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An Empirical Study on Resource Characteristics, Internal Risks and Governance Structure of R&D Alliance-including Analysis of Moderating Effect of Alliance Management Capability

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Abstract:

Based on the view of RBV and TCE，it aims to systematically investigate the interaction of resource characteristics, internal risks, governance structure of R&D alliance, and moderating effect of alliance governance capability on the relationship between resource characteristics and governance structure. We propose two conceptual models to help understand the relationship between them, and further use the structural equation modeling and hierarchical regression to test the hypothesis. The results show that strategic resources have positive effect on opportunistic threaten and structural intensity, while modularity has negative effect on opportunistic threaten, incoordination risk and contractual complexity. In addition, alliance governance capability has moderating effect on relationship between resource characteristic and contractual complexity.

Keywords: *Strategic resource, Modularity, Opportunistic threat, Incoordination risk, Governance structure.*

I. INTRODUCTION

More and more companies are looking for ways to form R&D alliances with partners to respond to the rapidly changing market environment [1]. Successful R&D cooperation can not only make full use of the existing business opportunities complemented by the various knowledge and skills, but also create new business opportunities by integrating the knowledge of each partner. We can improve the competitiveness of both sides of the alliance in a wide range [2]. In order to achieve the cooperative goal, both sides of the alliance need to invest the appropriate quality and quantity of resources, but unfortunately, these resources often face the risks within the alliance: because of the coexistence of cooperation and competition, partners may have a variety of opportunistic behaviors, such as deliberately concealing information,

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incomplete performance, and "sharp practice". At the same time, due to differences in organizational environment, skills understanding, and cooperation expectations, the two sides of the alliance may be difficult to coordinate their resource input and task cooperation. Therefore, it is necessary to match the appropriate governance structure, reduce opportunistic behavior among partners and coordinate the resources input of both sides to achieve the optimal through targeted management [3].

At present, the academic research on R&D alliance is mostly carried out from the aspects of formation motivation, management mode, knowledge sharing, partner contribution, output distribution, etc. There is still a lack of comprehensive and systematic evaluation on its resource characteristics, internal risks, governance structure and management capability. In some correlation studies, Rachelle C. Sampson, using the Knowledge Foundation View and Transaction Cost Theory, puts forward that the difference of R&D alliance's capability will impact the choice tendency of cooperation structure model [1] and further discusses the cooperation scope of R&D alliance with Joanne E. Oxley from the aspects of technical capability and cooperation structure model [4]; cited cases like Dries Faems and others vividly describe the cooperation and competition dilemma within R&D alliance, proposed two strategies to strengthen cooperation and three strategies to reduce competition [5]; Charles Chi Cui and others analyzed the performance of R&D alliance professionals from two aspects of perceived management ability and role allocation [6]. These studies neglect the difference of resource input caused by different alliance types, and do not take the characteristics of input resources, internal risks and governance structure as a system to study. As such, this paper first systematically analyzes the characteristics of input resources of R&D alliance, the relationship between internal risks and governance structure, and then considers the effect of alliance management capability on resource characteristics and adjustment of governance structure. The main issues discussed in this paper include: (1) the characteristics of R&D alliance resources, and what kind of internal risk the characteristics of the resources facing ; (2) whether the internal risk level of R&D alliance has an impact on its governance structure, and what the impact is; (3) whether the characteristics of R&D alliance resources have a shadow on its governance structure, and what the impact is; (4) whether the management ability of R&D alliance has moderating effect on resource characteristics and governance structure, and what kind of moderating effect it has.

II. A RELATION ANALYSIS ON RESOURCE CHARACTERISTICS, INTERNAL RISKS AND GOVERNANCE STRUCTURE

2.1 Relationship between Resource Characteristics and Internal Risk

In the R&D alliance, the knowledge and skills invested by the alliance are often critical and strategic because of the collaborative development of high-tech products/systems. Partners have strong incentives to achieve their goals by imitating, learning, and mastering resources of strategy that companies invest in the alliance, thereby weakening the competitive advantage of the company. For example, the cooperation between Apple and Microsoft gave the latter a

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chance to access the graphics window prototype and part of the source code of Apple, and eventually they developed their own operating system, which seriously damaged Apple's competitive advantage. Therefore, the higher the resources of strategy in the R&D alliance, the greater the opportunistic risk that companies face. In addition to opportunistic risks, because members often have different organizational structures, corporate cultures and knowledge and skills, R&D alliances also have internal factors such as organizational environmental gaps, skill understanding gaps, expectation gaps, and confidence gaps that are not conducive to the operation of the alliance [2], collectively referred to inconsistent risk. The higher the strategic level of the alliance is, the more significant the alliance's importance is. Cooperative members will devote more energy to coordinate each other's behavior, members will try to coordinate each other's behavior, try to control and reduce the risk of cooperation, thus it's conducive to maintaining the smooth operation of the alliance. As such, it is proposed that:

H1: the higher the level of resource strategy invested, the higher the opportunistic threat faced by the R&D alliance;

H2: the higher the level of resource strategy invested, the lower the incoordinated risk faced by the R&D alliance.

