Analysis of Traffic Security Risk Factors Based on ISM

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Abstract Employing biliometrics, this paper firstly identifies main traffic security risk factors from CNKI database; and then this paper investigates the interrelation between and structure of those risk factors by means of ISM.
Key words Traffic security; ISM; Risk factor; Risk identification

1 Introduction

The methods to identify traffic security risks are as follows but not limited to, safety key method, scenario analysis, work-risk decomposition, fault tree analysis, event tree analysis, financial statements analysis, hazard-operability analysis. Starting with comparative analysis of traffic safety management both at home and abroad, this paper firstly attempts to identify risk factors of traffic safety by use of bibliometrics based on CNKI literature database. Then adopting ISM method, this paper analyzes the interrelation between and the structure of those risk factors.

2 Literature Review

Exploring on traffic security risk factors is the starting point for traffic emergency management. Collected papers titled<International Crisis: Insights from Behavioral Research>[1] by (C.F. H.ermarm 1972) is one of earliest researches on fundamental factors causing emergencies. Since 90s, 20th century, western scholars have conducted extensive studies on emergency response capacity. During the period from 1997 to 2000, 56 provinces, regions and islands across America have completed the establishment of emergency response capacity index system when facing major emergencies[2], containing 13 management functions, 209 attributes and 1014 indexes[3]. Besides, the evaluation system of local emergency response capacity and crisis management was established across Japan in December, 2002[4]. Meanwhile Japan is investigating hazard mitigation policies based on hypothesis and evaluation of accidents all the time[5].

Zhao Xuegang (2009) firstly identified 3 risk sources using risk identification techniques, which are, failure of vehicle and equipment, human impairment and environment, and management flaw and organization fault. Then he constructed traffic security risk warning system according to analyses of risk factors[6], including a factor set of road traffic security, an index system, and a sub multivariate fuzzy comprehensive evaluation model of road traffic security risk warning[7]. Besides, SMS (safety management system) is a major measure taken in the improvement of aviation safety according to ICAO (international civil-aviation organization). Based on<Civil-aviation Management System Manual (trial)>and previous researches, (Jia Guijuan and Wang Hongjiao 2008) put forward a civil aviation safety risk management system containing risk identification, risk evaluation, risk control and forewarning indicator system. They illustrated the structure and operational process of the system[8]. Moreover, traffic safety is vital important to urban economy development and citizens' life. Accordingly, (He Shoukui 2007) established a safety risk evaluation index system. In view of fuzziness and uncertainty of safety data, He firstly employed evidence fusion theory to decide weight, and then advanced an empirical study on event risk evaluation using multi-attribute decision making method[9].

3 Identification of Traffic Security Risk Factors

The above researches have investigated traffic emergency response capacity and traffic risk factors from various aspects but not as a whole. However, improving traffic security management level is a systemic project which contains not only risk factors as a whole, but also relevance and structure of those risk factors.

(1) Risk factors of traffic security

CNKI is the largest Chinese journal full-text database which collects more than 8000 leading journals and performs dynamic updates continuously. In CNKI, there are 3281 papers, whose titles involve "traffic security" from the retrieval in 10th, August, 2010. The number of papers from 2003 till now is 2462, which accounts for 75.04%. It is thus clear that traffic security has gradually been the research focus since 2003. Among those papers, there are 14 papers pertaining to traffic security risk

factors. Based on bibliometrics [10], we select 4 risk factors with relatively larger probabilities, that is, human, vehicle, environment and management factors. Analyses of those 4 main factors are presented in Table 1.

Table 1 The Statistics of Risk Factors which Influence Traffic Security in Papers

Risk resource	Factors	Num	Probability (%)
Man	The quality and capacity of men, the faulty of drivers(1); the security conscious of passengers and attendants(1)	8	57.14
Machine	Vehicles(1), the state of machine(1); construction(1); station(1); parking area(1); electric traction system(1); railway control system(1); level crossing(1)	11	78.57
Environment	Unfavorable circumstance(2);road faulty(2);the frailty of traffic facilities(1);the capacity of the operation of road (1);environmental condition(1);external factors(such as power failure or climate)	10	71.43
Management	The faulty of management(2);the faulty of decision structure, management methods (such as security plans, security organization, the flexibility of security, security education), organization and management methods(1);the sound early warning and emergency mechanism (2);the risk warning system at sea(2);technical and managerial factors, technical and managerial system of traffic security risk(2);the evaluation, communication and system construction of road traffic security risk (1)	10	71.43

Table 2 The Detailed Table of the Risk Resource of Traffic Security

Object	Risk resource	Concrete description
Traffic security risk	Man	The thought and deed of drivers
		The technological level and capacity of drivers
		The security consciousness of drivers
		The quality of drivers
		The stamina of drivers
		The thought and deed of men
		The capacity of men
		The security consciousness of men
		The quality of men
		The stamina of men
	Machine	The condition of communication and navigation(Construction of infrastructural facilities)
		The state of the operation of vehicles(the state of the operation of equipments)
		The state of the maintenance of vehicles(the state of the maintenance of equipments)
	Environment	Weather condition
		Geography condition
		Contingent event
	Management	The construction of rules and regulations
		The management of technical training
		The education of security culture
		The degree of the emphasis on security work
	The frailty of facilities (Urban traffic, for instance)	The reliability of structure
		The reasonability of the line-shape
		The water stable aggregates of roadbed
		The scientific location of structures
		The quality of pavement projects
	The bearing capacity of the operation of road(Urban traffic, for instance)	The density of the road
		The road area per capital
		The degree of the load of road
		The number of the buses per 10,000 men

