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Research on Risk Measurement of Supply Chain Emergencies in International Capacity Cooperation

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Abstract: International capacity cooperation is easily affected by the interweaving of its internal and external environment. As the risk accumulation exceeds the threshold, a supply chain crisis and even emergency will occur and serious losses will be caused. Regarding multinational operation and international capacity cooperation, 208 cases were summarized to identify risk types and high-incidence areas, and a risk measurement index system was established. A Fuzzy AHP (Analytic Hierarchy Process) method was used to evaluate the importance of each risk index. It was found that country risk was the main cause of supply chain emergencies in international capacity cooperation. Construction, water and electricity supply, mining and manufacturing were major areas of emergencies. In international capacity cooperation, country risk and cross-cultural risk were more important in external risks, while in internal risk, financial risk and decision risk were more important.

Keywords: international capacity cooperation; emergencies; "the Belt and Road"; global value chain; Fuzzy AHP

Highlights

- The main hot spots of the ri sk of international capacity cooperation research have been proposed.
- It was found that country risk is the main cause of supply chain emergencies in international capacity cooperation
- Classification of the risk of international capacity cooperation.
- Using Fuzzy AHP, a measurement model of international capacity cooperation risk is presented.

1. Introduction

The Third Plenary Session of the Eleventh Central Committee proposed that China should actively develop foreign economic cooperation. The 14th National Congress proposed "go global" as a national strategy. General Secretary Xi Jinping (2013) proposed "the Belt and Road" cooperation initiative. Premier Li Keqiang (2014) pointed out that it was necessary to promote the leap of China's industry to the high-end of the global value chain in the government work report of the National People's Congress. Premier Li Keqiang (2015) also proposed to carry out international capacity cooperation. All of these government actions show that China has gradually shifted from the previous one that undertakes the industrial transfer to the one that gathers the dominant capacity to "go global". It is also the main idea that guides the development of the domestic network chain and gradually improves itself and moves toward the global value chain.

As China moves from the "world factory" status of the global value chain to the investment output country that predominates the "Belt and Road" capacity cooperation, China has attained remarkable achievements in foreign investment and transnational operations. The total volume of imports and exports of goods between China and the "Belt and Road" countries reached $6.975623 trillion from 2013 to 2017. In 2018 alone, this figure reached $1.3 trillion, $704.73 billion in exports and $5630.7 billion in imports, up 16.3% than a year before accounting for 27.4% of the total value of foreign trade, 3.7 percentage points higher than China's foreign trade growth rate [1].

However, there are many unavoidable risks in the process of integrating a domestic value chain into a global value chain. For example, while China have carried out international capacity cooperation with other countries, supply chain emergencies have erupted. International capacity cooperation is a joint action of transnational or cross-regional allocation of capacity supply and demand, and the formation of joint action requires the consensus of partners. Generally speaking, capacity cooperation is usually carried out in two channels: product output or industrial transfer. Supply chain emergencies are accidents caused directly or latent by occasional factors inside and outside the supply chain, which are formed and broken out in a short period of time, directly affecting and interrupting the operation of the supply chain and may bring disastrous consequences.

The emergencies will bring serious consequences to the logistics chain, supply chain, industrial chain and other network chains. And some supply chain emergencies can be caused by political and economic reasons. The occurrence of various emergencies in the supply chain has brought huge losses to the integrated bodies of core enterprises [2]. For example, in 2011, the war in Libya caused huge economic losses to 13 Chinese enterprises that have invested in Libya, involving $18.8 billion funds [3]. In November 2014, Mexico suddenly canceled the $4.4 billion high-speed rail contracts with Chinese companies [4]. In 2018, Malaysia announced the suspension of the Chinese-funded East Coast Railway Project, and so on [5].

The studies of emergencies show that in the foreign investment and transnational operation of enterprises, the structure of value chain and the external environment are more complicated, and the possibility of facing many risks and crises increases; the political risk especially has an adverse impact on business operations [6]. For example, ZTE and Huawei Technologies Co. have encountered serious crises in the operation of a global value chain.

On 16 April 2018, the U.S. Department of Commerce suddenly announced that U.S. companies will be banned from selling parts, goods, software and technology to ZTE for the next seven years. ZTE's main businesses, including base stations, optical communications and mobile phones, were affected to varying degrees. Although ZTE is the world's fourth largest communications equipment manufacturer, key chips and software cannot be separated from the United States' supply chain, therefore if the United States did not release the ban, ZTE could not survive. Finally, ZTE paid $1 billion in fines, $400 million in margin, plus $890 million in previous payments—over $2.29 billion—and accepted the supervision of the other party's dispatchers before formally lifting the sanctions. The results were reflected in ZTE's loss of about $7 billion in 2018, perhaps ZTE's worst loss in years [7].

On 16 May 2019, the Commerce Department's Department of Industry and Security of the United States added Huawei to an "entity list" that could threaten U.S. national security, banning Huawei from buying technology or accessories from U.S. companies. Under the ban, U.S. companies are banned from selling parts to Huawei and its 68 affiliated companies, and as a global communications company, many of Huawei's previous key components and mobile operating systems come from the United States, such as some chips, Android and so on. Affected by the "entity list" incident, some Huawei suppliers revealed that many orders had been affected and cut, among them, Huawei's mobile terminal business was most affected. Ren Zhengfei, the founder of Huawei, estimated that it will take three to five years for Huawei to resume revitalization [8].

Although there have been previous studies on foreign investment, transnational management and so on, few studies have discussed the risk identification and prevention of supply chain in international capacity cooperation. Especially under the new international situation, such as the

"Belt and Road" Initiative put forward by China and the continuous trade friction between China and the United States, the risks that will be faced in carrying out international capacity cooperation, as well as which risks need to be prevented, are in urgent need of research. Therefore, the supply chain emergencies in international cooperation in the past 10 years were analyzed, the risk types in international capacity cooperation was classified, the risks were evaluated and measured, in order to provide help for enterprise risk prevention and government policy making. On the basis of news reports and other literature, our research group counted 208 cases of supply chain emergencies in China's foreign investment, the "Belt and Road" cooperation initiative and international capacity cooperation. Chinese companies have lost hundreds of millions of dollars in these cases. These cases were used to analyze the supply chain emergencies in international capacity cooperation to explore the associated types of risks and the risk measurement.

