

Lin-xiu Wang, Mu-xi Yu, Si-jia Wang

# Driving Factors of Green Mining in Coal Mining Enterprises in China

**Abstract** This study constructs a Green Mining model based on identification and analysis of the four key driving factors of Green Mining in coal mining enterprises in China. Twelve research propositions are raised and empirically tested by using Structural Equation Model. The result shows that four key factors affect the intended implementation of Green Mining by improving a corporations efficiency and reputation. The diffusion of Green Mining technology has direct positive influence on the intended Green Mining implementation; Stakeholders' green appeal has a positive influence on the decision makers' attitude and values. The empirical study provides support for the government to establish a reasonable regulation and control mechanism to improve enterprises' enthusiasm for Green Mining. Four Green Mining incentive policies are raised to regulate and motivate the coal mining enterprises to improve their environmental behaviors. The government can adopt piece(s) of them to change the enterprises' roles from traditional passive to modern initiative.

**Keywords:** Green Mining, driving factor, Structural Equation Model, empirical study

## 1 Introduction

Coal plays an important role in China's energy system, which accounts for 90% of China's energy recourse reserves and 70% of production and consumption of energy resource. The mining, processing and utilizing of coal resource are changing and polluting the environment inevitably; however, at present, the miners put more emphasis on coal output and profit rather than on the

environmental. The over exploitation, excessive emission and low utilization in mining process are the root cause of harsh environment conditions and negative externalities (Zhang, 2011). Those destructive behaviors would severely hinder the sustainable development of the mining area and regional economy. In order to implement sustainability in coal industry, it is important to maximize coal resource utilization and reduce pollution. Experts and scholars have done systematic researches on coal resource utilization, ecological condition and sustainability in recent years. In 2003, Qian, a member of the Chinese Academy of Engineering, and his team, proposed a theoretical system of Green Mining, which defined the direction of environment-friendly technology in coal mining (Qian, Xu, & Miao, 2003).

There is no unified definition of Green Mining. The main idea of Green Mining concerning coal is a modern mode taking both recourse utilization rates and environmental influence into consideration. The core is to follow the principles of Recycling Economy and to coordinate with the environment. The low exploitation, low emission, and high utilization in mining process maximize the efficiency of resource exploitation; this also minimizes the influence of ecological environment, which maintain a balance between the enterprise's economy efficiency and social benefits (Lu & Wang, 2007).

Raising the awareness of Green Mining and implementing the method are imminent; however, Green Mining in China is slowly progressing because motivation is lacking. Based on the problem, the driving factors of Green Mining are identified and analyzed to find out the motivations for coal mining enterprise to implement Green Mining (Long & Dong, 2005).

## 2 Methods

### 2.1 Research hypothesis

#### 2.1.1 Identification of driving factors of Green Mining

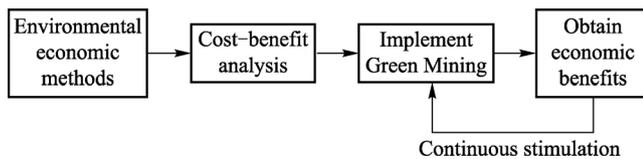
(1) Political environmental-regulation policy  
Theoretically, Green Mining benefits both the environment

Manuscript received March 25, 2015; accepted September 25, 2015

Lin-xiu Wang, Mu-xi Yu (✉)  
School of Mechanic and Civil Engineering, China University of Mining and Technology, Xuzhou 221116, China  
Email: ymx365@126.com

Si-jia Wang  
Smeal College of Business, Pennsylvania State University, State College, PA 16801, USA

and the economic; however, the limited rational characteristics of the enterprise, the behavioral agent to implement Green Mining, determined that Green Mining is actively implemented only when economic benefits are obtained. The key to change enterprises from passively following the government to actively participating for their own needs is illustrating the profitability of Green Mining, which depends largely on the environmental cost internalization (Maxwell, Lyon, & Hackett, 2000). Environmental resources utilized as a public good are free; therefore, human demand exceeds environmental capacity, resulting in serious environmental damages. Thus, environmental problems are rooted in the negative. If all external costs are internalized into the product price and paid by the polluter, enterprises should take both environment and economics into consideration when making business decisions. Guo (2007) indicated that the producers are motivated to seek technology innovation to reduce the environmental cost listed in the product price, thus obtaining environmental and economic benefits at the same time (see *Figure 1*).



*Figure 1.* Driving process of environmental-economic instruments.

### (2) Stakeholders' green appeal

Enterprises are not isolated. Various individuals and groups are the stakeholders in the competitive environment. In order to get more benefits, enterprises have to satisfy the stakeholders as much as possible and maintain a good relationship with one another. Zhang and Hu (2002) think the enterprises should manage to meet stockholders' goals and treat the other stakeholders reasonably. Briefly, to pay attention to Green Mining and then begin by implementing it is an optimal choice under the complicated conditions rather than a harebrained decision.

### (3) Corporate social responsibility

Green Mining is the result of the interaction of the Green Mining concept held by the enterprise top managers, the responses to the green appeal from external stakeholders, the green supply chain management and external design. The social responsibility of the decision makers plays a key role in this process. How social responsibility leads to the implementation of Green Mining is showed in *Figure 2*.

As shown in the diagram, the history and features of an enterprise affect its social responsibility strategy and the top managers' Green Mining philosophy, which directly influences the stakeholders' response to green appeal and the green supply chain management process. Top managers' behavior obviously plays a crucial role in this

process. The effect of the Corporate Social Responsibility strategy, the effect of specific green supply chain management and the response to green appeal, drive the enterprise's Green Mining performance and the profitability. In this way, enterprises achieve goals in both social responsibility and economic performance (Yu & Yi, 2007).

### (4) Diffusion efficiency of Green Mining

At present, socialization, intensive mass production as well as advance in science and technology, all provide the necessary conditions for Green Mining (Wang, Ma, Zhu, & Li, 2009; Wang, Li, Wei, & Zou, 2009; Wang & Zhu, 2009). The development of science and technology provides methods to use the coal resources which were difficult to mine or utilize previously. Technology improvement also reduces waste generated in production process. At the same time, the technical and economic policies, especially policies encouraging the economic growth mode to change from extensive to intensive, also contribute favorable conditions for Green Mining.

