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Research on Innovation Efficiency Evaluation in Tobacco Industry Based on IAHP

[1, 2]Chunshan Wang, [1]Junhai Ma and [1, 2]Shubing Guo
[1]College of Management Economic, Tianjin University, Tianjin 300072, China
[2]Yantai City Tobacco Monopoly Bureau, Yantai 264000, China

Abstract: With the unceasing change of tobacco market, the development of Chinese tobacco industry faces serious challenges of the market at home and abroad. Original expanding the scale of production quantity have seriously restricted the development of the tobacco industry. Therefore, we must change the development mode of Chinese tobacco industry and improve the efficiency of the development and innovation ability of tobacco enterprises, Chinese tobacco industry will win in the changing market competition. This study evaluates the innovation efficiency of China's tobacco industry based on the method of AHP and put forward development suggestion. This study has certain theory significance and practical application value, on the development of yantai tobacco industry has a good reference value.

Keywords: Development mode, IAHP, innovation efficiency, tobacco industry

INTRODUCTION

In recent years, China's tobacco industry development become gradually slow and even appears negative growth. One of the main reasons for slow development of the tobacco industry is the original vulgar management mode are not able to adapt the changing market (Jian, 2011). Because of international brand continuously entering, the market saturation and due to some of the new legislation and regulations about smoking, (Junju, 2008) the development of the tobacco industry faces severe challenges (Fucheng, 2011).

Nowadays, most of the tobacco enterprise scale is small and scattered, without the benefit of scale economy, science and technology is low. Shuangying (2009) Most of the tobacco enterprise management level is low and small tobacco enterprises have poor benefit (Dongyun and Weizhong, 2010).

Dispersion of tobacco industry raw material sources, which hasn't formed a large-scale production base, makes the most of tobacco enterprises in the development process (Jinchang *et al*., 2008). In addition, the achievements of the science and technology innovation ability are not strong and shortage of high-tech talent is still one of the main factors hindering the development of the industry (Liu *et al*., 2010). The extensive development mode has been unable to meet the needs of market development, should be on the tobacco industry product demand, carries on the comprehensive innovation and development mode (Baoan and Hai, 2001).

To improve extensive management mode and scientific and technological innovation ability of tobacco industry in our country, we need to make an objective evaluation about the present situation of the industry's innovation (Jian and Cheng, 1998). Only in this way we can suit the remedy to the case and put forward effective solutions. This study uses the method of AHP to evaluate the innovation efficiency of Chinese tobacco industry and put forward feasible suggestions which can help the development of tobacco industry according to the results of the assessment (Yu, 2003).

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IAHP IN INNOVATION EFFICIENCY EVALUATION

Chemicals and enzyme: Corn starch was purchased from Harbin Mei Wang Reagent Company, China. The water content was determined by drying the corn starch in a vacuum oven at 50°C until constant weight was achieved and was 16.2% (w/w). Oleic acid of analytical grade was purchased from Shanghai Chemical Co., China. Novozym 435 (Lipase B from Candida Antarctica immobilized on macroporous acrylic resin; specific activity: 10,000 U/g) was purchased from Novozymes, Denmark.; Dimethyl Sulfoxide (DMSO) of chromatography grade purchased from Shanghai Chemical Co., China; All the other chemicals are of analytical grade.

Corresponding Author: Junhai Ma, College of Management Economic, Tianjin University, Tianjin 300072, P.R. China, Tel.: 022-27892371

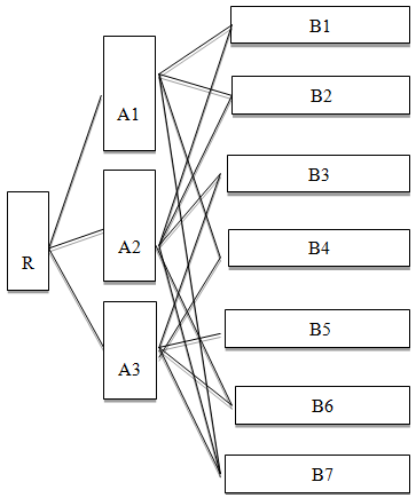

Fig. 1: Hierarchical structure of the innovation efficiency evaluation

Table 1: Importance and its score

Score	1	3	5
Importance	Same importance	Moderate importance	Obvious importance
Score	7	9	
Importance	High importance	Extreme importance	

The principle of IAHP: AHP method is a practical multi-criteria decision making method, which can decompose a complex problem by establishing clear hierarchy. In AHP, measure theory is introduced, that is establish judgment matrix by comparing with each other, solve the weight of the judgment matrix and finally calculate comprehensive weights of factors and sorting.