2. Literature Review

2.1. International Capacity Cooperation Theory

In the 1970s, after summarizing the previous monopoly advantage theory, internalization theory and product life cycle theory, J. H. Dunning put forward the eclectic paradigm of international production. In the view of Dunning, the mode, scope and structure of international production are determined by the advantages of the enterprise, and the advantages of the enterprise are formed by the incomplete competitive market. Dunning believes that if the real market is invalid, there are generally two types of this failure. One type is structural failure, such as market failure caused by tariff and non-tariff barriers set by the host country. Another type is transaction failure, such as market failure caused by excessive transaction costs caused by poor trading channels and excessive trading risk [9].

According to the eclectic paradigm of international production, outward foreign direct investment (OFDI) is the inevitable result of the growth and expansion of enterprises, and it is the business behavior in which enterprises combine their own ownership advantage, internalization advantage and location advantage to obtain the maximum profit under the condition of incomplete market. Although the eclectic paradigm of international production is mainly a deep research on the OFDI projects of developed countries, there are still some defects in explaining the OFDI projects of developing countries whose technology does not have the exclusive advantage. In the 1980s, Dunning combined a country's ability to attract OFDI and its ability to invest abroad with the level of economic development, and put forward the investment development cycle theory. In fact, the theory is the application and extension of the eclectic paradigm of international production in developing countries. Dunning believes that the main factors affecting OFDI in developing countries are still ownership advantage, internalization advantage and location advantage. In fact, the eclectic paradigm of international production has always had a strong explanatory power, after it was introduced into China's OFDI research. For example, Shao et al. analyzes the investment risk of OFDI based on the eclectic paradigm of international production [10]. Similarly, in international capacity cooperation, whether in the selection of cooperation projects, or the choice of cooperation location, as well as in the process of cooperation management, there are a variety of risks to face. These risk studies are part of international cooperative research. Therefore, based on the eclectic paradigm of international production, we studied the risk of international capacity cooperation.

2.2. Risk Type

There are many forms of international capacity cooperation, such as foreign trade transactions, overseas investment, industrial transfer, industrial cooperation and so on. From the perspective of the global value chain, with the help of literature research, the literatures related to foreign investment risk, industrial transfer risk, "go global" risk, transnational operation risk, supply chain risk and capacity cooperation risk and so on, are all useful.

2.2.1. Foreign Investment Risk

Foreign investment is the main entry point of international capacity cooperation [11]. Up to now, the relevant research has formed a series of research results. In these studies, most of the risk type of foreign investment involves political risk and related risks, such as the political and institutional risks as mentioned by Zhang [12] and the political risk which involves the risks arising from the policies and laws of the host country, war risk and nationalization risk, etc. as mentioned by Bai [13]. Shao et al. mainly consider political risk from the aspects of policy, nationalization, war and civil strife, capital transfer, government default and so on [10].

It is worth noting that from the initial focus on policy to the focus on war and civil strife, the scope of political risk is becoming more comprehensive. For example, Nie incorporates the risk of "discriminatory intervention" by political forces and the risk of encroachment into political risk [14]. Later, Zhang took into account the risk of terrorism as well as the risk of cultural conflict [15]. Tai et al. also classifies legal risk and labor risk as political risk [16]. China's Foreign Investment Development Report (2017) refers to the changes in relations with China and the geographical game between big powers, however, legal risk and cultural risk are not classified as political risk [17]. Sun divides risk into commercial risk and non-commercial risk, and non-commercial risk focuses on political risk or country risk [18]. According to these, risks such as politics related to the state can be classified as country risks.

In terms of non-political risk, it mainly involves operational risk, management risk, capital risk, technical risk and so on, such as the external investment environment risk and internal business risk mentioned by Nie [19]. It also mostly considers external risks, maybe because external risks often have a large impact on foreign investment.

Over time, the risk of foreign investment has not decreased due of economic development, which can be seen from the cases we collected. Moreover, the types of risks tended to be comprehensive and rich. At the same time, it can be found that the specific connotations of various risks were not identical, and the naming was not the same. For example, although political risks were involved in much research, the content emphasized by different scholars was not exactly the same. From the definition of 27 political risks collected by Mark Fitzpatrick in 1983, scholars still rarely agree on the definition of a political risk [20]. Furthermore, regarding the nationalist risk, some put it together with religious and cultural risk, or consider it to be a kind of political risk, some classify it as a management risk, and some tie it to terrorism. We put it into cross-cultural risk.

2.2.2. Industrial Transfer Risk

Industrial transfer is an important category within the research of capacity cooperation. The research on industrial transfer risk mainly focuses on the gradient transfer of industry [21], which is mainly about the risk from domestic to overseas, or the research on China's risk in undertaking international industrial transfer [22], which also confirms that in the previous industrial transfer, the main role played by China was the industrial receiving place. Research on capacity cooperation with other countries needs to be considered now. At present, China's "the Belt and Road" and international capacity cooperation are mainly composed of superior capacity going out and green extension of the network chain. This is fundamentally different from the concept of early industrial transfer.

2.2.3. "Go Global" Risk

The research on "go global" of Chinese enterprises began in 2000, and the number of related research increased year by year, with the beginning of research on international capacity cooperation in 2015, it reached the peak in recent years.

The main points of the "go global" risk classification are as follows: Li mainly refers to traditional political risk, economic risk, financial risk and non-traditional risks which include terrorism, religious and resource conflicts, ethnic conflicts, epidemics, biological violations, biochemical viruses and

weapons, natural disasters, human hazards, production safety and emergencies, etc. [23]. Liu et al. consider the types of risk from the aspects of politics, sovereignty, security, law, culture, trade unions, stakeholders and environmental protection [24]. Wang believes that the risk of "go global" for Chinese enterprises mainly included external risks, such as political, economic, legal, market, peer competition, and internal risks, including strategy, integration, human resources and management, etc. [25]. Han et al. believes that in the process of "go global", Chinese enterprises are mainly faced with economic policy risks such as industry, tax and foreign exchange [26].

It can be seen that the main focus of the "go global" risk is also the two aspects of external risk and internal risk. External risks mainly focus on political, security risk and economic risk associated with different countries' national conditions, social environment, etc. Internal risks are mainly related to business management.

