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Research Article

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Research of the warning classification model for product quality and safety based on social risk bearing capability

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ABSTRACT

Efficient responses to product quality safety incidents and taking effective preventive measures need accurate warning classifications. The warning system model of product quality and safety was constructed from product quality hazards and social risk bearing capability, 12 integrated indices were selected and the significance and calculation method of each index were determined. The weighting factors for each level were determined using an analytic hierarchy process; the classification was determined using a multi-level fuzzy logic method and divided into four grades: red, orange, yellow and blue. Three product quality and safety incidents were used as examples to validate the model. The results show that fuzzy logic method and AHP combined effectively computes the warning classification, and easy to consider various complex factors.

Key words: Social risk bearing capability; analytic hierarchy process; product quality and safety; warning

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INTRODUCTION

Product quality and safety issues related to the health of the people, life safety and social stability. In recent years, with the consumer market growing, product quality and safety incidents happen frequently, personal safety and people's health suffer from potential threats[1]. But in reality, the phenomenon of exaggeration or underestimation of its own risk exposure is common due to the subjective understanding bias of the public. Moreover, different people produce different responses and risk bearing capability to risks [2].So the establishment of a scientific and reasonable risk warning system of product quality and safety plays a vital role for effectively control and disposal the product quality and safety events. At present, the capacity for social risk warning grade product quality and safety incidents has no quantitative model in domestic, the paper proposes a fuzzy comprehensive evaluation method for product quality and safety warning quantitative classification of the model, which has important theoretical significance and practical value.

ESTABLISHMENT OF EARLY WARNING MODEL

Product quality and safety warning indicator system is the ordered set of early warning indicators which are built by risk factors and descript by qualitative or quantitative description, it is also a state of the quality of products to meet the exact warning of security [3-4].

The establishment of index system is to have features of sustainable, completeness, importance, etc. [5]. First, it is necessary to determine the main factors of product quality and safety warning classification, then extract the index value to determine the weight of each index in each level using factors AHP, finally, determine the results of early warning grading fuzzy comprehensive evaluation method[6]. If the result of the presence of early warning graded by a large deviation, it is necessary to re-select the main factors of early warning grading, and re-calculated[7].The steps of warning grading comprehensive fuzzy evaluation model calculation are shown in Figure 1.

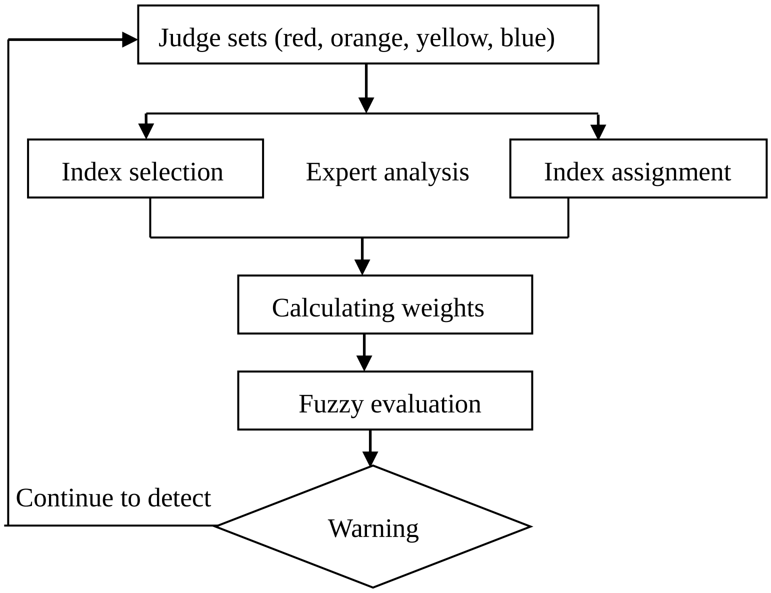

Fig.1 steps of warning grading comprehensive fuzzy evaluation model calculation

Determine early warning model evaluation set

Warning level is based on the degree of hazard events may cause, urgency and development trend, usually divided into four grades: Grade I (particularly important), grade II (major), grade III (large) and grade IV (general), and sequentially with red, orange, yellow and blue[8]. The early warning model which follows this method, is defined as the classification evaluation set {red, orange, yellow, blue}, and assigned section is (5 ~ 4, 4 ~ 3, 3 ~ 2, 2 ~ 1).

