Advance Journal of Food Science and Technology 10(1): 1-6, 2016
DOI: 10.19026/ajfst.10.1742
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: March 23, 2015 Accepted: April 28, 2015 Published: January 05, 2016

Research Article

Research for Security Early Warning on Agricultural Product Based on AHP

Weiren Sun, Minyu Xu and Delin Wu
School of Economics and Management, Daqing Normal University, Daqing, Heilongjiang 163712, China

Abstract: This study introduces domestic and foreign scholars' research achievements in industrial safety, industrial safety early warning and industry safety on APPI base on existing literature. And then the paper gives an introduction to the can ent financial support policy on the APPI and take a quantitatively study about the implementation of fiscal policy influence on the industry security early warning of APPI. On the base of the scholars of the existing research results and my research, I put forward the early warning index system of the APPI. The paper establish and run the BP neural network according to the data from 2001-2012. And I make a forecast about the industry security early warning of APPI on the basis of that BP neural network. The results show that the APPI in China is safe in 2014 and there is a slight danger in 2015 so we need take relevant effective measures to prevent risks. Finally, this study proposes the development proposals and policy suggestions on the APPI.

Keywords: AHP, APPI, early warning, layer analysis method, security warning system

INTRODUCTION

Industry security has always been an important part of national economic security, which is an important starting point for the government to formulate industrial policy, coordinate economic development and maintain national economic interests. Agricultural Product Processing Industry (APPI) is an important part of the Agricultural Industrialization in China, which not only meets the basic needs of human for food and increases the added value of agricultural products. The development of the APPI is the strategy focus for the promoting of agriculture industrialization management and the economic reconstruction of the rural areas. It is also the necessary procedure of joining together the small-scale agriculture production and the modern production. Furthermore, it is the key solution to the problems of agriculture product selling, agriculture efficiency improving and rural incomes increasing. Therefore, making a research on the safety early warning mechanism of the APPI is particularly important (Hao *et al*., 2004).

The great cohesion of the Chinese nation has been verified once again by fighting that heavy snow what happened in January 2008. When the whole country was fighting against snowstorm, people have gradually realized if the preparedness could be down, it might not be so bad! Be vigilant in peace time, this short term implied practical significance regardless of time and space. Especially about the grain problem, we have to think that with yes.

From the end of last year to early this year, food security problem the alarmed the world once again. FAO said that world grain prices rose in 37 countries have caused the food crisis. Grain security and the loan-to-crisis have become hot topics now. China has a population of 1.3 billion, for such a large population, grain consumption for the country to solve grain problems must always uphold the basic principle of relying on domestic and ensure that a certain amount of inventory and the necessary food self-sufficiency. Grain security is a key part of national economy security.

Several methods have been developed for MCDM problems, such as Analytic Hierarchy Process (AHP), fuzzy AHP, analytic network process (ANP) (Huang *et al*., 2008), grey method and extenics theory. There are no better or worse techniques, but some techniques better suit to particular decision problems than others do (Inaba and Mirbod, 2007). Fuzzy AHP is a useful tool to deal with imprecise, uncertain or ambiguous data and the high non-linearity and complexity of ecosystems and ecological and environmental issues (Hao *et al*., 2004). Decision makers usually feel more confident to give linguistic variables rather than expressing their judgments in the form of exact numeric values (Huang *et al*., 2008). Therefore fuzzy AHP is more appropriate for work safety evaluation in the hot and humid environment.

For traditional fuzzy AHP, the rating level is usually obtained by the maximum membership grade. And when calculating the final evaluation results, the linguistic variables are often expressed by exact values. In addition, when determining the weights of the

Corresponding Author: Weiren Sun, School of Economics and Management, Daqing Normal University, Daqing, Heilongjiang 163712, China

indexes, 9-point scale is usually used to represent subjective pair-wise comparisons in most problems. The advantages of fuzzy theory are weakened in traditional fuzzy AHP.

The great cohesion of the Chinese nation has been verified once again by fighting that heavy snow what happened in January 2008. When the whole country was fighting against snowstorm, people have gradually realized if the preparedness could be down, it might not be so bad! Be vigilant in peace time, this short term implied practical significance regardless of time and space. Especially about the grain problem, we have to think that with yes.