With the rapid development of information knowledge, skills and the network economy, more and more R&D alliances have formed a modular organization with various functions and services through the integration of resources [7]. Baldwin and Clark pointed out that modularity has greatly increased the speed of innovation, which is an effective means of complex product development [8]. Aoki Masahiko found that the essence of modularity is the block and isolation of information, after studying the modular evolution process. As "information package" in the module continues to increase, the interaction between modules is decreasing [9]. In the R&D alliance, companies do not need to independently develop all the components of the complex product system. Instead, they outsource some of the module components to the partner company by modularity of the product system and the resources invested, focusing on core technologies and key modules in ways that R&D to keep core knowledge and skills in your hands. At the same time, the division of labor of the modularity within the R&D alliance reduces knowledge sharing among enterprises, making partners only familiarize themselves with the information and knowledge of developed and produced of module components within the enterprise, while "nothing to know" about the information and knowledge of other module components [10]. Although the highly intensive knowledge and skills of the alliance have not changed, it has effectively reduced opportunistic behaviors such as theft of knowledge and "Free rider problem" of partners.

R&D alliance knowledge is highly intensive, and many knowledge, know-how and experience are embedded in the organizational environment or workflow of the enterprise. The heterogeneity of different knowledge skills, organizational environment, workflow and practices increases the difficulties of coordination among partners. At the same time, the partially convergent interests of alliance partners are also likely to lead to mutual inconsistency and non-integration. Modularity requires the standardization of interfaces between modules, and

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to some extent reduces the interdependence between modules of each system [11]. The existence of modularity's "two types of design rules" [7] makes the members of the alliance can use their own skills and working methods to complete their own work, independently finish the research and development of their respective modules, as well as ensure the unity of the system objectives, under the premise of obeying the rules of the system. The "loosely coupled" nature of the modularity organization greatly reduces the need for repeated negotiations within the alliance and decreases the complexity of coordination among cooperating members. As such, it is proposed that:

H3: the higher the level of resource modularity, the lower the opportunistic threat faced by the R&D alliance;

H4: the higher the level of resource modularity, the lower the incoordinated risk faced by the R&D alliance.

2.2 Relationship between Internal Risks and Governance Structure

Williamson has made opportunistic and limited rational behavioral assumptions on the subject of the transaction [12]. At present, the academic interpretation of the risks within the alliance mostly focuses on the opportunistic threat of the two partners: the partner fleeces the other's special property invested in the enterprise; partner should obtain corporate information as much as possible, and only provide minimum limits for their own information; partner deliberately exploits the loophole of contract to evade responsibility, or makes malicious interpretation of certain provisions, etc. [13-15]. But in addition to the opportunistic threat, there are still incoordinated risks within the alliance, which stems from the limited rationality of the transaction subject. Because they only have limited rationality, the two parties may not be familiar with each other's organizational culture and working methods; they have inappropriate expectations for the cooperation expectation; it is impossible to formulate such a comprehensive contract that they may face certain situations with multiple difficulties, etc. These will lead to inefficient cooperation and even affect the progress of cooperation. In the R&D Alliance, due to the high density of knowledge and skills, opportunistic threats and incoordinated risks are particularly high, and it is necessary to match appropriate governance structures, reduce internal risks, and maintain the smooth operation of the alliance in a bid to achieve strategic goals.

Most of the existing researches use the contractual and equity dichotomy to divide the structural model of strategic alliances [16]. This classification is based on the closeness with the cooperative structure: the contractual alliance is loose and the equity alliance is relatively tight. The contractual alliance can be further subdivided into a unilateral contract and a bilateral contract. The equity alliance can be divided into three types: unilateral shareholding, mutual shareholding and joint venture [17]. Studies have shown that the tighter the alliance structure, the lower the risk level between partners [18]. Compared with the contractual alliance, the equity alliance has higher requirements for the control of the alliance members, so that they can timely and effectively detect and suppress various opportunistic behaviors commonly found in the R&D alliance, such as stealing resources, concealing information, and not fully fulfilling commitments; through close long-term contact, the degree of trust between each other can be

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increased, the relationship capital between members can be improved, and the members of the alliance can be more easily coordinated with each other, thereby reducing the endogenous risk level. As such, it is proposed that:

H5: When the opportunistic threat is higher, the R&D alliance tends to be more closely structured;

H6: When the incoordinated risk is higher, the R&D alliance tends to be more closely structured.

Contract is an important means of alliance governance, which plays a complementary role to the alliance structure to a large extent [3]. The contract can stipulate the communication methods and work procedures for cooperation between the two parties, and evaluate the output through a series of specific indicators. The academic community has explored the contractual attributes of various alliances. Reuer.J and Arino.A describe the contractual characteristics from the roles and responsibilities of the partners [19]; Chiesa.V and others study the alliance contract from the pre-paid and franchise agreement patent rates [20]; Macneil comprehensively explored the dimension of contract complexity [21]. In order to achieve the cooperation goal, the alliance must teach the partners the necessary knowledge and special skills of the cooperation. On the other hand, the company is worried that the partners may abuse the knowledge and skills in other cooperation projects, and even leak to the competitors. (In many cases, the partner is a direct competitor). Correspondingly, partners need to pay for learning, so there is a strong incentive to internalize knowledge and skills for long-term use to dilute costs. The knowledge and skills of the R&D alliance are highly intensive, and the opportunistic threats are greater. Companies tend to develop complex and detailed contracts, including the relevant knowledge and skills, scope of use to limit partner abuse. Complex and detailed contracts stipulate not only what to do, but also how to do it [22]. That is, not only the output and evaluation criteria are specified through a series of indicators, but also the means of communication, work procedures, as well as rewards or penalties for complying with or violating the contract. This largely avoids the inconsistencies in the R&D alliance that are often not well-conformed and in every way. As such, it is proposed that:

H7: When the opportunistic threat is higher, the R&D alliance tends to be more complex contracts;

H8: When the incoordinated risk is higher, the R&D alliance tends to be more complex contracts.