Because the innovation factor is a complex and flexible system, it will appear uncertain subjective judgment in the process of comparing two factors. AHP can solve this problem.

Interval Analytic Hierarchy Process (IAHP), combines traditional interval mathematics with the AHP method, can solve the problem of interval estimation. We can get interval comprehensive weighting number by interval number matrix and vector calculation. Then we rank factors, it can reduce judgment subjectivity.

The core idea of IAHP method is: decomposition first, then synthesis. Based on these, the IAHP method application process is as follows: establish the hierarchical structure of the decision system; form interval judgment matrix of factors; test the consistency of judgment matrix; solve the weight of each influence factor. Figure 1 given the hierarchical structure of the innovation efficiency evaluation.

In that diagram, R represents innovation efficiency; A1 represents market share; A2 represents anti-risk capability; A3 represents innovation ability; B1 represents market share; B2 represents market develop; B3 represents capital efficiency; B4 represents science and technology; B5 represents innovation base; B6 represents innovation potential; B7 represents development ability.

The hierarchical structure of the decision making system: The hierarchical structure of the decision making system is the key to the IAHP method. First, we should know the decision-making target and analyze the related factors which influencing the decision goal. There are many factors that influence enterprise innovation efficiency and their relationship is complicated, we analyze the situation of the innovation for the tobacco industry. According to the actual situation, we establish IAHP hierarchy diagram, innovation efficiency analysis will be doing based on the diagram.

The comparative judgment of factors: In IAHP method, we use expert scoring for the comparison between two factors and use the measurement which is shown in the below to score for different degree of importance in Table 1.

Every factor should compare with other factors. In IAHP, the importance between two factors can be expressed by using interval number. For example, A1 is moderately important for A2. The upper limit of importance is 3.5; the lower limit of importance is 2.5. So the interval number of importance is [2.5, 3.5].

Factors in matrix follow reciprocity, $a_{ij} = a_{ji}$. $a_{ij} = a_{ji} = 1$, when i = j.

Consistency check: The judgment and comparison for importance factors are subjective, so inconsistent situations are easy to exist. The probability of this inconsistency will be rising with the more of factors. The inconsistency will reduce the effectiveness and accuracy of information and influences the correct calculation of the factor weight, so that reduce importance evaluation of reliability.

Especially for IAHP method, the comparison between two factors is a fuzzy interval range, the inconsistency will be enhanced and the consistency check of the judgment matrix becomes more necessary.

The consistency check of IAHP is the same as AHP. We should expand C.R. from a point to a interval number.

First, we calculate the weight vecto $w = \{w_1, w_2, \ldots, w_n\}$ of the judgment matrix $A = [a_{ij}]_{n\times n}$. Then we can calculate the biggest characteristic root λ_{max}, the equation is as follow:

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(Aw)_i}{nw_i}$$

where, all variables are interval numbers; $(Aw)_i$ is the no. i factor of the vector which can calculate with multiplying matrix A by weight vector w.

Table 2: Average random consistency factors

Dimension	1	2	3	4	5
R.I.	0.00	0.00	0.52	0.89	1.12
Dimension	6	7	8	9	
R.I.	1.26	1.36	1.41	1.46	

Table 3: The judgment matrix of A1, A2 and A3

	A1	A2	A3
A1	(1, 1)	(2, 3)	(0.25, 0.333)
A2	(0.333, 0.5)	(1, 1)	(0.182, 0.222)
A3	(3, 4)	(4.5, 5.5)	(1, 1)

Table 4: The judgment matrix of B1, B2, B3 and B4

	B1	B2	B4	B7
B1	(1, 1)	(2.5, 3.5)	(5.5, 6.5)	(4.5, 5.5)
B2	(0.286, 0.4)	(1, 1)	(3.5, 4.5)	(2, 3)
B4	(0.154, 0.182)	(0.222, 0.286)	(1, 1)	(0.333, 0.5)
B7	(0.182, 0.222)	(0.333, 0.5)	(2, 3)	(1, 1)

After we calculate λ_{max}, then calculate C.R. and the equation is as follow:

$$C.R. = \frac{C.I.}{R.I.}$$

where,
C.I. = The coincidence indicator
R.I. = The average random consistency index

We can calculate C.I. by using this formula:

$$C.I. = \frac{\lambda_{\max} - n}{n-1}$$

The value of R.I. can be gotten by consulting the average random consistency index table (Table 2).

