Risk management and risk control for state-owned firms of China

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Declaration

I confirm that this is my own work and the use of all material for other sources has been properly and fully acknowledged.

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Related Publications

Yuan Wu, Yinshan Tang(2012), *The risk management research on venture capital firms in China and West*, Risk management Innovation-driven Capability Building and Industry Development, The 8th International Symposium on Management of Technology, ISMOT 2012, Hangzhou, China

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Abstract

As global economic integration deepens and enterprises scale up their business, the enterprise groups have become the mainstream of the company's development form. Subsidiaries of the Company have grown in size and increasingly diversified. Thus how does the parent Company control its subsidiaries effectively has become an urgent challenge, especially for the state-owned enterprises in China. This thesis studies the management and control of state-owned enterprises in China, carrying certain theoretical and practical significance.

The research examined the theory and mechanism of management of SOEs, and evaluation on employee performance. It also analyzed performance evaluation, coordination and risk control strategies of SOEs' subsidiaries. The same studies were repeated on state-owned enterprise groups and extended to the strategies of risk management and risk control.

The thesis first examined the conundrum of effective cooperation between subsidiaries of different departments and the parent company for efficient allocation of resources. To tackle this headache, the IAHP and DEA model were adopted to help group decision makers better measure the performance of employees and organizations. The thesis used the Balanced Scorecard (BSC) tool as the main principle and the combination of fuzzy mathematics and Delphi and entropy weight methods as the main methodology to assess the performance. In addition, a novel method of using multi-reasoning, multi-dimensional and dynamic factors was developed to assess the performance of SOE employees, and this method was proven to be effective. Moreover, the super-efficiency DEA model which takes into account work performance, work ability, work attitude, job potential and other factors in the evaluation on employee performance was developed and tested. Finally, risk map for SOEs was proposed and evaluated.

Chapter 1 Introduction

1.1 Research Background

As global economic integration deepens and enterprises scale up their business, the enterprise groups have become the mainstream of the company's development form. Increasingly growing and diversified parent-subsidiary companies of the Group have made company's strategy-making and implementation ever more systemic and complicated. Against such backdrop, how large-scale patent company efficiently manages its subsidies has become a pressing issue in the group management.

Since the reform and opening-up policy, China's market economy system has been improved, with the quality and performance of the national economy constantly enhancing. Among the basic and key industries related to people's livelihood and national defense security, large-scale state-owned enterprises still dominate the national economy. In addition, state-owned assets have always been the vital material basis as well as the social security guarantee for the socialist market economy. However, with the development of the society and the further reform of state-owned enterprises, China's state-owned enterprise groups are overwhelmed with many problems in their management and control. The problems mainly exist in three major areas [1]:

(1) Deep-rooted problem-fragmented group

Some long-established state-owned enterprise groups were initially built by administrative power, or restructured by certain administrative bureaus, or organized by ways of administrative appropriation. Most of them "established subsidiary companies before building their parent company". As such, the enterprise group was formed by stocking companies, rather than bounding them together through mutual investment. This approach in which the enterprise group was established dictates that the group can only be passively controlled and the group headquarters is somewhat like an "asset management company" rather than an operating entity with state-owned assets. Moreover, various departments at different levels in the group stand in the way of efficient asset allocation, making the group as a feeble giant. The situation gets worse when poor capital management and out-of-control investment drive some subsidies to duck their responsibilities, with the mindset of "ask money from the group, have debts to be repaid by the group, and the insufficient fund can be complemented by the group", leaving the overall management at high-stakes.

(2) A striking departure from main business due to ambiguous positioning

Some state-owned groups are formed as a result of diversified business development, with many subordinate enterprises in different industries and fields, and even in fields that have no correlations with the group business. As a result, groups are embedded with ambiguous development positioning, undistinguished core business, fragmented business system, and weak management. Faced with the chaotic business development, many state-owned enterprise groups who had the intention to strengthen their control unexpectedly landed themselves in an area that marks a striking departure from its main business. They gradually became an asset management company that keeps profitable enterprises in the group but kicks loss-making ones out. The inconvenient truth is that some profitable business is not group's core business, nor is the core capabilities of the group, and even don't deserve further investment.

(3) Dilemma in control and power delegation, imbalance between centralization and decentralization

Some groups which are striving to strengthen management and control have also done many explorations. Yet many groups are confused with clear responsibilities in terms of the management of subsidies, for example, what matters should be subject to the group management and how to balance the strict and laid-back management, with the fear that strict management would strangle business growth whereas the laid-back style would risk losing control over subsidies.

From this point of view, management and control of state-owned enterprise groups over their subsidiaries is the primary task of the reform of state-owned enterprises. The state also attaches great importance to this issue and has gradually introduced relevant policies. To figure out effective models of corporate governance, some domestic and foreign companies have conducted studies and some scholars have also worked on this issue. However, there is no consensus on the classification of the group management model between the academic and the business community. Moreover, many domestic and foreign researches focus on the selection of specific management models, and there is no universally applicable theoretical method on how to choose the appropriate management model.

