

Research on Risk Management Capability Assessment and Emergency Response of Coal Mine Accident under the Coupling Effect of Multiple Disasters

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Abstract

In order to improve and enhance the emergency management capability of coal mining enterprises under the coupling effect of multiple disasters, this paper constructs a structural equation model of the emergency management capability of coal mining enterprises according to variables such as emergency preparedness ability, monitoring and early warning and emergency decision-making ability, information communication and emergency organization ability, emergency disposal and aftercare treatment ability of coal mining enterprises. A questionnaire on the emergency management capability of coal mining enterprises under the coupling effect of multiple disaster types was used to investigate coal mining enterprises, and the structural equation model was used to verify the proposed theoretical hypothesis. The results show that under the coupling effect of multiple disasters, the emergency preparedness ability, monitoring and early warning and emergency decision-making ability, information communication and emergency organization ability of coal mining enterprises have a positive impact on the emergency management ability of coal mining enterprises. According to this, suggestions are given to improve the emergency rescue capabilities of coal mining enterprises.

Keywords

Structural Equation Model; Multi-disaster Coupling; Risk Management; Emergency Management Capability; Safety Assessment; Coal Mine Accident.

1. Introduction

With the development of the economy and the development of science and technology, great progress has been made in the safety management of coal mines, but safety problems still exist[1], not only small accidents occur from time to time, but also major accidents have not been effectively controlled[2]. Coal enterprises have sudden incidents, frequent accidents, serious losses, wide scope of impact, and complex production systems[3]. However, there is resilience in three aspects: before, during and after the event[4]. One of the main reasons for mine emergencies is due to the mine's poor emergency response capabilities[5]. The study of mine emergency response capabilities under the coupling effect of multiple disaster types can enrich the theory of mine emergencies[6], improve the emergency management system, and timely discover the problems that need to be solved[7]. Therefore, this paper adopts the structural equation model method, proposes a hypothetical model[8], makes corrections, and combines examples to quantitatively analyze the relationship between the influencing factors of the emergency response ability of coal mining enterprises [9], so as to provide a scientific, reasonable[10], and scientific and reasonable emergency management

capability of coal mining enterprises under the coupling effect of multiple disasters. Valuable countermeasures[11].

2. Indicator System for Emergency Management Capacity of Coal Mining Enterprises

The following table shows the specific contents of the evaluation index system of the emergency management capacity of coal mining enterprises under the coupling effect of multiple disasters and the description of each index:

Table 1. Rating index system and description of emergency management capacity of coal mining enterprises under the coupling effect of multiple disaster types

Potential variables	The number of observed variables	Observation variables	Indicator description and judgment criteria (high indicator value corresponds to large value).
Emergency preparedness capability of coal mining enterprises under the coupling effect of multiple disaster types	6	Emergency Knowledge A1 Participate in Emergency Drill A2 Emergency Awareness A3 Culture of Safe Behavior A4 Information validly published A5	The degree of emergency knowledge of employees of coal mining enterprises The enthusiasm of employees of coal mining enterprises in participating in emergency drills Coal mining enterprises for emergency publicity and education training for emergencies Safety behavior of employees in coal mining enterprises The scientific and reasonable early warning information of coal mining enterprises is released
		Emergency facilities and supplies B1	Reserves of emergency equipment and facilities and distribution of emergency materials
Under the coupling effect of multiple disaster types, coal mining enterprises have the ability to monitor, warn and make emergency decisions	2	Regularly check for security risk c1 Proactive risk aversion C2	Regularly check the safety hazards in coal mining enterprises under the coupling effect of multiple disaster types Prevent the outbreak of a polycentric crisis
Information communication and emergency organization capabilities of coal mining enterprises under the coupling effect of multiple disaster types	4	Information Dissemination System D1 Contingency Plan D2 Effectively handles power D3 Effective control of the situation D4	Emergency information release system for coal mining enterprises under the coupling effect of multiple disaster types The degree of perfection of the emergency plan of coal mining enterprises under the coupling effect of multiple disaster types Personnel dealing with crises in coal mining enterprises under the coupling effect of multiple disasters Prevent the spread of the crisis
The emergency disposal and aftercare treatment capacity of coal mining enterprises under the coupling effect of multiple disaster types	2	Emergency response speed E1 Containing the spread of the crisis E2	Strike quickly to stop the crisis from expanding All departments achieve high-speed operation and strong guarantees

3. Evaluation Model of Emergency Management Capacity of Coal Mining Enterprises under the Coupling Effect of Multiple Disaster Types

3.1 Model Building

Based on the above assumptions, the initial model diagram of the structural equation model for the evaluation of the emergency management capacity of coal mining enterprises under the coupling effect of multiple disaster types shown in the figure is constructed.

