Evaluation on the Risks of Agricultural Industrial Chain Based on FAHP

——A Case of Regions Inhabited by Ethnic Groups in Wuling Mountain

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Abstract Through recognizing the risking factors of industrial chain and selecting appropriate evaluation method, the index system on evaluating risking factors including market risk, natural risk, contact risk and efficiency risk in industrial chain is constructed,26 weighting indicators under the four layers are set up. Taking regions inhabited by ethnic groups in Wuling Mountain as an example, the risking factors of agricultural industrial chain in the area are analyzed by adopting the FAHP. The influencing degree of each risking factor on credit risks is analyzed. The results assume that with the market risk, contract risk, natural risk and efficiency risk. The natural risks become the principal risks of agricultural industrial chain and it should be paid much attention to. The low credit risk is a major factor that causes the contract between enterprise and rural households. The flood, pests, diseases and disasters also should be paid high attention to that is regarded as risking factors. The risking factors that come from the efficiency risk layer, for example, the unequal profit distribution among enterprises has little effect on enterprises in industrial chain. The research results provide evidence for stipulating risk prevention measures.

Key words Industrial chain, Risk factors, Risk evaluation, China

Since Williamson (1975) put forward the concept of "middle network organization", people' understanding on each economic main body has become deeper and deeper[1]. As a "middle network organization", agricultural industrial chain is a management innovation with far-reaching effects. The existing theories and experiences show that agricultural enterprises can decrease trade costs, improve economic benefits and enhance competition through agricultural industrial chain. But the industrial chain faces many risks in actual operation. The industrial chain risks become the principal factor that restricts the effective function of industrial chain operation model. Therefore, identifying, evaluating risking factors in industrial chain and strengthening risk management of industrial chain are conducive to promoting the stability of industrial chain and reducing the risks and losses of industrial chain. The paper establishes the risk evaluation system and takes regions inhabited by ethnic groups in Wuyi Mountain area as an example to evaluate the risking factors of industrial chain in the area by using fuzzy analytic hierarchy process. According to the evaluation results, the countermeasures are put forward.

1 The establishment of risk evaluation system of industrial chain

1.1 Identification of factors Agricultural industrial chain risks means that in the operation of industrial chain agricultural enterprises or rural households, the actual profits of agricultural enterprises or rural households in industrial chain deviate from the expected profits affected by the uncertain factors within or without the industrial chain, thus, the violation of contract may appear and one party or multiple parties or the operation of the whole industrial chain might be obstructed. The agricultural industrial chain is more complex than general industrial chain risks[2]. The risk identification of agricultural industrial chain means clarifying various risking factors in agricultural industrial chain through analyzing massive information and phenomenon of the operation of agricultural industrial chain, so as to determine the risks and features of faced by agricultural industrial chain. There are many risks in agricultural industrial chain: natural risks, technology risks, system risks, market risks, prices, contract risks, moral risks, information risks, efficiency risks *et al*. Among those risks, there are both the inherent risks of agricultural production (such as natural risks), and the newly emerged risks in industrial chain (such as information risks). These risks affect one another make the identification, evaluation and management of the industrial chain more complex.

1.2 Selection of evaluation approaches AHP analysis method has four major defects[3], the paper introduces non-structural decision-making fuzzy set to analyze unit system theory on the basis of hierarchy analysis method[4], to construct judgment matrix and solve the single order of criteria level, and to eliminate the defects of hierarchy analysis in terms of consistency check and value assignment of subjective weight. This approach used for judging matrix is called Fuzzy Analytic Hierarchy Process (FAHP). In ranking various weighting factors in criteria level, the tone operators are adopted to define the influencing weights of index and judge the relative affiliation degree of each index to the importance of the criteria level at the upper level. Under the premise of determined risk index weight, the

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sampling survey, expert interview, small group discussion *et al.* are adopted to make the quantitative indexes and qualitative indexes available to weigh according to the principal of " quantization the indexes that can be quantized, the indexes can not be quantized should be given value with different grades". After integrating the relevant indexes of each level, the vector of the weights can be obtained. Taking the weight of each index as the factor and calculating the average value of weighted arithmetic, and then the index value of the final decision can be judged. Through comparing the indexes, the final optimized decision can be made.