When C.R<0.1, we think that matrix A satisfies consistency.

Calculate the weight vector: First, matrix R can be decomposed into R+ and R- and then calculate the largest characteristic root. Steps are as follow:

- Normalize matrix R
- Add matrixes, normalize new matrix
- Calculate the biggest characteristic root λ_{max} of matrix R+ and R-
- Calculate C.I.
- Calculate C.R., make consistency check and consistency judgment
- Calculate the characteristic root of the interval judgment matrix. According with the theorem of interval number and characteristic root, we can get:

$$w = \left[dw^-, uw^+\right]$$

$$d = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} r_{ij}^+}} = 0.952$$

$$u = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} r_{ij}^-}} = 1.042$$

Every component of the characteristic vector is w_1, w_2, w_3. At last, we can get characteristic weight and uncertain matrix.

IAHP EVALUATION OF INNOVATION EFFICIENCY

We can calculate the innovation efficiency of the enterprise by using the method of IAHP; and give the numerical significance of every factor as shown in Table 3 to 7.

Here, we calculate the consistency ratio and the weight vector of the matrix. Consistency checks and weight vector.

According to the characteristic weight vectors of R, A1, A2 and A3, we can get the weight of sub-factors against decision-making objectives. Then, calculate the final weight of every factor (Table 8).

According with the table, we can get the weight of every factor as follow:

$$w = [0.1456, 0.062, 0.1096$$
$$0.1745, 0.309, 0.0385, 0.1614]^T$$

The evaluation results show the weight rank for seven factors. Weights of science and technology and development ability are higher than others factors; it shows enterprise management foundation plays an important role in improving the efficiency of industry innovation in Chinese tobacco industries. Enterprise's development ability can ensure the enterprise innovation and the source of continuing operations, its weight is large. Market share can present enterprise business performance and the ability to control market, so it occupies a certain proportion. Potential market development and innovation mean enterprises' sustainable development ability and has indirect effect for the innovation improvement. These two factors have relatively small proportion in the assessment;

Table 5: The judgment matrix of B1, B2, B3, B6 and B7

	B1	B2	B3	B6	B7
B1	(1, 1)	(4, 5)	(0.2, 0.25)	(2.5, 3.5)	(0.333, 0.5)
B2	(0.2, 0.25)	(1, 1)	(0.125, 0.143)	(0.333, 0.5)	(0.154, 0.182)
B3	(4, 5)	(7, 8)	(1, 1)	(5.5, 6.5)	(2.5, 3.5)
B6	(0.286, 0.4)	(2, 3)	(0.154, 0.182)	(1, 1)	(0.222, 0.286)
B7	(2, 3)	(5.5, 6.5)	(0.286, 0.4)	(3.5, 4.5)	(1, 1)

Table 6: The judgment matrix of B3, B4, B5, B6 and B7

	B3	B4	B5	B6	B7
B3	(1, 1)	(0.25, 0.333)	(0.167, 0.2)	(2, 3)	(0.333, 0.5)
B4	(3, 4)	(1, 1)	(0.333, 0.5)	(4.5, 5.5)	(1.5, 2.5)
B5	(5, 6)	(2, 3)	(1, 1)	(6.5, 7.5)	(3.5, 4.5)
B6	(0.333, 0.5)	(0.182, 0.222)	(0.133, 0.154)	(1, 1)	(0.2, 0.25)
B7	(2, 3)	(0.4, 0.667)	(0.222, 0.286)	(4, 5)	(1, 1)