Based on the above analysis, in order to verify the constructed theoretical model, the following hypotheses are proposed:

H1: The emergency preparedness ability of coal mining enterprises under the coupling effect of multiple disaster types has a positive impact on the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises under the coupling effect of multiple disaster types.

H2: The emergency preparedness capability of coal mining enterprises under the coupling effect of multiple disaster types has a positive impact on the emergency disposal and aftercare treatment capabilities of coal mining enterprises under the coupling effect of multiple disaster types.

H3: The monitoring, early warning and emergency decision-making capabilities of coal mining enterprises under the coupling effect of multiple disaster types have a positive impact on the information communication and emergency organization capabilities of coal mining enterprises under the coupling effect of multiple disaster types.

H4: The information communication and emergency organization capabilities of coal mining enterprises under the coupling effect of multiple disaster types have a positive impact on the emergency disposal and aftercare treatment capabilities of coal mining enterprises under the coupling effect of multiple disaster types.

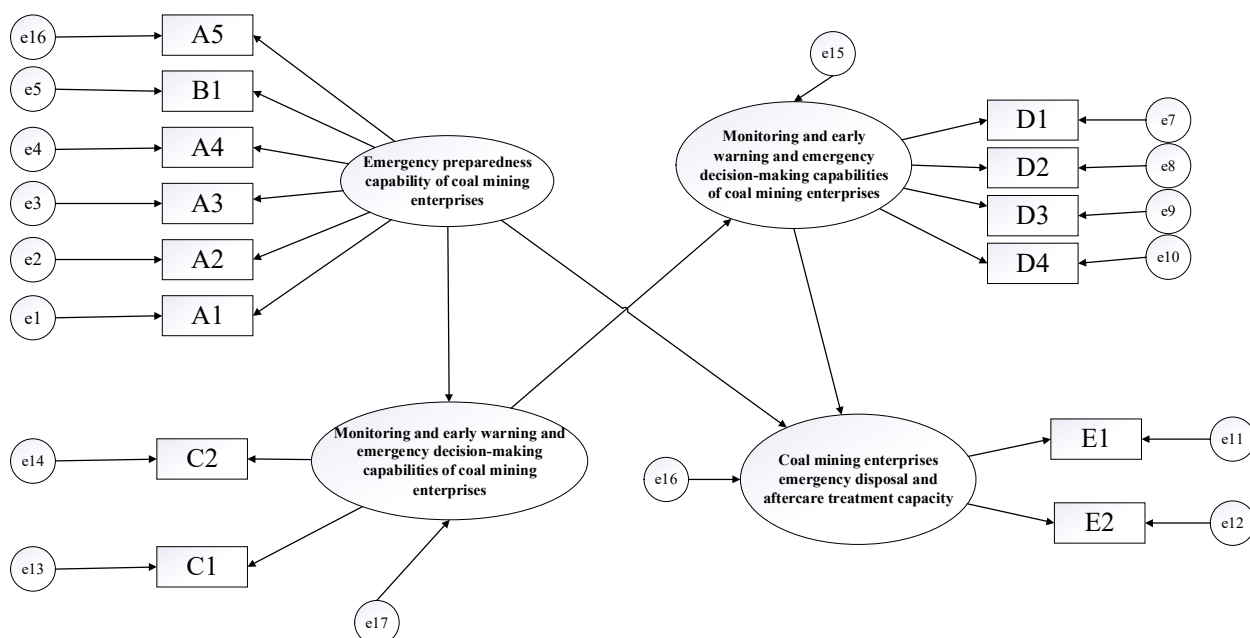


Figure 1. Evaluation model of emergency management capacity of coal mining enterprises under the coupling effect of multiple disaster types

3.2 Reliability Test

The recovered questionnaire data was analyzed using SPSS software, using Cronbach (Kronbach The size of the coefficient measures the credibility of the questionnaire, and its test results are as follows:

Table 2. Reliabilit summary

Clone Bach Alpha	Clone Bach Alpha based on normalization terms	The number of items
0.900	0.919	16

Through domestic and foreign studies, it can be seen that cronbach (clonbach) reliability evaluation criteria are: clonbach coefficient, if this value is higher than 0.8, indicating that this value is high confidence; if this value is between 0.7 and 0.8, it means that the reliability is better If this value is between 0.6 and 0.7, the reliability is acceptable, and if the value is less than 0.6, the reliability is not good. From table 5 of the calculation results, it can be seen that the Cronbach'Alpha (CA) of the observed variable is 0.919 above 0.9. It shows that the data has a high degree of credibility and can move on to the next step of research.