2.3 Relationship between Resource Characteristics and Governance Structure

The high resources of strategy means that companies have unique resources that have a significant impact on development, and these resources provide an important competitive advantage for companies [23]. When an enterprise establishes alliance cooperation, the partner may have various opportunistic behaviors, and learn, imitate or even transfer the resources of strategy invested by the enterprise into the alliance, which makes the enterprise adopt a structural model or complex contract to regulate the cooperation. Beyond that, the high resources of strategy often means that these unique resources can not be easily traded,

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irreplaceable, formed and imitated [24]. For example, technologies formed by a company over a period of time are intertwined with their working methods, organization methods, business processes and corporate culture. As long as they are contacted by the close cooperation of the R&D alliance, other companies are difficult to imitate or purchase. In order to ensure that these resources are available for a longer period of time before they are able to access these resources, partners also tend to choose closer collaboration or complex contracts designed to ensure the use of resources. Finally, companies are willing to invest in these resources of strategy, which means that companies expect this partnership to play a very valuable role in the long-term strategy [25], such as the importance of long-term competition for enterprises, comprehensive utilization of enterprise resources and information sharing. There are considerable contributions from the parties, so companies expect this cooperation to remain stable for a period of time, at least not in the short-term. In order to avoid tensions within the alliance due to conflicts of interest or mutual competition, companies tend to adopt a tighter alliance structure or more complex contracts to regulate and control cooperation. Therefore, this paper proposes:

H9: The higher the level of resource strategy invested, the more inclined the R&D alliance is to a tight structure.

H10: The higher the level of resource strategy invested, the more inclined the R&D alliance is to a complex contract.

Modularity is developed on the basis of the division of labor of complex systems. This mode of cooperation of division of labor only requires each member to undertake some cooperation tasks that are in line with their own technical and intellectual advantages. Other tasks are undertaken by partners with more comparative advantages, in the way that effectively avoiding redundant construction and significantly improving work efficiency and professionalism.

Modularity as an “embedded” mechanism, under the constraints of system rules, gives greater autonomy to cooperative members, so that enterprises can give full play to their own technological advantages to complete the development or operation of modules, optimize the alliance’s resource allocation [22]; the less interference of module’s design or changes for the development of other modules, Single partner’s R&D problem or default exit. The enterprise can easily find another partner to complete the development or operation of the outsourcing module without high friction costs, and will not affect the core modules mastered by the enterprise itself. By encapsulating information in different modules, modularity reduces the sharing of resources invested by alliance members, and weakens the need to emphasize formal governance of rules and procedures. Therefore, only a less tight cooperation structure can be used to supervise and coordinate the behavior between members of alliances.

However, unlike the traditional “task assignment” division of labor, each module is internally wrapped with a large amount of information. The company “shares” the knowledge and skills that are private but necessary for cooperation with the partners in the standardized way of coding each module. This in fact forms an isolation mechanism that achieves a balance between the sharing of alliance knowledge and the protection of private knowledge [10], which

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guarantees the degree of knowledge sharing necessary to accomplish the goals of the alliance, and also protects the private ownership of knowledge-based enterprises. Modularity design and development have greatly reduced the role of complex contracts to limit knowledge sharing and protect private knowledge.

Close alliance structure and complex contracts can reduce the opportunistic threat to enterprises and effectively balance resources and knowledge protection and sharing. The modularity design rules reduce the possibility of non-subjective knowledge contact and transfer between alliance members, effectively reducing the opportunistic behavior of partners stealing knowledge, "sharp practice", and decreasing the links and mutual relations between modules and the complexity of coordination among cooperating members. Thus, modularity can replace the role of tight alliance structures and complex contracts to some extent. So, assumption:

H11: The higher the level of modularity, the less inclined the R&D alliance is to a tight structure.

H12: The higher the level of modularity, the less inclined the R&D alliance is to a complex contract.

In summary, the conceptual model of the relationship between resource characteristics, internal risks and governance structure is shown in Fig 1.

