Risk Assessment of Energy Enterprises Based on Fuzzy Comprehensive Evaluation Model and Grey Correlation Degree Method

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ABSTRACT: *This article adopts the fuzzy comprehensive evaluation model and grey correlation degree method to conduct risk assessment on energy enterprises. Firstly, a risk assessment index system for energy enterprises was constructed, including financial, market, production, and environmental indicators. Then, a fuzzy comprehensive evaluation model is used to evaluate each indicator quantitatively, and the interrelationships between different indicators are comprehensively considered to obtain a comprehensive evaluation result. Next, the grey correlation method is used to analyze the comprehensive evaluation results and obtain the correlation degree between each indicator and the ideal state, to identify the risk points and weak links of energy enterprises. Through example verification, the fuzzy comprehensive evaluation model and grey correlation degree method used in this article can effectively assess the risk of energy enterprises. The evaluation results can clearly reflect the overall situation and existing risk points of energy enterprises, providing a scientific basis for risk management.*

Keywords: Cross-Border Merg`ers Acquisitions, Energy Enterprises, Legal Risks, Preventive Measures

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1. Introduction

Currently, China ranks second in the global energy consumer country list, and the lack of energy supply will seriously drag the pace of China's economic development. Over the past few years, under the guidance of the "going out" strategy, domestic energy enterprises' mergers and acquisitions to overseas enterprises have rapidly increased [1]. In 2016, China's overseas mergers acquisitions transactions reached $ 65.2 billion, of which energy and mining transactions were $ 335.26 billion,

which accounted for 26% of total transactions. Although the total amount of transactions achieved a higher value, it can't be ignored that China's energy enterprises "going out" also encountered a lot of problems and setbacks. In recent years, there have been massive failure examples in overseas investment in Chinese enterprises, which have brought a lot of economic losses to the state and enterprises [2]. These enterprises that are frustrated by overseas investment have a common characteristic: they can't properly deal with the legal risks of cross-border mergers and acquisitions.

Therefore, it is not difficult to conclude: in the process that the domestic energy enterprises expand the overseas market, the cross-border legal risk control must be properly handled because it will directly determine the success of the expansion of overseas markets. Practical experience shows that good legal risk awareness and control ability of enterprises will not only determine that the energy enterprises can continue to rise in cross-border mergers acquisitions [3]. It can even be said that it also determines whether the enterprises can successfully carry out their business activities in overseas markets. In this paper, according to the model of fuzzy comprehensive evaluation method and gray relational method, this paper makes a quantitative study and analysis to the risk assessment in energy enterprise mergers acquisitions and puts forward preventive measures at the legal level.

2. State of the Art

From the perspective of professional law, cross-border merger acquisitions can be divided into two stages: trading stage and post-trade integration. Whether the overseas merger acquisitions can be completed successfully is not only determined in accordance with the end of merger acquisitions of the transaction but also according to the next few years of operating conditions, whether the business is integrated rationally, and whether the planning of mergers acquisitions is completed. Because of the corporate culture characteristics of domestic enterprises, especially state-owned enterprises have encountered many problems in overseas acquisitions, particularly in the aspects of corporate values and subtle social rules [4]. For example, in China, in the process of enterprises completing the merger acquisitions, the two sides first need to consider the consultation with the relevant government departments, and then consider the consultation between the business people. Only by negotiating these two aspects of the relationship can mergers and acquisitions be completed successfully. However, in foreign countries, due to more stakeholders, the constraining force of laws and regulations to the merger acquisitions is greater, and the impact of merger acquisitions is also greater. Therefore, there is only 20% of the legal risk at the acquisition stage, and there is 80% of the legal risk at the operational stage. Chinese enterprises are at the beginning of their careers and are not clear about the laws and regulations in the area where the enterprises will be merged. Moreover, the cross-border operation management experience is lacking, which causes the amount of mergers and acquisitions is large, but the quality is very poor. Most of them are in the loss state, enterprises that are normally profitable are less, and the success rate of the mergers acquisitions is low. Therefore, it is urgent to put forward feasible preventive measures at the legal level [5].