Table 3. Reliability summary

Clone Bach Alpha	The number of items
0.937	14

3.3 Validity Test

The questionnaire validity test refers to the analysis of the validity of the questionnaire and the test of the degree to which the results of the questionnaire reflect the objective reality that it should reflect. The questionnaire data was imported into SPSS software and tested for validity with KMO measures and Bartlett sphere tests.

Table 4. KMO and Bartlett test

KMO sampling tangency quantity	0.870
Approximate chi-square	2341.773
Bartlett spherical degree test	
Degrees of freedom	136
Significance	0.000

From Table 4 KMO and Bartlett's test, the Sig value is 0.000, less than the significance level of 0.05, and passed the Bartlett spherical test, KMO The value is 0.870, which is higher than 0.8, so the survey results are suitable for exploratory factor analysis.

Table 5. Matrix Scale Question Dimension Analysis

Total variance interpretation							
ingredients	Initial eigenvalue			Extract the sum of squares of the loads			Sum of the squares of the rotating loads
	total	Percentage of variance	Cumulative %	total	Percentage of variance	Cumulative %	total
1	7.802	48.764	48.764	7.802	48.764	48.764	5.309
2	2.086	13.035	61.798	2.086	13.035	61.798	3.620
3	1.199	7.496	69.295	1.199	7.496	69.295	2.158
4	0.835	5.219	74.514	—	—	—	—
5	0.628	3.927	78.441	—	—	—	—

From the data results of Table 5, it can be seen that the matrix scale problem should be divided into three dimensions, and the cumulative variance contribution rate of these two dimensions is $69.295\% > 60\%$, which can be seen to be more reliable.

Table 6. Composition matrix after rotation

	ingredients		
	1	2	3
12. What do you think is the speed of the emergency disposal response of coal mining enterprises	0.832	0.216	—
16. What you think are the recovery measures after the emergency of the Coal Mining Enterprise Pavilion	0.800	0.216	—
6. Whether your coal mining enterprise regularly checks for potential safety hazards	0.745	0.438	—
14. You believe that coal mining enterprises use self-media channels (official accounts, microblogs, official websites, etc.) to release information on emergencies	0.741	0.218	- 0.142
15. You think the implementation speed and completion degree of the emergency disposal of the coal mining enterprise hall	0.740	0.386	- 0.105
11. You believe that the emergency monitoring personnel of coal mining enterprises are staffed (number of people, time invested, division of labor).	0.733	0.301	0.114
10. You think the soundness of the emergency plan of the coal mining enterprise	0.639	0.211	0.504
9. Whether you believe that the emergency information release system of coal mining enterprises is sufficient	0.615	0.317	0.356
5. Whether the emergency facilities and materials of your coal mining enterprise are sufficient	0.597	0.570	—
7. Whether your coal mining enterprise has strictly carried out body temperature monitoring and related epidemic prevention and control measures during the epidemic period	0.518	0.370	0.201
4. Do you know the methods of escape, self-help, mutual rescue when an accident occurs?	0.239	0.803	0.103
3. Whether the emergency publicity and education of your coal mining enterprise for emergencies is sufficient	0.370	0.797	—
1. Whether your understanding of emergency response knowledge is sufficient	0.218	0.770	—
2. Whether the emergency drill of coal mining enterprises under the coupling effect of multiple disasters is sufficient	0.364	0.753	—
8. Whether you think your coal mining enterprise is perfect in emergency decision-making	—	—	0.919
13. You believe that coal mining enterprises coordinate and link with other departments for emergencies	—	—	0.901
Extraction method: Principal component analysis method.			
Rotation method: Caesar's method of normalizing maximum variance.			
The rotation has converged after 5 iterations.			