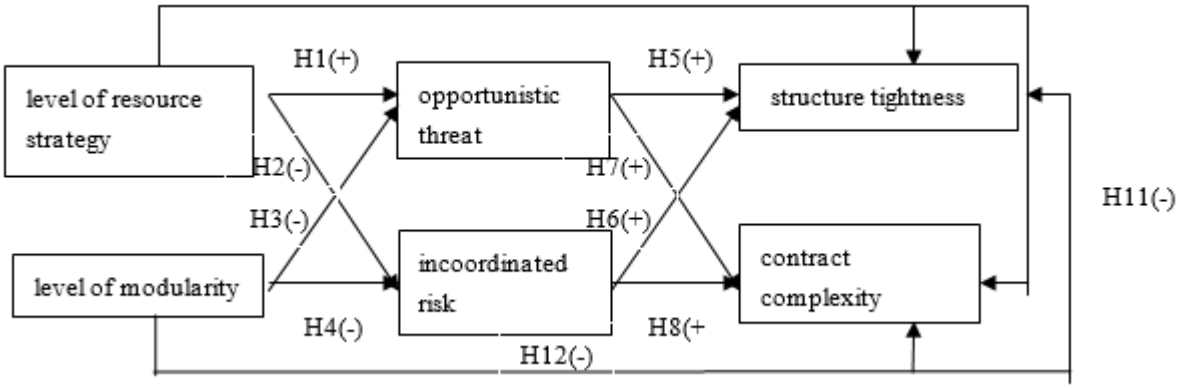

Fig 1: Relationship between resource characteristics, internal risks and governance structure

III. THE MODERATING EFFECT OF ALLIANCE MANAGEMENT ABILITY ON RESOURCE CHARACTERISTICS AND GOVERNANCE STRUCTURE

In order to achieve the predetermined alliance goals, in addition to paying attention to the alliance's governance structure, interest distribution, exit clauses and other formal design, it should also focus on the supervision and control of the alliance's cooperative development process after signing the agreement. The alliance will not automatically reach the other side of success. What creates value is not the agreement itself, but the ability of the two parties to manage the alliance [26]. Due to the high density of knowledge and skills, the R&D alliance has a considerable degree of information asymmetry. Therefore, the invested resources of strategy may face difficult evaluation problems. The two parties have different opinions on the potential value of resources of strategy to themselves, and then they may repeat bargaining and delaying

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negotiations for the next task and cooperation [27]; the two parties will also carry out a series of daily communication around resources of strategy, including meetings, joint teams, cooperative teams and sharing progress reports [28]. Managers can maintain the investment of resources of strategy by designing the alliance structure: the contract structure has lower requirements for management ability, but it is looser, less communication between members, lower control of members. The requirements of strict ownership structure for management ability have slightly risen, but members are more likely to communicate and coordinate, and their control over members is also higher. It is also possible to maintain the investment of resources of strategy by controlling the complexity of the contract: simple contract management costs are low, but the formulation is simple, and the room for interpretation and execution is relatively loose; complex contract management costs are high, but the formulation and implementation are cumbersome, and the control for members is high. Enterprises will choose the appropriate structural tightness and contract complexity based on the assessment of their own alliance management capabilities.

Modularity reduces the interdependence of the interface of each module by standardizing the interface between the modules, but the modularity itself also requires investment [22]. For example, structural design stripping core modules and peripheral modules requires specialized technology and knowledge, standardization of interface specifications between modules requires special design, etc. Sometimes such investment will exceed the management cost of adopting the original governance structure. Companies will compare the costs of developing or purchasing these knowledge and technologies with the benefits of driving modularity to limit excessive exposure to knowledge. And the transfer of knowledge and skills between partners may be unconscious. The establishment of strict alliance structures or complex contracts imposes cumbersome and strict restrictions on the interaction of cooperative members, which may make the task of the alliance difficult. If the company has confidence in its own alliance management capabilities, it will choose a strict shareholding structure or complex contract to achieve the alliance goal when the modular investment is high; if the enterprise has insufficient confidence in its own alliance management ability, it will try its best choose a loose contract structure or a simple contract while increasing your modular investment. As such, it is proposed that:

H13: Alliance management capabilities in the R&D Alliance have a significant regulatory effect on the relationship between resource strategy and the tightness of the alliance structure;

H14: Alliance management capabilities in the R&D Alliance have a significant regulatory effect on the relationship between resource strategy and the complexity of the contract;

H15: Alliance management capabilities in the R&D Alliance have a significant regulatory effect on the relationship between resource modularity and the tightness of the alliance structure;

H16: Alliance management capabilities in the R&D Alliance have a significant regulatory effect on the relationship between resource modularity and the complexity of the contract;

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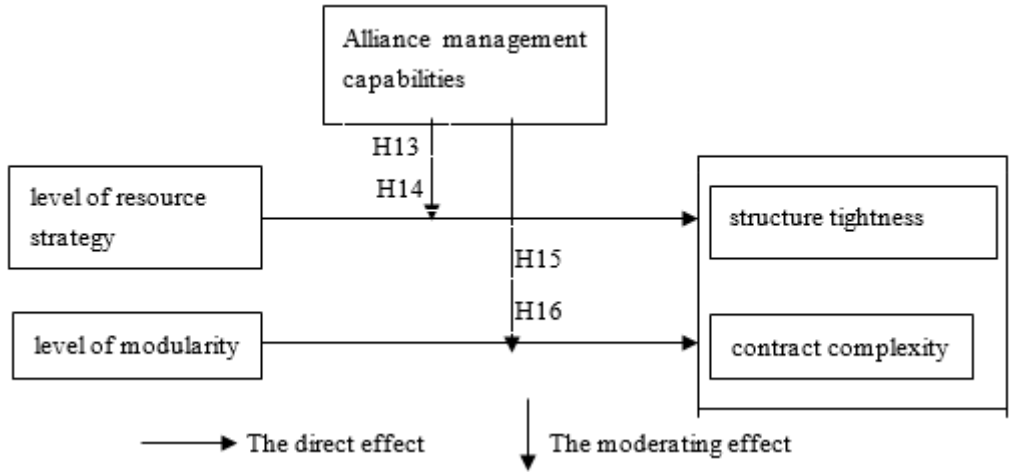