Table 1 Product quality and safety risk warning indicator system

Target layer		Guidelines layer	Index layer
Product quality and safety evaluation system (T)	Product factors	Product disaster Magnitude harmful factors (T_1)	The extent of health hazard(T_{11})
			The extent of damage to property(T_{12})
			Ability to repair damage(T_{13})
		Degree of diffusion of Product hazards (T_2)	Proliferation of regional(T_{21})
			Exposed persons to harmful products(T_{22})
			Flooding and the time factor(T_{23})
	Social affordability	Regional Vulnerability(T_3)	Population density of diffusion region(T_{31})
			Socio-economic factors of diffusion region(T_{32})
			Early warning processing capabilities of diffusion region(T_{33})
		Regional risk Resilience(T_4)	Risk awareness of exposed people (T_{41})
			Risk expectations of exposed people (T_{42})
			Risk acceptance of exposed people(T_{43})

Establishment of index system

The foundation of the product quality and safety research for early warning is to choose a reasonable scientific early warning indicator system. According to product quality and safety incidents that may occur, possible consequences of accidents as well as the public risk tolerance, the capacity of the social product quality and safety evaluation system is built from 12 dimensions, as specified in Table 1.

The factors of product quality hazardous are easily quantified directly by the quantized value method of mathematical statistics, numerical calculation; the social affordability factors are not easy to quantified, the indicator value can be obtained by questionnaires, vague language and expert scoring method. Due to space limitations, take the product of the health of the body exposed to hazards and risk awareness (T11 、T41)as examples.

Application of AHP to determine the target weight step

1) Judgment matrix

After the index value of each factor determined, each element method calculation of low level comprehensive evaluation factors set according to the fuzzy multi-level index value to obtain a high level of factors. Meanwhile, the membership function should be given. The model uses the method of AHP[10-11].

According to the hierarchical structure, the previous level elements as a criterion, compare their relative importance with the next level elements which they control using the proportion of 1-9 scale method. Then the expert judgment matrix element values should be given, thereby, to form the judgment matrix of Analytic Hierarchy (A).

$$\begin{bmatrix} 1 & 2 & 5 \\ \frac{1}{2} & 1 & 2 \\ \frac{1}{5} & \frac{1}{2} & 1 \end{bmatrix};\begin{bmatrix} 1 & 2 & 3 \\ \frac{1}{2} & 1 & 2 \\ \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix};\begin{bmatrix} 1 & 2 & 2 \\ \frac{1}{2} & 1 & 2 \\ \frac{1}{2} & \frac{1}{2} & 1 \end{bmatrix};\begin{bmatrix} 1 & 2 & 1 \\ \frac{1}{2} & 1 & \frac{1}{2} \\ 1 & 2 & 1 \end{bmatrix}$$

Table 2 The relative importance and the integrated importance (T_x)

	T_1	T_2	T_3	T_4	integrated importance
	0.263	0.316	0.245	0.176	
T_{11}	0.595				0.1565
T_{12}	0.277				0.0729
T_{13}	0.129				0.0339
T_{21}		0.539			0.1703
T_{22}		0.297			0.0939
T_{23}		0.164			0.0518
T_{31}			0.490		0.1200
T_{32}			0.312		0.0764
T_{33}			0.198		0.0485
T_{41}				0.400	0.0704
T_{42}				0.200	0.0352
T_{43}				0.400	0.0704

2) Consistency test

(1) Calculate the maximum eigenvalue of judgment matrix

The maximum eigenvalue A and its corresponding feature vector of the judgment matrix are calculated by formula 1, and the feature vector is the relative importance of each factor compared with its previous level elements.

$$\lambda_{\max} = \sum_{i=1}^{n}[(AW)_i / (nw_i)] \quad (1)$$

(2)Consistency test

To check whether there are discrepancies between the weights of each index, it is necessary to do random consistency testing for judgment matrix. Steps are as follows:

$$CR = CI / RI \quad (2)$$

Where CR is random consistency ratio, CI is the judgment matrix consistency index, RI is the average random consistency index.

