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Research on ranking evaluation models of safety risk in productive enterprises based on the perspective of supervision

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Abstract

Supervision with risk highlights the key area, enterprises and period. It is great for finding the principal contradiction in supervision of safe production, to improve the efficiency of government's regulation and further to realize the optimal configuration of the limited supervisory force from local government. This paper establishes the risk evaluation index system of incident and disaster for manufacturing enterprises based on the systematic investigation and analysis of 209 enterprises in T city, Shandong Province by referring to many research outcomes of scholars abroad and domestic, related laws and regulations and professional standards, choosing 6 B indexes which include 35 C indexes according to the four characteristics and core objective of inherent risk level of manufacturing enterprise, safety regulation level, records of hidden dangers and punishments and accident occurrences. This paper also applies analytic hierarchy process(AHP) to determine the weight of every evaluation indexes, and make mathematics modelling according to the determined index system and weight, then use the model to evaluate and classify the risks of the 209 enterprises of T city Shandong Province, and finally propose measures of safety risk ranking supervision of production for local government according to the result of classification.

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Keywords: safety production; Risk classification; Production enterprises; Safety regulation

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1. Introduction

As the number of the enterprises is growing rapidly in China, the types of enterprises have become increasingly diverse, the object of supervision is a very large, the In-site supervisory task is very arduous, and there is a huge gap between the existing monitoring capability and supervisory requirements [1]. Meanwhile, the current supervision of safe production in China is carried out mainly surrounding the accident or the superior instructions. It is difficult to meet the growing demand for dependable production supervision and make sure the security supervision in place. According to the "20/80 rule" of management, the statistics of accident risk at home and abroad show that 20% of high-risk objects often leads to 80% of the accidents, and in the other 80% lower risk objects, the probability of accident is less; The safe production supervision should focus on the 20% high-risk objects which lead to more accidents and this is the main guiding ideology of the modern risk management. It is beneficial, on the one hand, to seize the principal contradiction of the safe production problem, determine the scientific and reasonable government regulatory risk prevention and control strategy, improve the scientifically, rationality and effectiveness of the prevention of the production safety accident, and realize the modern safety production operation mode and protection mechanism of systematic and essential prevention in advance by the determination of high-risk regulatory objects with classification and the implement of the key regulation the to the high risk objects. On the other hand, it helps ensure that the maximum use of the supervision and inspection resources, improving the efficiency of the government safety regulation supervisory work, and achieve the optimal allocation of regulatory forces. Western developed country realized the hierarchical safety regulation of production enterprises in the 1960s. The well-known risk classification methods mainly include Daw Chemical's fire explosion index method, the British coal mining risk classification method and the US States professional casualty classification method, the key point of which is to carry out the safety ranking supervision of productive enterprises with the consideration of the inherent risks of enterprises, accidents occurred in enterprises and enterprise personnel casualties accident. At present, China is also promoting the safe production supervision and quantitative index system of enterprises, in order to facilitate the survival and development of domestic enterprises. Pushing production enterprise classification regulation in China is the inevitable trend for the security industry to be found in line with international standards [2-5]. But in our country, for the moment, there is not any unified enterprise risk classification standard applied to the situation of our country. Therefore, in view of the production enterprises, how to better play the effect of classification based on risk supervision, how to rigorously enforce production enterprise security supervision, perfect the supervision mechanism, supervise resources and control the prominent security risks, are the important tasks that our safety supervision departments are faced with.