MATERIALS AND METHODS

Analytic Hierarchy Process (AHP): The AHP established by Saaty (1977) is a method to solve multiple criteria decision problems by setting their priorities (Karahalios *et al*., 2011). AHP aims to settle the conflict between practical demand and scientific decision making and it also aims to find a way to blend process qualitative analysis and quantitative analysis (Mu, 1997). Decisions made using the AHP occur in two sequential phases: hierarchy design, which involves decomposing the decision problem into a hierarchy of interrelated decision elements (i.e., goal and evaluation criteria); and hierarchy evaluation, which involves eliciting weights of the criteria and synthesizing these weights and preferences to determine alternative priorities (Sanjay and Ramachandran, 2006).

The AHP is one of the extensively used MCDM methods (Bagranoff, 1989, Arbel and Orgler, 1990 and Moutinho, 1993). It has been successfully used in maintenance policy selection (Arunraj and Maiti, 2010), environmental decision-making, resources planning (Willet and Sharda, 1991) and conflict management (Saaty, 1990; Kang *et al*., 2007). AHP has also been employed for the risk assessment (Mustafa and Al-Bahar, 1991; Gaudenzi and Borghesi, 2006; Zayed *et al*., 2008).

From the above literatures, one of the main advantages of the AHP method is the simple structure. The AHP is designed in a way that represents human mind and nature. Therefore, AHP can create the chance of searching and evaluating the cause and effect relationship between goal, factor, sub-factor and alternatives using breaking down the structure of the problem (Milosevic, 2003). Moreover, the use of AHP does not involve cumbersome mathematics, thus it is easy to understand and it can effectively handle both qualitative and quantitative data (Cengiz *et al*., 2003).

Theory: A trapezoidal fuzzy number can be defined where the membership function is given by (Inaba and Mirbod, 2007):

$$\mu_{\tilde{m}}(x) = \begin{cases} \frac{x-a}{b-a} & (a \leqslant x \leqslant b) \\ 1 & (b \leqslant x \leqslant c) \\ \frac{d-x}{d-c} & (c \leqslant x \leqslant d) \end{cases} \tag{1}$$

We can column:

$$\tilde{A}(+)\tilde{B} = (a_1, a_2, a_3, a_4)(+)(b_1, b_2, b_3, b_4) = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4)$$

$$\tilde{A}(-)\tilde{B} = (a_1, a_2, a_3, a_4)(-)(b_1, b_2, b_3, b_4) = (a_1 - b_1, a_2 - b_2, a_3 - b_3, a_4 - b_4)$$

$$\tilde{A}(\otimes)\tilde{B} = (a_1, a_2, a_3, a_4)(\otimes)(b_1, b_2, b_3, b_4) = (a_1 b_1, a_2 b_2, a_3 b_3, a_4 b_4)$$

$$\tilde{A}(\phi)\tilde{B} = (a_1, a_2, a_3, a_4)(\phi)(b_1, b_2, b_3, b_4) = \left(\frac{a_1}{b_1}, \frac{a_2}{b_2}, \frac{a_3}{b_3}, \frac{a_4}{b_4}\right)$$

$$k\tilde{A} = (ka_1, ka_2, ka_3, ka_4)$$

$$(\tilde{A})^{-1} = \left(\frac{1}{a_4}, \frac{1}{a_3}, \frac{1}{a_2}, \frac{1}{a_1}\right)$$

Factor analysis is through the study of the internal dependencies between the variables to seek the basis structure of the observed data and uses a few variables to represent the basis data structure. The concrete model of factor analysis is shown in Formula 1-3.

It can be written as X = AF + E. In the formula, X = (X1, X2,..., Xn) is the dimensional vectors made by the influence factor of the normalized traveler passing time. F = (F1, F2, ..., Fm) (m<n) is the influence factors and these factors are uncorrelated and all the variances are 1. E = (ε1, ε2,..., εn) represent measurement errors, εí only affects Xí, ε1, ε2,..., εn are uncorrelated, εí and Xí are the same. A is the component matrix, aíj = Cov(Xí,Fj) (Kang *et al*., 2007):

$$\begin{bmatrix} X_1 \\ X_2 \\ \dots \\ X_{\text{n}} \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nm} \end{bmatrix} \begin{bmatrix} F_1 \\ F_2 \\ \dots \\ F_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \dots \\ \varepsilon_n \end{bmatrix} \tag{2}$$