Specifically, $$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (3)$$

RI is calculated by the Reciprocal matrix A', which is obtained by the Judgment matrix, the values are in the following table:

Table 3 The range of RI

n	1	2	3	4	5	6
RI	0.00	0.00	0.58	0.90	1.12	1.24

If $CR < 0.1$, it is considered that a satisfactory consistency of the single-level sort obtained, otherwise, it is need to re-calculate after adjust. The calculated value of the matrix is: 0.002, 0.003, 0.005, 0.006, less than 0.1, so the consistency check is passed.

3) Early warning models
The appropriate alarm limit range corresponds to the single index value (rated value),the scores of the guideline layer index were formed according to their corresponding weights, and then the guideline layer index weighted sum to form the composite index. Finally, the level of product quality and safety warnings is calculated. The warning level and score interval is denoted by Red (5-4 points), Orange (4-3 points), Yellow (3-2 points), Blue (2-1 points).

CASE STUDY

Incidents of product quality and safety

1)Chinese milk contamination
In 2008, some babies who were found suffering from kidney stones are caused by consumption of Sanlu infant milk, and there is about 700 tons of defective milk powder on the market. Until September 2008, there are 39965 babies who are outpatient treatment and recovered due to the use of this brand of milk powder, and 12892 babies are hospitalized, four are killed, and the total assets of 1.762 billion yuan loss.

2)Strollers event
In 2010, stroller quality problem occurred in Yunnan province. There is a possibility that the product caused by entrapment of children, and this incident involving from November 2009 to February 2010 and production in the province the 3700 sales range strollers.

3)Changan Automobile defects event
In 2013, Changan Automobile CS35 crankcase ventilation piping system design is unreasonable between June 2012 to between 3 and January 2013, the event involved 12,492 vehicles.

Survey methodology

Each index data of risk resilience in diffusion region was obtained by questionnaires way, and the investigation was carried out in different regions according different events, specifically as shown in Table 4.

Table 4 Product quality and safety incident investigation

incident	Survey region	Number of questionnaires	Number of recycling questionnaires	Questionnaire efficient
China milk contamination	Public of Beijing, Shijiazhuang, Baoding province	600	562	98%
Strollers event	Guardians of children aged 1-3 in kunming	200	191	94%
Changan Automobile defects event	Changan Automobile users	600	579	96%

Analysis

Social risk tolerance survey results show that there are differences of social risk tolerance in different events in different regions, as follows:

1) Different products differ from social risk tolerance
The social event risk tolerance survey of the three cases shows that people of different events affordability different, but society as a whole is low risk tolerance, as shown in table 5.

Table 5 Social risk tolerance of different events

events	Risk awareness	Risk expectations	Risk acceptance	Social risk tolerance
China milk contamination	3.6	4.0	4.3	3.86
Strollers event	1.2	1.8	2.0	1.64
Changan Automobile defects event	3.8	4.2	4.1	3.98

Table 6 Social risk tolerance in different areas

Survey area	Incidents	Risk awareness	Risk expectations	Risk acceptance	Social risk tolerance
Beijing	China milk contamination	4.3	4.2	4.0.	4.16
	Changan Automobile defects event	4.5	4.1	4.1	4.26
Shijiazhuang	China milk contamination	3.4	3.8	4.0	3.72
	Changan Automobile defects event	3.5	3.7	3.9	3.70
Baoding	China milk contamination	3.3	3.7	4.1	3.70
	Changan Automobile defects event	3.5	3.8	4.0	3.76

2) Difference of social risk tolerance in different geographical
The social risk tolerance survey results of the China milk contamination and the Changan Automobile defects event show that the capacity of social risk in Beijing is lower than in Shijiazhuang and Baoding in the same event, , specifically as shown in Table 4.

The final calculated by fuzzy comprehensive evaluation results are 4.5, 1.2, 3.3, respectively, corresponding warning level are red, blue, orange. This result is consistent with the actual.

CONCLUSION

The early-warning model of product quality and safety has established based on social risk tolerance, and three cases are studied. The following conclusions can be obtained after analysis.

1) Social risk tolerance is an important factor affecting product quality and safety risk warning, and there is a great impact on the overall target. The investigation and analysis are combined with product quality and safety incident, and the analysis results coincide with the actual situation, so they have some theoretical and practical value.

2) Studies through cases show that the establishment of early warning using fuzzy evaluation method based on hierarchical model of social risk tolerance is feasible and provides a method for the implementation of product quality and safety risk warning contingency plans.

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