This paper, with the basic theory of risk assessment, analyzes systematically the recent situation of safety production of the 209 large and medium-sized enterprises in T city, Shandong province, and build an index system of manufacturing enterprise production safety risk assessment and grading calculation model, which consider production enterprise multidimensional risk factors comprehensively. According to the classification model the production enterprises can be subdivided into different risk levels, with reasonable and effective means of regulation, finally the incidence of accidents can be reduced, and the efficiency of the government safety regulation can be improved [6]. According to the actual situation of T city in Shandong province, this article only studies the risk assessment classification of manufacturing enterprise, and designs the risk grading index system of manufacturing class manufacturers with the research process of combining static risk grading index and static index, drawing lessons from a risk assessment of the academic research results, according to the relevant specification requirements. It can effectively improve the work efficiency of government regulators, enhance safety management level of government by using analytic hierarchy process (AHP) to determine the index weight, combining with the relevant standards, laws and regulations, establishing the index quantification standard, building the risk classification model, on the basis of value at risk to risk grading evaluation of manufacturing enterprises in Shandong province, according to the results of the risk grading evaluation reasonable government regulators corresponding regulation strategy.

2. Establishment of the enterprise production safety risk grading index system

2.1. Evaluation index selection principle

The scientific selection, to set up the index body is the key of whether can accurately evaluate the size of the enterprise safety production or not, enterprise production safety risk involves multiple factors, many available indicators for selection , this article selects indicators follow the following five principles, to ensure that the constructed index system of science[7]:

(1) The systemic principle: enterprise production process, involving multiple links and is a complex system, selection of evaluation index to consider various influence factors of enterprise's safety production, the evaluation index and evaluation target organically linked, at the same time should also pay attention to the index system of hierarchy clear, reasonable structure, coordinated; To seize the main influencing factors, to ensure the comprehensiveness of evaluation and credibility.

(2) The representative principle: the selected indicators closely related to enterprise safety in production, the selection of indicators can reflect directly as a result, and to reflect the indirect effect, avoid selection has nothing to do with the evaluation objects and contents of index.

(3) The measurability principle: the selected indicators to be able to be measured or measure, as far as possible, use Numbers to talk, digital to specification, diameter should agree, data collection easier, and the index design must be in accordance with national and local production safety related guidelines, policies, laws and regulations.

(4) Independent principle: The same level indicators should not have a containment relationship, which ensures the index can reflect the enterprise production activities from different aspects security risk level.

(5) Comparability principle: the stronger the evaluation indexes system of comparable, the greater the credibility of evaluation results. Therefore, establishment of evaluation index should be objective reality, comparison.

2.2. Establishment of evaluation index system

According to the disaster situation and characteristic analysis of T city production enterprise safety accident in Shandong province, occupational accidents are the main risk of manufacturing companies faced. According to the selecting principle of evaluation index, this article is based on the formation mechanism of production safety accidents disasters and the evolution process, from the level of inherent risk level of the manufacturing enterprise, the safety management, accident, hidden trouble and punishment records in four aspects, such as the characteristics and the core target, the 6 B level indicators are selected, a total of 35 C level indicators to build the manufacturing enterprises of accident disaster risk evaluation index system (as shown in Fig. 1). Among them, the inherent risk is the enterprise itself has the dangerous situation of objective response; The safety management level is a reflection of its for risk control ability; Hidden trouble and punishment record is the possibility of response; Accident is its risk of inertia reaction.

3. Establishment of enterprise production safety risk evaluation model

3.1. Data processing

This article selected indexes from Shandong Province safety bureau and *Shandong Statistical Yearbook 2012*. Because each indicator is changed, scope amplitude is very big, needing simple data processing before the application in advance, namely the first normalization processing, make each index values are in the range of [0, 1].

3.2. Index weight determination

This article used the analytic hierarchy process (AHP) to determine the weight of each evaluation index. Analytic hierarchy process (AHP) is by the famous American operations research experts named T.L. ShaDan in the 1970 s, it is a solution to the problem of multi-objective complex combination of qualitative and quantitative, systematic,

hierarchical decision analysis method, especially suitable for those difficult to fully use the quantitative analysis of the complex problems. In this paper, using analytic hierarchy process (AHP) to calculate the indexes weight[8]. The detail is shown in table 1.

