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Industrial sustainable development level in China and its influencing factors*[1]

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Abstract

This research aims to set up a comprehensive index system to evaluate the sustainable development level of the industrial sector in China and to determine the key influencing factors that hinder the sector's sustainable development. To achieve these research goals, we build a theoretical model with 26 indexes selected from resource, environment, economy, and society subsystems. An empirical analysis is conducted through Principal Component Analysis and Structural Equation Modeling. Results indicate that the sustainable development level of China's industrial sector became positive in 2007 and peaked in 2012. The environment subsystem has the largest effect on the sustainable development level. The sustainable development level is also greatly influenced by solid wastes, production of non-renewable resources, energy consumption per unit of gross domestic product (GDP), and industrial research and development (R&D) expenditure. The basic conclusion is that the sustainable development level of the

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industrial sector in China can be enhanced through improving the utilization efficiency of resources, increasing the contribution of technology progress to GDP, and developing renewable resources.

Key words: *sustainable development level, industry, environment, resources, influencing factor*

JEL classification: *O25, O53, P28*

1. Introduction

China has made great economic achievements over the past 30 years and has gained the title of world factory. The industrial sector has played a significant role in the country's economic growth. However, the contribution rate of this sector to China's GDP has declined since 2001 and dropped to its lowest rate in 2009. Many factors have caused the decline of the contribution rate of the industrial sector. The development of China's industrial sector was motivated by low labor and low resource costs rather than advanced technologies and effective management methods. Insufficient social welfare for industrial workers must be improved, and this issue continuously increases the labor cost. China is presently facing considerable resource and environmental constraints. The industrial sector covers 60% of the total energy consumption and more than 20% of the total water consumption. The environmental pollution far exceeds the carrying capacity of nature. The deterioration of the environment leads to serious consequences, such as toxic haze, greenhouse effect, acid rain, water pollution, and so on. The traditional development pattern of the industrial sector no longer fits China's development, and the sustainable development of this sector has become a pressing issue.

Economy is the core of China's sustainable development, and its key problem is the sustainable development of the industrial sector, which involves different subsystems. Social progress can provide an enhanced external environment for the sustainable development of the industrial sector. Efficient resource utilization serves as the inexhaustible driving force for the sustainable development of the industrial sector. Pollution governance and environment protection are the performance indicators of industrial progress. The sustainable development level of the industrial sector should be evaluated from the perspective of the system. The identification of major influencing factors, estimation of the current sustainable development level, and establishment of the interaction between each factor and the sustainable development level are necessary steps to assess the sustainable development level. This study aims to improve the harmonious sustainable development of the four subsystems in China.

For the research of the stated problems, the following hypothesis has been set: the sustainable development of the industrial sector in China is influenced by various factors in the economy, society, resource, and environment subsystems.

2. Literature review

Sustainable development was introduced in the well-known report *Our Common Future* by the World Commission on Environment and Development. In this report, sustainable development is defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs, which aims to improve life quality without harming the ecosystem (Altleri, 1990; Ng, 2004). Bansal (2005) argued that sustainable development rests on the principles of environmental integrity, social equity, and economic prosperity (Marcus and Fremeth, 2009). Jabarreen (2008) analyzed the theoretical framework of sustainable development from six aspects. Hall, Daneke and Lenox (2010) assumed that entrepreneurship is significant to sustainable development. From the perspective of ecological capacity of natural capital, Rees (1992) and Borucke et al. (2013) established the Ecological Footprint Index. From the viewpoint of thermodynamics, Brown and Ulgiati (1997) introduced the energy index of sustainable development. The Yale Center for Law and Policy Environment and the Center for International Earth Science Information Network at Columbia University co-developed the Environment Sustainability Index (Hao, Li, and Meng, 2010). Li, Wang, and Zhao (2012) built an index system consisting of resource, environment, technology, and industrial economic efficiency. Karahasanović, Tatić, and Avdić (2013) exploited a new sustainable development index for developing countries. Comprehensive evaluation methods for index systems were suggested by World Business Council for Sustainable Development, Global Reporting Initiative, and Organization for Economic Cooperation and Development, from which index systems were set, including Human Development Index, Sustainable Progress Index, Sustainable Economic Benefits Index, Genuine Development Index, and Genuine Saving Index (Hao, Li, and Meng, 2010). Some scholars discussed the sustainable development from the perspective of energy consumption and new energy (Granjou et al., 2013; Hassine, 2015).

Some scholars have established index systems to evaluate the sustainable development level of china. Zhang and Wen (2008) analyzed the effects of environmental protection policies on China's sustainable development. From the perspective of energy consumption and carbon emission, Chen and Santos-Paulino (2013a, b) discussed the determinants of productivity growth in China, revealed that the sustainable productivity of China's industry was stimulated by the development of high-technology light industry, and identified the problems of industrial sustainability in post-reform China. Zhang, Lior, and Jin (2011) studied the energy situation and its sustainable development strategies in China (Ma et al., 2011). Olsen (2007) analyzed the effect of clean development mechanism on sustainable development. Fang and Jin (2010) investigated the influence of economic structure adjustment on sustainable development in China. Xie, Li, and Zhao (2010) evaluated the sustainable development level of China's coal chemical industry. Yu et al. (2015) studied the low-carbon transition of iron and steel industry in China.

The studies in this literature review mainly focus on the problems of sustainable development in developing countries (Mebratu, 1998), and a number of achievements have been made from studying sustainable development in China. Although the existing literature provides considerable enlightenment to this paper, a widely recognized evaluation method to test the sustainable development level of industries in China is lacking. This study is an attempt to build an analysis framework to evaluate the sustainable development of the industrial sector in China. After proposing the analytical framework and theoretical model, this study conducts an empirical study. First, Principal Component Analysis (PCA) is used to extract a common factor of each subsystem, and the weighted average of each common factor is used to calculate the sustainable development level of industries. Then, Structural Equation Modeling (SEM) is established for the whole system and four subsystems. Finally, the degree of effect of the four subsystems on the sustainable development level is calculated.