1.3 Design of the index system for evaluating risking factors in industrial chain According to the source of risking factors in industrial chain and the weight differences of each risking factor, four principal risks including natural risks, contract risks, market risks and information risks , are selected to establish risk evaluation system(Table 1).

1.3.1 Natural risks. Agriculture is a typical high-risk industrial. Agricultural production is the economic activities that combine economic reproduction and natural reproduction. Agricultural production is in the face of various risks. With agriculture or the industries related to agriculture, natural risks are unavoidable. Natural risks mean in the process of developing order agriculture, the natural disasters, caused by non-regular movement of natural forces (including windstorm, fire, flood, draught, hailstorm, pests *et al.*), and the possible economic losses to signatory caused by the natural features of agro-products (fresh and live, easy to go bad, hard to transport)[5]. In industrial chain, the company and company, company and rural household all confront with natural risks. The appearance of industrial chain does not eliminate the risks, but changes the reasonability sharing main body from the single rural household to joint share of company and rural household[6]. Natural risk is an important risking factor that can not be ignored in violating contract, if the natural disasters happen, the production and supply of agro-products will be affected. The drop of the supply of agro-products will lead to the rise of market price of agro-products. Driven by profits, rural households will violate the contract and sell their products to the market with higher prices. The paper designs seven indexes for natural risks: windstorm, hailstorm, fire, draught, pests, diseases and epidemic and the natural features of agro-products.

1.3.2 Contract risks. The contract risk is the joint concern of many scholars and managers. In industrial chain, agricultural enterprises and industrial rural household connect together through contract. Contract is the bridge and bond for connecting companies and rural households. The contract risk can be defined as follows. In the contracting relation, the possible losses bought to the counterpart or the third party due to company' or rural households' complete or partial violation of the contract. According to contract theory, driven by the limited rationality of human being and the behaviors of opportunism, in reality, the contract is incomplete and the complete contract is just an ideal state. Out of optimized profits, the opportunism of rational economic person is inevitable. Six indexes of contract risking factors are designed: internality of contract, format of contract, terms of contract, and self-implementation mechanism of contract, profit distribution mechanism of contract and costs of violating contract.

1.3.3 Market risks. Market risks come from the unbalanced demand and supply of market and the price fluctuations caused by it. From the perspective of industrial chain, the emprises have avoided the market risks of primary agro-products to a large degree. However, compared with other products, the change of supply and demand of agro-products market has its distinctions. The "perverseness rule" of supply curve and the "cobweb rule" of demand curve are enough for showing the distinctiveness of the changed of agro-products market[7]. Therefore, no matter the chagne of supply and demand relatios of primary agro-production, or the change of supply and demand relations in market of the final consumption products, all have great uncertainty. Before and after the operation of agricutural industy chain, the market risks still exsit. The industrial chain integrates company and rural houehols, which has ovecome the market risks to a cenrtain degree, but the market risks have not been eliminated. Seven indexes are desigened to describle market risks: purchase of primary agro-products, sale of primary agro-prouction, unbalanced market supply and demand of agro-products, fluctuations of market price of agro-products, immature agro-products market, asymmetry market information of agro-products, lagging of product market adjustment.

1.3.4 Efficiency risks. Efficiency is the most important consideration factors of the management of agricultural industrial chain. Only the high efficiency agricultural industrial chain can attract the participation of other enterprises and rural households and form reliable alliance. Efficiency risk is a traditional risk. The risk is the possible pessimistic response and exit of industrial chain caused by the unsatisfied results of the cooperation between enterprises and enterprises, or between enterprises and rural households. Six indexes are designed to describe efficiency risks: weak power of core enterprises, uneven level of enterprises in industrial chain, unfair profit distribution of enterprises in industrial chain, imperfect coordination mechanism of industrial chain, low overall quality of farmers, farmers' weak contract awareness.