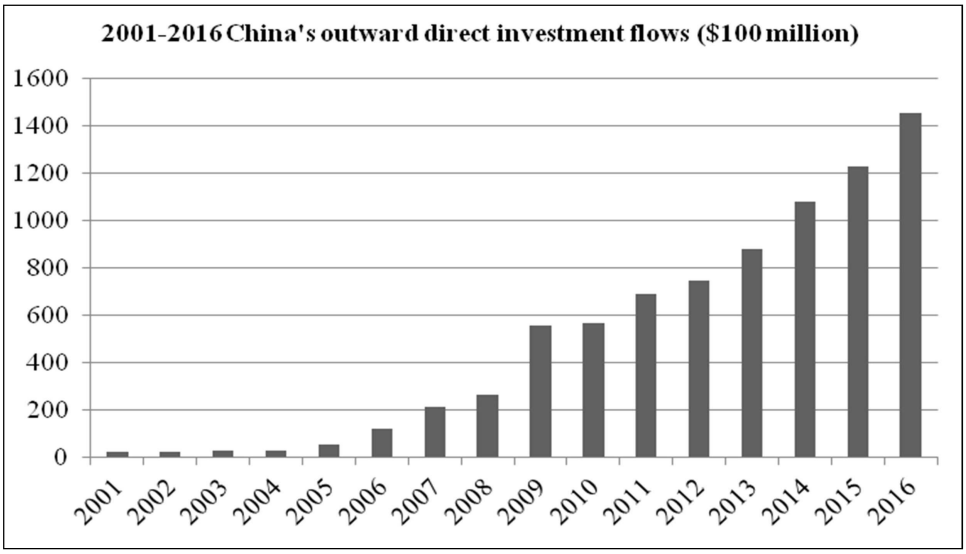

Figure 1. China's outbound direct investment flows from 2001 to 2016

3. Methodology

3.1. Legal Risk of the Cross-border Mergers Acquisitions of Energy Enterprises

At present, the investment flows of overseas mergers and acquisitions of Chinese enterprises have increased year by year. From 2001 onwards, the investment flows of overseas mergers acquisitions in China have shown a certain proportion increase [6]. The overseas direct investment flows in China in 2001-2016 are shown in Figure 1.

Among them, most of the overseas investment flows are used to invest in the energy enterprises. The foreign direct investment flow chart of China in 2016 is shown in Figure 2.