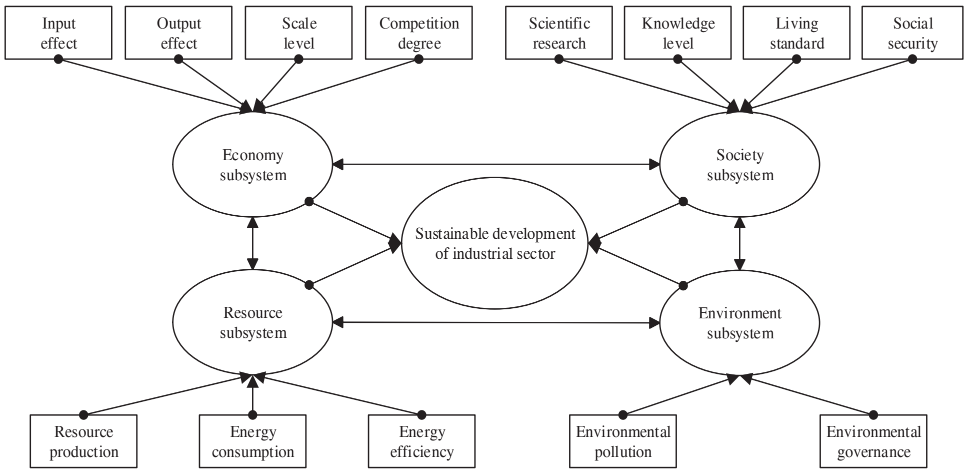
3. Methodology

3.1. Theoretical model

Sustainable development requires coordinated development among the economy, society, resource, and environment subsystems. Economic growth is the impetus of sustainable development. A rational economic structure and an efficient development pattern can promote industry development. Social progress is the goal of sustainable development. A harmonious and healthy society can create a favorable external environment for the sustainable development of the industrial sector. Since the reform and opening up in 1978, the rapid economic development in China has been relying on the excessive depletion of resources. However, sustainable development requires both saving resources and utilizing renewable resources. Environmental issues have become the focus of the present concerns in China. Toxic haze is currently a huge threat to the economic and social development. Environmental disruption frequently causes extreme climates, infectious diseases, and natural disasters, among others. The environment and resource problems seriously affect economic and social sustainable development.

We obtain the theory model of the sustainable development level of China's industrial sector according to the connotation of sustainable development and the corresponding influencing factors of the four subsystems. Figure 1 illustrates the theoretical model of this study. In this model, the sustainable development level of the industrial sector is influenced by the four subsystems.

Figure 1: Theoretical model of the sustainable development level of the industrial sector



Source: Authors' concept

The influencing factors of the economic subsystem include input effect, output effect, scale level, and competition degree. The influencing factors of the society subsystem are scientific research level, knowledge level, living standard, and social security. The influencing factors of the resource subsystem include resource production, energy consumption, and energy efficiency. The influencing factors of the environmental subsystem are environmental pollution and environmental governance. The theoretical model has two characteristics. First, the model studies the relationships of the four subsystems and proves their harmonious uniformity. Second, the selected indicators are comprehensive and representative. Therefore, we can obtain the typical common factors of each subsystem, and the empirical and theoretical models are perfectly integrated.

3.2. Measurement index system

According to the theory model, each subsystem has several indexes (see Table 1). In the economy subsystem, average wage and main business cost can represent the input effect. Average wage indicates the quality of labor in the industrial sector, and main business cost measures the aggregate level of input. Total profit and main business income can measure the output effect. Fixed-asset investment reflects the scale level of the industrial sector. Export proportion of high-tech product and aging population proportion represent the competition degree of the industrial sector. The former reflects the competitiveness of the industrial sector, whereas the latter reflects the competitiveness of the labor force.

Table 1: Sustainable development index system of China's industrial sector

General Level	System Layer	Object Layer	Index Layer
Sustainable development level of China's industrial sector (Z)	Economy subsystem	input effect	average wage (X_1); main business cost (X_2)
		output effect	total profit (X_3); main business income (X_4)
		scale level	fixed assets investment (X_5)
		competition degree	export proportion of high-tech products (X_6); aging population proportion (X_7)
	Society subsystem	scientific research	R&D expenditure (X_8); R&D personnel full-time equivalent (X_9)
		knowledge level	proportion of high school educated or above (X_{10}); the number of graduate students (X_{11})
		living standard	average wage/price level (X_{12}); Engel's Coefficient of town family (X_{13})
		social security	coverage rate of basic medical insurance (X_{14}); coverage rate of basic endowment insurance (X_{15})
	Resource subsystem	resource production	production of non-renewable resource (X_{16}); production of renewable resource (X_{17})
		energy consumption	energy consumption per unit of GDP(X_{18}); proportion of industrial water consumption (X_{19})
		energy efficiency	conversion rate of energy processing (X_{20})
	Environment subsystem	environmental pollution	SO_2 emissions (X_{21}); waste water emissions (X_{22}); solid waste production (X_{23})
		environmental governance	industrial SO_2 comprehensive discharge compliance rate (X_{24}); industrial waste water discharge compliance rate (X_{25}); comprehensive utilization rate of industrial solid waste (X_{26})

Source: Authors' concept

In the society subsystem, R&D expenditure and R&D personnel full-time equivalent demonstrate the scientific research level. They represent the intensity and the human input of scientific research, respectively. The proportion of high school educated or above and the number of graduate students reflect the Chinese knowledge level. Average wage/price level and Engel's Coefficient of town family represent the living standard of employees. The coverage rate of basic medical insurance and endowment insurance reflect the degree of social security.

In the resource subsystem, the proportion of non-renewable resources and renewable resources indicates the condition of resource production and use. Energy consumption per unit of GDP and proportion of industrial water consumption show the degree of energy and water consumption by industrial production, respectively. Conversion rate of energy processing represents the utilization efficiency of energy.

In the environment subsystem, the quantity of SO_2 emission and waste water emission and the solid waste production reflect the degree of environmental pollution by industrial production. The industrial SO_2 comprehensive discharge compliance rate, industrial waste water discharge compliance rate, and comprehensive utilization rate of industrial solid waste reveal the ability of environmental governance. Each aforementioned index (X_i) is listed in Table 1. We set the sustainable development level of China's industrial sector as variable Z and establish the sustainable development index system of the industrial sector.

3.3. Research methods

1) PCA. PCA is premised on the idea that large correlations are evident among variables, and thus we should first evaluate whether the index system is suitable for factor analysis (i.e., validity analysis). The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and Bartlett's Test of Sphericity are used. KMO is used to test the sampling adequacy. A large value implies a good fit for factor analysis. Generally, we can use factor analysis if the value is larger than 0.5. We set the significance level of Bartlett's Test of Sphericity to 0.01. If the probability is smaller than the significant level of 0.01, the set of variables is suitable for factor analysis.