2.2.4. Transnational Business Risk

The main research focuses on multinational enterprise management and mergers and acquisitions, involving national risk (or political risk), foreign exchange risk, decision risk, financial risk, market risk, integration risk and so on [27]. The obvious development trend is that it previously focused on political risk in war, expropriation, nationalization, etc., and began to pay attention to changes in host country policies, regional protection, economic and political retaliation, intra-regional coordination, third-country intervention, nationalism and religion contradictions, political participation of interest groups and non-governmental organizations within countries, and other political risks (national risks) [28]. It can be seen that the changes of government policies in various countries have a certain impact on the occurrence of supply chain emergencies.

2.2.5. Value Chain Risk

Duan et al. divided the value chain risk into endogenous risk and exogenous risk [29]. The former refers to the escalation risk accumulated by the internal causes of industrial clusters under the global value chain, while the latter refers to the escalation risk caused by the external reasons. Wang et al. believes that it includes market risk, information transmission risk, moral credit risk, system risk and strategic risk [30]. Therefore, the risks inside and outside the value chain of international capacity cooperation needed to be considered.

2.2.6. Supply Chain Risk

The research on supply chain risk formed a series of research results. Among them, for the type of supply chain risk, scholars were also considered from both internal and external aspects. For example, the endogenous risk and exogenous risk mentioned by Ma [31], Ni [32], Geng et al. [33] etc. have similar views. Dong conducts a detailed division, arguing that external risks mainly include risks in nature, society, economy, policy, credit and market. Internal risks mainly include technology, information, human-machine, logistics, strategy and ethics [34]. There were also many scholars who did not divide risks internally or externally.

2.2.7. International Capacity Cooperation Risk

The current research on the classification of risk is mainly as follows: Zhao et al. divides it into political risk, system risk, diplomatic risk, economic risk, competition risk and social risk [11]. Guo et al. considers it mainly includes geopolitical risk, social risk, economic risk and big power game risk [35]. Mei mainly emphasizes the country risk of international capacity cooperation and defines it from four dimensions, including expropriation, exchange restrictions, war and political violence and default [36].

It can be seen that the existing literature mainly emphasizes external risks, which is mainly focused on political risk, social risk and economic risk. There is not much discussion regarding other risks involved in international capacity cooperation, such as natural risk, legal risk, technical risk and so on.

It also does not consider the supply chain risk inside and outside the value chain from the perspective of the global value chain in the context of international capacity cooperation.

2.3. Risk Measurement

Shao et al. uses multi-level fuzzy comprehensive evaluation to analyze and evaluate the investment risk of OFDI projects [10]. Su et al. study the attribute hierarchy model based on triangular fuzzy numbers, and the application of them in the evaluation system is also introduced [37]. Li et al. use Fuzzy AHP (Analytic Hierarchy Process) to assess risk in Chinese shale gas investments abroad [38]. Leśniak et al. use Fuzzy AHP to make contractors' bidding decisions [39]. It can be seen that it is feasible to use Fuzzy AHP in the supply chain emergency risk measurement of international capacity cooperation.

This paper made a systematic definition for the supply chain emergency risk of international capacity cooperation, and strove to comprehensively sort out the risk classification from the perspective of the global value chain, and used Fuzzy AHP to establish a risk measurement model of international capacity cooperation. The result was analyzed by using the eclectic paradigm of international production.

3. Methodology

We selected the cases in which China participated in international cooperation frequently in the past ten years as the object of study. By interviewing enterprises, consulting media reports, literature and government websites (such as China's "Belt and Road" website), we searched for some emergencies that had occurred in international cooperation in China, considering that most of the cases that can be collected were cases that had led to losses, and that the cases leading to losses were of more representative significance. Finally, 208 cases were collected.

Referring to the previous literature and collected cases, the research group gave the definition and classification of supply chain emergency risk in international capacity cooperation, and established the risk measurement index system of international capacity cooperation. Then, the Fuzzy AHP was used to evaluate the risk. Fuzzy AHP is a qualitative and quantitative analysis method, taking into account the fuzziness of human subjective judgment, and has a strong applicability. In the risk assessment, the team selected three experts and asked them to attach importance to the risks in international capacity cooperation according to the established risk assessment index system, combined with their own experience in research or practice. Two of them studied international capacity cooperation, and one was a project manager with experience in transnational operations. In order to ensure the consistency of scoring, a total of two marks were scored at an interval of one week. The team compared the two scores, discussed the changes in the two scores, discussed them with the experts again, and obtained the final risk score matrix. Then, according to the expert score and calculation, the ranking and weight of each risk were obtained, and the risk assessment model of international capacity cooperation was established. The model was used to evaluate two international capacity cooperation projects of a company with successful experience and failure cases in recent years, and the effectiveness of the model was verified. Finally, the eclectic paradigm of international production was used to analyze the results, and the corresponding suggestions to the government and enterprises were put forward.

4. Supply Chain Emergency Risk Types of International Capacity Cooperation

Through the 208 cases, it could be seen that Chinese enterprises suffered losses due to various uncertain factors in their external cooperation. The reasons were related to the comprehensive effects of politics, economy, society, technology and so on. According to the causes of international capacity cooperation emergencies, supply chain emergency risks of international capacity cooperation could be divided into two categories, that caused by external factors and internal factors of the global value chain. External factors included natural disasters, politics (political instability, war and civil strife, national strategic conflicts, etc.), laws, economies (exchange rate fluctuations, derivatives trading

differences, debt defaults, etc.), culture (cultural, religious conflicts, etc.). Internal factors were accidents, investment decisions, management, finance and so on. Combined with the above literature, the supply chain emergency risks of international capacity cooperation was divided into external risks and internal risks, which is shown in Table 1.

Table 1. Supply chain emergency risk types of international capacity cooperation.

