4); (iii) Visualization. This study implements the visualization through the VS.NET BI (Figure 5).

This method divides the multidimensional structure of the multidimensional database into the fact tables and the dimension tables. The fact tables are used to store data and dimensional keywords. The dimensional tables are used to store the level and members of the table and other descriptive information of the dimension table. In the correlation analysis of the regional 3E indicator, the fact table is used to store the target indicator data. The dimension keywords are time and city. The dimension table is used to store the basic indicator data. This study uses the dimension keyword to connect all the links with the fact table, which is called star design.

2.2. Model Construction

2.2.1. Selection of Indicators

To study the relationship between the two systems, this paper selects the indicators that can reflect the status of the system synthetically, and inputs the data to the 3E decision support platform. This paper builds the indicators system according to the following principles. Principle of intergraty: the OLAP technology is used for data preprocessing, which is an intuitive way to remove the relationship that has an unobvious influence among indicators; Principle of science: the construction of the indicator system must be strictly in accordance with the scientific meaning of the development in order to form an organic entirety and reflect the real nature of the development objectively. This study collects the high-quality and reliable data at a reasonable cost. When studying the quantitative relationship between the two systems, this paper selects indicators to form an indicator system, and then uses the selected indicators to form the indicators collection. For example, when studing the relationship between the two systems of A and B, this paper selects the indicator system to construct the indicators matrix of the system:

$$A = (A_1, A_2, A_3, A_4, A_5, \ldots A_i) \tag{1}$$

$$B = (B_1, B_2, B_3, B_4, B_5, \ldots B_j) \tag{2}$$

2.2.2. Process of Qualitative Analysis

This study sets qualitative constraints to the indicator data through the OLAP technology, makes the two system indicator sets A and B have the two-dimensional matrix Cartesian product, and obtains the correlation matrix C, denoted by:

	MeasureLevels
Natural-gas Total Consumption	Industrial Emissions
-----all the Natural-gas Consumption	35,057.00
32620	3,227.00
64833	3,080.00
95740	3,227.00
104774	2,966.00
138471	3,005.00
167368	3,035.00
270213	3,198.00
317397	3,532.00
383803	4,641.00
433823	5,146.00

Figure 6. Data list.

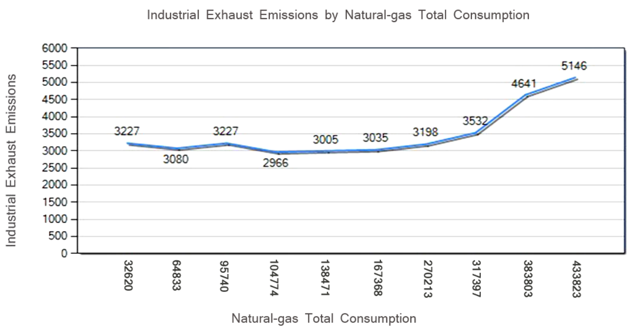

Figure 7. Relationship curve.

Table 1. Correlation Matrix

A	B_0	B_1	B_2	B_3	B_4	B_5	B_j
A_0	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_1	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_2	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_3	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_4	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_5	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
A_i	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N

$$A \times B = C \tag{3}$$

$$C = \begin{Bmatrix} c_{11} & c_{12} & \cdots & c_{1j} \\ c_{21} & c_{22} & \cdots & c_{2j} \\ \vdots & \vdots & & \vdots \\ c_{i1} & c_{i2} & \cdots & c_{ij} \end{Bmatrix} \tag{4}$$

As an element of system B, C_{ij} stands for the degree of the influence of B_j on A_i. The model uses the characteristics of the OLAP technology for the qualitative constraints of the indicator data. As shown in Figures 6 and 7, the use of the OLAP tools gets two indicators data list intuitively and the relationship curve. According to the degree of influence in this figure, a value to the elements in C is given, as shown in Table1. If the impact is significant (denoted as Y) or vague (denoted as N), this paper presents a correlation matrix set C, which makes a preparation for further quantitative accurate analysis.