2) SEM. SEM measures the manifest variables to obtain the latent variables and tests the accuracy of the established model. First, we draw the path diagram of the latent and manifest variables. Then, the AMOS software completes the parameter estimate and model test. Finally, the standardized coefficients are illustrated in the path diagram.

4. Empirical data and analysis

4.1. Data sources

The data sources of the 26 indexes are explained as follows. First, some of the indexes are directly obtained from authoritative China statistical yearbooks or official websites. For example, average wage (X_1), main business cost (X_2), main business income (X_4), R&D expenditure (X_8), coverage rate of basic endowment insurance (X_{15}), and conversion rate of energy processing (X_{20}) are from the China Statistical Yearbook (1996-2013). Total profit (X_3), R&D personnel full-time equivalent (X_9), the number of graduate students (X_{11}), Engel's Coefficient of town family (X_{13}), and coverage rate of basic medical insurance (X_{14}) are from the official website of the National Bureau of Statistics. Fixed assets investment (X_5) and export proportion of high-tech products (X_6) are from the Statistical Bulletin of National Economic and Social Development (1996-2013). Proportion of industrial water consumption (X_{19}) and waste water emissions (X_{22}) are from the Water Resources Bulletin (1997-2013). SO_2 emissions (X_{21}), solid waste production (X_{23}), industrial SO_2 comprehensive discharge compliance rate (X_{24}), industrial waste water discharge compliance rate (X_{25}), and comprehensive utilization rate of industrial solid waste (X_{26}) are from the National Environment Statistical Bulletin (1996-2013). Second, the other indexes are calculated using the data from authoritative China statistical yearbooks or official websites. For example, the average wage/price level (X_{12}) is the average wage per capita in the manufacturing sector divided by the consumer price index. The production of non-renewable resource (X_{16}) is the percentage of both coal and crude oil * total energy production / 100. The production of renewable resource (X_{17}) is the sum of the percentage of natural gas, hydropower, nuclear power, and wind power * total energy production / 100. The initial data used to calculate X_{12}, X_{16}, and X_{17} are from the China Statistical Yearbook (1996-2013). The aging population proportion (X_7) is the number of people aged 65 or older than 65 / the total population. The proportion of high school educated or above (X_{10}) is the population of high school and college education / the total population. The energy consumption per unit of GDP (X_{18}) is the total energy consumption / total GDP. The initial data used to calculate X_7, X_{10}, and X_{18} are from the official websites of the National Bureau of Statistics.

To ensure the consistency and the comparability of the data, the index data are divided by the base period data to obtain dimensionless data (with 1995 as the basic period). The following equation is set:

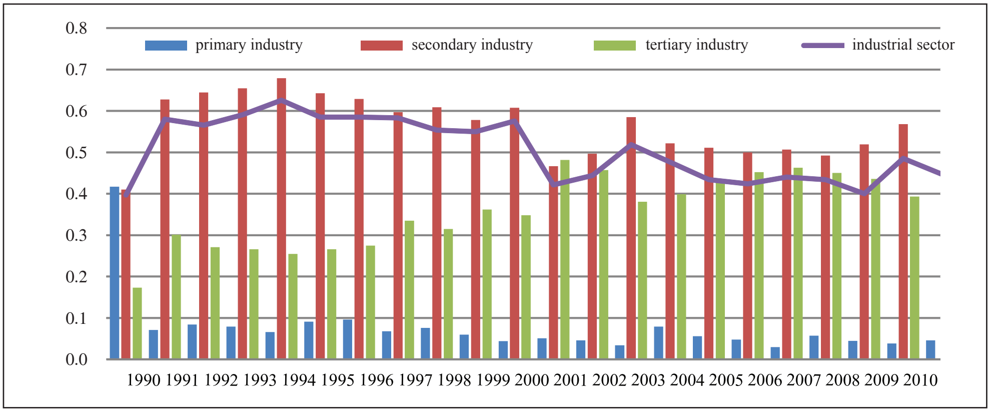
$$Y_i(t) = X_i(t)/X_i(0),\ i = 1, 2, ..., 26;\ t = 0, 1, ..., 17. \quad (1)$$

In Equation 1, $X_i(t)$ is the value of the i th index at the t th year, $X_i(t)$ is the value of the i th index at 1995, and $Y_i(t)$ is the variation of i th index between t th year and 1995. According to the relationships between each index and the sustainable development level, we adjust the positive and negative signs of the non-dimensional data and set the negative relationship indexes as $-Y_i(t)$ and positive relationship indexes as $Y_i(t)$. When t = 0, it means 1995; when t = 1, it means 1996 and so on.

4.2. Descriptive statistics

According to the contribution of the industrial sector to China's GDP (see Figure 2), the lowest contribution rate (39.7%) is in 1990 and the highest (62.6%) is in 1994. The industrial sector has an average contribution rate of 50.11% over the past 23 years. However, the contribution rate has declined since 2001 and dropped to 40.59% in 2012, which is considerably lower than the tertiary industry's contribution rate of 45.56%.

Figure 2: Different industries' contribution rate to China's GDP



Note: Secondary industry includes the industrial sector and the building industry.

Source: China Statistical Yearbook

The SPSS software is used for the descriptive statistics of the non-dimensional data. Both the skewness value and the kurtosis value are under the critical value (see Table A1 in the appendix). Other indicators reveal that the data are suitable for further statistical analysis. The results of variance analysis indicate that $F = 19.162$, $P(Sig) < 0.0001$. Therefore, the samples are suitable for further empirical analysis. The variance analysis table is not listed here because of the paper length limitation (see Table A1 for the descriptive statistics).

4.3. Validity analysis

We conduct validity analysis before using the PCA. In the economy subsystem, the coefficient of KMO is 0.744, which is larger than 0.5. Therefore, the samples are adequately large to conduct a factor analysis (Barbara, 2001). From Bartlett's Test of Sphericity, the approximate chi-square χ^2 is 468.086. The degree of freedom is 21, and the corresponding value of P is significant under the level of 0.01. Similarly, the indexes of society, resource, and environment subsystems all pass the validity test (see Table A2 in the Appendix). Therefore, further statistical analysis can be performed.