### 2.1.2 Model building & variable relationship assumption

According to the researches on the willingness of an enterprise to implement Green Mining, there are four key driving factors: the government regulation (GOV), stakeholders' green appeal (STA), leader's attitudes and values (LED) and the diffusion of Green Mining technology (TEC). The conceptual model of the driving forces for enterprises' Green Mining is built as in *Figure 3*. The two observed variables, GOV and STA, influence the aspiration to implement Green Mining by directly or indirectly affecting the two latent variables, LED and TEC. LED and TEC then influence the efficiency value of Green Mining (EFF) and reputation effect of Green Mining (REP) separately or collaboratively; meanwhile, LED and TEC influence the willingness of implementation of Green Mining (WIS) directly or indirectly through affecting EFF and REP.

Based on the purpose and structure of the study and combined with the theological basis, there are 12 hypotheses:

H1: Government regulation has significant positive effect on Green Mining technology diffusion.

H2: Government regulation has significant positive effect on leaders' attitude.

H3: Government regulation has significant positive effect on efficiency value.

H4: Government regulation has significant positive effect on reputation effect.

H5: Stakeholders' green appeal has significant positive effect on leaders' attitudes and values.

H6: Stakeholders' green appeal has significant positive effect on efficiency value.

H7: Stakeholders' green appeal has significant positive effect on reputation effect.

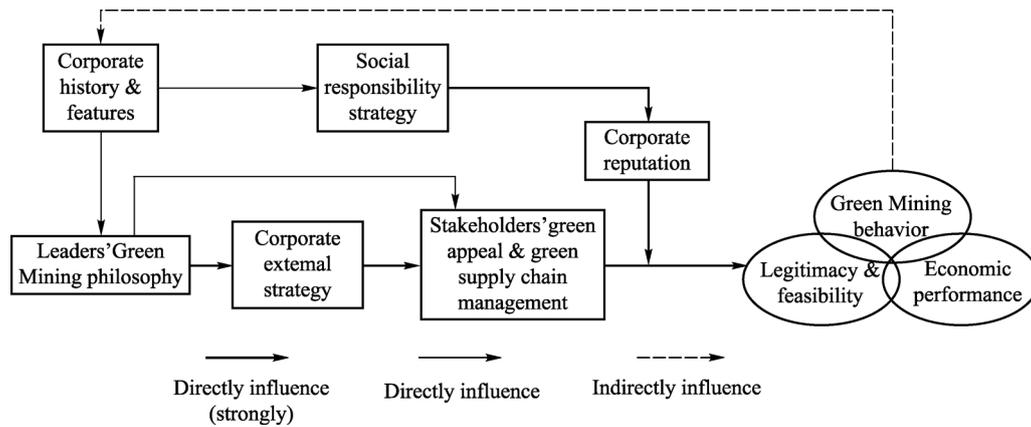


Figure 2. Myers' Corporate Social Performance Theory.

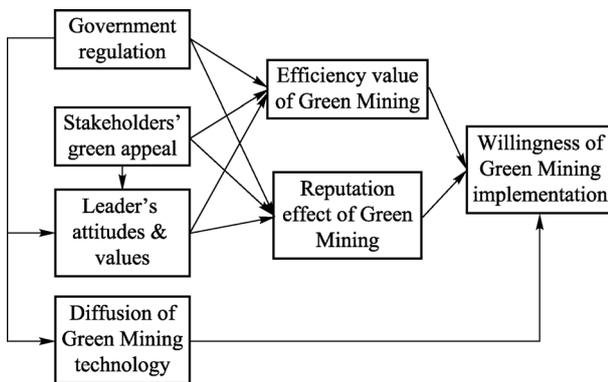


Figure 3. Conceptual model of driving factors of Green Mining.

H8: Leaders' attitudes and values have significant positive effect on efficiency value.

H9: Leaders' attitudes and values have significant positive effect on reputation effect.

H10: The diffusion of Green Mining technology has significant positive effect on the willingness of implementation of Green Mining.

H11: Efficiency value has significant positive effect on willingness of implementation of Green Mining.

H12: Reputation effect has significant positive effect on willingness of implementation of Green Mining.

## 2.2 Definition of concept

### 2.2.1 Efficiency value of Green Mining

Efficiency is utilizing input factors to produce the optimal product quantity combination and most efficiently meet people's desires and needs under the condition that resources (raw materials, human resources, capital, etc.) are limited. Efficiency comes into effect when certain criteria are met. It means the enterprises are making the best use of the economic resources.

In this research, the efficiency value of Green Mining means that the implementation of Green Mining has a positive effect on achieving enterprises' internal goal, meeting social requirements (government, public groups, local residents, etc.) and reaching the win-win situation of direct economic effectiveness and indirect effectiveness such as environment, technology, and management improvement.

### 2.2.2 Reputation effect of Green Mining

The reputation is not only the integrity of enterprises but also the corporate's responsibilities, such as the concern about social problems, the protection of ecological systems, the involvement of philanthropy, and care of employees as well as the quality of product and after-service. The Green Mining reputation effect is the value of intangible assets. It represents the influence on, or result of, the corporations' reputation (social and economic), which are the consequences of displaying great initiative-taking responsibilities during the business operation process, even the whole lifecycle. *Figure 4* shows the several benefits of Green Mining.

## 2.3 Questionnaire designing & variable measurement

### 2.3.1 Research scale designing

There are seven variables in this research, including the leaders' attitude and values, stakeholders' green appeal, government regulation, Green Mining technology diffusion, corporate efficiency value, corporate reputation effect and willingness of Green Mining implementation. The scales with reasonable validity and reliability and the qualitative research conclusions with high reference recognition in documents are selected and cited in the research; Meanwhile, the questionnaire is designed and modified based on the features of pre-surveyed enterprises. The Five-Point Likert Scale is used in the design. It

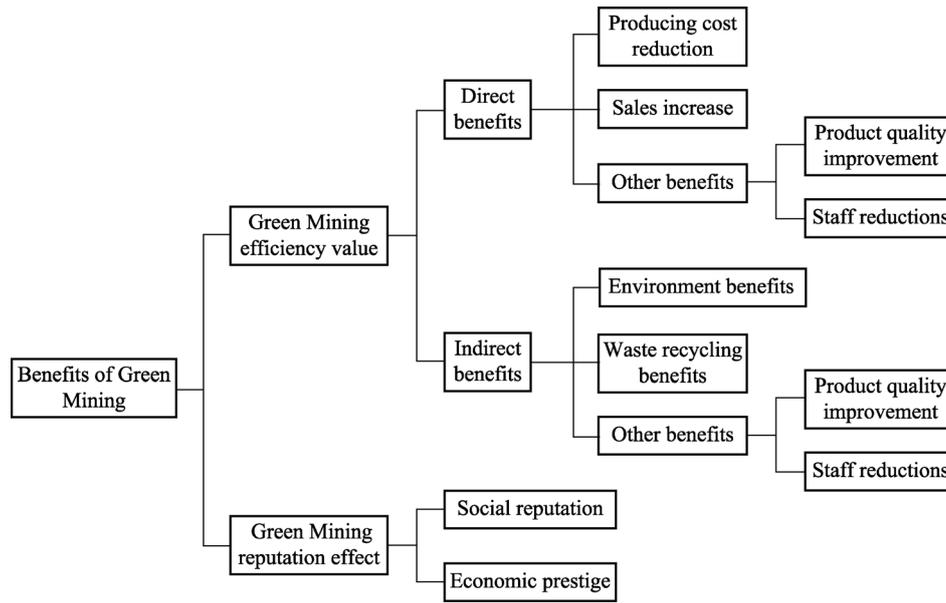


Figure 4. Benefits of Green Mining.