2.2.3. Quantitative Analysis

To carry out the qualitative constraint analysis of the indicator data with the OLAP technology, the study gives us a research direction. After the pretreatment of the use of the OLAP technology for the indicator data, this study uses statistical methods to carry out a quantitative analysis precisely. This study makes an assumption that the influence function is f_{ij}, and the influence function matrix F is:

$$\mathrm{F} = \begin{Bmatrix} f_{11} & f_{12} & \cdots & f_{1j} \\ f_{21} & f_{22} & \cdots & f_{2j} \\ \vdots & \vdots & & \vdots \\ f_{i1} & f_{i2} & \cdots & f_{ij} \end{Bmatrix} \tag{5}$$

A variety of mathematical models were used in this study. To fit the function by the relationship between the indicators, the smallest error of the mathematical model is selected to obtain the influence function of the relationship between two indicators. This study assumes that the influence weight of different indicators B_j (j = 1, 2, ..., j) for the same indicator A_i is r_{ij}. Each indicator A_i is corresponding to a longitudinal matrix R_i:

$$R_i = \begin{Bmatrix} r_{i1} \\ r_{i2} \\ \cdots \\ r_{ij} \end{Bmatrix} \tag{6}$$

Let matrix R is:

$$R = (R_1, R_2, \ldots, R_i) \tag{7}$$

Let matrix G is:

$$G = F \times R \tag{8}$$

Then, we have:

$$\mathrm{G} = \begin{Bmatrix} g_1 & & \cdots \\ & \mathrm{g}_2 & \\ & \ddots & \\ \vdots & & \mathrm{g}_i \end{Bmatrix} \tag{9}$$

where:

$$g_i = \left(f_{i1}, f_{i2}, \cdots, f_{ij}\right) \begin{Bmatrix} r_{i1} \\ r_{i2} \\ \cdots \\ r_{ij} \end{Bmatrix} = F_i R_i = R_i^T F_i^T \tag{10}$$

g_i is the integrated influence function for all indicators of system B on the indicator A_i of system A.

A detailed description of the application of the model to examples of the environmental protection and the economic development is in the following section.

3. Study of Energy-Saving and Emission-Reduction

Along with the social development and the increasing attention to the sustainable development, the low carbon development has become an effective way to achieve the economic development. Therefore, how to achieve energy-saving and emission- reduction as well as how to develop the economy has become a focus of the research subject. The environmental protection and the economic development are interrelated with each other, it is necessary to take a balanced development into consideration synthetically. Moreover, the indicator relationship between economy and environment is complex, thus this paper studies the effects of these two indicators, and identifies the key impact of indicators in order to achieve energy-saving and emission-reduction. This paper uses an example of the effects of economic development and environment indicators in Beijing.

3.1. Selection of Indicators

The selection of indicators mainly follows two principles: the principles of science and the principle of integrity. The selected indicators system of the economic development and the environment status are shown in Figure 8.

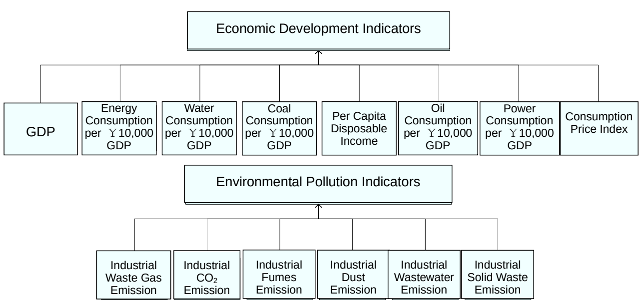

Figure 8. Selected indicators system of economic development and environment status.