4.4. Principal component analysis

According to PCA, we extract the principal components when the eigenvalue is larger than 1 (see Table A3 in the appendix). The eigenvalue of the first factor in the economy subsystem is 6.590. Its variance contribution rate is 94.14%, which indicates that the linear combination contains 94.14% overall information of the variables. Thus, we extract the first factor as the common factor of the economy subsystem. Similarly, the common factor of the society subsystem is the first factor that has an eigenvalue of 7.276 and a variance contribution rate of 90.96%. The common factor of resource subsystem is the first factor that has an eigenvalue of 4.288 and a variance contribution rate of 85.76%. Two common factors can be found in the environment subsystem with eigenvalues of 4.223 and 1.267 and a cumulative variance contribution rate of 91.49%.

Factor loading represents the relevance between variables and common factors. A large value implies a strong correlation. To retain the explanation of the common factors' name, we use the largest variance method to rotate the factor loadings matrix orthogonally (see Table A4 in the appendix). In the economy subsystem, the loadings of seven indexes (from $Y_1(t)$ to $Y_7(t)$) are extremely high in the first common factor. The factor explains each aspect of economic development, and thus it is called the economic development factor (F_1). The second common factor explains the level of society development, and thus it is the called social progress factor F_2. The third common factor is called the resource advantage factor (F_3). The environment subsystem has two common factors. The first one explains the variables of SO_2 emission, waste water emission, and solid waste production, and thus it is called the environmental pollution factor (F_{4-1}). The second one explains the comprehensive utilization rate of industrial solid waste, and thus it is called the environmental governance factor (F_{4-2}). The regression method can be used to obtain the factor score coefficient matrix and the factor score equations. The factor score in each variable is used as the weight of each variable, and the value of each factor is obtained through the weighting method. The factor score equation is omitted because of paper length limitation.

4.5. Structural equation modeling

The five common factors are set as the manifest variables, and the four subsystems and Z are regarded as the latent variables. We obtain the SEM after setting up the parameter limits. According to the results in Table 2, the model fits the sample data well. The proximity of CFI and IFI to 1 implies goodness of fit. The fit is good when P (CMIN) is higher than 0.05 and CMIN/DF statistics is less than 2.

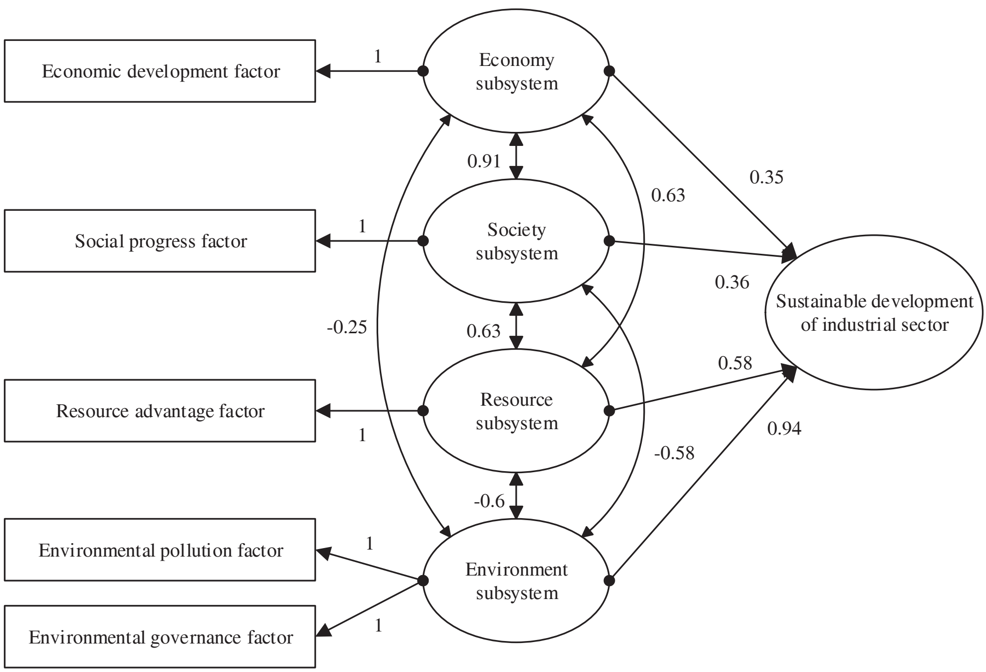
Table 2: Test of goodness of fit of Z and the four subsystems

Fit Indices	CFI	IFI	P(CMIN)	PNFI	PCFI	CMIN/DF
Statistics	0.789	0.838	0.131	0.340	0.394	1.7

Source: Authors' calculation

The effects of the four subsystems on the industrial sector's sustainable development level are positive (see Figure 3). The environment subsystem has the largest effect at 0.94, followed by the resource subsystem at 0.58. The effects of society and economy subsystems are 0.36 and 0.35, respectively, and they have the relatively smaller influences on the sustainable development level.

Figure 3: Paths of the sustainable development system of the industrial sector



Source: Authors' calculation

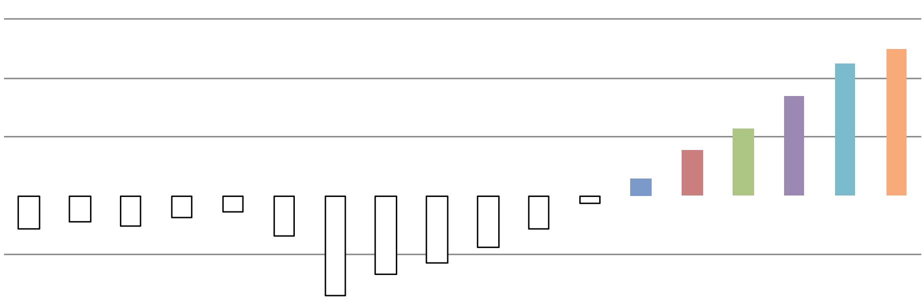
A positive synergy exists among economy, society, and resource subsystems. The economy and society subsystems are complementary related, and they have the highest positive correlation (0.91). The correlation between economy improvement and resource development is 0.63, and the correlation between society subsystem and resource subsystem is 0.63. The correlations between the environment subsystem and the three other subsystems are negative, thus indicating that the development of society, economy, and resources has harmful effects on the environment. Resources have a large negative influence on the environment (-0.6) and society subsystems (-0.58). Environmental pollution is caused by resource subsystems, including the remaining waste of water resources and energy resources utilization. Another source of environmental pollution is urban household waste. Clearly, the conflicts between the environment subsystem and the other three subsystems must be solved at the soonest possible time.