2 Evaluation on risking factors in industrial chain on the basis of FAHP

2.1 Evaluation process The paper conducted an empirical investigation on the risks of agricultural industrial chains in Miao autonomous region of Tujia ethnic groups in Enshi, Hubei Province, Zhangjiajie of Hubei Province, Huaihua district, Tongren district of Guizhou Province, Qianjiang areas of Chongqing. The questionnaires and interviews are adopted in the investigation. Combining the suggestions of scholars and the existing research results, the hierarchy analytic structure figure is established according to the sources of risking factors in agricultural industrial chain in ethnic groups of Wuyi mountain area. And then the hierarchy analysis(Fig.1). The target layer is risks in industrial chain. The four sources of risks is the criteria layer of decision, the lowest level is index layer. The codes of indexes are in accordance with that in Table 1.

Table 1 The index evaluation system of risking factors in agricultural industrial chain

Sources of risks	Weighting indexes	Codes of indexes	Sources of risks	Weighting indexes	Codes of indexes
Market risk B_1	Purchase of primary agricultural products	C_{11}	Natural risks B_2	Windstorm	C_{21}
	Sale of primary agricultural products	C_{12}		Hailstorm	C_{22}
	Imbalanced demand and supply of agricultural products market	C_{13}		Drought	C_{23}
	Fluctuations of market price of agricultural products	C_{14}		Diseases, pests and disasters	C_{24}
	Immature agricultural products market	C_{15}		Natural feature of agricultural products	C_{25}
	Asymmetry of market information of agricultural products	C_{16}		Diseases	C_{26}
	Lag of market adjustment of agricultural products	C_{17}		Fire accidents	C_{27}
Contract risk B_3	Internal risk of contract	C_{31}	Efficiency risk B_4	Unequal profit distribution of industrial chain enterprises	C_{41}
	Format of contract	C_{32}		Uneven levels of enterprises among industrial chain	C_{42}
	Contract terms	C_{33}		Low overall quality of farmers	C_{44}
	Self-implementation mechanism	C_{34}		Imperfect adjustment mechanism among industrial chain	C_{44}
	Profit distribution mechanism	C_{35}		Weak power of core enterprises	C_{45}
	Credit costs	C_{36}		Farmers' weak awareness on contract	C_{46}

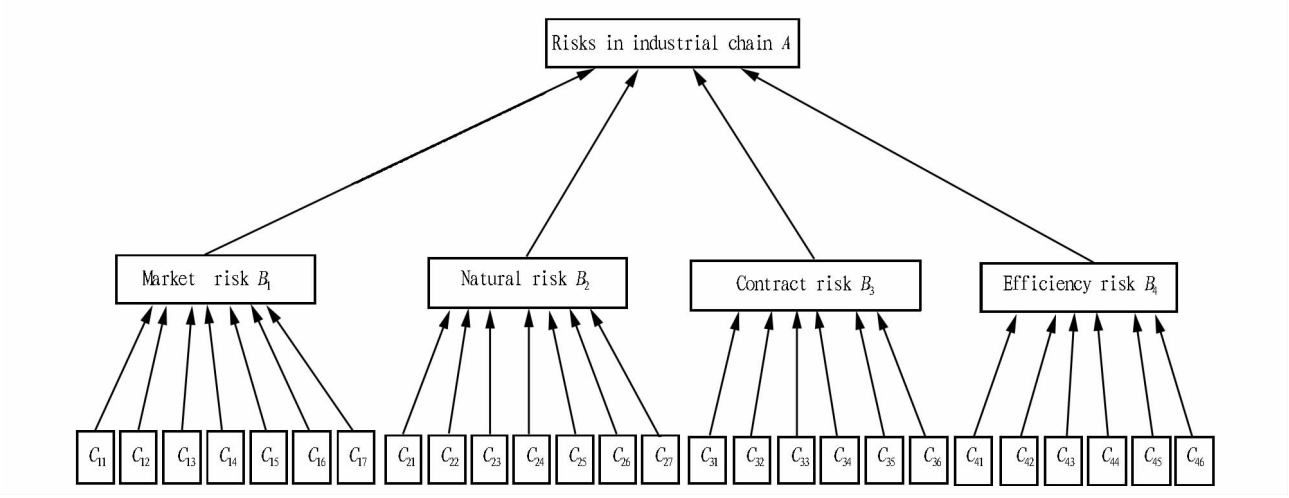

Fig.1 The evaluation hierarchy structure of agricultural industrial chain risk

The key of using FAHP is to establish dual importance comparison matrix on the basis of constructing decision-making target structure, each criteria layer and the hierarchy structure of prediction indexes.