includes fifty-three measurement indicators indicating seven principal factors and six items that describe basic information of the surveyed enterprises. The scale is designed to empirically study the driving factors for coal mining enterprises to implement Green Mining.

### 2.3.2 Analysis of sample structure

The middle and senior managers from some representative mining groups such as China Coal Energy Group, Jizhong Energy Group, Yankuang Group, Shanxi Coking Coal Group, Xuzhou Mining Group, etc. were interviewed and requested to fill in the questionnaires on the spot. At the same time, more than twenty medium or large coal-mining enterprises, distributing over Shanxi, Shaanxi, Henan, Sinkiang, Inner Mongolia and Ningxia Province, took part in the Internet-based questionnaires. Two hundred ninety valid questionnaires were collected in total, among which 153 were from face-to-face interview and 137 were collected by E-mail.

### 2.3.3 Pearson analysis of corporation features and Green Mining demands

The research shows that the features of the surveyed enterprises have a great impact on the willingness to implement Green Mining. With SPSS13.0 and its related functions, Pearson correlation analysis was conducted to find out the relationships between corporate features and the variables of Green Mining implementation willingness, verifying the differences in the impact on Green Mining implementation willingness between each variable. Combined with the data from the questionnaires, the relation-

ships between corporations' age (AGE), corporate total assets (AST), the number of employees (NUM), EFF, REP and the willingness of Green Mining implement (WIS) are tested by using Pearson correlation coefficient. The results are shown in Table 1.

Table 1 show the correlation coefficient matrix of relative variables, then systemize as Table 2 that three main variable correlations can be concluded based on the levels of significance of the variables.

(1) WIS is significantly and positively correlated with EFF, REP, AGE, and AST, and has a positive correlative relationship with NUM

The tables show that the willingness to implement Green Mining is strongly correlated with corporate efficiency value, corporate reputation effect, term of operation and total assets. Corporate efficiency value and reputation effect has a more notable positive correlation among others and the correlation coefficients are 0.443 and 0.445, which are of significance at the level when  $\alpha=0.01$ . Although the coefficients are smaller than the former two, the corporations' age and total assets have positive correlation with the willingness of Green Mining implementation and both reach the significance level. The correlation coefficient of corporate age is 0.186 and has significance at the level of  $\alpha=0.01$ . The correlation coefficient of total assets is 0.130 and is of significance when  $\alpha=0.05$ .

The correlation coefficient of the amount of employees and willingness of Green Mining implementation is 0.069. Although the coefficient is small and does not reach the significance level when  $\alpha$  equals to 0.01 or 0.05, to some extent, it indicates that the more employees and stakeholders, the greater positive impact on the willingness of Green Mining implementation. To be concluded the higher

**Table 1***Correlation Coefficient Matrix of Relative Variables*

		EFF	REP	WIS	AGE	AST	NUM
EFF	Pearson Correlation	1	0.537**	0.443**	0.226**	0.120*	0.014
	Sig. (2-tailed)		0.000	0.000	0.015	0.085	0.815
	<i>N</i>	290	290	290	290	290	290
REP	Pearson Correlation	0.537**	1	0.445**	0.132**	0.093	0.159**
	Sig. (2-tailed)	0.000		0.000	0.024	0.140	0.016
	<i>N</i>	290	290	290	290	290	290
WIS	Pearson Correlation	0.443**	0.445**	1	0.186**	0.130*	0.069
	Sig. (2-tailed)	0.000	0.000		0.022	0.065	0.239
	<i>N</i>	290	290	290	290	290	290
AGE	Pearson Correlation	0.226**	0.132**	0.186**	1	0.285**	0.459**
	Sig. (2-tailed)	0.015	0.024	0.022		0.000	0.000
	<i>N</i>	290	290	290	290	290	290
AST	Pearson Correlation	0.120*	0.093	0.130*	0.285**	1	0.748**
	Sig. (2-tailed)	0.085	0.140	0.065	0.000		0.000
	<i>N</i>	290	290	290	290	290	290
NUM	Pearson Correlation	0.014	0.159**	0.069	0.459**	0.748**	1
	Sig. (2-tailed)	0.815	0.016	0.239	0.000	0.000	
	<i>N</i>	290	290	290	290	290	290

Note: \* Correlation is significant at the 0.05 level (2-tailed). \*\* Correlation is significant at the 0.01 level (2-tailed).

**Table 2***Correlations Analysis of Relative Variables*

Variable 1	Variable 2	Correlation Coefficient	<i>P</i> -value	Correlation Relationship
WIS	EFF	0.443	$P < 0.01$	Positive
WIS	REP	0.445	$P < 0.01$	Positive
WIS	AGE	0.186	$P < 0.01$	Positive
WIS	AST	0.130	$P < 0.05$	Positive
EFF	REP	0.537	$P < 0.01$	Positive
EFF	AGE	0.226	$P < 0.01$	Positive
EFF	AST	0.120	$P < 0.05$	Positive
REP	AGE	0.186	$P < 0.01$	Positive
REP	NUM	0.130	$P < 0.05$	Positive

corporate expected return on corporate efficiency value and reputation effect, the greater willingness of Green Mining implementation.

(2) EFF is significantly and positively correlated with REP, AGE, and AST

Similar to the willingness of Green Mining implementation, the corporate efficiency value also has a significant positive correlation relationship with reputation effect, corporate age and total assets. At the level of  $\alpha=0.01$ , corporate efficiency value has notable positive correlation relationship with reputation effect and term of operation. The corresponding correlation coefficients are 0.537 and

0.226. At the level of  $\alpha=0.05$ , efficiency value and corporate total assets are positive correlated and the coefficient is 0.120. To conclude, enterprises with good reputation, long term of operation and large total assets have better producing and sales techniques. They have better understanding of the importance of corporate social image and resource environment problem and thus tend to make great efforts to promote Green Mining.

