Risk Evaluation of Non-lethal Weapon Procurement based on Comprehensive Fixed Weight-Variable Weight Model

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ABSTRACT: To make fixed weight confirmation more scientific and rational, this paper introduces entropy theory and improves original fixed weight - variable weight model based on fixed weight - variable weight model. This paper takes non-lethal weapon procurement for example, applies improved fixed weight - variable weight model for risk evaluation and compares fixed weight - variable weight model before and after the improvement visually and clearly according to the chart. Risk evaluation results comply with actual situations. This paper provides reliable and important basis for risk management of non-lethal weapon procurement.
KEYWORD: non-lethal weapon procurement; risk evaluation; fixed weight - variable weight model

1 INTRODUCTION

Since 1990s, fighting against terrorism and transnational crime, stopping riot and safeguarding world peace have been common problems for the whole world. Gradually, our country has increased the outlay on non-lethal weapons procurement [1]. Faced with the huge outlay budget, reasonable, scientific and exact risk assessment is absolutely necessary. Fixed weight and variable weight model has been widely used in procurement risk evaluation and management decision, etc and weight assessment is based on subjective method, which leads to the subjectivity of decision-making [2]. This thesis integrates subjective and objective methods, which makes weight assessment and analysis of the result scientific and reasonable [3].

1.1 *Evaluation index system of procurement risk of non-lethal weapons*

Non-lethal weapons procurement differs from the common procurement like individual procurement, family procurement and enterprise procurement, etc. It has following features: (1) The publicity of capital source. The capital is from annual military expenditure. (2) The subject of the procurement. The aim is to make armed police force complete missions in duty, anti-terrorist and some other emergency successfully. (3) The particularity of the procurement. Non-lethal weapons refer to weapons and equipments can only make the living arms lose fighting ability but not kill them [4]. (4) The mobility of relevant office-holder. Job transfer of non-lethal weapons buyers will affect the duration of the procurement.

Table 1 Evaluation Index System of Procurement Risk of Non-lethal Weapons

Procurement risk of non-lethal weapons(u)	Cost risk(u_1)	1. Risk from improving performance index (u_{11}); 2. Risk from the uncertainty of cost(u_{12}); 3. Risk from bad care during transportation (u_{13}).
	Personnel risk (u_2)	1. Risk from low personal quality (u_{21}); 2. Risk from interest demand of the buyers (u_{22}); 3. Risk from personal mobility (u_{23}).
	Technology risk (u_3)	1. Risk from the complexity of the procurement item system (u_{31}); 2. Risk from the innovation of the procurement item system (u_{32}); 3. Risk from bad technical support (u_{33}).
	Environment risk (u_4)	1. Risk from natural environment (u_{41}); 2. Risk from social environment (u_{42}).
	Guarantee risk (u_5)	1. Risk from management (u_{51}); 2. Risk from supply (u_{52}); 3. Confidentiality risk (u_{53}).

2 WEIGHT ASSESSMENT OF THE EVALUATION INDEX OF PROCUREMENT RISK OF NON-LETHAL WEAPONS

2.1 *Subjective methods to confirm the evaluation index weight value*

Use APH[5][6] to calculate the initial weight W^1 the evaluation index of procurement risk of non-lethal weapons. The following are methods:

(1)Establish a hierarchical structure model to analyze the connection and influence between non-lethal weapons risk factors and divide them into several hierarchies.

(2)Establish judgment matrix A The values in the matrix is determined by the D-value of the average risk values. When 0≤D-value≤10, the number is 1. When 10＜D-value≤20, the number is 2.The rest can be done in the same manner. When D-value＜0, the number is the reciprocal of absolute value of the D-value.

(3)Calculate weight vector quantity to get the maximum eigenvalue $\lambda_{\max}$ .And calculate the corresponding feature vector W^3

(4)Test the consistency of the matrix $CR=\frac{CI}{RI}$ ($CR=\frac{CI}{RI}$), n is the number of the hierarchy, RI is the consistency index of corresponding matrix.

(5)Based on the result of (3), calculate the synthetic weight W^1.

2.2 *Objective methods to confirm the index weight value*

Based on the processed matrix, calculate the entropy weight W^2 of the index. The uncertainty of relative importance degree of index j can be calculated by the following formula[7]:

$$H(y_j)=-\sum_{i=1}^{n}\frac{y_{ij}}{y_j}\ln\frac{y_{ij}}{y_j},\ (y_j=\sum_{i=1}^{n}y_{ij},\frac{y_{ij}}{y_j}<1) \quad (1)$$

Based on the extremum property, standardize the formula:

$$e(y_j)=\frac{H(y_j)}{\ln n}=-\frac{1}{\ln n}\sum_{i=1}^{n}\frac{y_{ij}}{y_j}\ln\frac{y_{ij}}{y_j} \quad (2)$$

Based on $e(y_j)$ to calculate the evaluation weight of index j W_j^2:

$$W_j^2=\frac{1-e(y_j)}{m-\sum_{i=1}^{m}e(y_j)} \quad (3)$$

2.1 *Calculate the final fixed weight*

Plus the index weight of APH with the index weight of entropy method to get the fixed weight[8]

$$W^0=\alpha W^1+(1-\alpha)W^2 \quad (4)$$

3 VARIABLE WEIGHT EVALUATION MODEL OF EVALUATION INDEX OF NON-LETHAL WEAPONS PROCUREMENT RISK

(1) The risk factor's value in different stage of non-lethal weapons procurement is $R=\{R_1,R_2,\cdots,R_m\}$