2.1.1 Determination of decision target. The target of empirical research is to seek the indexes that have great impacts on the appearance of risks under the comprehensive analysis framework of various risks in industrial chain of agriculture, to provide warning indexes and management approaches for preventing and controlling risks. Therefore, the key of analysis is the weight of influencing factors of risk evaluation model, rather than the score of risks.

2.1.2 Testing on index weight. Combining the systematic fuzzy optimality theory, the dual importance ranks of each risk weighting indexes is marked. The specific calculation is completed by four steps:

The first step: establishing the importance comparison matrix E of index level under the fixed criteria level.

The second step: conducting integration test on the importance dual comparison matrix. The importance dual comparison matrix without testing need to be adjusted until the transitivity is satisfied, the ranks can be operated and the influencing weight of indexes can be reflected.

The third step: calculating the relevant affiliation degree of importance scale. After comparing the indexes in pairs, the tone operators are introduced according to different importance degree to realize the quantitative scale of importance. According to Chinese language habits, nine tone operators are inserted between equal important and can not be compared: slight, not so obvious, relatively obvious, explicit, obvious, perfect,

very, most, extreme. There are eleven tone operators in 10 grades. The value assignment of equal importance = 0.5, can not be compared = 1. The value is given to eleven tone operators by equivalent error of 0.05. is the quantitative scale of the *j* importance tone comparing with *i* index(Table 2).

Table 2 The quantitative scale of tone operator and degree value of relative membership

Tone operator	Quantitative scale a_{ij}	Relative membership degree r_{ij}
The same	0.50	1.000
Slight	0.55	0.818
Not so obvious	0.60	0.667
Relative obvious	0.65	0.538
Explicit	0.70	0.429
Obvious	0.75	0.333
Perfect	0.80	0.250
Very	0.85	0.176
Most	0.90	0.111
Extreme	0.95	0.053
Can not be compared	1.00	0

The fourth step: normalization of the vectors of quantitative scale at each criteria level, the weighting vectors of indexes at each level can be obtained. For example, the weighting vector of risking indexes at "natural risks level" is as follows:

$$\omega^1 = (\omega_{11}, \omega_{12}, \omega_{13}, \omega_{14}, \omega_{15}, \omega_{16}, \omega_{17}) = (0.156, 0.096, 0.234, 0.072, 0.193, 0.124, 0.124)$$

In the same way, through comparative analysis and integration test adjustment, the comparative analysis and integration test of vectors at other index levels can be obtained. The rearranged vector at other index level and weights of other criteria levels is $\omega^i = (\omega_{i1}, \omega_{i2}, \cdots, \omega_{in})_T$ and the weighting vector at target level of four criteria levels is $\omega^B = (\omega_{B1}, \omega_{B2}, \omega_{B3}, \omega_{B4})$. Thus, the evaluation influencing weighting vectors of 26 risk evaluation indexes at index level to the contract risks at target level can be obtained as follows:

$$\omega = \omega_{ij} \cdot \omega_{Bi}$$

In the equation, the specific number of value of *j* is determined by the number of indexes at index level, for example, in criteria level B_1, $j=7$, and in criteria level B_3, $j=6$.

2.2 Evaluation results Adopting fuzzy analytic hierarchy process can effectively combine quantitative analysis and qualitative analysis together to realize the analysis on the importance of contract risk. Under the approach of quantitative scale of tone operator, the risking factors are introduced into the whole risk index system, and then the fuzzy comprehensive weight and ranks of each risking index can be obtained(Table 3).