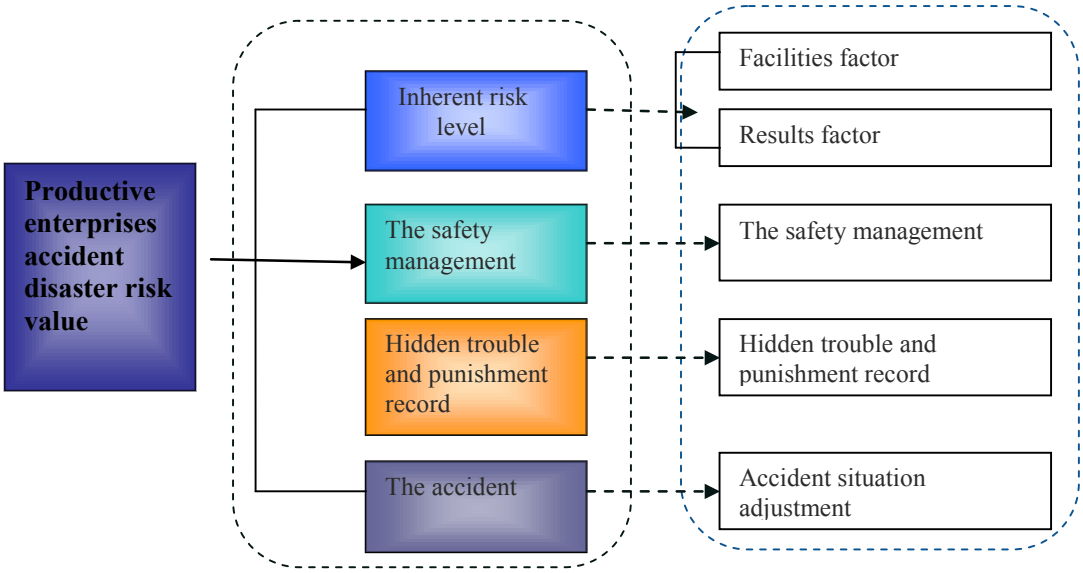

Fig.1. Productive enterprise risks grading index system of accident disaster.

With reference to relevant laws and regulations standard and related situation, determine the assignment of three indicators standards. The parameter values between 0-100 points, the greater the risk score, the greater the surface. Including facilities, equipment and process factors (B_1), hidden trouble and punishment factor (B_6), accident factor (B_7) is a positive indicator; And the working environment factor (B_2), staff situation factor (B_3), safety management factor (B_4) as a negative index[9].

3.3. Establishment of calculating model

In the regulatory object index of risk, hazard and punishment record and accident situation two indicators is a dynamic index; At the same time, from the Angle of administrative regulation, the emergence of the hidden danger and accident record and punishment should work as a regulatory priority factors, in that hidden trouble and punishment record will be used as dynamic adjustment factor index and accident situation. To reflect its importance, its value contribution is geometric series amplifier, using the exponential function of 2 which is more commonly used. Productive enterprises set up a disaster risk value calculation model, as showed in the following formula:

$$R = 2^{\frac{B_5+B_6}{200}} \bullet \left(\sum_{i=1}^{4} B_i W_i\right) = 2^{\frac{B_5+B_6}{200}} \bullet \sum_{i=1}^{4}\left(\sum_{j=1}^{m} C_{ij} W_{ij}\right) W_i$$
$$= 2^{\frac{B_5+B_6}{200}} \times \left[(0.166 \times C_{11} + 0.178 \times C_{12} + \ldots + 0.232 \times C_{15}) \times 0.282 + \ldots + (\ldots + 0.292 \times C_{54}) \times 0.142\right]$$
$$= 2^{\frac{B_5+B_6}{200}} \times (0.0468 C_{11} + \ldots + 0.0414 C_{47})$$

where: R is production enterprise accident disaster risk value;

W_i—the secondary index weights i;

W_{ij}—the item i the first j a three-level index weights of the secondary indicators;

C_{ij}—the first in the secondary targets I. J is a three-level index score.

Table 1. Enterprise production safety risk assessment index system and weight value.