Types of Risk		Risk Meaning	Typical Cases
External Risks	Natural Risk	Risks due to natural phenomena, physical phenomena and other material phenomena, such as earthquake, flood, fire, wind, disaster, frost, drought, plague, and various plague, etc. [40].	On 16 April 2016, an earthquake measuring 7.8 on the Richter scale struck off the coast of Ecuador, 654 people were killed, 68 people were missing and more than 16,000 people were injured. On 13 April 2016, the first four units of the Sinclair Hydropower Station project which was built by a Chinese company had just been put into production. Fortunately, after systematic risk investigation, it was safe in the event of a strong earthquake [41].
	Country Risk	In international economic activities, the possibility and consequences of losses caused by the sovereign actions of the state, including the risks of economic foundation, solvency, social resilience, political risk and relations with China [42].	In 2015, the Greek government announced the suspension of the privatization plan of Piraeus Port, saying that it would reassess cooperation with the COSCO Group. Although the Deputy Minister of Shipping of the country later said that the new Greek government respected the agreement reached with the COSCO Group in 2008, it still reflects the great uncertainty of overseas investment [43].
	Cross-cultural Risk	In cross-border economic activities, due to the cultural differences between investment and business entities, the resulting cultural conflicts cannot be resolved reasonably, resulting in the failure of economic cooperation and the failure of mergers and other risk consequences, including the cultural risk of the family, value difference risk, communication risk, religion and customs risk, etc. [44].	In 2016, Samoan media reported that some of the product descriptions of a Chinese-made baby bath lotion were incorrectly translated in English, making it impossible for local consumers to understand its exact meaning. Subsequently, the Ministry of Commerce, Industry and Labor of Samoa conducted an investigation into the baby body soap, requiring local importers to stop importing the product, and the products already on the shelves to be recalled [45].
Internal Risks	Cooperative Risk	The uncertainty and consequences of the lack of mutual trust because of the lack of necessary communication between enterprises [46].	A Chinese engineering company signed a housing construction contract with the relevant departments of Gabon through an intermediary. When the contract did not complete the signing process and the other party's funds were not in place, the company began construction. Later, because the contract could not be implemented, the company suffered huge losses and there were labor disputes, the incident caused a bad influence [47].
	Financial Risk	The possibility and consequences of economic losses suffered by an enterprise in various financial activities, due to various unpredictable and uncontrollable factors, which cause the final financial results obtained by the company to deviate from the expected business objectives within a certain period of time and within a certain range [48].	After a Chinese enterprise signed the equipment design and installation contract with a Tajikistan company, the capital chain of the Tajikistan party broke, resulting in a long-term shutdown of the project and causing great losses to the Chinese company [49].

Table 1. *Cont.*

Types of Risk	Risk Meaning	Typical Cases
Information Risk	A relatively risky phenomenon of information inaccuracy, lag and other adverse consequences caused by information asymmetry and serious information pollution in the process of sharing information [50].	A Chinese company acquired an iron mine in western Australia, because of inadequate access to geological data and project information. It was later found that the mine was not hematite, but magnetite. Coupled with the lack of supporting ports, railways and other mine export channels, the project had a huge loss [51].
Logistics Risk	The possible risks and uncertainties in or after the operation of logistics projects, including logistics timeliness risk, logistics security risk, logistics accuracy risk, logistics cost risk, customs clearance risk and so on [52].	A Chinese enterprise exported bearings to Russia, because of the difference of customs code, the import tax rate was very different. According to the report of the relevant competitive enterprises, the Russian Customs approved the export products of the Chinese enterprises at a high tax rate, resulting in loss of enterprises and reduction of market share [53].
Decision Risk	The possibility and consequences that decision-making activities cannot achieve the desired purpose due to the existence of many uncertain factors, such as subject, object and so on [54].	In 2011, China Overseas Engineering Co., Ltd. participated in the Polish A2 Highway Project, with a total price of 1.3 billion Polish zloty (about 3.049 billion RMB), but the project was already struggling in the past two-thirds of the time limit, with an estimated loss of 395 million US dollars (about 2.545 billion RMB). Eventually, it decided to abandon the project. The Polish Highway Authority filed a claim for 741 million zloty ($271 million) with the Overseas China Commonwealth [55].
Credit Risk	The risk of breach of contract—the possibility and consequences of the failure or unwillingness of the counterparty to perform the contract, which constitutes a breach of contract and causes losses to the relevant stakeholders [56].	A Chinese oil equipment exporter trusted too much the commercial credit of a Venezuelan oil company, failed to sign the self-protection clause and delivered the goods lightly. Due to the long-term arrears of about 1 billion yuan, the enterprise bankrupted and was taken over by other enterprises [57].
Operational Risk	In the course of business operation, because of the complexity and variety of the external environment and the limitation of the cognitive ability and adaptability to the environment, the enterprises may fail in operation or fail to achieve the expected objectives of operation activities. Operational risk refers the possibility and the losses associated with this [58].	When a Chinese-funded enterprise contracted a project in Cameroon, it signed a subcontract with a Chinese enterprise. The latter subcontracted the civil engineering to individuals, forming a "layer by layer subcontracting", which led to the general contractor unable to control the construction team. The three parties had disputes over the construction period, project quality and project funds, and then spent more than half a year and bore a large economic loss before rectifying the problem. But as a result, the project could not be completed and delivered on time, which had a negative impact on the outside world [59].
Technology Risk	The possibility and consequences that the economic benefits of investment projects may deviate from the level predicted or expected by people because of the change of technological factors. Including the risk of technology shortage, technology development risk, technology protection risk, technology use risk, technology acquisition and transfer risk, etc. [60].	In 2006, because Toyota, GM, Volkswagen, Nissan and other international automobile giants went to Russia for production, Russia no longer urgently needed to introduce foreign automobile enterprises, so it began to choose joint ventures, and Chinese automobile enterprises became the target of "tacit rejection" [53].

Political risk is the biggest risk to investors; the major impact of political risk in the country's risk on international capacity cooperation is highlighted by Mei [36], Li et al. [61]. The avoidance of country risk requires the adoption of special procedures and measures, which is difficult and complex.

Among the 208 emergency cases of international capacity cooperation sorted out by the research group, three cases were difficult to distinguish or had no clear attribution, however, in the other 205 cases, according to the risk type, the proportion of country risk was close to 50% (Figure 1). The search information mainly came from the network and literature, therefore it was inevitably incomplete information. For example, there were relatively few emergencies that could be searched for in terms of logistics risk and technical risk, while the proportion of country risk emergencies was very high; this may be because emergencies of country risk are more likely to be reported by the media.