After the orthogonal rotation of the component matrix at the basis of variance maximization, we can calculate the factor contribution coefficient matrix Γ, so the passing time influence factor can be written as F = Γ·X, that is (Hadi, 2008):

$$\begin{bmatrix} F_1 \\ F_2 \\ \dots \\ F_m \end{bmatrix} = \begin{bmatrix} \tau_{11} & \tau_{12} & \dots & \tau_{1n} \\ \tau_{21} & \tau_{22} & \dots & \tau_{2n} \\ \dots & \dots & \dots & \dots \\ \tau_{m1} & \tau_{m2} & \dots & \tau_{mn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \dots \\ X_{\text{n}} \end{bmatrix} \tag{3}$$

$$\mathbf{R}_1 = \begin{bmatrix} 0 & 1/3. & 0 & 1/3 & 1/6 & 1/6 \\ 0 & 1/2 & 1/6 & 1/3 & 0 & 0 \\ 0 & 5/6 & 1/6 & 0 & 0 & 0 \\ 1/3 & 2/3 & 0 & 0 & 0 & 0 \end{bmatrix}$$

$$\mathbf{R}_2 = \begin{bmatrix} 0 & 1/6 & 1/3 & 1/3 & 0 & 1/6 \\ 0 & 1/6 & 1/3 & 1/6 & 1/3 & 0 \\ 0 & 1/6 & 0 & 2/3 & 1/6 & 0 \end{bmatrix}$$

$$\mathbf{R}_3 = \begin{bmatrix} 0 & 1/6 & 1/3 & 1/3 & 0 & 1/6 \\ 1/6 & 1/2 & 0 & 1/6 & 1/6 & 0 \\ 1/3 & 1/3 & 1/3 & 0 & 0 & 0 \end{bmatrix}$$

Table 1: Safety evaluation index system and evaluation table

The checking result	Before the improvement	After the improvement
The sorting values of the level weights	W1 = 0.5672, W2 = 0.1326	W1* = 0.5461, W2*= 0.1394
	W3 = 0.1624, W4 = 0.1837	W3* = 0.1487, W4* = 0.1629
The maximum eigen value	4.342657	4.000005
CI	0.114219	1.71245E-06
RI	0.9	0.9
CR	0.126910	1.90273E-06

$$\mathbf{B}_1 = \mathbf{W}_1^{*T} * \mathbf{R}_1 = (0.1344, 0.2628, 0.3616, 0.1371, 0.1039, 0.1723)$$

$$\mathbf{B}_2 = \mathbf{W}_2^{*T} * \mathbf{R}_2 = (0, 0.2006, 0.4617, 0.2374, 0.0739, 0.2135)$$

$$\mathbf{B}_3 = \mathbf{W}_3^{*T} * \mathbf{R}_3 = (0.2124, 0.4127, 0.2536, 0.1314, 0, 0.1702)$$

If we design robotic system on the basis of Table 1, the next task is how to comprehensively integrate those subsystems. Previous robot system architecture model often concentrates on smaller, areas within the field (Yavuz, 2007), therefore, in this study, we provide full three-dimensional integrated reference.

SAFETY EVALUATION AND EARLY WARNING RATING SYSTEM

The process of the work safety evaluation and earning warning rating for the hot and humid environments are as follows.

Establish the decision group: A decision group composed of security professionals, management technicians and workers is firstly formed (Hancock and Vasmatzidis, 2003). In order to obtain representative views, knowledge coverage and different academic viewpoint of the decision makers should be considered, the ratio of security professionals, management technicians and workers should be reasonably considered. If the decision group is established as above, fair and reliable evaluation results can be obtained.

With the development of science and technology, the emergence and development of intelligent systems provide strong support to modern enterprises and institutions. They change the traditional mode of work, greatly improved work efficiency urban food emergency command system as a typical intelligent application of the field of food security, Its establishment and improvement could make effective supervision and scientific analysis and a reasonable forecast and strong control to food production, processing, transportation ·market supply and marketing. What is more, it can timely feedback all kinds of food the field of information to the food department relevant businesses in charge, the relevant departments can be able to quickly take the appropriate measures to optimize the allocation of resources, reduce losses, reduce losses and risk, maintain social stability as shown in Eq. (4):