(2) The analysis of relations structure of the main influences

The traffic accidents are influenced by multiple factors which are mutually related and interacted

and form complicated system structure. By applying the interpretive structural model [11], we can find surface direct factors, middle indirect factors and deep elementary factors from those complicated factors. According to 4 main factors mentioned above and added by 2 other factors which are the frailty of facilities and the bearing capacity of the maintenance of road, we can identify the 6 factors of the interpretive structural model of traffic security factors-man, machine, environment, management, the frailty of facilities and the bearing capacity of operation.

(1) Identify the interaction between various factors

By analyzing traffic accidents and the previous results, we can identify the logical relationship of various factors and then get the adjacency matrix R, R is the 7×7 matrix and the element of which can be defined:

$$r_{ij} = \begin{cases} 1, s_i \ \ directly\ influence\ s_j \\ 0, s_i \ \ not\ directly\ influence\ \ s_j \end{cases}, (i, j = 1, 2, ...7)$$

$$\text{then} \quad R = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 \end{bmatrix}$$

(2) Divide the stage relationship of various factors

We can get the reachability matrix through the adjacency matrix: $M=(R+I)^n$. I is 7×7 identity matrix, and we can compute by the soft ware Matalab:

$$M = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 \end{bmatrix}$$

The concrete data of the reachability set R(Si) of various factors in the matrix M, the antecedent set A(Si) and the union of R(Si) and A(Si) is shown in table 3.

Table 3 The First-level Reachability Set and Antecedent Set of the Main Factors which Influence Traffic Security

Si	R(Si)	A(Si)	R(Si)∩A(Si)
0	**0**	**0、1、2、3、4、5、6**	**0**
1	0、1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
2	0、2	1、2、3、4、5、6	2
3	0、1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
4	0、1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
5	0、1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
6	0、1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6

Table 4 The Second-level Reachability Set and Antecedent Set of the Main Factors which Influence Traffic Security

Si	R(Si)	A(Si)	R(Si)∩A(Si)
1	1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
2	2	1、2、3、4、5、6	2
3	1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
4	1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
5	1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6
6	1、2、3、4、5、6	1、3、4、5、6	1、3、4、5、6

By the data in table 3, we can get L(1)={0}, remove row 0 and column 0 in M shown in table 4 and search the second-level elements.

By the data in table 4, we can get L(2)={2}, remove row 2 and column 2 in M shown in table 5 and search the third-level elements.

Table 5 The Third-level Reachability Set and Antecedent Set of the Main Factors which Influence Traffic Security

Si	R(Si)	A(Si)	R(Si)∩A(Si)
1	1、3、4、5、6	1、3、4、5、6	1、3、4、5、6
3	1、3、4、5、6	1、3、4、5、6	1、3、4、5、6
4	1、3、4、5、6	1、3、4、5、6	1、3、4、5、6
5	1、3、4、5、6	1、3、4、5、6	1、3、4、5、6
6	1、3、4、5、6	1、3、4、5、6	1、3、4、5、6

By the data in table 5,we can get L(3)={1、3、4、5、6}.

4 Conclusion

We can establish the interpretive structural model of the main factors which influence traffic security, which is shown in figure 1.

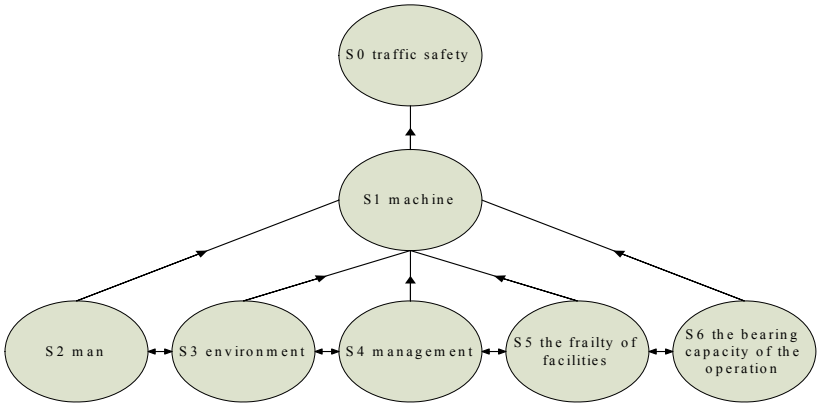

Figure 1 The Interpretive Structural Model of the Main Factors which Influence Traffic Security

As can be seen from figure 1, the traffic security is influenced by six main factors which are man, machine, environment, management, the frailty of facilities and the bearing capacity of the operation. The element of machine is in the core position, which is the core element which influences the traffic security and the key bond of other five factors. The pairwise coupling between those five factors and the machine factor or the pairwise and multiple coupling is among their own cause traffic accidents. Therefore, the factors of man, machine, environment and management influence and restrict each other. In order to maintain the normal operation of the traffic system, we should consider adequately various factors which influence traffic security and coordinate all factors which constitute the system.

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