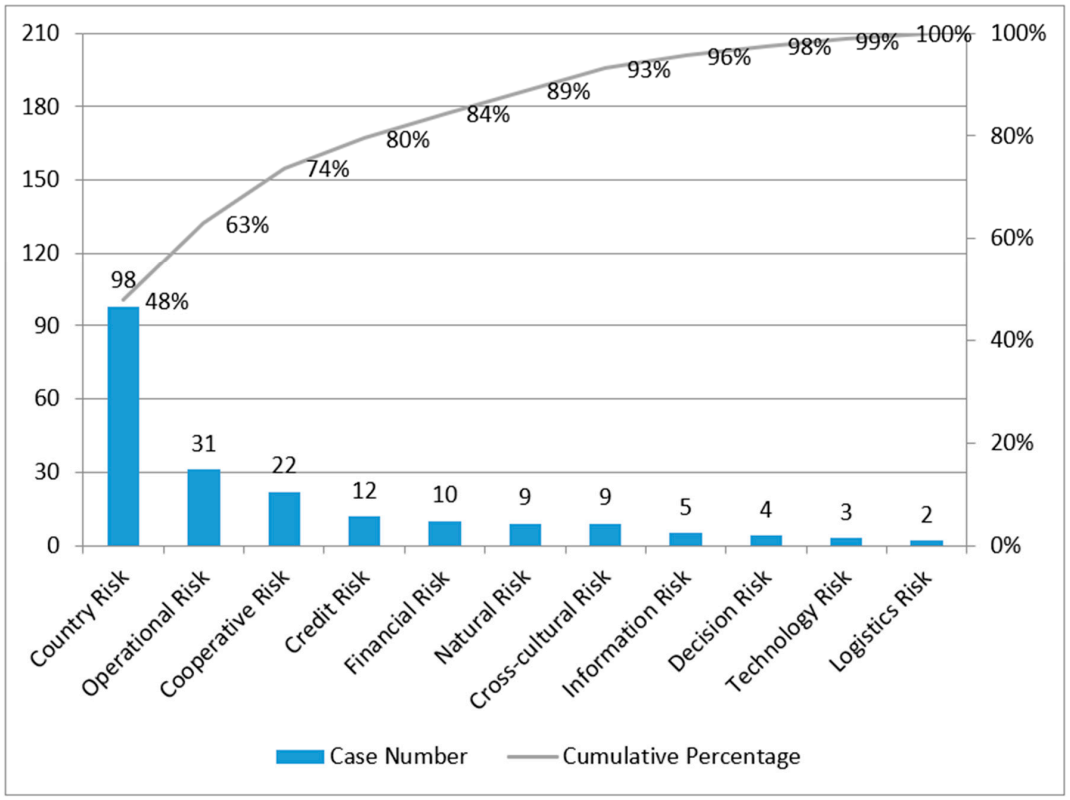

Figure 1. Barrette analysis of risk classification of emergency cases.

5. Industrial Areas Where Emergencies are Easy to Erupt

Some industrial areas are areas where it is easy for emergencies to break out, which were confirmed in the emergency cases collected by the research group. However, the risk aversion measures cannot be used in all kinds of risks and fields, so the influencing factors of the risk should be deeply studied, and different legal coping strategies should be adopted for different risk types.

As can be seen from Figure 2, the risks of overseas industrial network chains could be divided into three categories: construction business, production and supply of electricity, gas and water, mining and the manufacturing industry accounted for the first category (about 82%), logistics and information services for the second category (about 11%) and the rest for the third category (about 7%). The first category was the industrial field where emergencies were most likely to break out; producer services, such as transportation and information transmission were more prone to emergencies, and finally, accommodation, forestry, animal husbandry, fisheries and other industrial fields.

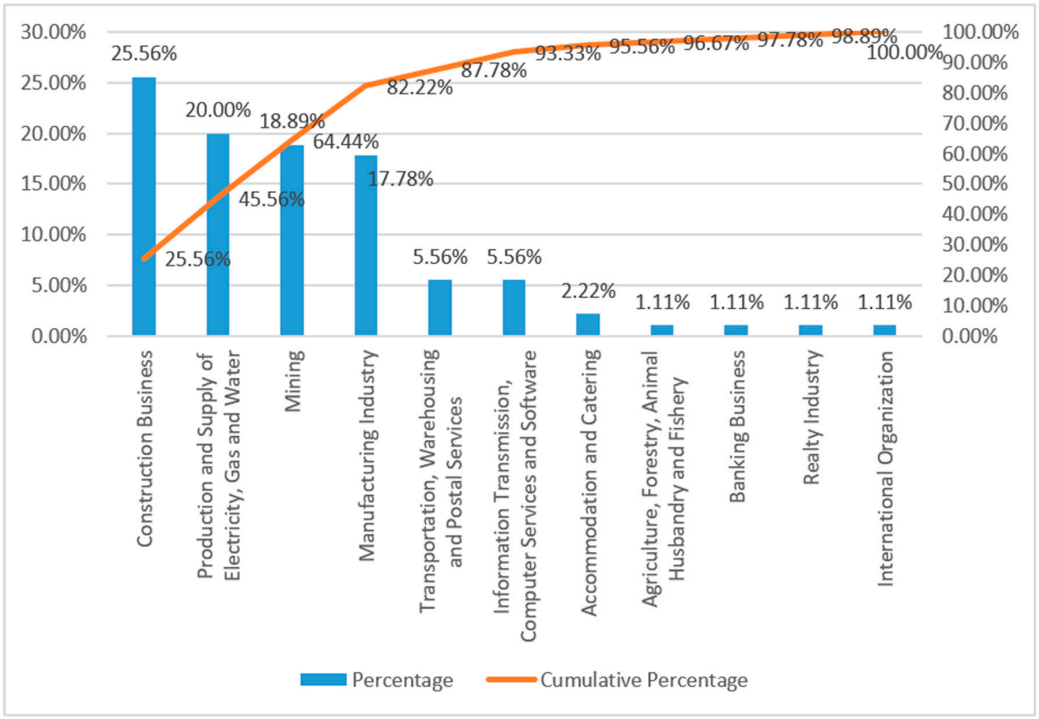

Figure 2. Classification of the occurrence of emergencies in the industry.

6. Risk Measurement and Application Case of International Capacity Cooperation

6.1. Risk Measurement Indexes and Identification

According to the risk types of Table 1, the risk measurement index system of international capacity cooperation was established, and the in-depth comparative analysis was carried out (Table 2).

Table 2. Risk measurement index system of international capacity cooperation.