From the rotated composition matrix of Table 6, it can be seen that according to the rotated component matrix value > 0.5 belongs to the same latitude to meet the requirements, and it can be seen that Q1, Q2, Q3, Q4, Q5 and Q6 should be at the same latitude, Q5, Q6, Q7, Q9 Q10, Q11, Q12, Q14, Q15, Q16 should be at the same latitude Q8 and Q13 should be at the same latitude, but the values of Q5 and Q6 of the first latitude are greater than the values of the second latitude, so the second latitudes of Q5 and Q6 It should be deleted, and the remaining questions are only loaded above 0.5 in a single dimension, which belongs to the valid question terms, passes the validity test, and should be retained.

Model results and countermeasure analysis.

The SPSS data is imported into AMOS for model data analysis, and the analysis results are as follows:

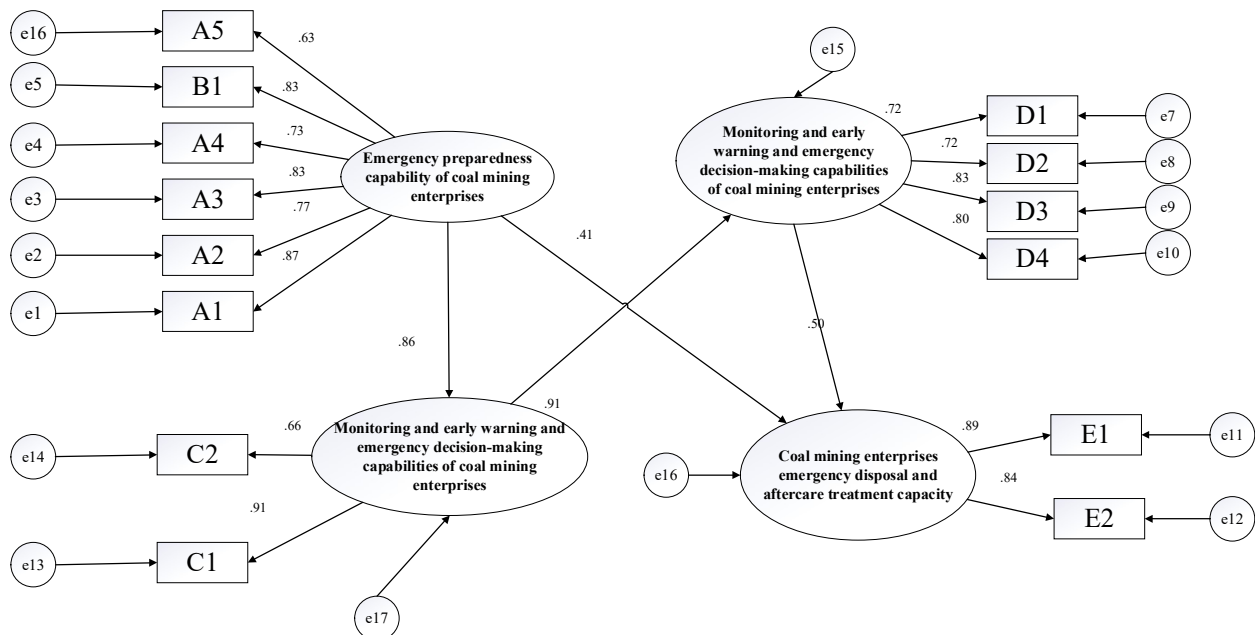


Figure 2. Standardized parameter path diagram of the evaluation model of emergency management capacity of coal mining enterprises under the coupling effect of multiple disaster types

After the ANALYSIS software analyzes the structural equation model, Figure 2 is obtained, which can be seen from Figure 2, and the path coefficient supports the research hypothesis. It can be seen from the path diagram of the evaluation model of the emergency management capacity of coal mining enterprises under the coupling effect of multiple disasters:

The emergency preparedness capacity of coal mining enterprises, the monitoring and early warning and emergency decision-making ability of coal mining enterprises, and the information communication and emergency organization capabilities of coal mining enterprises have different degrees of influence, and they have an impact on the emergency management capabilities of coal mining enterprises through the emergency handling and aftercare capabilities of coal mining enterprises; the emergency preparedness capabilities of coal mining enterprises have an impact on the emergency management capabilities of coal mining enterprises through the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises, the information communication and emergency organization capabilities of coal mining enterprises, and the emergency handling and aftercare processing capabilities of coal mining enterprises. The monitoring, early warning and emergency decision-making capabilities of coal mining enterprises have an impact on the emergency handling and aftercare capacity of coal mining enterprises through the information communication and emergency organization capabilities of coal mining enterprises; the emergency disposal and aftercare treatment capabilities of coal mining enterprises are affected by the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises, the information communication and emergency organization capabilities of coal mining enterprises, and at the same time, the emergency handling and aftercare processing capabilities of coal mining enterprises also have an impact on the emergency management capabilities of coal mining enterprises. The larger the path coefficient, the greater the impact on the emergency management capabilities of coal mining enterprises.