Table 7: The consistency ratio and the weight vector of the matrix

Matrix	$[C.R.^{+}, C.R.^{-}]$	$C.R.$	Consistency	Weight vector
R	$C.R.=[-0.238, 0.347]$	0.0550	Y	$w=[0.231 \quad 0.113 \quad 0.656]^T$
A1	$C.R.=[-0.126, 0.216]$	0.0900	Y	$w=[0.558 \quad 0.248 \quad 0.068 \quad 0.126]^T$
A2	$C.R.=[-0.073, 0.178]$	0.0525	Y	$w=[0.148 \quad 0.042 \quad 0.488 \quad 0.074 \quad 0.248]^T$
A3	$C.R.=[-0.100, 0.179]$	0.0390	Y	$w=[0.083 \quad 0.242 \quad 0.471 \quad 0.046 \quad 0.159]^T$

Table 8: Weights of factors

	A/weight			
	A1	*A2*	*A3*	Comprehensive weight b_i
B	0.231	0.113	0.656	
B1	0.558	0.148	0.000	0.1456
B2	0.248	0.042	0.000	0.0620
B3	0.000	0.488	0.083	0.1096
B4	0.068	0.000	0.242	0.1745
B5	0.000	0.000	0.471	0.3090
B6	0.000	0.074	0.046	0.0385
B7	0.126	0.248	0.159	0.1614

they play an important role for the long-term development of the enterprise.

DEVELOPMENT PROPOSAL FOR TOBACCO INDUSTRY

The tobacco industry's development in our country is under the situation of special economic and policy system, its extensive labor-intensive growth mode is necessary in the process of its development history. Therefore, the change of tobacco industry from extensive to intensive is long-term system engineering; it should begin with the economic operation mechanism, social science and technology and talent orientation. So, the following measures are put forward:

- Promote the development of science and technology of tobacco and talent cultivation vigorously. Science and technology is the first productive force. High-tech development and the training of high-quality talent are convenient ways for undoubted realization of the tobacco industry development from extensive to intensive. Research funds, talent cultivation and achievements transformation are the most important for the development of science and technology, those need communication and cooperation among tobacco enterprise, its management departments and research institution. Developing staffs with science and technology, culture and high-quality business and promoting scientific research and application are useful for the change from extensive to intensive.
- Optimize the structure of tobacco enterprise assets and achieve the optimal allocation of resources. Technology equipment, capital and talents are power foundation for promoting enterprise development and its quality level is the key to the affective of the enterprise profitability. So, it is necessary to optimize the industrial structure and adjust resource configuration mode for rapid development in tobacco industry. For the reasonless of assets structure and less profitable of tobacco enterprise, we should intensify its rectification, encourage the enterprise merger and bankruptcy liquidation, to promote the flow of internal resources. At the same time, we should correctly evaluate the profit ability and development potential of the tobacco enterprise, guide the input of capital and talents effectively and realize the maximization of the resource's utilization efficiency.
- Guide the tobacco companies to intensive and diversified development. Diversified development help tobacco industry to reduce risk and the expansion of the market, it will do advantageous to the change of technology intensive and the adjustment of industrial structure.
- **Intensify policy support and guide:** Based on the particularity of China's socialist market economic system, national policies and regulations have a strong guiding role for the development of the enterprise. So we should make full use of national policy guidance and promote tobacco enterprise development mode to change from extensive to intensive.

CONCLUSION

The development of tobacco enterprise from extensive to intensive, one of the important way is the science and technology innovation, this study take IAHP method to have an analysis to the innovation efficiency of tobacco enterprises; the author puts forward three aspects affecting the efficiency of innovation in tobacco enterprises and seven evaluation

points. The weight factor of the seven evaluation point analysis was determined, using simulated data of nine tobacco enterprises in Yantai city as an example to analyze, draw the common innovation high efficiency enterprise: the importance of science and technology talents. This fully illustrated in the process of innovation, "science and technology is the first productivity" and innovative talent is the first scientific and technological innovation. So, in the future development of the city Yantai tobacco enterprises, improving the innovation efficiency is very important, most effective means is to introduce scientific and technological personnel, important enlightenment of the development of this point is also the city of Yantai tobacco enterprises, has important practical significance for the sustainable and healthy development to the whole tobacco industry. This study applied IAHP method to evaluate the efficiency of the tobacco industry, the factors affecting the efficiency of proposed improvement program, has very good guidance to the practical problem.

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