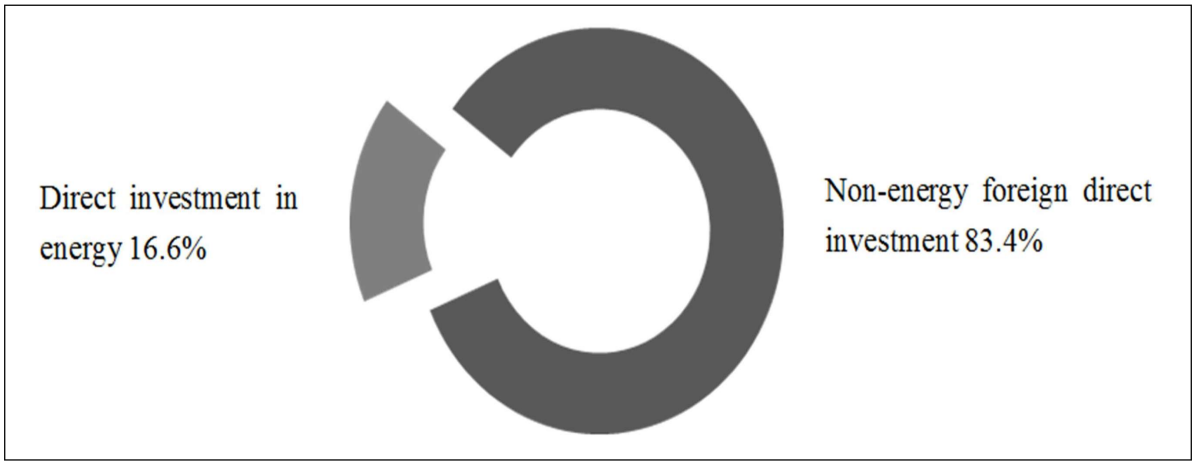

Figure 2. China's outbound direct investment flow chart in 2016

Investment regions also begin to change from Europe and the Americas and other developed areas to Asia, Latin America and North America areas. However, compared with Western developed countries, the extent of the legal system in these areas is often relatively backward, so there is a greater legal risk in the investment in these areas. However, in most cases, the enterprises tend to only focus on the business while ignoring local legal risks [7]. Thus, it is easy to get into trouble during business activities. In general, the legal risk is divided into the following types:

• Environmental Legal Risk

Overseas mergers and acquisitions do not attach importance to the host country's environmental protection law, bringing a very large risk to the production and operation. At the legal level, implementing the "no-fault principle" is a common practice of the international community. Environmental responsibility has become an increasingly serious responsibility for the business process. This requires Chinese enterprises to have a good sense of environmental responsibility and coping strategies in their business process [8]. As shown in Figure 3, there is a two-hole bridge in the West Australian magnetite project of the CITIC Group. The domestic cost is about 5 million RMB; however, in Australia, in order to protect the ecological environment, the final cost reaches 500 billion RMB, and the cost difference is great. In addition to construction costs, environmental conflicts between energy investors and local residents can also pose a significant risk to enterprises [9]. Now, Canada's Ontario is facing an unprecedented environmental crisis, which is because the developers fail to deal with the issue of environmental protection. With this situation, Ontario has modified the mining law, increased the requirements of mining companies and sought proposals for the development plans from local residents [10].

• Labor Legal Risk

Developed countries have more mature labor protection mechanisms. After the acquisition of target enterprises, the labor wages, compensation and adjustment issues may be involved. Some of the powerful trade union organizations and the apparent labor protection policies make it difficult for Chinese energy enterprises to invest well overseas. From June 2005 to July 2006, in the Peruvian investment company's iron ore, China's Shougang Group suffered three workers' strikes, which caused the company to suffer millions of dollars in economic losses. In addition, every strike ended with a requirement to meet the salary increase. German law stipulates that enterprises with more than five employees have the right to require trade unions

to represent the interests of their employees, and the trade unions can participate in the daily business management [11]. After the merger of Chinese enterprises and German enterprises, the failure was caused because the enterprises fail to reach an agreement with the trade union.