Equation A1 is a measuring model, and Equation A2 is a structural model (see Equations A1 and A2 in the Appendix). ECS, SOS, RES, and ENS represent the economy, society, resource, and environment subsystems, respectively. δ_i is the exogenous manifest variable error. ζ_i is the endogenous latent variable error. F_4 is the arithmetic average of $F_{4\text{-}1}$ and $F_{4\text{-}2}$. The weight of each common factor is decided by the relative level of its coefficient. The weights of F_1, F_2, F_3, and F_4 are 0.192, 0.202, 0.183, and 0.423, respectively. Then, we estimate the sustainable development level of the industrial sector (Z) using the weighted average method.

5. Results and discussion

The trends of F_1, F_2, F_3, F_4, and Z are shown in Figure 4 and Figure 5. The industry of China was not developing sustainably before 2007. After 2007, the value of Z continued to increase and surpass 1 in 2011. F_1 and F_2 have a high synergistic effect. The values of F_1 and F_2 increased from 1995 to 2012 and exceeded zero in 2005.

Figure 4: Trend of Z

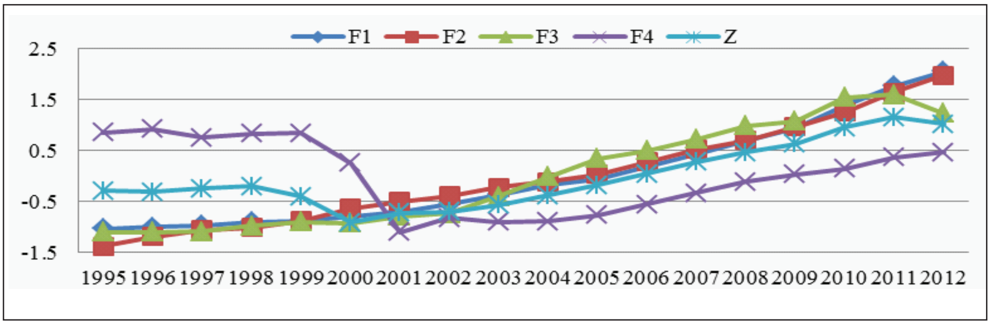


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Z	-0.28279	-0.22296	-0.26075	-0.18604	-0.13945	-0.33665	-0.85001	-0.66772	-0.57286	-0.44027	-0.28391	-0.06801	0.147431	0.388241	0.564766	0.849948	1.121065	1.239962

Source: Authors' calculation

The economy and society subsystems changed from unsustainable to sustainable. F_3 continued to increase from 1995 to 2010, thus indicating that the sustainable development of resources had achieved substantive progress. However, F_3 declined in 2012. F_4 had small changes from 1995 to 1999, and it decreased in 2000. Environmental pollution was extremely serious in 2000 and 2001, which mainly explains the descending sustainable development level of the environment. F_4 began to increase slowly after 2001 and exceeded zero in 2009. The environmental sustainability did not grow as fast as the other subsystems. These trends directly hindered the sustainable development of the industrial sector. The trend of Z is similar to that of F_4, and it establishes that the environment subsystem has the greatest effect on the sustainable development level of the industrial sector.

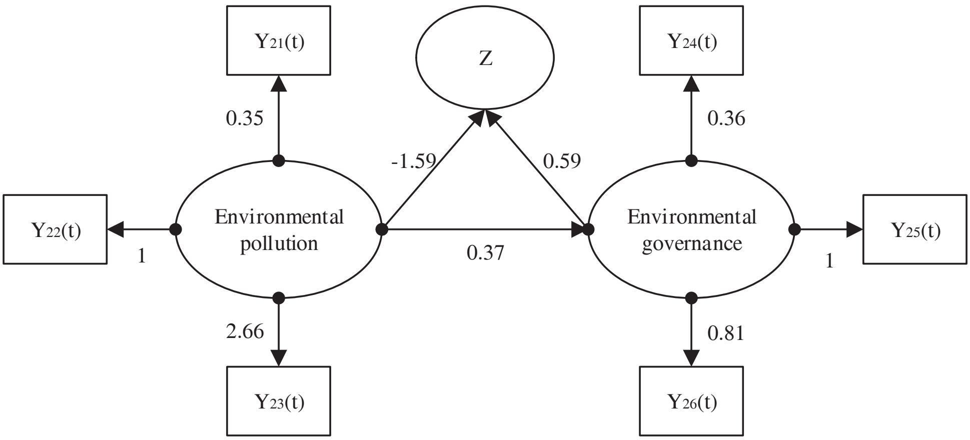
Figure 5: Trends of four principle components and Z



Source: Authors' calculation

The specific relationship between Z and each subsystem is subsequently analyzed. The previous analysis shows that the environment subsystem has the largest effect on the sustainable development level of the industrial sector in China. Thus, we set the six indexes of the environment subsystem as the manifest variables and the two sub-objectives, and Z as the latent variables. We obtain the structural equation model after setting up the parameter (see Figure 6).

Figure 6: Paths of Z and the environment subsystem



Source: Authors' calculation

Table 3 reveals that the model fits well. GFI, AGFI, NFI, RFI, and PNFI are between 0 and 1. Their proximity to 1 indicates the goodness of fit of the model. The fit is good when CMIN/DF is smaller than 2. According to the test results, the model fits extremely well.