Target Layer	Criterion Layer	Primary Index	Evaluation Reference Content
International Capacity Cooperation Risk	External Risks	Natural Risk R_1	According to the frequency of natural disasters in recent years, judging by the possibility, risk and vulnerability of natural disasters
		Country Risk R_2	According to the results of country risk rating in CROIC-IWEP, the corresponding risk score is 1–9
		Cross-cultural Risk R_3	Ethnic culture risk, value difference risk, communication risk, religion and customs risk, and so on
	Internal Risks	Cooperative Risk R_4	The degree of mutual trust of the main partners, the fairness of benefit distribution, the effectiveness of the corresponding risk mechanism, and so on
		Financial Risk R_5	Major failure rate of information technology and equipment, capital flow, final product cost, capital flow of main node enterprises, overall coordination ability of core enterprises, etc.
		Information Risk R_6	Coordination of information sharing and intellectual property protection, bullwhip effect intensity, failure degree of data storage and transmission, etc.
		Logistics Risk R_7	Late delivery rate, product damage rate, customs clearance, etc.
		Decision Risk R_8	Market volatility, understanding of the target market, etc.
		Credit Risk R_9	Using the credit rating results, the corresponding risk score is 1–9
		Operational Risk R_{10}	The core business capability and structural stability of the main node enterprises, etc.
		Technical Risk R_{11}	Enterprise technological innovation ability, supplier production flexibility, exclusive supplier, etc.

Information source: Table 1.

6.2. Evaluation Method and Steps of Index Measurement

The Fuzzy AHP method was used to quantify the risk of international capacity cooperation; the main steps are as follows:

6.2.1. Defining the Risk Index Comparison Scale Criteria

When comparing the relative importance of the i-th risk with the j-th risk, the relative weight a_{ij} is used to describe it. If there are n kinds of risks involved in the comparison, the corresponding pairwise comparison matrix $A = (a_{ij})_{n\times n}$ can be constructed. Among them, a_{ij} is measured by 0.1–0.9 scaling method as shown in Table 3.

Table 3. Comparison scaling criteria for risk indexes.

Scale	Explanation
0.5	Risk R_i is as important as risk R_j
0.6	Risk R_i is slightly more important than risk R_j
0.7	Risk R_i is significantly more important than risk R_j
0.8	Risk R_i is much more important than risk R_j
0.9	Risk R_i is extremely important than risk R_j
0.1, 0.2, 0.3, 0.4	If the risk R_i is compared with the risk R_j to obtain a judgment a_{ij}, the judgment of the risk R_j compared with the risk R_i is $a_{ji} = 1–a_{ij}$

6.2.2. Construct a Fuzzy Judgment Matrix

Suppose there are k experts, n kinds of risks $R = \{R_1, R_2, \ldots, R_n\}$, then, $\widetilde{a}_{ij}^x = (l_{ij}^x, m_{ij}^x, u_{ij}^x)$, $(i, j = 1, 2, \ldots, n; x = 1, 2, \ldots, k)$. It is the degree of fuzzy judgment that the risk R_i is more important than the risk R_j, which is obtained by the pairwise comparison of the expert x. Of which, l_{ij}^x and u_{ij}^x refer to the degree of ambiguity of the right and left expansion judgment. The greater the value of u_{ij}^x-l_{ij}^x, the more vague the judgment; m_{ij}^x is the median value of membership degree 1 of $\widetilde{a}_{ij}^x$. Because the fuzzy judgment matrix is complementary, there are:

$$\widetilde{a}_{ji}^x = (1 - u_{ij}^x, 1 - m_{ij}^x, 1 - l_{ij}^x). \tag{1}$$

The set of triangular fuzzy judgment matrices are constructed as follows:

$$\left\{ \widetilde{A}^k \middle| \widetilde{A}^k = (\widetilde{a}_{ij}^x)_{n\times n} = \left(l_{ij}^x, m_{ij}^x, u_{ij}^x\right)_{n\times n}, (i, j = 1, 2, \ldots, n; x = 1, 2, \ldots, k) \right\}. \tag{2}$$

6.2.3. Comprehensive Measure of the Importance of Evaluation Indexes

Through matrix A transformation and Formula (3) calculation, the triangular fuzzy vector set of index ranking in each layer can be obtained. That is, the comprehensive measurement of the importance degree I_i of each risk index is obtained.

$$I_i = \sum_{j=1}^{n} \widetilde{a}_{ij} \Big/ \sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{a}_{ij} = \left(\frac{\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{l}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{u}}, \frac{\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{m}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{m}}, \frac{\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{u}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \widetilde{a}_{ij}{}^{l}} \right). \tag{3}$$

6.2.4. Compare the Importance of Each Index

The possibility that each index is more important than other indexes at the same level is calculated, that is, the probability of $I_i > I_j$ $(j = 1, 2 \ldots, n,\ i \neq j)$ is:

$$d_i = \min_{j=1,2,\ldots,n;j\neq i} \left[\frac{l_j - u_i}{(m_i - u_j) - (m_j - l_j)}, 1 \right]. \tag{4}$$

According to Formula (4), the single index weight vector of each index R_i is obtained as follows:

$$w = [d_1, d_2, \ldots, d_n]^T. \tag{5}$$

Then normalize, set

$$D_i = \frac{d_i}{\sum_{i=1}^{n} d_i}, i = 1, 2, \ldots, n. \tag{6}$$

Get the weight vector of the risk index:

$$W' = [D_1, D_2, \ldots, D_n]^T. \tag{7}$$

The q-th criterion layer corresponds to the weight λ_q of the target layer, and the comprehensive weights of all indexes are calculated:

$$W = [\lambda_1 W'_1, \lambda_2 W'_2 \ldots, \lambda_q W'_q]. \tag{8}$$

6.2.5. Determine the Score r_i for Each Index of Each Program

Using Delphi method and the method described in Table 2, for the i-th index, it is assumed that k experts have made a judgment. The number of people who choose "extreme high risk", "very high risk", "more high risk", "general risk" and "low risk" are k_1, k_2, k_3, k_4 and k_5, and the corresponding index scores are as follows:

$$r_i = \frac{9 \times k_1 + 7 \times k_2 + 5 \times k_3 + 3 \times k_4 + k_5}{k}. \tag{9}$$

Then the comprehensive score Z of the alternative is calculated, and the higher the Z value, the higher the risk.

$$Z = \sum_{i=1}^{n} r_i W_i, i = 1, 2, \ldots, n. \tag{10}$$

6.3. Measure Analysis and Comprehensive Weight Calculation

(1) Three experts were invited to evaluate the risk importance of enterprises in international capacity cooperation, and the triangular fuzzy number judgment matrix of external risk was constructed as shown in Table 4.