(3) REP is significantly and positively correlated with AGE and NUM

The correlation coefficients of corporate reputation effect and the corporate age on and the number of employee are

0.186 and 0.130. They reach the significance level when  $\alpha=0.01$  and  $\alpha=0.05$ . The data shows that term of operation has a significantly positive effect on corporate social reputation and image. Enterprises attach more importance to corporate social reputation and influence as the term of operation and investment increase simultaneously. As a result, enterprises have more motivation and aspiration to implement Green Mining.

## 2.4 Data validity and reliability test

### 2.4.1 Validity analysis of data

The variables selected were referred to research results and conclusions which are approved widely by domestic and international experts. thus, the research needs to use exploratory factor analysis to test construct validity at first. Confirmatory factor analysis is used to test construct validity after the formation of the structure of relationship.

#### (1) Exploratory Factor Analysis (EFA)

The exploratory factor analysis in this research is conducted with SPSS13.0, in which KMO is 0.836. It explains that the data is qualified for factor analysis with Bartlett's test of sphericity ( $P < 0$ ). Principal component analysis with varimax rotation is used to generate seven factors forcibly and fifty three measurements from returned questionnaires are exploratory factor analyzed.

According to the judgment standard used by American statisticians, measurements with factor loading smaller than 0.5 are processed by deleting measurements (TEC1, TEC2, TEC10, GOV10, GOV11, STA1, STA9, and EFF2). The final exploratory factor analysis results are shown in Table 3, Table 4.

**Table 3**

*KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
	Approx. Chi-Square	df	Sig.
0.822	5888.501	990	0

**Table 4**

*Final Total Variance Contribution Rates (N = 290)*

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative/%	Total	% of Variance	Cumulative/%	Total	% of Variance	Cumulative/%
1	13.36	25.207	25.207	13.36	25.207	25.207	11.79	22.247	22.247
2	6.632	12.513	37.719	6.632	12.513	37.719	5.18	9.770	32.017
3	5.393	10.175	47.894	5.393	10.175	47.894	4.34	8.182	40.199
4	3.319	6.262	54.156	3.319	6.262	54.156	3.96	7.464	47.662
5	2.056	3.879	58.036	2.056	3.879	58.036	3.20	6.034	53.697
6	1.945	3.670	61.705	1.945	3.670	61.705	3.19	6.022	59.718
7	1.737	3.277	64.982	1.737	3.277	64.982	2.79	5.268	64.982

According to the results from Table 3, 45 measurements have KMO coefficient of 0.822 which is higher than 0.8 and achieve good fitness degree. Concomitant probability of Bartlett's test of sphericity is 0.000 which is less than the level of significance (0.5). Thus, the null hypothesis of Bartlett's test is rejected and the result of Bartlett's test reached significant level. Therefore, forty-five measurements designed for research are suitable for factor analysis. Table 4 shows the final total variance contribution rates by using exploratory factor analysis after varimax rotation in SPSS13.0. The results show that the cumulative variance explanation rate of the seven factors is 64.982%, which indicates that the questionnaire data has convergent validity. The factor loadings of measurement items on other latent variables are less than 0.5, which means that the data are also with well discriminate validity.

#### (2) Confirmatory Factor Analysis (CFA)

In this research, confirmatory factor analysis is conducted by the fixed loading method in LISREL 8.70 software which showed in Table 5. The factor loadings of the first measurement items of each latent variable were set 1 and the  $t$  scores are set not showed in the results. From the model fitting level point of View,  $P$ -value equals to 0.00, which is smaller than the reference value (0.05), in the Chi square test and reaches the significance level. Also,  $\chi^2/df$  equals to 2.48, which is smaller than 3 and means that the data fits the model well.

Generally speaking, models have ideal fitting degree when RMR and RMSEA are smaller than 0.07 and GFI, NFI, NNFI, and CFI are above 0.9 (Wen, Hou, & Marsh, 2004). The fitting degree will increase if RMR and RMSEA get smaller and GFI, NFI, NNFI, and CFI get higher. In this research, RMR = 0.073, RMSEA = 0.071, NFI = 0.92, NNFI = 0.87, CFI = 0.88. Thus, the model fits the data well. Hair, Anderson, Tatham, and Black (1998) indicated that, the model's fitting degree is great when AGFI is above 0.9 and is good when AGFI is above 0.8. AGFI in this research equals to 0.7 and is acceptable. Both of PNFI (0.78) and PGFI (0.67) are larger than the suggested value (0.5), which means the model has high fitting degree with the data (Byrne, 2001).

**Table 5***Fitting Test of Confirmatory Factor Analysis*

Measurement Index	Absolute Fitting Test					Increment Fitting Test				Brief Fitting Test	
	Chi-Square Text	CMIN/DF ( $c^2/df$ )	RMR	GFI	RMSEA	AGFI	NFI	NNFI	CFI	PNFI	PGFI
Recommended Standard	$P < 0.05$	$P < 3$	$P < 0.08$	$P > 0.9$	$P < 0.1$	$P > 0.7$	$P > 0.9$	$P > 0.9$	$P > 0.9$	$P > 0.5$	$P > 0.5$
Standard	2350.58 ( $P = 0.00$ )	2.48	0.073	0.92	0.071	0.7	0.92	0.87	0.88	0.78	0.67

**Table 6***Reliability Analysis of Data*

Variable	Cronbach's $\alpha$ -value
LED	0.851
TEC	0.794
GOV	0.817
STA	0.832
EFF	0.796
REP	0.826
WIS	0.807
Reliability	0.906

#### 2.4.2 Reliability analysis of data

In this sample data reliability testing, the Cronbach's  $\alpha$ -values of LED, GOV, STA, REP, and WIS are all above 0.8. The Cronbach's  $\alpha$  value of TEC and EFF are 0.794 and 0.796. All of the values are up to the standard and point out that the questionnaire contents have high internal consistency, and the data are highly reliable for the Cronbach's  $\alpha$  value higher than 0.7 (Hou, Wen, & Cheng, 2004). The reliability value of the questionnaire is 0.906 and this indicates that the internal factors variable structure is reliable (see Table 6).

According to the reliability and validity analysis, Indexes of the data reliability and validity in this research are accepted as statistical requirements. Thus, the data are suitable to analyze the models proposed in the research.