Level indicators	The secondary indicators	Weights (W_i)	Level 3 indicators	Weight (W_{ij})	Quantitative standard
Risk value	1.The equipment and process factors (B_1)	0.282	1.1 Number of special equipment (C_{11})	0.166	100"
			1.2dangerous chemicals (C_{12})	0.178	100"
			1.3 Is there a gas station, oxygen station or acetylene Station (C_{13})	0.192	100"
			1.4 combustible or flammable gas storage (C_{14})	0.232	100"
			1.5 whether there is easy to cause dangerous process (C_{15})	0.232	100"
	2.The working environment factor (B_2)	0.227	2.1 Natural environment s(C_{21})	0.164	100"
			2.2 Whether in key areas (C_{22})	0.154	100"
			2.3 Hazards (C_{23})	0.171	100"
			2.4 Degree of Hazard(C_{24})	0.202	100"
			2.5 factories and workshop channels (C_{25})	0.062	100"
			2.6Items placed situation (C_{26})	0.051	100"
			2.7 fire control facilities and signs (C_{27})	0.069	100"
			2.8workshop equipment layout (C_{28})	0.068	100"
			2.9 workshop lighting lamps and lanterns (C_{29})	0.059	100"
	3.The employee situation factor (B_3)	0.122	3.1 The number of employees (C_{31})	0.21	100"
			3.2 Special Operations personnel Numbers System (C_{32})	0.43	100"
			3.3 Culture degrees (C_{33})	0.18	100"
			3.4 Physical conditions(C_{34})	0.18	100"
	4. Safety management factor (B_4)	0.227	4.1 Safety management institutions and personnel (C_{41})	0.139	100"
			4.2 The safety management system and operation procedures (C_{42})	0.139	100"
			4.3 in the workplaces where security check (C_{43})	0.176	100"
			4.4 Employee Safety production training time (C44)	0.273	100"
			4.5The ratio of related certificates (C_{45})	0.273	100"
	5. Contingency factor (B_5)	0.142	5.1 Risk analyses (C_{51})	0.228	100"
			5.2 Contingency plans scales(C_{52})	0.185	100"
			5.3 Emergency drills (C_{53})	0.295	100"
			5.4 Emergency supplies power scales(C_{54})	0.292	100"
	6. Hidden trouble and punishment factor adjustment factor(B_6)	Adjustment factor	6.1 Payment of municipal hidden trouble number (C61)	—	(1) 100 points
			6.2 The rectification record number (C_{62})	—	1 –70 points
			6.3 punishment record numbers (C_{63})	—	In recent 30 points 1 times the first year; The last 2 years 1 –20 points; the last 3 years 1 – 10.
			6.4 Payment of municipal hidden trouble number (popular C_{64})	—	Recently for the first year 1– 60 points; The last 2 years 1 –40 points; The last 3 years 1 –20 points.
	7. Accident factors(comprehen sive)be nearly three years(B_7)	Adjustment factor	7.1 General accident frequencies(C_{71})	—	One 30 points
			7.2 larger accident frequencies (C_{72})	—	One assigned 50 points
			7.3 Number of major accidents (C_{73})	—	170 points
			7.4 Number of extremely large accidents (C_{74})	—	170 points

3.4. Determine the accident disaster risk classification table

According to the R value according to the standard of production enterprises are shown in Table 1 accident disaster risk classification.

Table 2. Productive enterprise accident disaster risk classification standard table

R value	Risk level	Note
R⩾80	Very high	Check the high frequency
60⩽R＜80	High	Check the relatively high frequency
40⩽R＜60	Medium	Check the relatively low frequency
R＜40	Low	Check the low frequency

3.5. Application example

Applying the model of the risk classification, but for the risk evaluation of T City 209 production enterprises in Shandong province, classification results are shown in Table 3.

Table 3. Productive enterprise accident disaster risk classification standard table.