It can be seen from Figure 2 that the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises have the greatest impact on the emergency management of

coal mining enterprises, followed by the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises, and the emergency disposal and aftercare capabilities of coal mining enterprises. The results show that the emergency disposal and aftercare treatment capabilities of coal mining enterprises have a positive positive impact on the emergency management capabilities of coal mining enterprises, and the higher the coordination and linkage ability of coal mining enterprises, the more conducive it is for coal mining enterprises to deal with emergencies.

In the emergency preparedness capacity of coal mining enterprises, the negative load of factors participating in emergency drills (A2), emergency publicity (A3), and emergency facilities and materials (B1) is larger. Therefore, coal mining enterprises should often carry out emergency publicity education and training for employees in coal mining enterprises, so that employees in coal mining enterprises can understand and remember emergency knowledge, so that emergency knowledge can be rooted in the hearts of employees, and when doing something, they can directly associate emergency knowledge and make it quickly Judgment, stop the occurrence of emergencies from the source. At the same time, coal mining enterprises must have emergency facilities, but also have sufficient emergency materials, such as fire extinguishers, medical kits, etc., to ensure that even if the crisis occurs, reduce personnel and property losses. At the same time, coal mining enterprises should have their own coal mining enterprise safety culture, strengthen the safety awareness of coal mining enterprise employees, so that they first consider safety, not only responsible for themselves, but also responsible for other employees of coal mining enterprises.

In the monitoring and early warning and emergency decision-making capabilities of coal mining enterprises, regularly check for potential safety hazards (C1) and effectively release information (C2) factor load is larger. The occurrence of crises will have certain laws, so the staff of coal mining enterprises should carefully analyze the emergencies that occur in coal mining enterprises, or study emergencies at home and abroad, find out the laws of crisis occurrence, and formulate reasonable measures to prevent the occurrence of crises. Coal mining enterprises should regularly check whether the fire extinguishers and fire hydrants in coal mining enterprises are damaged, repair unqualified emergency facilities and materials in a timely manner, and regularly check the safety hazards existing in coal mining enterprises to avoid the occurrence of emergencies. Coal mining enterprises may invite some experts and other professionals to conduct risk assessments in coal mining enterprises, understand whether there are hidden dangers in coal mining enterprises, and put forward opinions to make the risk assessment more professional.

In the information communication and emergency organization capabilities of coal mining enterprises, the emergency plan (D2) and the information release system (D1) factor load is larger. Coal mining enterprises should have a complete monitoring and early warning system, timely monitor the occurrence of crises, and make preparations at the first time to reduce the loss of personnel and property. Coal mining enterprises should have a sound emergency plan to cope with unexpected situations. At the same time, coal mining enterprises should regularly organize employees to conduct emergency drills, so that employees can not be afraid of danger and reduce danger when they encounter a crisis. Coal mining enterprises should set up special emergency management personnel, and the relevant personnel should fundamentally understand the importance of emergency management of coal mining enterprises and improve the quality of emergency management personnel of coal mining enterprises.

In the emergency handling and aftercare capacity of coal mining enterprises, the leaders of coal mining enterprises assign tasks to each department of coal mining enterprises, so that they have a clear division of labor, so as to ensure that useful resources can be gathered at the first time of crisis and improve the efficiency of command. Personnel of relevant departments should strengthen communication with various departments, and at the same time need active cooperation between various departments to improve the efficiency of emergency rescue. If an emergency occurs, the information should be reported to the government in a timely and accurate manner, and all departments should respond immediately and link with each other to minimize casualties. Among the

emergency disposal and aftercare capabilities of coal mining enterprises, the factor load of curbing the spread of crisis (E1) is relatively large. After the crisis occurs, it is necessary to arrange the affected employees and ensure the lives of employees. At the same time, lessons learned through crises are used to avoid the recurrence of such incidents.