Table 2. A_0- Industrial Waste Gas Emission and B_0- Indicator

Year	Regional GDP	Industrial Exhaust Emissions
2001	3707.96	3035.00
2002	4315.00	2966.00
2003	5007.21	3005.00
2004	6033.21	3198.00
2005	6969.52	3532.00
2006	8117.78	3946.00
2007	9846.81	4639.00
2008	10879.00	5146.00

3.2. Model Development

Details of the indicator set $A\{A_0, A_1, A_2, A_3, A_4, A_5\}$ are shown as follows: A {A_0-industrial waste gas emissions, A_1-industrial sulfur dioxide emissions, A_2-industrial smoke emissions, A_3-industrial dust emissions, A_4-industrial wastewater emissions, A_5-industrial solid waste emissions}. Typical economic indicators are selected as a research base, which is called indicators collection B {B_0, B_1, B_2, B_3, B_4, B_5, B_6, B_7}. Details are shown as follows: B {B_0-GDP, B_1-energy consumption per ￥10,000 GDP, B_2-water consumption per ￥10,000 GDP, B_3-coal consumption per ￥10,000 GDP, B_4-disposable income per resident, B_5-oil consumption per ￥10,000 GDP, B_6-resident consumption price index, B_7-power consumption per ￥10,000 GDP (Shen et al., 2012) }.

3.3. Preprocessing of Indicator Data with OLAP

The element indicator C_{00} represents the influence degree of B_0 on A_0, C_{01} represents the influence degree of B_1 on A_0 ... ... C_{57} represent the influence degree of B_7 on A_5.The value of the elements of set C has a significant impact (denoted as Y) or vague impact (denoted as N) (Chen and Wang, 2011). Indicator A_0 (industrial waste gas emission) and indicator B_0 (data of GDP) are shown in Table 2. Because the order of magnitude of different indicator data is relatively different, it is necessary to standardize the data (Stohr et al., 1999). Table 3 provides indicator A_0 and standardized indicator B_0.

Table 3. Indicator A_0- Industrial Waste Gas Emissions and B_0-Standardized Indicator Data of GDP

Year	Regional GDP	Industrial Exhaust Emissions
2001	0.34	0.59
2002	0.40	0.58
2003	0.46	0.58
2004	0.55	0.62
2005	0.64	0.69
2006	0.75	0.77
2007	0.91	0.90
2008	1.00	1.00

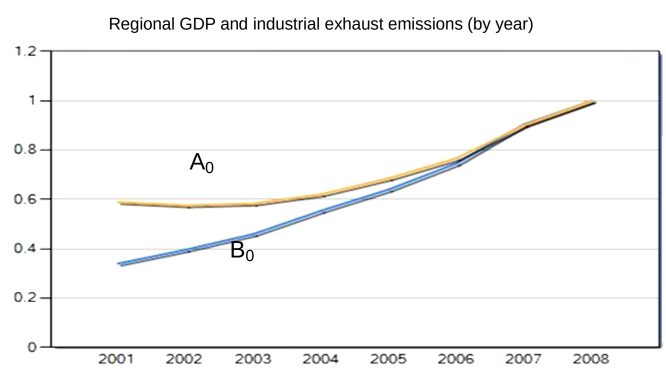

Figure 9. Impacts of GDP (B_0) on Industrial Waste Gas Emission (A_0).

The impact of indicator B_0 on indicator A_0 with OLAP is shown in Figure 9. The impact of the B_0 indicator on A_0 indicator is clear, so the value of COO element is Y. According to this method, the impact matrix is generated in Table 4.

Table 4. Indicator Relationship Matrix

A	B_0	B_1	B_2	B_3	B_4	B_5	B_6	B_7
A_0	Y	Y	N	Y	N	N	N	N
A_1	N	Y	N	Y	N	N	N	N
A_2	N	Y	N	Y	N	N	N	N
A_3	N	Y	N	Y	N	N	N	N
A_4	N	Y	Y	N	N	N	N	N
A_5	N	Y	N	Y	N	N	N	N

Table 5. Description of Mathematical Model

Dependent variable	Industrial Waste Gas Emissions
Equation	MOD_1
1	Linear
2	Logarithm
3	Quadratic
4	Cubic
5	Recombination
6	Power
7	S
8	Increase
9	Exponent
10	Logistic
Independent variable	GDP

In Table 4, the subset of the set C is {C_{00}, C_{01}, C_{03}, C_{11}, C_{13}, C_{21}, C_{23}, C_{31}, C_{33}, C_{41}, C_{42}, C_{51}, C_{53}}. The value of the 14 elements is Y. It shows that the degree of influence of the indicator is significant. This paper uses a mathematical model to further study the indicators.