### 3 Results

#### 3.1 Optimization results

Fixed loading method is applied to revise the models in LISREL 8.70 software. Theoretically, all the paths with  $t$  values lower than 1.96 should be deleted or revised. Thus, the path between TEC and EFF is removed from the model; however, the path from LED to REP is reserved because all

the indexes of fit show that the fitted effect turns worse when removed. What is more, the interaction between decision makers' attitude and value and corporate reputation value is of great importance in the research, the factor effect research will be defective if the path is deleted. The optimal model was operated in LISREL and the result is showed in *Figure 5*. Accordingly, the value of latent variables' load on the most of the measurement items are greater than 0.5. The significances are also high. Therefore, the measurement is effective.

According to Table 7, all paths pass the  $t$ -test except the path from LED to REP. However, this path is reserved according to the previous analysis between LED and REP.

Table 7 shows the standardized path coefficients. The direct, indirect, and total effects are shown in Table 8.

#### 3.2 Hypothesis testing and interpretation

According to the result from SPSS and structural equation model simulation, all the twelve hypotheses pass the test except H6 (Table 8).

GOV has positive influence on TEC ( $\gamma = 0.29$ ,  $P < 0.001$ ). The direct effect value is 0.29 which means GOV and TEC are significantly correlated and H1 is true.

GOV has positive influence on LED ( $\gamma = 0.31$ ,  $P < 0.001$ ). The direct effect value is 0.31 which means GOV and LED are significantly correlated and H2 is true.

GOV has positive influence on EFF ( $\gamma = 0.43$ ,  $P < 0.001$ ). The direct effect value is 0.33 and the indirect effect value is 0.10, which means GOV and EFF are significantly correlated and H3 is true.

GOV has positive influence on REP ( $\gamma = 0.31$ ,  $P < 0.001$ ). The direct effect value is 0.28 and the indirect effect value is 0.03, which means GOV and REP are significantly correlated and H4 is true.

STA has positive influence on LED ( $\gamma = 0.11$ ,  $P < 0.001$ ). The direct effect value is 0.11 and H5 is true.

In the mediating effect test, the mediation effect between STA and WIS does not pass. Thus, H6 fails.

AST has positive influence on REP ( $\gamma = 0.33$ ,  $P < 0.001$ ). The direct effect value is 0.32 and the indirect effect value is 0.01, which means AST and REP are significantly correlated and H7 is true.

LED has positive influence on EFF ( $\gamma = 0.42$ ,

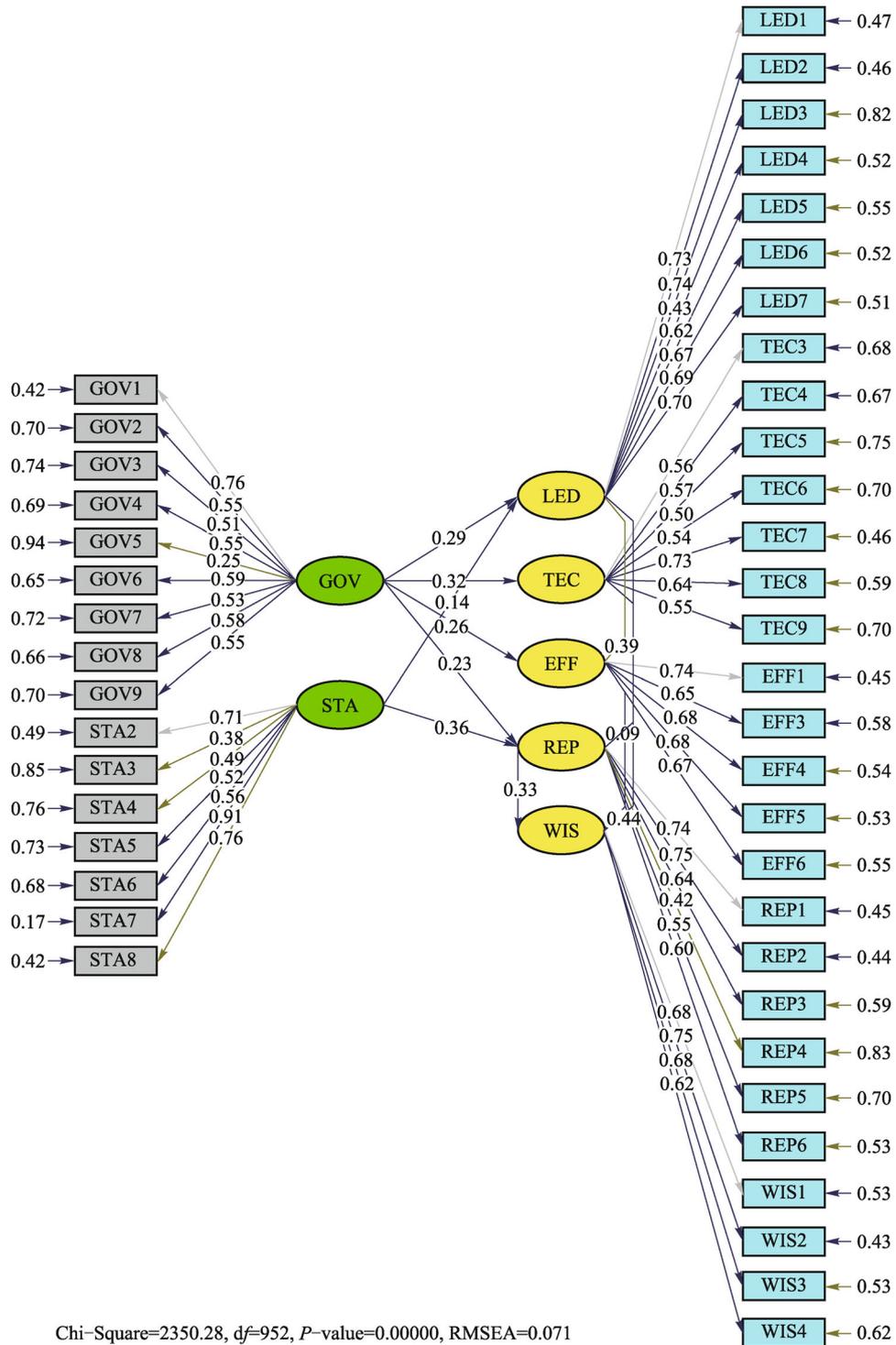


Figure 5. Optimal model of SEM.

$P < 0.001$ ). The direct effect value is 0.42, which means LED and EFF are significantly correlated and H8 is true.

The value of total effect value LED has on REP is 0.10 which means that the influence is not significant. However, the correlation between LED and REP is important in this research. Therefore, although H9 is insignificant, the path

between LED and REP is still reserved in structure equation model in order to keep the whole research complete.