(2) The comprehensive triangular fuzzy judgment matrix was constructed. Assuming that the risk assessment ability of the three experts was the same, the experts were given the same weight of 1/3, and the comprehensive triangular fuzzy judgment matrix shown in Table 5 was obtained.

Table 4. Triangular fuzzy judgment matrix of external risks.

	R_1	**R_2**	**R_3**
R_1	(0.5, 0.5, 0.5)	(0.3, 0.3, 0.4) (0.3, 0.4, 0.5) (0.2, 0.3, 0.4)	(0.3, 0.3, 0.4) (0.4, 0.5, 0.6) (0.2, 0.3, 0.4)
R_2	(0.6, 0.7, 0.7) (0.5, 0.6, 0.7) (0.6, 0.7, 0.8)	(0.5, 0.5, 0.5)	(0.7, 0.7, 0.8) (0.4, 0.5, 0.6) (0.5, 0.6, 0.7)
R_3	(0.7, 0.7, 0.6) (0.4, 0.5, 0.6) (0.6, 0.7, 0.8)	(0.2, 0.3, 0.3) (0.4, 0.5, 0.6) (0.3, 0.4, 0.5)	(0.5, 0.5, 0.5)

Table 5. Comprehensive triangular fuzzy judgment matrix of external risks.

	R_1	**R_2**	**R_3**
R_1	(0.500, 0.500, 0.500)	(0.267, 0.333, 0.433)	(0.300, 0.367, 0.467)
R_2	(0.567, 0.667, 0.733)	(0.500, 0.500, 0.500)	(0.533, 0.600, 0.700)
R_3	(0.567, 0.633, 0.667)	(0.300, 0.400, 0.467)	(0.500, 0.500, 0.500)

(3) Formula (3) was used to rank the external risk indexes, as shown in Table 6.

Table 6. Ranking of indexes for external risk.

The Importance of Risk Indexes	**Ranked Fuzzy Vector Set**
I_1	(0.049, 0.069, 0.098)
I_2	(0.081, 0.107, 0.138)
I_3	(0.070, 0.093, 0.120)

According to the comparison of Formulas (4) and (5), the single ranking vector of external risks indexes was obtained: $w_E = (0.1789,\ 1,\ 0.5493)^T$, the weight vector of external risks index was obtained by normalization treatment: $w_E = (0.1035,\ 0.5786,\ 0.3178)^T$.

Similarly, the single ranking vector of internal risks indexes was obtained: $w_I = (0.9138,\ 1,\ 0.3684,\ 0.5147,\ 1,\ 0.7213,\ 0.6615,\ 0.3158)^T$, and the weight vector of internal risks index was $w_I = (0.1663,\ 0.1820,\ 0.0670,\ 0.0937,\ 0.1820,\ 0.1313,\ 0.1204,\ 0.0575)^T$.

(4) A comprehensive ranking of risk indexes was conducted. Assuming that external risk and internal risk were equally important for international capacity cooperation, they were given 0.5 weights respectively, and the comprehensive ranking vector W of each risk index is shown in Table 7.

Table 7. Comprehensive weight of each risk index.

Criterion Layer	**External Risk**				**Internal Risk**						
Index	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}
Weight	0.0518	0.2893	0.1589	0.0831	0.0910	0.0335	0.0468	0.0910	0.0656	0.0602	0.0287

The risk types were sorted according to their weight values, the result is shown in Figure 3.

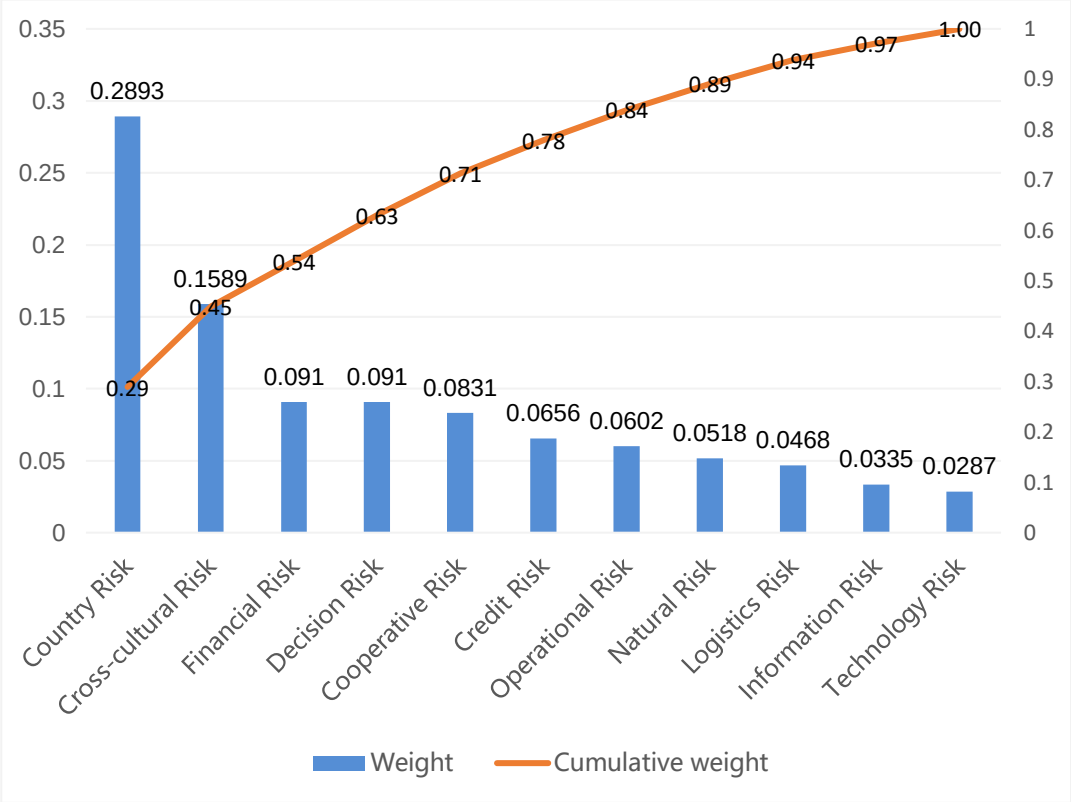

Figure 3. Risk ranking of international capacity cooperation.