3.4. Quantitative Analysis of Indicators Relationship

This study assumes that the influence function of indicator B_0 (GDP) on indicator A_0 (industrial waste gas emissions) is f_{01}, namely: $A_0 = f_{01}(B_0)$; the influence function of indicator B_1 (energy consumption per ￥ 10,000 GDP) on indicator A_0 is f_{02}, namely: $A_0 = f_{02}(B_1)$; the influence function of indicator B_3 (coal consumption per ￥ 10000 GDP on indicator A_0 is f_{03}, namely: $A_0 = f_{03}(B_3)$. Let the integrated influence function of indicators B_0, B_1, B_3 on A_0 be g_0, namely: $A_0 = g_0(B_0, B_1, B_3)$. This study brings the relationship function between the two sides into the equation, leading to a functional model as shown below:

$$A_0 = g_0(f_{01}(B_0), f_{02}(B_1), f_{03}(B_3)) \tag{11}$$

$$A_1 = g_1(f_{11}(B_1), f_{12}(B_3)) \tag{12}$$

$$A_2 = g_2(f_{21}(B_1), f_{22}(B_3)) \tag{13}$$

$$A_3 = g_3(\mathrm{f}_{31}(B_1), f_{32}(B_3)) \tag{14}$$

$$A_4 = g_4(f_{41}(B_1), f_{42}(B_2)) \tag{15}$$

$$A_5 = g_5(f_{51}(B_1), f_{52}(B_3)) \tag{16}$$

Regarding the following mathematical calculation, only the specific calculation steps of the function $A_0 = g_0(f_{01}(B_0), f_{02}(B_1), f_{03}(B_3))$ are given. The other functions are calculated in the similar way. Table 5 lists the selected mathematical model. When the two indicators are put into the equations above, the results are shown in Table 6. In Table 6, the column shows the fitting value of every equation and the original data, and the two variables (R square and Sig.) explain the fitting value of the fitting selection equation from different aspects. When the R square value is higher than 0.8 and the Sig value is less than 0.1, the equation is feasible. This table above shows that the value of R square of the cubic equation is 0.962, the Sig value is 0, the fitting value is to be the highest among all the selection equations, and thus the cubic equations is the most suitable one for simulating the function f_{01}.This study assumes that the amount of indicator A_0 (industrial waste gas emissions) is y, and the total value of indicator B_0 (GDP) is x, leading to the following function:

$$f_{01}: y = -0.155\, x_3 + 1.672\text{E-}5\, x_2 + 1.213\text{E-}9\, x + 3347.275 \tag{17}$$

The influence function of indicator B_1 (energy consumption per ￥10,000 GDP) on indicator A_0 (industrial waste gas emissions) is f_{02}:

$$f_{02}: y = -21109.586\, x_3 + 14155.174\, x_2 + -2994.539\, x + 12997.987 \tag{18}$$

The influence function of indicator B_3 (coal consumption per ￥10000 GDP) on indicator A_0 is f_{03}:

$$f_{03}: y = -53255.479\, x_3 + 78261.770\, x_2 + -37560.304\, x + 14948.521 \tag{19}$$

This study obtains the functions of f_{01}, f_{02}, and f_{03}, which indicates that B_0, B_1, and B_2 are influenced by A_0.Then three factors are integrated and the final function is obtained: $A_0 = g_0(f_{01}(B_0), f_{02}(B_1), f_{03}(B_3))$.This study uses the multiple linear regression model to get the influence coefficients which indicate that B_0, B_1, and B_2 have a significant impact on A_0:

$$g_0 = r_1 * f_{01}(B_0) + r_2 * f_{02}(B_1) + r_3 * f_{03}(B_3) + n \tag{20}$$

where n is a constant.