$$R_t = Y_t / YTD_{t-1} \times 100 - 100 \quad (4)$$

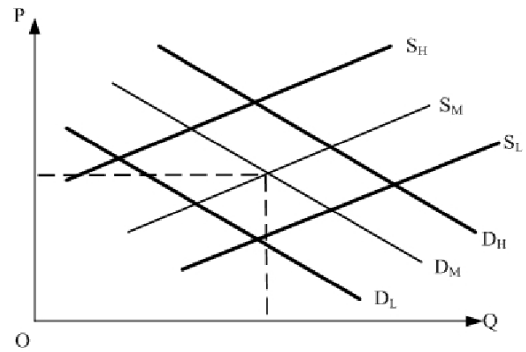

Fig. 1: The change of supply and demand

In urban food emergency command system, early warning model as well as early warning plans are the core part of the system. They play a key role in the early warning function. Through food data collection analysis, combination, processing and finishing, early warning model can make accurate predictions for scientific warning. When the warning level produced by early warning model, the system set off the early warning plan corresponding to the early warning level. The implementation plan process as soon as possible. The implementation of preventive measures. Currently, there are lots of modeling programs. They have advantages and disadvantages of each model created in the early warning accuracy, complexity, etc. However, due to the grain field warning model with large dimensions and the characteristics of nonlinear and small sample size and unbalanced, their methods cannot meet well all the requirements. In addition, the traditional early warning plan that customized solutions with fixed mode complex, customized, long development cycle, is unable to meet needs that are simple, flexible and fast to customize plan in the system as shown in Fig. 1.

Establish the evaluation framework and index: The establishment of a proper index system is the basis of work safety evaluation of the hot and humid environments. The health of a person at work depends upon the stability of the core body temperature. Muscular work can increase the heat production in the body 10-20 times that at rest. The excess heat generated in the body is dissipated through convection, radiation and evaporation. Thermal homeostasis is maintained by achieving a balance between the various avenues of heat gain and heat loss from the body. For the heat

Table 2: Total hierarchical result

C/B	B1	B2	B3	B/A	W*
C1	0.5461			0.3333	0.1853
C2	0.1394				0.0602
C3	0.1487				0.0413
C4	0.1629				0.0724
C5		0.3333		0.3333	0.1316
C6		0.3333			0.1258
C7		0.3333			0.1291
C8			0.2847	0.3333	0.0916
C9			0.6428		0.2462
C10			0.0793		0.0197

Table 3: Fuzzy evaluation result from experts for security early warning level

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6
C1	B	B	D	E	F	D
C2	B	D	B	D	C	B
C3	B	B	B	B	B	C
C4	B	A	A	B	B	B
C5	C	B	F	D	C	D
C6	B	D	E	D	C	C
C7	D	D	B	D	E	D
C8	B	B	C	A	C	B
C9	D	B	A	B	E	B
C10	B	A	C	B	A	C

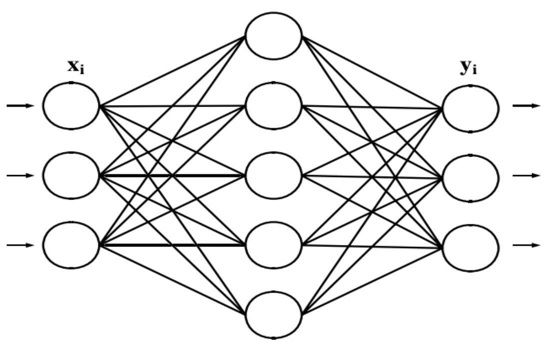

Fig. 2: Typical AHP model

production depends on the work and environment and heat loss is strongly influenced by the external conditions such as temperature, vapor pressure, air velocity and insulation. Therefore, the work safety in hot and humid environments is highly dependent on the work activity, the environment and the worker as shown in Fig. 2.

The hierarchy evaluation index system is constructed in Table 1 to 3. The second level shows the criteria that must be satisfied to fulfill the overall goal. The general criteria level involved three major criteria: work, environment and workers. Each of these three criteria needed further decomposition into specific items in the third level. There are three work components which can affect heat production: work nature, work intensity and work duration. Therefore the work is decomposed into three sub-factors: work nature, work intensity and work duration. As the heat loss is strongly influenced by the external conditions, thus the environment is decomposed into four sub-factors: temperature, humidity, airflow velocity and heat radiation intensity. In addition, the proficiency and adaptability of the worker, the safety training and the personal protection can also affect the work safety. So the worker is decomposed into three sub-factors: seniority structure, safety training and personal protection.