TEC has positive influence on WIS ( $\gamma = 0.14$ ,  $P < 0.001$ ). The direct effect value is 0.18 and indirect value is  $-0.04$ . Thus, H10 is true.

**Table 7**

*Standardized Path Coefficients*

Path	Standardized Estimate	t-value
GOV → TEC	0.33	4.18
GOV → LED	0.29	3.87
GOV → EFF	0.29	3.95
GOV → REP	0.23	3.09
STA → LED	0.14	2.05
STA → REP	0.36	5.13
LED → EFF	0.40	22.12
LED → REP	0.09	1.26
TEC → WIS	0.17	2.55
EFF → WIS	0.45	6.00
REP → WIS	0.33	4.65

**Table 8**

*Direct Effect, Indirect Effect, and the Whole Effect among Variable*

Variables Relationship	Direct Effect	Indirect Effect	Whole effect
GOV → TEC	0.29	--	0.29
GOV → LED	0.31	--	0.31
GOV → EFF	0.33	0.10	0.43
GOV → REP	0.28	0.03	0.31
STA → LED	0.11	--	0.11
STA → REP	0.32	0.01	0.33
LED → EFF	0.42	--	0.42
LED → REP	0.10	--	0.10
TEC → WIS	0.18	-0.04	0.14
EFF → WIS	0.37	--	0.37
REP → WIS	0.26	--	0.26

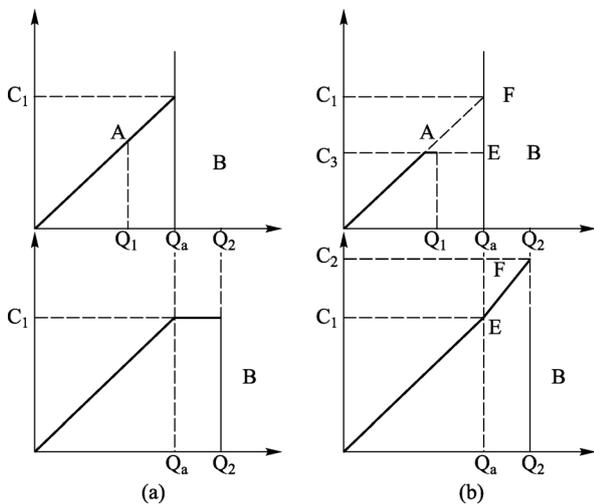


Figure 6. (a) Emission permits transaction of different enterprises. (b) Emission permits transaction between different pollution regions in the enterprise.

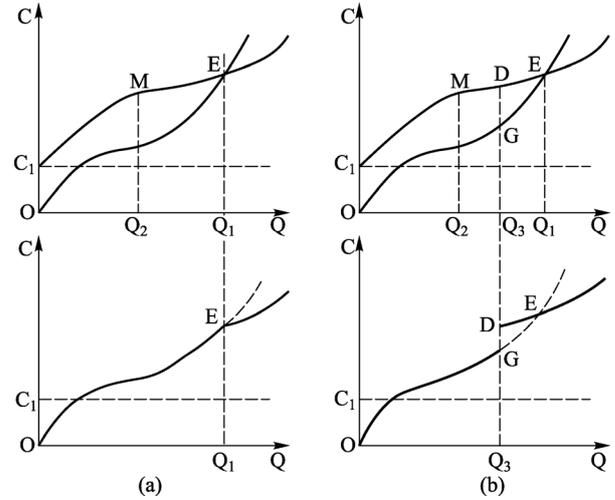


Figure 7. Incentive effect analysis of supportive subsidy used in stimulation towards Green Mining process.

EFF has positive influence on WIS ( $\gamma=0.37$ ,  $P < 0.001$ ). The direct effect value is 0.37, which means EFF and WIS are significantly correlated and H11 is true.

REP has positive influence on WIS ( $\gamma=0.26$ ,  $P < 0.001$ ). The direct effect value is 0.26, which means REP and WIS are significantly correlated and H12 is true.

According to the hypothesis test, apart from the hypothesis that LED has significant effect on REP, other hypotheses are supported by the data analysis result.

## 4 Discussion

The incentive system in China of Green Mining implementation relies on the laws and other compulsory regulations instead of economic instruments. According to the previous statements, the incentive system should be a combination of multiple means which are more motivated than policy regulated. Therefore, regulation control and motivation means are designed to make the government work better in actualization of Green Mining.

### 4.1 Commands-control policy

A system of effluent charge is the government's environmental management system which imposes a fee on the organizations or individuals for discharging pollution by law. It plays a regulative and promoted role in energy conservation, emission reduction, and Green Mining implementation. It is mandatory because in accordance with the law the fee must be paid. It is also orientative since the enterprises follow the market rules for their self-interests by managing the production activities to reduce the discharging through replacing inputs, disposing outputs and reducing production.

The enforcement of the policy depends on the govern-

ment's authority and the interest is following government regulation. Under this system, the perspective benefit of both enterprise and government is related to their behaviors. After analyzing the benefit relationship of both sides, to maximize the social benefit, the government can choose the measures or combos from the followings:

(1) Added extra fines

Enforcing punishment of the enterprises without environmental obligations would raise the production cost and lower their efficiency value (EFF). If the illegal activities are explored in public, they would not only be punished and public censured but also lower the reputation value (REP). Adding the extra fines would affect the choice of excess emission and improve regulation efficiency.

(2) Enhanced supervision of environmental regulation department

The national environmental authorities should enhance the supervision of the regulation department by putting Environmental Protection Responsibility System in to practice during the administration of this government, peer review of National People's Congress, Review System, Environmental Administrative Enforcement Accountability System, and Enforcement Efficiency Examining and Assessment System. All above are bound to increase regulatory pressure and driver, which can advance government regulation efficiency.

(3) Increasing the cost of dereliction of duty by the regulation department and improving benefits of fulfilling their duty

As a professional department, the environmental regulation organization authorized by government involves many interests; the behaviors probably are not always suitable for the regulation of set objectives. Therefore, the Environmental Administrative Enforcement Accountability System should be pursued to regulate the law-enforcing acts in place and enhance the degree of accuracy. Once department officials learn the higher costs of non-enforcement and the increased benefits of enforcement, then the department can continuously innovate the means of executing the law and improve efficiency.

(4) Reducing the cost of supervision and inspection of environment

Environmental supervision and inspection cost is bound to affect the environmental monitoring level. On the one hand the supervision department can reduce the management cost by completing and perfecting procedures and methods of the environmental management system implementation, optimizing the inspection path, strengthening the connection of the monitoring links, and reducing the information communication cost. On the other hand, they can enhance training and promote more scientific methods such as Green Mining auditing and green accounting, advanced monitoring technique such as pollution sources on-line monitoring device.