Regulatory object category	Regulatory object the number(home)	Kind of risk	Risk level			
			Very high	High	Medium	Low
Manufacturing companies	209	Occupational injuries	3	19	145	42

For statistical objects with different level of risk supervision, proportion is shown in Fig.2:

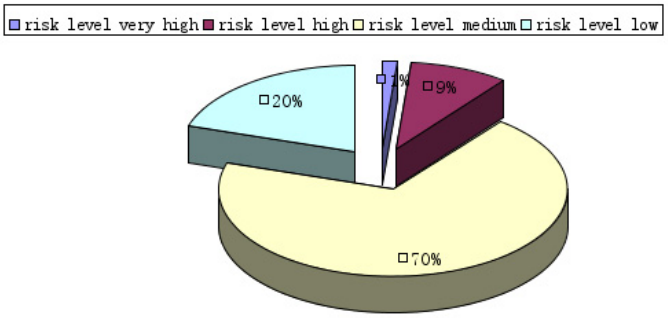

Fig.2. T city in Shandong province production enterprise security risk profile.

4. Classification regulation

1) According to the production enterprise risk evaluation results, we can examine the different risk level of the enterprise implement scheme and regulatory measures, focus on the enterprise of high risk and high, so as to realize the reasonable regulatory resources and regulatory object matching[10-11].

2) For those high risk level of production enterprises we should supervise and urge the rectification and guide the enterprises having conditions of hire safety intermediary service agencies to provide a safe technology and consulting service, promote enterprise gradually improve production safety management level.

3) For those high risk, high, and medium level of production enterprises and the enterprise, after safety rectification we can apply to the local safety regulators proposed relegation, organized by safety regulator in accordance with the provisions of intermediary institutions or professional evaluation, in conformity with the corresponding conditions, can be degraded; For those enterprises risk level is low and medium, we once found the level of safety management index decline or there are serious accidents, after safety regulators put forward rectification opinions rectification still powerless, they can be upgraded.

4) Those hazards or problems were found in the inspection of production enterprises, shall be ordered to correct or be subject to administrative penalties.

5) For those licenses is not complete or illegal production and operation of enterprises, if their problems are serious and after a lot of supervise and urge the rectification is invalid or the enterprises still refuses to rectification, will be ordered to suspend production or business reorganization or by other administrative penalties, submit to the government to shut down at the same level when necessary.

6) Production enterprise accident situation, all kinds of inspection and rectification, review should be recorded in a timely manner, and in enterprise information security conditions. For some high risk level of the production enterprises, the risk level can be published to the society and to report the competent department of industry and investment, the homeland, the securities regulatory departments and the relevant financial institutions.

5. Conclusions

1)The model of government safety supervision based on risk classification serves to catch hold of the principal contradiction in safe productive supervision, and improve government efficiency of supervision. It is both the model innovation of safety supervision and the growing tendency of modern safety regulation.

2) Risk classification indexes are the conceptual and concrete statistics to reflect the current state of the regulatory object production safety, they are directly related to the accuracy of the evaluation results. Therefore, the selection of industrious enterprise risk grading index involves inherent risks of enterprises, the existing safety management level, hidden trouble and punishment records and accidents as well as social and cultural factors. Meanwhile, in practice, the related parameters should be adjusted according to the practical situation after a periodical supervision, so that the calculation and analysis result of value-at-risk approaches more to the practice.

3) Working mechanism based on risk ranking system should be established to give play to the function of ranking indexes of government safety production supervision, model and system platform, to find the main source of risk, to improve supervision efficiency by combining daily supervision and risk ranking system, so that the risk ranking system can play a great role.

4) The risk index system and evaluation model constructed in this paper applies only to manufacturing enterprises because of the huge differences of main risk factors that manufacturing enterprises are faced with a different area. Safety productive risk of different area and different industry is closely related to the development of local society, economy and culture. It has the nature of dynamics, complexity and indeterminacy and that causes trouble to evaluate the safety productive risk of an area. Therefore, research from different angles and with variety methods is antitype expected.

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