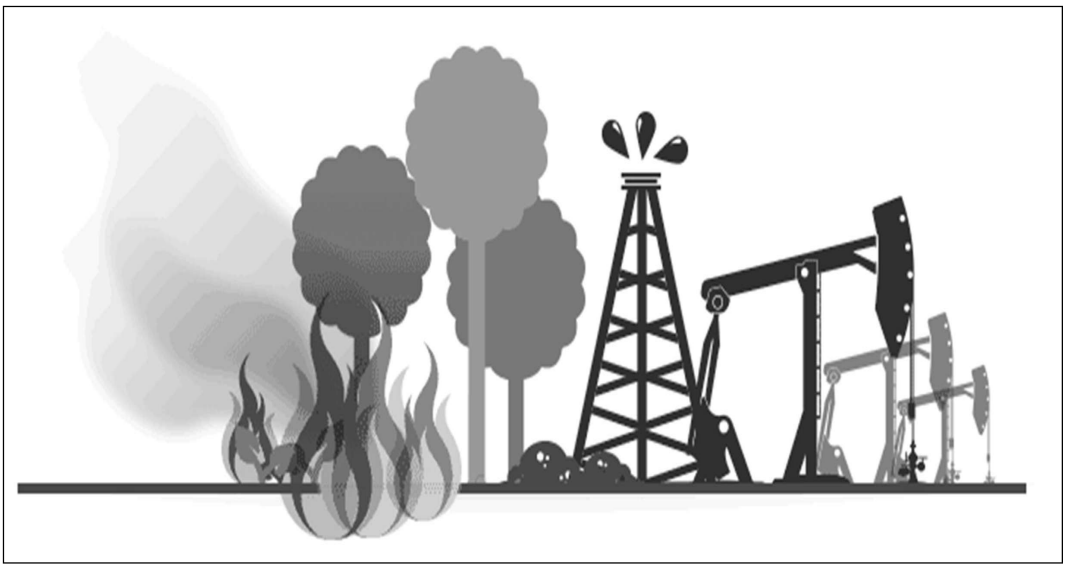

Figure 3. Environmental protection legal risk schematic

• Tax Legal Risk

In the designated mergers acquisitions plan, Chinese enterprises tend to focus on the enterprises' size, pricing, and investment recovery period, while the related tax planning and business management model, profit remittance, exit strategy and other issues are not considered in detail. At the same time, the foreign tax system and tax collection and management system are completely different from the domestic systems, which also increases the tax risk of overseas investment management of enterprises. For example, some energy engineering contracting enterprises do the contracting construction in the overseas EPC, the local income tax and the business tax rate is relatively high, and the pre-tax deduction policy is strict, which doesn't allow the local place to deduct a lot of fees. Even in the local tax incentives, the supplementary tax is still required after the profits are back to China [12]. However, if the local tax laws are analyzed carefully, some countries may be exempt from the local income tax. A single purchase contract is designed, and the contract can be regarded as the owner directly imports materials and equipment, then, the local income tax is exempted, and the business tax also isn't involved. So, the entire packaging EPC contract can be split, thereby reducing taxes.

From the definition, the risk is the unpredictable loss that occurs at the time of doing something. In mathematics, in order to quantify the loss caused by the risk, the following formula is used to define the risk: . In this formula, R represents event risk, P represents the risk coefficient of implementing the event, R indicates the probability of encountering an adverse event during event execution, C represents the effect after implementing this event. Based on risk identification, and according to previous merger case accumulation experience, mathematical methods are used to estimate the merger acquisition risk probability and risk. The enterprise merger acquisition decisions and merger acquisition risk management are built based on risk assessment, which is also a very difficult part of the risk management process. Risk assessment is essentially to accurately assess the risk of mergers and acquisitions. However, mergers and acquisitions' risk assessment and pricing are too high. And the underestimation of the merger will also bring harm to the business [13].

3.2. Fuzzy Comprehensive Evaluation Method for Risk Assessment

The fuzzy comprehensive evaluation method is an evaluation method formulated by taking fuzzy mathematics as the basis. Based on the fuzzy mathematics comprehensive evaluation method of the qualitative evaluation theory, fuzzy mathematics is used to carry out the quantitative evaluation to the things or various factors of objects, and then comprehensively evaluate them. The fuzzy comprehensive evaluation method has some advantages in solving some nonlinear fuzzy problems, and applying this evaluation method can often draw clear results. So, the evaluation method is widely used to express uncertainty.

The fuzzy comprehensive evaluation method contains the following important parameters:

• **The domain U:** this parameter is mainly used to represent all risk factor sets that may appear in the merger acquisition process. According to this parameter, the visibility results identification can be directly carried out to the merger acquisition risk.

• **Fuzzy set A:** this constant is mainly used to indicate the set of the influence quantification degree caused by different risk factors in the mergers and acquisitions process. This parameter is the basis for establishing a risk assessment model in the mergers and acquisitions process.

• Membership indicates the degree of closeness between the risk factors and merger acquisition risk in the merger acquisition process. In mathematics, a positive correlation exists between the membership degree and the merger acquisition risk.

• Membership function V is mainly used to quantify the fuzzy method between risk factors in mergers and acquisitions. According to this function, the main interval of the risk assessment range of time can be directly obtained.