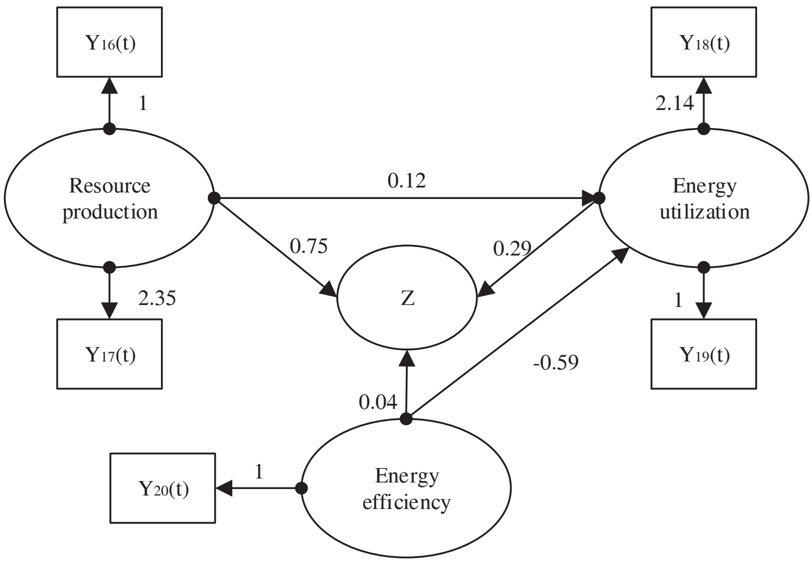
Table 3: Goodness of fit test of Z and the environment subsystem

Fit Indices	GFI	AGFI	NFI	RFI	PNFI	CMIN/DF
Statistics	0.988	0.878	0.874	0.874	0.874	0.022

Source: Authors' calculation

Environmental pollution has the greatest negative effect on the sustainable development level (Z). The standard estimated coefficient of environmental pollution to Z is -1.59. Therefore, when environmental pollution increases 1 unit, Z will decrease 1.59 units. Clearly, environmental pollution is the major obstacle in improving the sustainable development level of the industrial sector in China. The standard estimated coefficient of environmental governance to Z is 0.59, which indicates that when environmental governance increases 1 unit, Z will increase 0.59 units. Therefore, the intensity of environmental governance should be improved. The standard estimated coefficient of environmental pollution to environmental governance is 0.37, which implies that environmental governance helps to decontaminate only 37% of the total pollution. The regression coefficients of $Y_{23}(t)$, $Y_{22}(t)$, and $Y_{21}(t)$ to environmental pollution are 2.66, 1.00, and 0.35, respectively. Solid waste production has the largest effect on environmental pollution, followed by waste water emissions and SO_2 emissions. The regression coefficients of $Y_{25}(t)$, $Y_{26}(t)$, and $Y_{24}(t)$ to environmental governance are 1.00, 0.81, and 0.36, respectively. The results prove that industrial waste water discharge compliance rate has the largest effect on environmental governance, followed by comprehensive utilization rate of industrial solid waste and industrial SO_2 comprehensive discharge standard rate.

Figure 7: Paths of Z and the resource subsystem



Source: Authors' calculation

The resource subsystem has the second largest effect on the sustainable development level of the industrial sector in China. Therefore, we set the five indexes of resource subsystem as the manifest variables and the three sub-objectives and Z as the latent variables. After setting up the parameter, we construct the SEM (see Figure 7). The test results fit well (see Table 4).

Table 4: Goodness of fit test of Z and the resource subsystem

Fit Indices	GFI	AGFI	NFI	RFI	PNFI	CMIN/DF
Statistics	1.000	0.999	0.999	0.999	0.899	0.0007

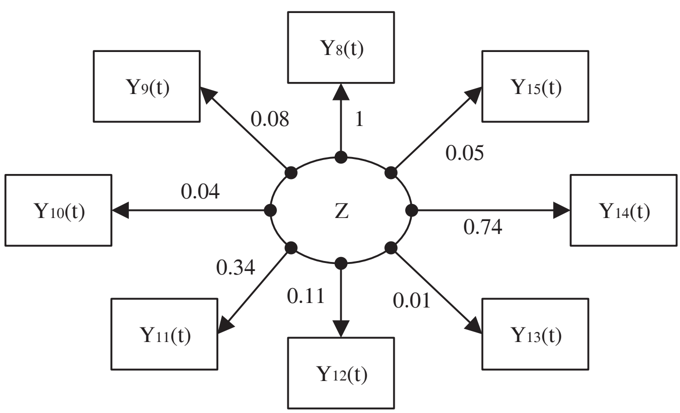
Source: Authors' calculation

The standard estimated coefficient of resource production to Z is 0.75, and it indicates that when resource production increases 1 unit, Z will increase 0.75 units.

Resource production has the largest influence on the sustainable development level of the industrial sector. The standard estimated coefficient of energy utilization to Z is 0.29. The standard estimated coefficient of energy efficiency to environmental governance is 0.04. The standard estimated coefficients of energy efficiency and resource production to energy utilization are -0.59 and 0.12, respectively. The effect of energy efficiency on energy utilization is more considerable than that of resource production on energy utilization. The regression coefficients of $Y_{17}(t)$ and $Y_{16}(t)$ to resource production are 2.35 and 1.00, respectively. The production of non-renewable resources has a larger effect on resource production than the production of renewable resources. The regression coefficients of $Y_{18}(t)$ and $Y_{19}(t)$ to energy utilization are 2.14 and 1.00, respectively. The energy consumption per unit GDP has a larger influence on energy utilization than the proportion of water consumption. The regression coefficient of $Y_{20}(t)$ to energy efficiency is 1.00, and it implies that energy efficiency increases 1 unit and conversion rate of energy processing increases 1 unit.

The society subsystem has the third largest effect on the sustainable development level of the industrial sector. Thus, we set the eight indexes of the society subsystem as the manifest variables and Z as the latent variable. After setting up the parameter limit, we obtain the structural equation model (see Figure 8).

Figure 8: Paths of Z and the society subsystem



Source: Authors' calculation

As shown in Table 5, the test results indicate a good fit. The regression coefficients of $Y_8(t)$, $Y_{14}(t)$, $Y_{11}(t)$, $Y_{12}(t)$, $Y_9(t)$, $Y_{15}(t)$, $Y_{10}(t)$, and $Y_{13}(t)$ to Z value are 1.00, 0.74, 0.34, 0.11, 0.08, 0.05, 0.04, and 0.01, respectively. Industrial R&D expenditure has the largest influence on the sustainable development level, followed by coverage rate of basic medical insurance, number of graduate students, average wage/price level, R&D personnel full-time equivalents, and coverage rate of basic endowment insurance. Engel's Coefficient of town family has the lowest influence.