Fig 2: The effect of alliance management ability on resource characteristics and governance structure

IV. EMPIRICAL RESEARCH DESIGN

4.1 Samples and Data Collection

This paper uses large sample data to test the relevant hypothesis. We pre-tested the initial questionnaire based on literature research to ensure the content validity of the questionnaire. During the pre-testing of the questionnaire, experts from relevant fields were invited to participate in the revision of the questionnaire indicators. Then, in the R&D alliances in Chongqing and Chengdu, a small-scale interview was conducted, and the pre-test of the questionnaire was carried out to further modify and improve the content of the questionnaire to form a final questionnaire. From November 2015 to July 2016, 400 questionnaires were distributed to R&D alliance enterprises in Chongqing, Chengdu, Shenzhen and Beijing, and 237 were collected. Table I is a descriptive statistic for the sample.

4.2 Variable Measurement

The main variables of this paper are resource strategy level, resource modularity level, opportunistic threat, inconsistent risk, structural tightness, contract complexity and alliance management ability.

1) Resource Strategy. The higher the strategic level of the alliance is, the more significant the alliance's importance is. Refer to the Das & Teng [29] study to generate a scale of 4 items; 2) Modularity level. The level of modularity reflects the degree of technical modularity of alliance resources. Referring to the study of Tiwana [10] and Lau et al. [30], a scale of three items was generated; 3) Opportunistic threats. Referring to the research of Reuer & Arino [19] and Nie Huihua and Li Jinbo [31], it became a scale of 4 items; 4) Incoordinated risk. Referring to the study of Zineldin [32], a scale of 4 items was generated; 5) The tightness of the alliance structure. Referring to the research of Gulati & Singh [33] and Santoro & McGill [34], the alliance structure is divided into one-sided contract, bilateral contract, unilateral shareholding, bilateral shareholding, joint venture five according to the degree of closeness. Kind; 6) Contract

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complexity. Drawing on the research of Ryall & Sampson [35], a scale of four items was formed. 7) Alliance governance capabilities. Referring to the study of Scahreiner & Kale [27], it became a scale of four items. 8) Control variables. Control variables include whether foreign (FOR: Foreign) and firm size (SIZE) are involved. When there is no foreign investment involved in the cooperation, FOR=0, when there is foreign investment, FOR=1; the size of the enterprise is divided into three types: large, medium and small (50 million and above, 10 million to 50 million, less than 10 million), respectively marked as 0, 1, 2. The title item is specifically shown in Table II.

TABLE I. Descriptive statistics of the companies surveyed

Enterprise Size (Single Choice N=237)	Less than 10 million	34.7%	Cooperative Partner Size (multiple Choice N=185)	Less than 10 million	0.36
	10 million to 50 million	45.5%		10 million to 50 million	0.48
	50 million to 200 million	13.5%		50 million to 200 million	0.21
	More than 200 million	6.30%		More than 200 million	0.11
Industrial Distribution (Single Choice N=237)	Electronics and Information Technology	28.4%	Cooperative Motivation (multiple Choice N=185)	Risk Reduction	0.27
	Software Technology	20.7%		Cost Reduction	0.32
	Bioengineering and New Medicine	14.6%		Learning	0.22
	New material Technology	13.8%		Gaining Resources	0.39
	New Energy and Energy Saving Technology	14.2%		Others	0.08
	Others	8.3%	Ownership System (Single Choice N=237)	Technology Licensing	0.17
Ways of Cooperation (multiple Choice N=185)	State Owned	12.4%		R&D Agreement	0.31
	Privately Operated	40.3%		OEM	0.24
	Foreign Tradesman	26.1%		Co-organizing Projects	0.35
	Others	21.2%		Joint Venture	0.28

V. EMPIRICAL ANALYSIS AND DISCUSSION

5.1 Relationship between Resource Characteristics, Internal Risks and Governance Structure

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TABLE II. The test results of index certificate authenticity

VARIABLE	ITEMS TABLE	FACTOR LOADING	CROBACH'S A COEFFICIENT
Strategy of Resource（SR）	V1. Resources invested in the alliance are of high value	0.710	0.7573
	V2. Resources invested in the alliance are irreplaceable	0.725	
	V3. Resources invested in the alliance are not easy to imitate	0.784	
	V4. Resources invested in the alliance are not easy to trade	0.767	
Resource Modularity(RM)	V5. The knowledge and skills (products) involved in the collaboration can be broken down into multiple modules.	0.713	0.7023
	V6. There is a stable standardized interface between modules.	0.695	
	V7. Each module has been highly standardized	0.736	
Opportunistic Threat (OT)	V8. Partners have hidden information behavior	0.784	0.8493
	V9. Partner has incomplete performance	0.846	
	V10. Partner has stolen resource behavior	0.772	
	V11. Partner has a “sharp practice" behavior	0.825	
Inconsistent Risk (IR)	V12. Lack of understanding of the partner's organizational environment	0.747	0.7285
	V13. Lack of understanding of partner cooperation expectations	0.716	
	V14. Lack of recognition of the way partners work	0.648	
	V15. Lack of confidence in the partner's ability to perform	0.720	
Structural Tightness (ASI)	V16. Ways of cooperation (unilateral agreement, bilateral agreement, unilateral shareholding, bilateral shareholding, joint venture)	0.655	0.655
Contract Complexity (CC)	V17. Regularly report all related transactions	0.815	0.8228
	V18. Timely record of violations of the cooperation agreement	0.753	
	V19. Use or contain proprietary information or resources to sign a confidentiality clause	0.781	
	V20. Agreement includes complete termination clause	0.864	
Alliance Governance Capabilities(AGC)	V21. Good coordination in the league	0.785	0.7983
	V22. Good communication skills in the league	0.728	
	V23. Good ability to assign tasks	0.812	
	V24. Good assessment of results	0.736	