• **Fuzzy matrix R:** it is mainly used to test the quantitative relationship between different risk factors; then, the quantitative relationship among different risk factors is calculated through the matrix function, and the form of probability expresses the quantitative relation value.

• **Fuzzy evaluation model B:** The parameter is mainly used to assess the degree of risk faced by enterprises in the assessment process. The model is composed of different risk occurrence probabilities and its existing state.

The basic model is shown as follows:

• The research object in the model is assumed to be P: Its factor set is $U = \{u_1, u_2, u_3,....,u_m\}$, and the judgment level set is $V = \{v_1, v_2, v_3,....,v_m\}$. After conducting the centralized index fuzzy evaluation to different factors in U, its judgment matrix can be obtained:

$$R = \begin{bmatrix} r_{11} & r_{12} & ... & r_{1m} \\ r_{21} & r_{22} & ... & r_{2m} \\ r_{n1} & r_{n2} & ... & r_{nm} \end{bmatrix} \quad (1)$$

• Among them, r_{ij} is the degree of membership of u_i about v_j.

• According to integrate the important indexes among different factors into a set $A = \{a_1, a_2, a_3,....,a_m\}$, among them, $\sum_{i=1}^{n} a_i = 1$ meets, and the following formula is obtained:

$$\overline{B} = A \,.\, R = (\overline{b_1}, \overline{b_2},...., \overline{b_m}) \quad (2)$$

• After normalization, $B = \{b_1, b_2,...., b_m\}$ is obtained. Then, the evaluation level of the object can be determined.

3.3. Grey Relational Analysis Method for Risk Assessment

The core of the gray correlation is to calculate the relevance. The evaluation of the basic concept is based on the system dynamic process, that is, the system before the statistical data that the geometric relation is related to the similarity, then, whether the contacts are close is determined. The closer the curve is, the more significant the correlation between the corresponding sequences is, the smaller the relevance will be. The comparison of the grey correlation degree is a comparison of the geometric figures of several curves, that is, the more similar the geometric shape is, the closer the development trend is, and the stronger the correlation is. The geometry is intuitive, but it can't be quantified [14]. If many curves are similar, it

is difficult to determine the degree of association of each curve directly. For the investment in the enterprise value judgments, it is necessary to select an optimal and ideal sample as a reference sequence; then, the comprehensive comparison and sorting are carried out for the reference sequence of the evaluation objects by calculating the correlation of each sample. However, the most difficult problem of the optimal sample is that there is no very effective way to determine the optimal sequence. The key issue has become the largest shortboard of the method.

The basic model is shown as follows:

Assuming that the reference data column is often recorded as $X0$, the value of the first moment is recorded as X_0 (1), the value of the second moment is recorded as $X0(2)$, the value of the Kth moment is recorded as $X_0(k)$. Thus, the reference sequence X can be expressed as:

$$X_0 = (X_0(1), X_0(2), \ldots, X_0(n)) \tag{3}$$

The comparative sequence in the correlation analysis is usually recorded as $X_1, X_2, \ldots X_k$, then, the representation methods that are similar to X are:

$$X_1 = (X_1(1), X_1(2), \ldots, X_1(n)) \tag{4}$$

$$X_k = (X_k(1), X_k(2), \ldots, X_k(n)) \tag{5}$$

For a reference data column X_0 , there are several comparison sequences $X_1, X_2, \ldots, X_n$. The following relationship can be used to represent the difference between the comparison curves and the reference curves in each point.

$$\xi_i(K) = \frac{\min\limits_i \left(\Delta_i(min)\right) + \rho \max\limits_i \left(\Delta_i(max)\right)}{| x_0(K) - x_1(K) | + \rho \max\limits_i \left(\Delta_i(max)\right)} \tag{6}$$

In the formula, $\xi_i(K)$ is the relative difference between the comparison curve X and the reference curve X in the kth moment, ρ is the resolution factor, $0< \rho<1$, generally, $\rho = 0.5$ is taken.