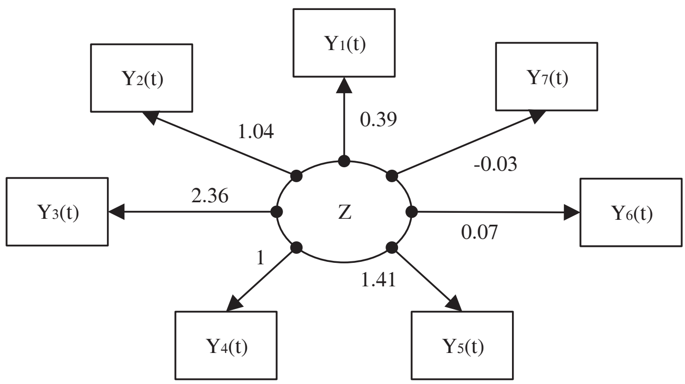
Table 5: Goodness of fit test of Z and the society subsystem

Fit Indices	GFI	AGFI	NFI	RFI	PNFI	CMIN/DF
Statistics	0.998	0.997	0.995	0.999	0.995	0.92

Source: Authors' calculation

The economy subsystem has the fourth largest effect on the sustainable development level of China's industrial sector. We set the seven indexes of the economy subsystem as the manifest variables and Z as the latent variable. After setting up the parameter, we obtain the structural equation model (see Figure 9).

Figure 9: Paths of Z and economy subsystem



Source: Authors' calculation

The test results in Table 6 indicate a good fit. The regression coefficients of Y_3(t), Y_5(t), Y_2(t), Y_4(t), Y_6(t), Y_1(t), and Y_7(t) to Z are 2.36, 1.41, 1.04, 1.00, 0.39, 0.07, and -0.03, respectively. Total profit has the highest influence on the sustainable development level, followed by fixed-asset investment, main business cost, main business income, and average wage. The proportion of aging population has the lowest influence.

Table 6: Goodness of fit test of Z and the economy subsystem

Fit Indices	GFI	AGFI	NFI	RFI	PNFI	CMIN/DF
Statistics	1.000	1.000	1.000	1.000	1.000	1.04

Source: Authors' calculation

Serious environmental pollution and inefficient resource utilization are sizable obstacles to the sustainable development of China's industrial sector. Fortunately, the sustainable development level of this sector has been increasing in recent years. The value of the sustainable development level exceeded zero in 2007 and has continued to increase since then. This increase indicates the great progress of China in environmental governance and industrial development policies in the past decade. At the beginning of the reform and opening up in the 1980s, the industrial development in China over-relied on resources and primary production factors and neglected environmental protection and efficient resource utilization. As a result, the capacity of the sustainable development of the environment declined sharply by the end of the 1990s. After joining the World Trade Organization in 2001, the need for sustainable development has been increasing and the intensity of environmental governance and the efficiency of resource utilization have been increasing greatly. An inflection point became evident in the sustainable development levels of the industrial sector and the environment in 2001, and it indicates that the external factor is one of the important influencing factors of China's sustainable development level. Environmental pollution seriously hinders sustainable development, and the influence of the resource subsystem on the sustainable development level is smaller than that of the environment subsystem. Similar to environmental protection, efficient resource utilization remains important. The level of environment protection is actually closely related to efficient resource utilization. In addition, the shortage of per capita resources is another important factor that affects the sustainable development level of China's industrial sector. In the society subsystem, the main influencing factor is R&D expenditure, and the scientific research level between China and developed countries has a large gap. The influence of the economic subsystem on the sustainable development level of the industrial sector is relatively small, and total profit is the main influencing factor at the sustainable development level. Therefore, China should increase the input of advanced production factors and enhance technological progress in the proportion of GDP.

6. Conclusion

The presented results of our analysis proved the hypothesis that the sustainable development of China's industrial sector is influenced by various factors in the economic, social, resource, and environment subsystems. Valuable empirical results are also achieved. Economic development, social progress, environment improvement, and efficient resource utilization enhancement have positive effects on the sustainable development level of the industrial sector. The environment subsystem has the largest effect on the sustainable development level, followed by the resource subsystem; the society and economy subsystems have relatively smaller effects. The environment subsystem has a negative correlation with the other three subsystems. The economy subsystem has synergy with the society and resource subsystems. The society subsystem has a positive correlation with the resource subsystem. The sustainable development level is greatly influenced by solid waste production, compliance rate of industrial waste water discharge, production of non-renewable resources, energy consumption per unit of GDP, and industrial R&D expenditure. This research contributes to the existing economic literature by building a long-term and comprehensive theoretical model to evaluate the sustainable development level of China's industrial sector and by determining the main influencing factors in the different subsystems. The limitations of the empirical analysis are primarily related to the data availability. Due to the availability of the micro data, the empirical analysis has not been carried out on the micro level. Because of the policy complexity of different regions in China, we have not analyzed the influence of the regional policies on the sustainable development level. For the future research, the following directions can be stated: the impact of regional policies and its implementation on the sustainable development level should be taken into consideration; the data of industrial enterprises should be collected to conduct the empirical analysis to find the influencing factors that hinder the improvement of the industrial sustainable development level. Through the empirical research, the obtained results suggest the following: First, to improve the sustainable development level of the industrial sector, China should strengthen the governance of waste gas, strictly control the incremental solid pollutants, close factories that pollute environment seriously, and adopt strict punitive measures on unqualified pollution discharges. Second, China should encourage the innovation of emissions reduction, offer fiscal subsidies for the purchase of energy-saving equipment, and provide favored policies to use clean energy. The government should improve the R&D subsidies for energy saving and emission reduction of state-owned and private enterprises and increase the incentives to enterprises that have effective emission reduction. Third, China should improve energy utilization efficiency and optimize energy consumption structure. Fourth, China should take measures to increase the investment in industrial scientific research and high-level talents, relax restrictions on R&D expenditure, and improve the total R&D level of the industrial sector. Fifth, China should fully liberalize the fertility policy and improve employee benefits. China should release the family planning policy, delay the retirement age, and increase the proportion of employers in the pension insurance and housing provident fund. Finally, as the society and the economy are developing well, considerable attention should be given to the optimization of the environment and the efficiency of resource utilization.