RESULTS AND DISCUSSION

Merites of Agent-oriented modeling: The theory related processed agricultural products' quality safety early-warning is analyzed. At first, the paper defines related concepts. In related theory analysis, from the basic theories of food safety, the general development rule of processed agricultural products' quality safety is summarized. From the Angle of economics theory, processed agricultural products' quality safety has the attribute of credit article and public goods. Based on economic early-warning theory, this study proposes the concept, principle and method of processed agricultural products' quality safety early-warning. That is:

$$\tilde{B} = W^{*T} *(B_1, B_2, B_3) = (0.1157, 0.2876, 0.3604, 0.1793, 00569, 0.1293)$$
$$E_1 = \tilde{B} * V^T = 57.0486$$

From the purpose of clarifying early-warning meanings, the current of processed agricultural products' quality safety in our country is analyzed. The overall situation is following: the level of quality safety is being improved, but the overall situation is not optimistic. The characteristics of agricultural product processing development is detailed analysis. From the angle of management of quality safety, the paper points out problems existing in agricultural product processing development of our country and discusses the problems existing in the quality safety management.

The influence factors of processed agricultural products' quality safety are analyzed. They are the warning source of processed agricultural products' quality safety. The influence factors are divided into endogenous and exogenous source according to the process control factors. The endogenous source includes: the level of materials safety, the level of administer use safety, the level of environmental hygiene management and the level of processing technology safety management. The exogenous source includes the level of national supervision, the level of consumer food safety consciousness and the level of agricultural product processing development. Every aspect includes various factors.

From the analysis of warning elements, the index system of processed agricultural products' quality safety is studied. According to the statistics and analysis results of 101 expert consultation questionnaires about the index system, the idea index system is established. Then the idea index system (including 26 indexes) is adjusted into practical index system (including 26 indexes) basing on the principle of data's availability and quantification. The comprehensive index method is applied to calculate the index weight.

The paper studies the early warning model of processed agricultural products' quality safety. The total warning degree evaluation model is established with Delphi method. 18 early-warning index forecasting models of practical index system are studied using time series smooth forecasting method and curve trend extrapolation method. The warning limits of 18 single indexes and comprehensive index are determined.

Using the historical data, the paper does an empirical research on processed agricultural products' quality safety in our country. With the application curve estimation and exponential smoothing prediction model of SPSS17.0 software and combining qualitative analysis, the future status of of 18 indexes are predicted in a short term. The paper evaluates warning situation of 18 single indexes and total warning degree from 2002 to 2007 and predicts the trend of 2008 and 2009.

Finally, from the nation supervision, industry construction, science and technology support, information sharing and so on four aspects, the paper proposes policy and suggestion to enhance our country's level of processed agricultural products' quality safety management:

The basic analyses on the early-warning of agricultural product market risks: Based on the characteristics of agricultural product market risks and the forms of agricultural product risks, the fundamental theories on the early-warning of agricultural product market risks, including the structures, the functions and the operation mechanisms on the early-warning systems of agricultural product market risks are discussed and meanwhile the methods to the yellow early-warning of agricultural product market risks are selected as the methods early to warn agricultural product market risks.

The analyses of the warning sources of agricultural product market risks: the warning sources of agricultural product market risks are composed of the production manners the distribution status, the demand transformation and the supply and demand surroundings of agricultural products. The individual farmer operation is the main management method of agricultural production in China. According to marketability of agricultural products produced, farmers can be divided into three types: the self-supported, market orientated and those between the above two types. Based on the analysis of the production mode, cost effect and distribution channels of agricultural products, the article pointed out that most farmers should be charged with market risks. However, the capabilities of the farmers to bear these risks are different according to the difference in production levels and categories. The selections of distribution channels of agricultural products decide whether farmers are wholly charged with market risks or partly. According to the analyses to the transformed demand status of agricultural products, it could be concluded that the transformations of demands to agricultural products between rural residents and urban residents would cause the demand changes of income elasticitiies to agricultural products; the demand to agricultural products in processing and foodstuff industries would sharply increase in the future. Meanwhile, the exports of preponderant agricultural products, for example, fruit, vegetable and aquatic products would increase in competitive international markets. The instability of the supply and demand environment of agricultural product has added up to the possibility of the risks. In conclusion, the factors to influence the agricultural product market risks exist in various aspects of the systems and environments of the supply and demand of agricultural products through analyzing the warning sources. In addition, the analyses of the warning sources of agricultural product market risks has set the foundation for the construction of the early-warning index systems on agricultural product market risks and for the decision of the prediction-control strategies.

The studies on the early-warning models of agricultural product market risks: Firstly, early-warning models were constructed. BP artificial neural network models were selected as the frameworks of early-warning models to early warn the price and policy risks of agricultural products, the early-warning signal output systems of credit, policy and price risks were settled, the false and leaked warning and construction problems of the early-warning systems of agricultural product market risks were discussed; secondly, Real cases were studied, in which pork price risk models were successfully constructed on the basis of BP artificial neural networks.