(5) Increasing the external cost of over-standard pollution emission

The decision making of over-standard pollution emission is related to participation costs of public scrutiny and reporting and the public pollution condition. The higher cost public have, the more inclined to discharge pollution over-standard. Establishing the system of public participation and incentives for reporting is increasing the external cost and lowering the reputation value (REP). Therefore, the establishment of environmental monitoring, social supervision, judicial action with the combination of prevention and punishment system and the system of public participation in environmental protection, is an effective way to improve the efficiency of regulation.

#### 4.2 Tradable emission permits system

Tradable emission permits can promote enterprises' Green Mining by applying this policy mechanism within one enterprise's pollution exchange compensation activities between different sources of pollution and emissions trading activities between different enterprises.

Different pollution sources from one enterprise trading as shown in *Figure 6(a)*: a branch company pay the cost of  $C_1$  bought emissions permits  $Q_a$ , it only use the emissions of  $Q_1$ , saving emission  $(Q_a - Q_1)$  can be transferred to another branch company of the enterprise who needs  $Q_2$  emissions  $(Q_a - Q_1 = Q_2 - Q_a)$ , this enterprise's total emissions does not change. Enterprise can distribute emission rights according to control principle that each branch company equals the marginal cost of pollution, which is beneficial for the enterprise to choose its own emissions path for Green Mining technology, thus ensuring its pollution control cost minimization.

Emissions rights trading between different enterprises as shown in *Figure 6(a)*, the enterprise with higher Green Mining efficiency will sell the saving emission  $(Q_a - Q_1)$  to who need more emissions. This trade will compensate the seller enterprise to some degree because the seller enterprise pays the cost of  $C_1$  bought emissions permits  $Q_a$  at first.

Emission rights trading can minimize the cost of the pollution treatment because the trade makes the polluters whose pollution treatment is the cheapest take more responsibility for reducing the pollution. In addition, the tradable emission permits by allowing trading license, also greatly reduce the cost of the polluters to abide by the rules. The problems of emission permits trading are also very serious. On one hand, the determination of emission rights relies on sufficient historical data and scientific reference standard, negotiations with different enterprises are necessary to accomplish the emission rights, which will surely increase the governance cost of environmental regulation. On the other hand, the policy core of tradable emission permits system is to guide enterprises to Green Mining step by step, accounting management achievements at each stage is necessary. Then set higher pollution control goals on the basis of accounting. All these activities

need to pay a part of social cost resulting from the difficulties of measurements of emissions and supervision of accounting.

A feasible tradable emission permits system requires the punishment of over-permits emission. Once the regional hotspot turned up, we can use some replaceable systems such as transactions by regions, the surrounding permits transactions or pollution compensation system. The transaction by regions means the polluters can make the deal only within the same region. The surrounding permits transactions can be made depending on the relative effects of emission on the monitoring point. The pollution compensation system requires no violation permit to accomplish the transaction in the area. Mendelsohn (1986) indicated that for some pollutants, market-based regulation without considering the spatial difference would lose majority of advantages from cost saving. When there is a difference between polluters' cost of pollution reduction, the market-based regulation has tremendous potential on cost reduction; however, the commands-control policy is more adaptable and effective when a variety of pollution damage punishments exist.

#### 4.3 Subsidy system of Green Mining based on technology diffusion

The Green Mining technology diffusion (TEC) is an important driving factor of implementing Green Mining. From the perspective of technology diffusion, designing the subsidy system of Green Mining plays an important role in Green Mining regulation design. With the supportive financial subsidies, the enterprise's enthusiasm raised up and the governance cost of implementing Green Mining reduced, the overall cost effect of implementing Green Mining is considerable.

As shown in upper left of *Figure 7*, supposing that the input of enterprise into special technology of Green Mining is  $C_1$ , the cost function curve change from OE curve to the  $C_1E$  curve because of improvement of production technology. New cost curve will begin lower than the original cost curve when the production more than  $Q_1$  (point E) because under the action of learning effects, unit of output material consumptions reduce.

There are three prominent characteristics of this promotion mechanism: firstly, the subsidies are dynamic changing, not static. Government's spending has priorities. Secondly, the subsidies are limited, not a permanent social burden. Thirdly, subsidies of Green Mining mechanism will be canceled after the enterprise reaps the benefits; enterprises can still implement Green Mining self-sustaining and further enhance the level of Green Mining efforts with the profit accumulation. As shown in lower left of *Figure 7*, this policy mechanism of enterprise cost curve is still the original cost curve before point E, becomes the new cost curve after point E, formed a bending curve as showed by the black thick lines.

The government can stop subsidies to enterprises of Green Mining earlier than point E to save the social welfare. At this time, the enterprise will implement Green Mining spontaneously for its own sake. Assuming that subsidies of Green Mining mechanism will be canceled when the production of enterprise is  $Q_3$ , corresponding to the D point on the new cost curve and the G point on the original cost curve. So the area of DEG is the saving social costs to promote enterprise implement Green Mining. Finally the enterprise actual cost curve is a jump, with fault cost curve of OG/DE (as shown black thick lines in lower right of *Figure 7*).

D point should locate at the key stage of Green Mining, between M (the peak point of subsidy investment) and E (cost curve turning point). After implementing technical mechanism of subsidy, in ensuring that the energy using efficiency is increased and emissions goals are achieved ahead of time, observing the status of production and sale, government can gradually reduce and eventually stop the supportive fiscal subsidies of new technology used in Green Mining when the market is in good condition and production runs smoothly.

#### 4.4 Motivation of coal enterprise decision-makers

The enterprise's Green Mining behavior, such as the development and application of Green Mining technology, the harmless management and resource utilization of industrial by-products, as well as the "three wastes" treatment, is ostensibly a kind of purposeful activities by the enterprise organization (take environmental responsibility actively, or response to environmental regulation); however, it is the decision maker of the enterprise who makes the strategic decision and starts the behavior. To conclude, the willingness and involvement of Green Mining is correlated with the decision makers' characteristics, including the business senses, moral judgments and business decision-making abilities, risk appetite and innovative spirits.

When it comes to conflicts between moral beliefs and profit motive during business, personal factors of the decision maker are particularly important. The enterprises pursue profits in nature, the decision makers are bound to take economic performance into consideration, so in the study of incentive mechanism of enterprise decision maker's involvement in Green Mining, moral judgments as well as economic performance both should be considered.