(2) Calculate the weight of the bottom index relative to the aim $W^0=\{W_1^0,W_2^0,\cdots,W_m^0\}$

(3) According to the formula

$$W_i(R)=W_i^0\times S_i(R)\Big/\sum_{j=1}^{m}W_J^0S_j(R)$$

$$i=\{1,2;\cdots m,\} \quad (5)$$

$$S_j(R)=\begin{cases}\left|e\times\dfrac{(b-R_j)}{b}\right|^{\frac{1}{mW_j^0}}+d & R_j\in(0,b]\\ d & R_j\in(b,c]\\ \left|\dfrac{R_j-c}{1-c}\right|^{\frac{1}{mW_j^0}}+d & R_j\in(c,1]\end{cases}$$

($\sum_{j=1}^{m}W_j(R)=1$, j=1,2,…,m;) b, c, d, e within [0,1];

b is punishment level

c is motivation level

d is adjustment level

e is the range of motivation and punishment

4 CASE ANALYSIS

4.1 *Establish non-lethal weapons procurement risk evaluation index trends fixed weight*

(1) Use APH to calculate the subjective weights and ask relevant experts to evaluate it. Take 3 indexes for an example.

According to the experts marking, we can establish a matrix:

$$A=\begin{bmatrix}1 & 1/3 & 1/3\\ 3 & 1 & 1\\ 3 & 1 & 1\end{bmatrix}$$ and figure out $\lambda_{\max}=3\,(CR<0.1)$, and figure out W^1=(0.0448,0.1376,0.1376)

(2) According to the entropy method formulas (1)~(3), figure out W^2=(0.0432,0.1033,0.1456)

(3) Take $\alpha=0.5$ for an example. According to the formula (4), figure out

$W^0=0.5W^1+0.5W^2$=(0.0440,0.1205,0.1416).

4.2 *Evaluation of non-lethal weapons procurement risk*

Given one risk factor value is R, b=0.4, c=0.7, d=0.2, e=0.8, figure out the result according to the established evaluation system (m=14) and fill them in Table 2.

Table 2 The value procurement risk evaluation of non-lethal weapons

Risk factor	u_{11}	u_{12}	u_{13}	u_{21}	u_{22}	u_{23}	u_{31}	u_{32}	u_{33}	u_{41}	u_{42}	u_{51}	u_{52}	u_{53}
W^1	0.13	0.0936	0.0364	0.0429	0.0312	0.0559	0.0448	0.1376	0.1376	0.0432	0.0368	0.0861	0.0546	0.0693
W^0	0.1403	0.0881	0.0421	0.0573	0.0278	0.0618	0.0440	0.1205	0.1416	0.0388	0.0271	0.1021	0.0513	0.0572
R	0.716	0.4	0.43	0.426	0.416	0.391	0.408	0.451	0.546	0.776	0.45	0.512	0.375	0.755
$S_i^1(R)$	0.3998	0.2000	0.2000	0.2000	0.2000	0.2059	0.2000	0.2000	0.2000	0.3033	0.2000	0.2000	0.2199	0.3740
$S_i^0(R)$	0.4249	0.2000	0.2000	0.2000	0.2000	0.2096	0.2000	0.2000	0.2000	0.2798	0.2000	0.2000	0.2154	0.3202
W^4	0.2131	0.0767	0.0298	0.0352	0.0256	0.0472	0.0367	0.1128	0.1128	0.0537	0.0302	0.0706	0.0492	0.1063
W	0.2454	0.0725	0.0347	0.0472	0.0229	0.0533	0.0362	0.0992	0.1166	0.0447	0.0223	0.0841	0.0455	0.0754
Fixed weight evaluation value before improvement $I^0 = W^1 \times R^T$							0.5217							
Variable weight evaluation value before improvement $I^1 = W^4 \times R^T$							0.5577							
Variable weight evaluation value after improvement $I^2 = W \times R^T$							0.5550							

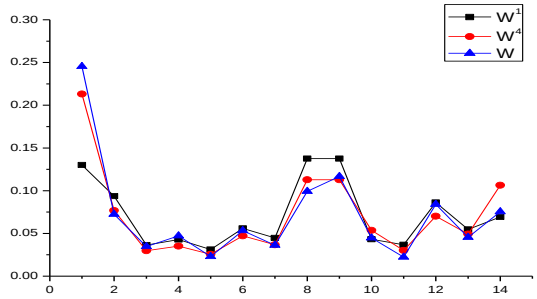

Figure 1 Comparison diagram before and after improvement

Take the 14 index of non-lethal weapons as abscissa and take the weight value before and after improvement as ordinate. Analyze the data as we can see in Figure 1, when the risk value >0.7, the weight value increase correspondingly. The improved model retains the advantages of punishment and motivation. Also, the diagram shows that weight model before improvement can not reflect same value's weight well. But the improved model can reflect the effects that risk values have on the weight very well. Thus it can be seen that the model can reflect the procurement risk of non-lethal weapons more scientifically, which can provide the decision- maker more reasonable basis.

5 SUMMARY

This thesis uses APH and entropy method to integrate subjective weights and objective weights so that weights assessment can be more scientific and reasonable. Meanwhile, based on relevant methods of combined weight theory, I established a non-lethal weapons procurement model and used this model to evaluate risk in non-lethal weapons procurement. I think the evaluation result has great guiding significance for non-lethal weapons procurement.

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