Among them,

$$\min\limits_i \left(\Delta_i(min)\right) = \min\limits_i \left(\min\limits_k | x_0(K) - x_i(K)\right) \tag{7}$$

$$\max\limits_i \left(\Delta_i(max)\right) = \max\limits_i \left(\max\limits_k | x_0(K) - x_i(K)\right) = 1 \tag{8}$$

It can be seen from the above formula that the calculation process involves more correlation parameters, so the calculation results obtained are also prone to have the status quo of decentralized arrangement, which is not conducive to analyzing and comparing the results. Therefore, the mean processing needs to be carried out for the calculation result. The general expression of relevance is:

$$r_i = \frac{1}{N} \sum_{K=1}^{N} \xi_i(K) \tag{9}$$

4. Result Analysis and Discussion

Through the summary, it can be concluded that the main risks of energy enterprises in the cross-border merger acquisition process can be divided into industrial, market, legal, information, integration, and financial risks. The degree of impact of the

mergers and acquisitions caused by different risks is different. These different effects are mainly expressed by using the degree of importance of the risk factors. The specific values are shown in Table 1. At present, there are three different M&A programs that are available for business selection. The weight of the risk factors in these three different programs is shown in Table 2:

Risk factor	Market risk	Information risk	Legal risk	Industrial risk	Integrating risk	Financial risk
Important degree	0.284	0.153	0.040	0.097	0.265	0.161

Table 1. The Importance of Mergers Acquisitions Risk Factors

Weight value	Market risk	Information risk	Legal risk	Industrial risk	Integrating risk	Financial risk
Plan a	0.335	0.28	0.04	0.09	0.245	0.1
Plan b	0.225	0.09	0.22	0.08	0.05	0.335
Plan c	0.05	0.3	0.075	0.295	0.065	0.215

Table 2. Probability of Merger Risk Factor Xj

4.1. Application of Fuzzy Risk Assessment Method

Assuming $B = A * R$

In this evaluation, as the main element of the mergers acquisitions risk of the enterprises, the main merger acquisitions risk factors form a set, namely, U = {market risk, information risk, legal risk, industrial risk, integration risk, financial risk}. The merger acquisitions risk level is divided into: V = {high, low}. At the same time, in order to facilitate the comparison of the calculation results, the risk critical point L needs to be set. Assuming $L = 0.2$, when $Xi > 0.2$, the risk level is high, $Xi = 1$; when $Xi < 0.2$, the risk level is low, $Xi = 0$. According to Table 2, the fuzzy evaluation matrix can be obtained:

$$R_1 \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \end{bmatrix} \quad R_2 \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} \quad R_3 \begin{bmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{bmatrix} \tag{10}$$

It can be known from the meaning of the title:

• Through the normalisation process, the comprehensive evaluation result of three merger acquisition programs can be obtained: $B1 > B2 > B3$

• According to the results of the above analysis, it can be seen that the risk of program 3 is the smallest, which is the optimal option; followed by Program 2; the risk of the program 1 is the biggest.

4.2. Application of Grey Relational Evaluation Method

Setting that the critical point of risk probability value is $L = 0.2$. According to Table 2, the risk characteristic matrix can be obtained as follows:

$$X_K = \begin{Bmatrix} X_1 \\ X_2 \\ X_3 \end{Bmatrix} = \begin{bmatrix} 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \end{bmatrix} \tag{11}$$

According to Table 1, $X_0 = \{0.284, 0.153, 0.040, 0.097, 0.265, 0.161\}$ can be known, then, the initialization processing is carried out to X_0, and the following is obtained :

$$X_0 = \left(\frac{0.284}{0.284}, \frac{0.153}{0.284}, \frac{0.040}{0.284}, \frac{0.097}{0.284}, \frac{0.265}{0.284}, \frac{0.161}{0.284} \right) \tag{12}$$