Table 7 shows the results of the multiple regression linear equation, the coefficient data and the examined data. It is indicated that, r_1 is 0.979, r_2 is -2073.026, r_3 is 17081.566 and n is -9247.749.

$$R_i = \begin{Bmatrix} 0.979 \\ -2073.026 \\ 17081.566 \end{Bmatrix} \tag{21}$$

$$g_0 = 0.979\, f_{01} + -2073._{026}\, f_{02} + 17081.566\, f_{03} + -9247.749 \tag{22}$$

Table 6. Summary of Fitting Degree and Estimated Parameters of Function f_{01}

Equation	Summary		Parameters			
	R square	Sig.	Constant	*b*1	*b*2	*b*3
linear	.760	.000	2512.641	.192		
logarithm	.551	.002	-3011.728	777.920		
quadratic	.961	.000	3504.097	-.269	3.878E-5	
cubic	.962	.000	3347.275	-.155	1.672E-5	1.213E-9
recombination	.766	.000	2665.816	1.000		
power	.565	.002	628.438	.203		
S	.367	.022	8.304	-582.953		
increase	.766	.000	7.888	4.975E-5		
exponent	.766	.000	2665.816	4.975E-5		
Logistic	.766	.000	.000	1.000		

Table 7. Coefficient Data and Examined Data of Function g_0

Model	Non-standardized coefficient		Standardized coefficient	*t*	Sig.
	B	Standardized error			
constant	-9247.749	2435.003		-3.798	.003
GDP	.979	.160	4.444	6.136	.000
energy consumption per ￥10,000 GDP	-2073.026	712.147	-1.706	-2.911	.016
coal consumption per ￥10,000 GDP	17081.566	4072.935	5.202	4.194	.002

$$g_0 = 0.979\ (-0.155\ B_{03} + 1.672\text{E-}5\ B_{02} + 1.213\text{E-}9\ B_0 + 3347.275) + (-2073.026)\ (-21109.586\ B_{13} + 14155.174\ B_{12} + -2994.539\ B_1 + 12997.987) + 17081.566\ (-53255.479\ B_{33} + 78261.770\ B_{32} + (-37560.304\ B_3) + 14948.521) + (-9247.749) \tag{23}$$

$$g_0 = (0.979,\ \text{-}2073.026,\ 17081.566) \begin{Bmatrix} -0.155\,B_0^{\,3} + 1.672E-5\,B_0^{\,2} + 1.213E-9\,B_0 + 3347.275 \\ -21109.586\,B_1^{\,3} + 14155.174\,B_1^{\,2} + -2994.539\,B_1 + 12997.987 \\ -53255.479\,B_3^{\,3} + 78261.770\,B_3^{\,2} + -37560.304\,B_3 + 14948.521 \end{Bmatrix} -9247.749 \tag{24}$$

Three indicators (GDP, energy consumption per ￥10000 GDP and coal consumption per ￥10000 GDP) have obvious influences on industrial waste gas emission. According to Beijing's 10-year indicators, this study provides the influence function of these three indicators on industrial waste gas emission.

4. Conclusions

This study creates an OLAP multi-indicator relational model, which can be applied to reflect the relationship among economy, energy and environment in the specific area, and to support the cooperation among energy-sector, economy-sector and environment-sector. This study obtains the relational function between economy (set *A*) and environment (set *B*) indicators through our model. For example, the interactive effect relations between set *A* and set *B*: $A_1 = g\ (f_1 (B_1), f_2 (B_3), f_3 (B_5))$. The synthesized effect function of the three indicators (B_1, B_3, B_5) on indicator A_1 is g, through this function. This study analyzes the effects of B_1, B_2, and B_3 on A_1, and then counts the effects of indicator A_1 on indicators B_1, B_3, and B_5.

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