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TABLE III. Goodness table of model overall

FITTING INDEX	INDEX VALUE	FITTING SITUATION
F	0.017	>0.05, very good
GFI	0.925	>0.9, very good
AGFI	0.833	>0.8, very good
NF	0.976	>0.9, very good
IFI	0.928	>0.9, very good
TLI	0.951	>0.9, very good
CFI	0.928	>0.9, very good
RMSEA	0.024	<0.06, very good
AIC	263.370	Relatively small value
CAIC	543.086	Relatively small value
ECVI	0.415	Relatively small value

Exploratory factor analysis was performed on each variable and item using SPSS software. As shown in TABLE II, the Crobach's α coefficient of all variables exceeded 0.7, indicating that the index has a high internal consistency, so the reliability passed the test. The factor load of all variable indicator dimensions is close to or exceeds 0.7, which is a good description of the relevant elements of the metric that meet the basic requirements of statistical testing. Then the AMOS is used to estimate the parameters of the hypothesis and conceptual model. The test results of each fitting index are shown in Table III. The final fitting indexes are very good.

Table IV shows the results of hypothesis testing of structural equation models. As shown in Table IV, the correlations between the main variables and the symbols are roughly consistent with the research hypothesis, and most of the path relationships have reached a significant level, which indicates that the pre-assumed structural equation model can better support the main theoretical viewpoints proposed in this paper.

H1 is supported by empirical data, R&D alliances with high resource strategy levels are vulnerable to opportunistic threats, a conclusion similar to that of Dunne et al. [36]. H2 has not received empirical support. The reason may be: the theoretically invested high resources of strategy have increased the need for coordination within the alliance. However, due to the limited nature of the transaction subject, that is, human beings, the employees of the alliance first existed cognitively. Differences, followed by friction from cognition to execution, also take a long time from establishing cognition to execution. The data we surveyed contains many R&D alliances established by small and medium-sized high-tech enterprises at this stage. The actual investigation found that the duration of such alliances is not too long, which affects the final analysis results.

H3 and H4 have attained empirical support. That is, the modularity of the R&D alliance has been validated by the impact of opportunistic threats and incoordinated risks within the alliance, which is consistent with Tiwana's empirical conclusions [22].

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TABLE IV. Hypothesis test results of path model study

HYPOTHESIS	PATH RELATIONSHIP	CORRELATION VALUE	P VALUE	THROUGH THE SITUATION
H1	Resource strategy level → opportunistic threat	0.235	0.041	Supporting
H2	Resource of strategy → incoordinated risk	-0.024	0.177	Not supporting
H3	Modularity level → opportunistic threat	-0.463	0.000	Supporting
H4	Modularity level → incoordinated risk	-0.348	0.027	Supporting
H5	Opportunistic threats → structural tightness	0.143	0.039	Supporting
H6	Incoordinated risk → structural tightness	0.086	0.263	Not supporting
H7	Opportunistic threats → contract complexity	0.429	0.000	Supporting
H8	Incoordinated risk → contract complexity	0.237	0.018	Supporting
H9	Resource of Strategy → structural tightness	0.056	0.352	Not supporting
H10	Resource of Strategy → contract complexity	0.135	0.012	Supporting
H11	Modularity level → structural tightness	-0.244	0.006	Supporting
H12	Modularity level → contract complexity	-0.382	0.000	Supporting