In the process of involvement and decision-making of Green Mining behaviors, moral judgments and economic performance are two related factors of chaos effect (complexity and variety of behaviors such as positive participation and continuous improvement, avoiding Green Mining technology input, end treatment, pay for emissions, and illegal disposal). Based on the study of two factors of decision makers on incentive mechanism level, there are

several countermeasures:

(1) Stimulating the firm's perform for implementation of Green Mining by decision maker, is the driving force of encouraging the decision maker to increase sense of morality and value, performing social responsibility, developing circular economy and then realizing the sustainable development of society. According to the former analysis, in order to stimulate decision maker to take environmental (social) responsibility actively, personal interest must be related.

(2) Decision maker's personal interest is an abstract concept, in order to maximum excitation under asymmetric information conditions, the SASAC and environmental regulation department should take part in the salary design of enterprise decision makers. The most effective way to examine whether the decision maker makes efforts to reduce the emission is to balance the dualism: first, the enterprise's target profit; second, the enterprise's emission reduction targets.

(3) The two factors (environmental performance and economic performance) examining the decision makers' efforts to reduce the emission are in fact two goals which the decision makers consider in Green Mining activities. With a multi-objective decision-making model, solution of optimization with the reasonable order of the two particular goals was conducted; it is found that the order of two consideration factors has a great impact on the involvement stimulation of the decision makers.

## 5 Conclusions and policy implications

The four factors, which have key effect on the WIS, are GOV, STA, LED, and TEC. A research system was set up based on these four factors. A Richter Magnitude Scale was also developed for the survey on enterprises' aspiration to implement Green Mining. According to the structure equation model, there are six main conclusions:

(1) GOV has significant positive influence on the LED, EFF, and REP.

(2) STA has positive influence on LED and significant positive influence on REP.

(3) AST has significant positive influence on EFF and insignificant influence on REP.

(4) TEC slightly affects EFF but has positive influence on WIS.

(5) EFF has significant positive influence on WIS.

(6) REP has significant positive influence on WIS.

According to the experience of the implementation of the cleaner production, the only way to build the sustainable motivation mechanism of cleaner production is to change the management from passive end-of-pipe control to active source control. The keys to the deep and lasting implementation of cleaner production are enterprises' initiative and enthusiasm. The empirical study provides theoretical support for the government to establish a

reasonable regulation and control mechanism, to improve enterprises' enthusiasm for Green Mining, to force and lead enterprises to improve their environmental behaviors by changing their roles from the traditional passive to initiative.

Based on the analysis of four influencing factors of the enterprise Green Mining implementation, there are several Green Mining incentive policies:

(1) The government can promote implementation of pollution discharge regulations by the policy and policy mix that increase the pollution charge, dutiful income and undutiful cost of regulation authority, the enterprise external loss, supervision strength of superior environmental regulation departments and reduce the cost of environmental supervision, so as to maximum the social profit.

(2) A discharge permit system can be developed to promote the emission compensation exchange activities between different pollution sources and emission trading activities between different enterprises. This would fully enable the enterprises to choose the technical route of emission reduction freely as the most effective way to control pollution.

(3) When applying Green Mining technology subsidy incentive measures, policy subsidy ought to be delivered when the implementation of Green Mining reaches the most crucial phase. After the application of the technology subsidy mechanism, under the assurance of increasing energy efficiency and meeting emission targets, production and sales condition of the products should be observed; if the market is steady and production supply is ample, the subsidy for Green new technology can be gradually cut back and even stopped for a lower governance cost.

(4) In the performance examination of the enterprise decision makers, environmental goals deserve priority. Only in this way, the incentive level of decision maker for Green Mining implementation can be higher than that when economic targets come first. With the model optimization, there are countermeasure to the personal behaviors at a mechanism level. The most effectual means of Green Mining implementation and emission reduction is to take both economic performance and environmental performance into consideration, while making sure that the weight and order of the environmental performance take a leading position in assessment system.

**Acknowledgements** This article was supported by a grant from the China Social Science University Humanity Programs Foundation of Ministry of Education (No. 11YJAZH091) and the National Natural Science Foundation of China (Grant No. 41171441).

## References

Byrne, B.M. (2001). *Structural Equation Modeling with AMOS: Basic Concepts, Applications and Programming*. New Jersey: Erlbaum

- Guo, C. (2007). The new trend of China's environmental regulation and development. *Review of Economic Research*, 27, 30–35
- Hair, J., Anderson, R., Tatham, R., & Black, W. (1998). *Multivariate Data Analyses (5th ed)*. New Jersey: Prentice-Hall
- Hou, J., Wen, Z., & Cheng, Z. (2004). *Structural Equation Model and Its Applications*. Beijing: Educational Science Publishing House
- Long, R., & Dong, J. (2005). Game analysis on mining enterprises carrying out Green Mining and the policy recommendations. *China Mining Magazine*, 14, 17–20
- Lu, M., & Wang, X. (2007). The concept, technological system and developing trends of Green Mining. *Industrial Minerals and Processing*, 4, 36–38
- Maxwell, J., Lyon, T.P., & Hackett, S.C. (2000). Self-regulation and social welfare: the political economy of corporate environmentalism. *Journal of Law & Economics*, 43, 583–618
- Mendelsohn, R. (1986). Regulating heterogeneous emissions. *Journal of Environmental Economics and Management*, 13, 301–312 .
- Qian, M., Xu, J., & Miao, X. (2003). Green technique in coal mining. *Journal of China University of Mining & Technology*, 32, 343–348
- Wang, L., Li, K., Wei, X., & Zou, Y. (2009). Research on induction of enterprise's clean production behavior—Based on two key value powers. *Ecological Economics*, 3, 41–44
- Wang, L., Ma, H., Zhu, C., & Li, K. (2009). Study on the efficiency of emission control: based on mixed strategy model. *Ecological Economics*, 6, 52–55
- Wang, L., & Zhu, C. (2009). Research on the two-factors priorities about the salary system design of decision-makers based on cleaner production performance: information management, innovation management and industrial engineering. *2009 International Conference on, Xi'an*
- Wen, Z., Hou, J., & Marsh, H. (2004). Structural equation model testing: cutoff criteria for goodness of fit indices and chi-square test. *Acta Psychologica Sinica*, 36, 186–194
- Yu, H., & Yi, X. (2007). Driving factors analysis of corporate social responsibility. *Commercial Times*, 8, 109–111
- Zhang, X. (2011). The game theory analysis of Green Mining. *Coal Economic Research*, 4, 42–44
- Zhang, Z., & Hu, P. (2002). The green management, an instrument for enterprises to boost up their competitive advantage. *Science and Technology Management Research*, 6, 47–50