4. Countermeasures and Recommendations

In recent years, emergencies in China have occurred frequently, and incidents such as gas explosions, impact pressure, floods, fires, and dust explosions in coal mining enterprises are common in coal mining enterprises, and these emergencies have posed a serious threat to the safety of the lives and properties of coal mining enterprise employees. Therefore, it is very important to improve the emergency management capabilities of coal mining enterprises, and it is very necessary to put forward countermeasures and suggestions for the emergency management capabilities of coal mining enterprises.

4.1 Improve the Emergency Management System and Mechanism of Coal Mining Enterprises

Improve the emergency management system of coal mining enterprises, continuously improve the rules and regulations for emergency management of coal mining enterprises, clarify the responsibilities of various departments of coal mining enterprises, and make the division of labor clear and each perform its own duties. At the same time, it is necessary to break the original stereotypical model, have the courage to innovate, and build a smart coal mining enterprise. Establish a sound emergency response mechanism, once an emergency occurs, immediately issue an early warning, coal mining enterprises immediately make decisions, so that coal mining enterprise employees evacuated to a safe area, at the same time, the relevant rescue organizations to the scene in the first time, is the injury, loss to the minimum.

4.2 Strengthen Emergency Preparedness Capacity

Integrate the emergency team, emergency materials, emergency facilities, etc. of coal mining enterprises. Coal mining enterprises shall set up sufficient fire hydrants, fire extinguishers, etc. within the prescribed scope, and shall be inspected regularly. Ensure that the emergency staircase of coal mining enterprises and other emergency places are unobstructed, and there must be no blockage.

4.3 Create an Emergency Cultural Atmosphere for Coal Mining Enterprises

When an emergency comes, serious accidents caused by the employees of coal mining enterprises do not understand the knowledge of escape, self-help knowledge, etc. still occur from time to time, so in order to improve the emergency management capabilities of coal mining enterprises, it is very important to improve the emergency awareness of coal mining enterprise employees.

4.4 Promote the Coordination and Linkage of Various Departments

When a crisis occurs, all departments must act immediately. The leaders of coal mining enterprises must rush to the scene at the first time and direct the scene. Assign tasks to various departments to make responsibilities clear. All departments are linked to each other to speed up the efficiency of rescue and prevent the further expansion of the disaster situation.

5. Conclusion

In this paper, an evaluation model of the emergency management ability of coal mining enterprises is established in four aspects: the emergency preparedness ability of coal mining enterprises, the monitoring and early warning and emergency decision-making ability of coal mining enterprises, the information communication and emergency organization ability of coal mining enterprises, and the emergency disposal and aftercare treatment capabilities of coal mining enterprises under the coupling effect of multiple disasters, and the reliability and validity of this model are tested.

According to the model research, it can be seen that the emergency preparedness ability of coal mining enterprises under the coupling effect of multiple disasters has a positive impact on the

monitoring and early warning and emergency decision-making ability, emergency disposal and aftercare processing ability, and information communication and emergency organization ability of coal mining enterprises; the monitoring and early warning and emergency decision-making ability of coal mining enterprises has a positive impact on the information communication and emergency organization capabilities of coal mining enterprises, and the emergency disposal and aftercare processing capabilities of coal mining enterprises. The information communication and emergency organization capabilities of coal mining enterprises have a positive impact on the emergency disposal and aftercare capabilities of coal mining enterprises.

China's start to emergency management is late, in recent years at home and abroad coal mining enterprises accidents frequent, so the study of gas explosion, impact pressure, flood, fire, dust explosion and other disasters under the coupling effect of coal mining enterprises emergency management capabilities is of great significance to improve coal mine safety, this paper uses the structural equation model to study the emergency management capabilities of coal mining enterprises, but due to my limited theoretical knowledge and practical work experience, the research on the emergency management capabilities of coal mining enterprises is not in-depth. In the future study, the observation variables can be further enriched according to the actual situation to further enrich the observation variables to have a deeper understanding of the current situation of emergency management of coal mining enterprises. At the same time, according to the evaluation of the emergency management ability of coal mining enterprises, it is possible to find out the shortcomings in the emergency management of coal mining enterprises, and put forward more scientific and reasonable countermeasures for the emergency management of coal mining enterprises.

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