It can be seen that in the international capacity cooperation, the most important risk was the country risk, then the cross-cultural risk in the external risk. Of course, it was not that the natural risk was not important, but the frequency of natural risk was relatively lower than other risks, so the attention paid to it was also lower [62].

Among the internal risks, financial risk and decision risk were the first ones, which could also be confirmed from the cases collected by the research group. The losses caused by financial risk and decision risk were often huge, and it was difficult to make up and recover.

At the same time, although the technology risk ranking was the last, this was mainly related to China's foreign capacity cooperation, which was mainly related to energy and manufacturing, however, the technological risk was not unimportant, especially the core technological risk in the high-tech industry—Huawei and ZTE's cases illustrate the importance of core technology risk. In particular, in the case of ZTE, because of the risk of core technology, when other inducements caused emergencies, it was precisely the core technology that had a significant impact on enterprises.

6.4. Case Use of Risk Measurement Model

Using the previous model, the supply chain risks of two projects in which a pharmaceutical company cooperated with Indonesia and Cambodia were measured (hereinafter referred to as Project 1 and Project 2).

Several experts were invited to determine the score r_i, of each index of the corresponding scheme according to Formula (9), using the Delphi method and the method described in Table 2. Then, the comprehensive score of the options (Table 8) was obtained by using Formula (10), and the judgment was made.

Table 8. Risk assessment of capacity cooperation between the company and Indonesia and Cambodia.

Risk Type	Project 1	Project 2
Country Risk	6.0	4.0
Cross-cultural Risk	6.0	4.0
Financial Risk	3.0	3.0
Decision Risk	3.5	3.0
Cooperative Risk	4.0	3.5
Credit Risk	4.5	3.5
Operational Risk	5.0	4.0
Natural Risk	4.0	3.0
Logistics Risk	3.5	2.5
Information Risk	4.5	4.0
Technology Risk	5.0	6.0
Total Risk Score	4.57090	3.56335

Data source: risk score from expert evaluation.

According to the result which is shown in Table 8, the total risk faced by the company in Project 1 of cooperation with Indonesia was 4.57090, which was significantly higher than that of 3.56335 with Cambodia, which was also confirmed in practice. Project 1 was not successful in the end and Project 2 is still in operation. This also proves the validity of the model to a certain extent.

7. Conclusions and Discussion

In this paper, 208 emergency cases of international capacity cooperation were collected, the emergency risk of supply chain of international capacity cooperation was systematically defined and classified, and the risk measurement model of international capacity cooperation was established by using Fuzzy AHP, and then the model was empirically tested with the international capacity cooperation project of a company. The study found that:

(1) Through the above analysis of international capacity cooperation cases, we found that construction, water, electricity, gas supply industry, mining and manufacturing were the main areas of international capacity cooperation emergencies.

(2) In international capacity cooperation, country risk and cross-cultural risk were more important in external risks, and in internal risks, financial risk and decision-making risk were more important. This coincided with the view that location advantage was the decisive factor in the choice of OFDI in the eclectic paradigm of international production. Because the main sources of country risk and cross-cultural risk were other countries, this coincided with the factors such as endowment, policy, market environment and so on when considering the location advantage in international capacity cooperation. If enterprises want to carry out international capacity cooperation for a long time and stability, location advantage was the decisive factor.

(3) In addition, the scores of financial risk, decision risk, cooperative risk, credit risk, operational risk, logistics risk and others were relatively high, because these were basically internalized advantages, involving not only an enterprise itself, but also having a relationship with the industry or supply chain, which is often more difficult to control than the control of the enterprise itself. Ownership advantage was a prerequisite for enterprises' international capacity cooperation.

(4) As in the previous analysis, the scores of technology risk and information risk were relatively low. This just proves that most of the enterprises involved in international cooperation had technological advantages or information advantages, that is, certain ownership advantages. If this advantage was lost, it was very difficult to "go global". This was illustrated in the case of ZTE.

Combined with the risk assessment system constructed in this paper, we put forward the following suggestions:

(1) The inter-state relation is the highest level of international capacity cooperation, source of risk, often the most serious, which is a vital factor in emergency early warning, response and integrated control. The inter-state relation and other unconventional governance should be positioned into the regular management of the inter-state relation process, to facilitate the formation of emergency early warning, integrated management process for response and the emergency control.

(2) The government should actively participate in the construction of the global governance system, build an official communication coordination mechanism to strengthen communication with the host country, improve the legal policy system of external investment, and timely update the foreign investment guide information (such as the national investment guide information on the "Belt and Road" website), give better play to the role of overseas production capacity cooperation zone, and provide risk early warning help for enterprises.

(3) Enterprises should strengthen the comprehensive risk assessment of cooperative projects in international capacity cooperation. There are many factors that affect capacity cooperation, and the risks are complex and sensitive. Therefore, enterprises should flexibly determine the risk size in different environments.

(4) Enterprises should build a risk prevention system for international capacity cooperation, strengthen the identification of external risks and avoid the possibility of emergencies caused by changes in the external environment. In the selection of production capacity partners, it is necessary to strengthen the investigation of external risks such as host government stability, exchange rate change, inflation degree, cross-cultural risk, government intervention and policy change. Enterprises should strengthen the analysis of internal risks, to the financial situation of the enterprise, the reputation of the cooperative object, the management level and mode of the enterprise itself, the operation of the cooperative project, and so on, and we should pay attention to them in real time.

(5) Enterprises should make better use of all kinds of foreign investment guide information (such as the national investment guide information on the "Belt and Road" website), consider the risks of cooperative projects as carefully as possible. Enterprises can also use a variety of professional services to avoid risks (such as the use of insurance companies, etc.).

In the use of the model, the assessment of risk requires careful evaluation by experts to increase its accuracy. With regard to the threshold of risk, which is, when the risk of evaluation gets to a certain point, the possibility of the sudden explosion of the enterprise is relatively large, which was a lack of the current research, but also the future research direction.

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