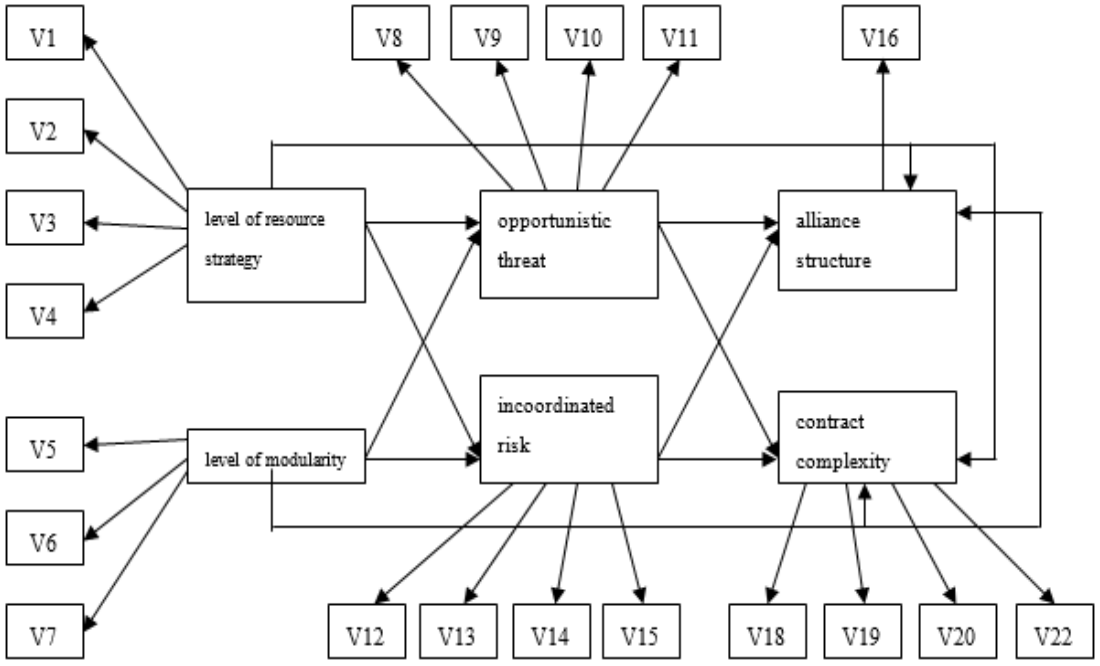

Fig 3: structural equation model calculation results

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H5 indicates that companies will strengthen their opportunistic behavior in cooperation by designing tight structures to strengthen their control over partners. A more extreme approach is to develop the alliance into an acquisition [37], to eliminate the opportunistic threat of partners through a more rigorous hierarchy of integration, but such measures will also increase the transmission loss of information due to the increase of internal levels. Companies will face a new "boundary" balance [38]. H6 didn't receive data support. I believe that it is because alliance members take more relationship governance to strengthen coordination between the two sides. The use of relationship governance mechanisms, such as frequent peer-to-peer communication, establishing cooperative teams, more frequent management contacts, sharing decision-making, and joint problem-solving teams, to a certain extent, can enhance mutual trust within the alliance and internal members' identification of their own identity effectively mitigates opportunism and strengthens coordination of resources of strategy among partners [7].

H7 and H8 received data support. Complex contracts can prescribe the assets that both parties must invest in, the behaviors allowed by both parties, and the role of each partner in the alliance and the responsibilities that should be assumed through specific performance indicators, expected performance, and dispute resolution [39], mitigating opportunistic behavior and coordinating efforts between alliance partners.

H9 did not receive data support, and H10 received empirical support. Perhaps our research involves so many small and medium-sized high-tech enterprises at the current stage, they are usually in a fast-growing market. As for them, selling equity to venture capital institutions is often more attractive than selling them to R&D partners, so that the tendency to choose a contract becomes a reasonable act.

H11 and H12 have empirical support, indicating that the high level of modularity makes the R&D Alliance less inclined to a tighter structure and more complex contracts. As an emerging knowledge isolation mechanism, modularity has gained wider and wider use in the alliance [40]. Modularity gives the members of the alliance greater autonomy, and achieves a balance between the sharing of alliance knowledge and the protection of private knowledge, enabling enterprises to fully utilize their technological advantages to complete the development or operation of modules, and optimize the alliance resource allocation [22].

5.2 Verification and Discussion on the Regulatory Effect of Alliance Management Ability on Resource Characteristics and Governance Structure

The hierarchical adjustment is used to analyze the regulatory effect. Firstly, the mean, standard deviation and correlation coefficient of each variable are statistically analyzed. Secondly, the influence of resource strategy level and modular level on the structural tightness and contract complexity of R&D alliance is investigated. Thirdly, the variables of alliance management ability are added to the model, and finally the interaction items of the independent management variables and resource characteristics are increased in the model.

Table V shows the mean, standard deviation, and correlation matrix of the variables. By centralizing the variables, there is no obvious correlation between the variables in the

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correlation matrix, and there is no multicollinearity. Table VI shows the results of the hierarchical regression.

TABLE V. Descriptive statistics of variables

VARIABLE	MEAN	STANDARD DEVIATION	1	2	3	4	5	6	7
ASI	2.622	3.283	1.000						
CC	3.886	4.157	0.219**	1.000					
SR	3.055	3.446	0.168**	-0.231*	1.000				
RM	2.871	2.545	-0.335	0.284**	0.066	1.000			
AGC	3.604	4.734	0.274*	0.114	0.105**	0.301**	1.000		
FOR	0.479	1.035	0.326*	0.387**	0.188	-0.241**	0.336*	1.000	
SIZE	0.368	0.671	0.184**	0.262	-0.211*	0.094	-0.123*	0.229	1.000

TABLE VI. The results of hierarchical adjustment

VARIABLE	STRUCTURAL TIGHTNESS			CONTRACT COMPLEXITY		
	MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 7	MODEL 6
ASI	0.121	-0.109	-0.026	0.169*	0.348*	0.225*
RM	-0.153*	-0.196*	-0.208**	-0.252*	-0.147**	-0.103**
AGC		-0.047	0.085		0.116	0.131*
AS×AGC			-0.197			-0.152*
RM×AGC			0.068			-0.055**
FOR	0.156*	0.133*	0.191*	0.269*	0.166*	0.074*
SIZE	0.114*	0.125*	0.184**	0.178*	0.094	0.088
F Value	26.473*	43.502**	47.395**	22.660*	38.251**	45.396**
R2	0.21	0.33	0.42	0.21	0.33	0.42