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Razina industrijskog održivog razvoja u Kini i faktori utjecaja[1]

Hongjian Cao[2], *Jianying Zhang*[3], *Nengsheng Luo*[4], *Zheng Zhang*[5]

Sažetak

Cilj ovog istraživanja je uspostaviti sveobuhvatan indeks sustava za procjenu razine održivog razvoja industrijskog sektora u Kini i odrediti ključne čimbenike koji sprječavaju održivi razvoj tog sektora. Za postizanje ovih znanstveno-istraživačkih ciljeva, izgradili smo model od 26 indeksa odabranih iz resursa, okoliša, gospodarstva i društvenih podsustava. Empirijska analiza provodi se pomoću analize glavnih komponenti i modeliranja strukturnih jednadžbi. Rezultati pokazuju da je razina održivog razvoja kineskog industrijskog sektora postao pozitivan 2007.godine, a vrhunac dosegnuo 2012. godine. Podsustav okoliša ima najveći utjecaj na razinu održivog razvoja. Razina održivog razvoja također je pod velikim utjecajem krutog otpada, proizvodnje neobnovljivih resursa, potrošnje energije po jedinici bruto domaćeg proizvoda (BDP-a) i troškova za industrijsko istraživanje i razvoj. Osnovni zaključak je da se razina održivog razvoja industrijskog sektora u Kini može poboljšati povećanjem učinkovitosti korištenja resursa, većim doprinosom tehnologijskog napretka u BDP-u i razvijanjem obnovljivih resursa.

Ključne riječi: *razina održivog razvoja, industrija, okoliš, resursi, faktor utjecaja*

JEL klasifikacija: *O25, O53, P28*

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Appendix

Table A1: Descriptive statistics

Index	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
$Y_1(t)$	-3.537	.570	2.420	-.868	.536	-.411	1.038
$Y_2(t)$	-5.887	1.335	5.664	-1.094	.536	.005	1.038
$Y_3(t)$	11.780	3.029	12.852	1.133	.536	.024	1.038
$Y_4(t)$	5.679	1.280	5.428	1.097	.536	.007	1.038
$Y_5(t)$	7.282	1.924	8.163	1.385	.536	.988	1.038
$Y_6(t)$	1.616	.123	.521	-.282	.536	-1.825	1.038
$Y_7(t)$	-1.227	.036	.153	-.377	.536	-.768	1.038
$Y_8(t)$	10.786	2.971	12.606	1.604	.536	1.941	1.038
$Y_9(t)$	1.971	.248	1.052	1.071	.536	-.012	1.038
$Y_{10}(t)$	2.123	.132	.560	-.054	.536	-.112	1.038
$Y_{11}(t)$	6.030	1.160	4.922	.587	.536	-1.250	1.038
$Y_{12}(t)$	3.094	.342	1.451	.519	.536	-.830	1.038
$Y_{13}(t)$	-.792	.022	.094	-1.306	.536	.344	1.038
$Y_{14}(t)$	12.762	2.259	9.586	.236	.536	-1.382	1.038
$Y_{15}(t)$	1.608	.132	.561	.780	.536	-.445	1.038
$Y_{16}(t)$	1.509	.119	.503	.476	.536	-1.314	1.038
$Y_{17}(t)$	2.190	.275	1.168	.791	.536	-.635	1.038
$Y_{18}(t)$	-.643	.040	.169	-.429	.536	.059	1.038
$Y_{19}(t)$	-1.094	.017	.074	-.112	.536	-1.715	1.038
$Y_{20}(t)$	.995	.004	.018	.158	.536	-1.405	1.038
$Y_{21}(t)$	-1.449	.063	.267	.459	.536	-.692	1.038
$Y_{22}(t)$	-1.804	.137	.581	.731	.536	-1.203	1.038
$Y_{23}(t)$	-2.247	.300	1.274	-1.211	.536	.600	1.038
$Y_{24}(t)$	1.014	.031	.131	-1.054	.536	.213	1.038
$Y_{25}(t)$	1.498	.057	.243	-1.106	.536	-.346	1.038
$Y_{26}(t)$	1.287	.041	.176	-.078	.536	-.899	1.038

Source: Authors' calculation

Table A2: KMO and Bartlett's test of sphericity

	Economy Subsystem	Society Subsystem	Resource Subsystem	Environment Subsystem
KMO Measure of Sampling Adequacy	0.744	0.808	0.664	0.729
Approx. Chi-Square Bartlett's Test of Sphericity df. Sig.	468.086 21 .000	378.757 28 .000	140.771 10 .000	113.297 15 .000

Source: Authors' calculation

Table A3: Total variance explained

System	Component	Extraction sums of squared loadings		
		Eigenvalues	Variance %	Cumulative %
Economy subsystem	1	6.590	94.14	94.14
Society subsystem	1	7.276	90.96	90.96
Resources subsystem	1	4.288	85.76	85.76
Environment subsystem	1	4.223	70.38	70.38
	2	1.267	21.11	91.49

Source: Authors' calculation

Table A4: Component matrix

Index	$Y_1(t)$	$Y_2(t)$	$Y_3(t)$	$Y_4(t)$	$Y_5(t)$	$Y_6(t)$	$Y_7(t)$	
Component 1	-0.982	-0.999	-0.993	0.989	0.993	0.978	0.851	
Index	$Y_8(t)$	$Y_9(t)$	$Y_{10}(t)$	$Y_{11}(t)$	$Y_{12}(t)$	$Y_{13}(t)$	$Y_{14}(t)$	$Y_{15}(t)$
Component 1	0.939	0.975	0.965	0.978	0.998	0.773	0.987	0.994
Index	$Y_{16}(t)$	$Y_{17}(t)$	$Y_{18}(t)$	$Y_{19}(t)$	$Y_{20}(t)$			
Component 1	0.987	0.963	0.861	-0.942	0.871			
Index	$Y_{21}(t)$	$Y_{22}(t)$	$Y_{23}(t)$	$Y_{24}(t)$	$Y_{25}(t)$	$Y_{26}(t)$		
Component 1	0.927	0.971	0.635	0.042	-0.979	-0.882		
Component 2	0.014	-0.151	-0.669	0.970	0.025	0.366		

Source: Authors' calculation

The measuring model (A1) and structural model (A2)

$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_{4-1} \\ F_{4-2} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \mathrm{ECS} \\ \mathrm{SOS} \\ \mathrm{RES} \\ \mathrm{ENS} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \end{bmatrix} \tag{A1}$$

$$[Z] = [0.35 \quad 0.36 \quad 0.58 \quad 0.94] \begin{bmatrix} \mathrm{ECS} \\ \mathrm{SOS} \\ \mathrm{RES} \\ \mathrm{ENS} \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \\ \zeta_4 \end{bmatrix} \tag{A2}$$