According to formula (5.4), the difference sequence can be calculated, namely:

$$|X_0 - X_1| = (0, 0.461, 0.141, 0.342, 0.067, 0.567) \tag{13}$$

$$|X_0 - X_2| = (0, 0.539, 0.859, 0.342, 0.933, 0.433) \tag{14}$$

$$|X_0 - X_3| = (1, 0.461, 0.141, 0.658, 0.933, 0.433) \tag{15}$$

$$\min_i \left(\Delta_i(min) \right) = \min_i \left(\min_k | x_0(K) - x_i(K) \right) = 0 \tag{16}$$

$$\max_i \left(\Delta_i(max) \right) = \max_i \left(\max_k | x_0(K) - x_i(K) \right) = 1 \tag{17}$$

According to formula (6), the correlation coefficient can be calculated. Among them, $\rho = 0.5$. The following Table 3 can be gained:

	Market risk	**Information risk**	**Legal risk**	**Industrial risk**	**Integrating risk**	**Financial risk**
$k = 1$	1	0.520	0.780	0.594	0.882	0.469
$k = 2$	1	0.481	0.368	0.594	0.349	0.536
$k = 3$	0.333	0.520	0.780	0.432	0.349	0.536

Table 3. Correlation of Risk Factors

According to formula (9), r1=0.707 r2=0.555 r3=0.492 can be obtained, and then, r1>r2>r3 can be gained.

It can be seen that the risk degree of Program 1 is the highest, and the merger acquisition risk of program 3 is the lowest.

4.3. Comparison and Summarization of Two Evaluation Models

According to the above two methods of analysis, it is concluded that Program 1 has the greatest merger acquisition risk, followed by program 2, and program 3. Taking into account the least risk, program 3 has been selected. Table 1 shows that in the process of mergers and acquisitions, the market risk and integration risk are the two most important risk factors for the enterprises, and the proportions are 0.284 and 0.265, respectively. Therefore, in the process of merger acquisitions, enterprises should accordingly avoid the impact of negative factors on the mergers acquisitions process, take full account of market risk integrate risk factors, and develop the appropriate strategies to mitigate the risk. In these three cases, the impact of the market risk and integration risk is 0.05 and 0.065, respectively, and program 3 is the best way to avoid the risk.

There are many risks in cross-border merger acquisition projects because of the combined effects of various factors. To reduce the risk of cross-border mergers acquisitions projects in each link, the risk measurement should be determined, and the risk should be controlled accurately. Based on the risk judgment of cross-border merger acquisitions, it is helpful to make up for the competitive disadvantage and improve the economic efficiency of the enterprise by establishing a model to determine which program is the least risky strategy [15]. In addition, the energy companies can also avoid the legal risk that may appear in the process of mergers acquisitions from the following major aspects:

• Conducting a full and detailed legal investigation on the mergers and acquisitions in the earlier stage.

• Using the professional legal design and means to avoid risks.

• Improving the mechanism to deal with cross-border mergers acquisitions and integrate legal risks.

• A complete mergers acquisitions program can be obtained only by carrying out the deep thinking and research on the cross-border mergers acquisitions of enterprises from multiple aspects and multiple levels.

5. Conclusion

At present, the ranking of China in the global energy consumer country list is second, and the lack of energy supply will seriously drag the pace of China's economic development. Over the past few years, under the guidance of the "going out" strategy, the number of mergers and acquisitions of the domestic energy enterprises to overseas enterprises has increased rapidly. However, because enterprises need to face a lot of challenges in overseas investment activities, the investment involves different laws and business environments in the international environment. No matter how simple the problem is, it may be amplified in a complex environment and finally has a very bad effect on the energy enterprises in international operations. Therefore, in this paper, according to the use of the model of the fuzzy comprehensive evaluation method and gray relational degree method, quantitative research and analysis was carried out to the risk assessment in mergers acquisitions of energy enterprises, and the preventive measures were formulated according to the relevant laws. Experiments show that these precautions can effectively reduce the occurrence of the risks. Of course, due to the limitations of personal knowledge and the length of the article, it is the shortcoming of this paper that further study isn't carried out to propose a more comprehensive solution.

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