CONCLUSION

The early-warning of agricultural product market risks was systematically studied according to the relation between supply and demand of agricultural products, futures and options and game theories, based on the guidelines of warning source analyses, the construction of early-warning index systems, the early-warning and prediction-control of risks. The content of this study covers the basic analyses to the early-warning of agricultural product market risks and to the warning sources, the construction of the early-warning index systems about agricultural product market risks and the prediction-control strategies against agricultural product market risks.

ACKNOWLEDGMENT

This study is supported by the National Social Science Foundation of China under Grant No. 13CJY092.

REFERENCES

Arbel, A.Y. and E. Orgler, 1990. An application of the AHP to bank strategic planning: The mergers and acquisitions process. Eur. J. Oper. Res., 48: 27-37.

Arunraj, N.S. and J. Maiti, 2010. Risk-based maintenance policy selection using AHP and goal programming. Safety Sci., 48: 238-247.

Bagranoff, N.A., 1989. Using an analytic hierarchy approach to design internal control system. J. Account. EDP, 4: 37-41.

Cengiz, K., C. Ufuk and U. Ziya, 2003. Multi-criteria supplier selection using fuzzy AHP. Logist. Inform. Manage., 16(6).

Gaudenzi, B. and A. Borghesi, 2006. Managing risks in the supply chain using the AHP method. Int. J. Logistics Manage., 17(1): 114-136.

Hadi, N., 2008. Fuzzy numbers: Positive and nonnegative. Int. Math. Forum, 36(3): 1777-1780.

Hancock, P.A. and I. Vasmatzidis, 2003. Effects of heat stress on cognitive performance: The current state of knowledge. Int. J. Hyperther., 19(3): 355-372.

Hao, X.Y., H.T. Liu, S.B. Yang, S.Z. Fang, Q. Ma, X.Y. Zhao, W. Zhang and G.T. Pan, 2004. The tendency of physiological and psychological change of the armored vehicle drivers working continuously in hot environment. Chinese J. Ind. Hygiene Occup. Dis., 22(4): 257-260.

Huang, C.C., P.Y. Chu and Y.H. Chiang, 2008. A fuzzy AHP application in government-sponsored R&D project selection. Omega, 36(6): 1038-1052.

Inaba, R. and S.M. Mirbod, 2007. Comparison of subjective symptoms and hot prevention measures in summer between traffic control workers and construction workers in Japan. Ind. Health, 45(1): 91-99.

Kang, H.Y., O. Ogunseitan, A.A. Shapiro and J.M. Schoenung, 2007. A comparative hierarchical decision framework on toxics use reduction effectiveness for electronic and electrical industries. Environ. Sci. Technol., 41(2): 373-379.

Karahalios, H., Z.L. Yang, V. Williams and J. Wang, 2011. A proposed system of hierarchical scorecards to assess the implementation of maritime regulations. Safety Sci., 49(3): 450-462.

Milosevic, D., 2003. Project Management Toolbox: Tools and Techniques for the Practicing Project Manager. John Wiley and Sons, Hoboken, NJ.

Moutinho, L., 1993. The use of the Analytic Hierarchy Process (AHP) in goal assessment: The case of professional services companies. J. Prof. Serv. Market., 8: 97-114.

Mu, X.D., 1997. Grassland Systems Engineering. Chinese Agricultural Press, Beijing. (In Chinese)

Mustafa, M.A. and J.F. Al-Bahar, 1991. Project risk assessment using the analytic hierarchy process. IEEE T. Eng. Manage., 38(1): 46-52.

Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. J. Math. Psychol., 15(3): 234-281.

Saaty, T.L., 1990. Eigenvector and logarithmic least squares. Eur. J. Oper. Res., 48(1): 156-160.

Sanjay, V. and M. Ramachandran, 2006. Multicriteria evaluation of Demand Side Management (DSM) implementation strategies in the Indian power sector. Energy, 31(12): 2210-2225.

Willet, K. and R. Sharda, 1991. Using the analytic hierarchy process in water resource planning: Selection of flood control projects. Socio-Econ. Plann. Sci., 25: 103-112.

Yavuz, H., 2007. An integrated approach the conceptual design and development of an intelligent autonomous mobile robot. Robot. Auton. Syst., 55: 498-512.

Zayed, T., M. Amer and J. Pan, 2008. Assessing risk and uncertainty inherent in Chinese highway projects using AHP. Int. J. Proj. Manag., 26(4): 408-419.