* $p<0.10$; ** $p<0.05$

Models 1 to 3 have structural compactness as a dependent variable. Model 1 shows that the level of resource strategy has no significant impact on the structural model of the R&D alliance, and the level of modularity remarkably affects the R&D Alliance's tendency to contractual structure ($p < 0.1$). Model 2 adds alliance management capabilities based on model 1 variables. Model 2 shows that alliance management capabilities have no significant impact on structural models. Based on Model 2, Model 3 adds the interaction items of alliance management capability and resource strategy level and modular level. Model 3 shows that the alliance management capability is not significant in the impact of the resources of strategy and the level of modularity on the role of structural models.

Models 4 to 6 have contract complexity as a dependent variable. Model 4 shows that the level of resource strategy significantly affects the R&D alliance's tendency to complex contracts ($p < 0.1$), and the level of modularity significantly affects the R&D alliance's

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preference for simple contracts ($p < 0.1$). Model 5 adds alliance management capabilities based on model 4 variables. Model 5 shows that alliance management capabilities have no significant impact on structural models. Based on Model 5, Model 6 adds an interaction term between the alliance management capability and the resource feature independence factor. Model 6 shows that alliance management capabilities weaken the role of resource strategy level in contract complexity ($p < 0.1$) and weaken the effect of modularity on contract complexity ($p < 0.05$).

Hierarchical adjustment results show that H13 and H15 are not supported by empirical data. I believe that there are the following reasons: On the one hand, the path relationship between resource strategy level and alliance structure model is not supported by empirical data. On the other hand, the data sample contains many R&D alliances of small and medium-sized high-tech enterprises at the current stage. Short time of establishment and less management experiences are not enough to influence the resource input and alliance structure model. H14 and H16 have obtained empirical support, indicating that the alliance management ability weakens the role of resource strategy level and modular level on contract complexity. So the alliance management ability, to a certain extent, can play a similar effect to the contract, replacing it. Part of the role.

VI. CONCLUSION

This paper uses a large sample of questionnaires to verify the relationship between resource characteristics, the relationship between internal risk and governance structure, and the management ability of alliance management through structural equation modeling and hierarchical adjustment. The main findings are as follows:

(1) The resource characteristics of the R&D alliance have an important impact on its internal risk level. The high resources of strategy invested by the R&D alliance are vulnerable to opportunism. Partners have strong incentives to learn, imitate, and internalize these resources. After that, they will weaken the competition of enterprises whether they are used in other occasions or leaked to competitors. The modularity of resources realizes the balance between sharing the goal of private knowledge and limiting the excessive exposure of knowledge, weakens the opportunistic threat, and weakens the risk of incoordinated interaction through the standardization of contact interface and less interaction dependence. Enterprises in the R&D Alliance can effectively control internal risk levels and better achieve cooperation goals by controlling the quality of input resources and adjusting the level of modularity.

(2) The internal risk level of the R&D alliance has an important impact on its governance structure. From the perspective of internal risks, the R&D alliance tends to have a tighter cooperation structure and more complex contracts when the opportunistic threat is high. Close-knit equity alliances have strong control over members and can detect and suppress various opportunistic behaviors commonly found in R&D alliances in a timely and effective manner. Complex contracts specify the quantity, form and scope of input of knowledge and skills to limit the abuse of partners and inhibit opportunistic behavior. When faced with high risk of inconsistency, the R&D alliance tends to have more complicated contracts, and enhances coordination between the two parties through detailed evaluation of cooperation results

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evaluation standards, cooperation processes such as communication methods and work procedures. The choice of governance structure should be able to achieve the best match with the internal risk level of the alliance. The appropriate governance structure can support the good operation of the alliance and complete the strategic goals of the enterprise.

(3) The resource characteristics of the R&D alliance have an important impact on its governance structure. This study shows that in order to protect the high resources of strategy invested, the R&D alliance tends to adopt more complex contracts, and the modularity of resources weakens this tendency. Enterprises realize the protection of core knowledge and skills through the less interactive dependencies provided by modularity, and give members of the alliance more autonomy to make full use of their own private knowledge and skills, thus reducing the adoption of strict control structure and complex contracts. In the empirical results of this study, we have seen that the R&D alliance has partially replaced the traditional governance structure through modularity. With the further development of R&D cooperation in China, the future R&D alliance may pay more attention to its modular transformation.

(4) Alliance management ability has a regulatory impact on the relationship between resource characteristics and contract complexity. Management capabilities weaken the complexity of contracts for resources of strategy, but reinforce complexity of simple contracts due to the modularity, which can be considered as an alternative to modular high investment. The improvement of management ability can also alleviate the conflict between sharing knowledge skills and limiting excessive exposure of knowledge skills to a certain extent.

However, this paper analyzes the relationship between resource characteristics, internal risks, governance structure and management capabilities only from the perspective of the strategic level and modularity of resources of strategy invested by the R&D alliance. For further discussion the impact of resource nature, asset types, such as resource flows, the clarity of property and asset property rights on the governance mechanism of the alliance and the impact of modularity on the governance of traditional alliances are not involved. These issues are worthy of deep study.

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