Table 3 Influencing weights and ranks of each risk indexes

Index layer	Criteria level (weight)				Fuzzy comprehensive weight	Index layer and total order
	B_1(0.189)	B_2(0.368)	B_3(0.293)	B_4(0.148)		
C_{11}	0.155				0.032	
C_{12}	0.095				0.019	
C_{13}	0.231				0.046	
C_{14}	0.062				0.025	
C_{15}	0.191				0.038	
C_{16}	0.123				0.025	
C_{17}	0.122				0.025	
C_{21}		0.092			0.035	
C_{22}		0.092			0.036	
C_{23}		0.213			0.077	max(2)
C_{24}		0.213			0.077	max(2)
C_{25}		0.152			0.056	
C_{26}		0.216			0.077	max(2)
C_{27}		0.014			0.008	min
C_{31}			0.221		0.068	
C_{32}			0.094		0.027	
C_{33}			0.145		0.043	
C_{34}			0.106		0.033	
C_{35}			0.159		0.047 8	
C_{36}			0.277		0.088	max(1)
C_{41}				0.094	0.017	
C_{42}				0.206	0.032	
C_{43}				0.145	0.023	
C_{44}				0.122	0.019	
C_{45}				0.161	0.025	
C_{46}				0.254	0.039	

It can be seen from Table 3 that:

From the perspective of B level, the natural risks have the biggest impacts on the stability of industrial chain. It is closely related to the blocked transportation, poor natural situation, frequent natural disasters and backward infrastructure. The ethnic groups in Wuyi Mountains range three provinces and one city. The transportation, telecommunication, electric power, irrigation and some other infrastructure are backward, which lead to the poor capability of enterprises and rural households in resisting natural risks. Natural risks have become the prior risks of the stable agricultural industrial chain. But the risking factors from "efficiency risks" have slight and even impacts on the stability of agricultural industrial chain. It implies that the efficiency risks have certain impacts, but the impacts are limited. It is related to the backward regional economic development, low technology level, insufficient management experiences and low

production efficiency.

From the perspective of the *C* level, the fuzzy comprehensive weight of the " costs of violating the contract " (C_{36}) between enterprises and rural household is 0.088, which is the biggest number. It is the major factor that leads to the appearance of industrial chain risks. The low cost of violating the contract is the fundamental reasons that cause the industrial chain risks. The second major three risking factors all come from " natural risks" and they are drought(C_{23}), pest, diseases and disasters (C_{24}) and epidemic (C_{26}), the fuzzy comprehensive weight is 0.077, which is in accordance with the risking factors mainly come from natural risks level in B level . It is related to the poor geographic environment, abominable natural situation and backward infrastructure. Fire has the smallest impacts among natural risks(C_{27}), the weight of fuzzy comprehensive is 0.008 . The following one is unfair distribution of enterprises in industrial chain(C_{41}), the fuzzy comprehensive weight is 0.017.

3 Conclusions and suggestions

3.1 Conclusions

Firstly, from the perspective of the market risk, contract risk, natural risks and efficiency risks, the risking factors come from the natural risks are the highest factors. Natural risks have become the most important risks in agricultural industrial chain, which should be paid much attention to.

Secondly, low cost of violating contract is an important factor that causes the violation of contract.

Thirdly, drought, pests, diseases and epidemic are the risking factors that should be paid high attention to.

Fourthly, the risking factors come from efficiency risk, for example, the unfair distribution of profits among enterprises has little impacts on risks in industrial chain.

3.2 Suggestions In view of the problems of natural risks, the enterprises should establish the emergency response planning. The computer information should be fully made use of to establish the information handle center of risking factors. The global position supervision should be adapted to effective supervise on risking factors in various sections.

With the problems of low cost of violation, the cost of violation should be improved, the profits of violating costs should be decreased and the contract management should be intensified. The process of signing contract and performing the contract should be supervised. When the violation of contracts happens, the party who violate the contract should not only be punished, but also compensates the losses causes by his action. The cost of violating contract should be improved from the root and the profits from violating the contract should be decreased, so as to promote the stable and healthy of order agriculture[8].

Due to the distinctive features of ethnic groups in Wuling Mountain, the government should intensify the investment; perfect public equipments; vigorously support the pillar enterprises in terms of policy and finance. The government should optimize market environment, regulate market order, cultivate private cooperative organization and vigorously introduce rural households to industrial chain operation to create favorable external environment and fundamental situation for the healthy operation of industrial chain.

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