In general, despite the fact that problems of the group have become a research hotspot in the theoretical circle, the research on group management and control theory is still in its infancy, especially the shortage of empirical research . In addition, there is still much work to be done on the management and control of state-owned group given its characteristics. Considering that state-owned groups dominate China's existing enterprise groups, especially large-scale enterprise groups, therefore, the research on group management and control based on the characteristics of state-owned groups carries important theoretical and practical significance, and it is worthy of in-depth discussion and research. This topic is based on the

above background, and the author tries to offer some new ideas and methods for the management and control of state-owned enterprise groups.

1.2 Research Approaches and Routes

This topic analyzed the background and existing problems of the current state-owned enterprise groups, and proposed the necessity of management and control of state-owned enterprise groups. In terms of control, it is more important to use scientific and reasonable mathematical methods and models to evaluate, coordinate and optimize sub-companies. The management and control of state-owned enterprise groups include the selection of management and control modes, the selection of management control mechanisms, the application of management and evaluation methods, and risk control in the process of management and control. This thesis mainly proposes: Performance evaluation methods for employees from state-owned group ——super-efficiency DEA evaluation model; evaluation and optimization methods among holding subsidiaries of state-owned enterprise group—— DEA method evaluation model; performance evaluation method for holding subsidiaries of state-owned enterprise group—fuzzy synthetic evaluation model; coordination decision-making and evaluation methods for holding subsidiaries of state-owned enterprise group— interval AHP method evaluation model; and risk control strategies under the management and control of state-owned group. The thesis also carried out empirical studies on these mentioned strategies, providing ideas and models for the management and control, and performance evaluation of state-owned enterprises.(Figure 1-1 Studying Route of this Thesis)
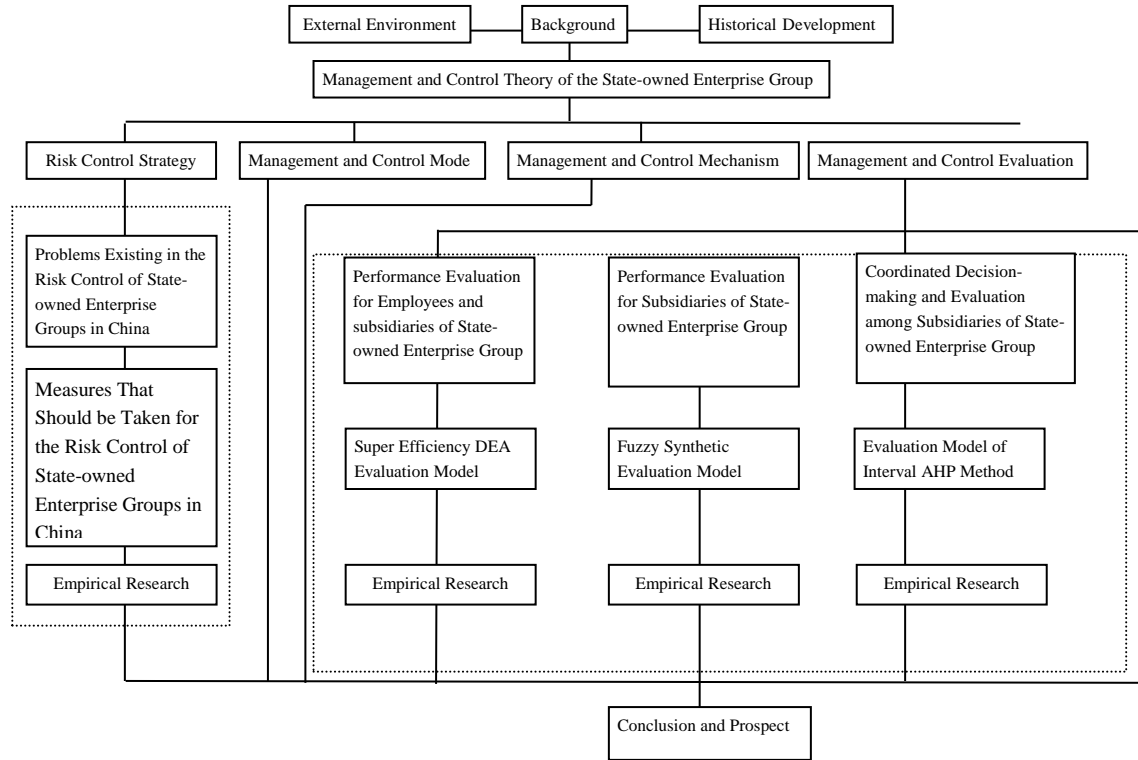
Figure 1-2 Studying Route of this Thesis

1.3 Aim and Objective

Evaluating the investment risks and performance of state-owned companies in China has always been a challenge, especially the management and allocation of capital for subsidiaries annually. There are some other tricky matters, for example, whether there is a method or to balance and manage the group and subsidiaries, and how to manage and control group companies.

Aim –to understand and develop a tool which will enable state-owned enterprises in China make management and risk control more effective as well as to create a model which can evaluate employee and company's performance in state-owned enterprises .

Objectives- this work main objectives is in development of management and control model, including its empirical application as DEA and IHAP to evaluate the performance of state-owned group in China. In doing this work will analyse the challenges and conditions faced by the state-owned enterprises and offered suggestions how evaluation of control and performance can be improved.

1.4 Research Significance

(1) Facilitate the reform of state-owned enterprises

Decades of reform for the state-owned enterprises in China have shown initial success, but some deep-seated problems that restrict the development of enterprises have gradually emerged. The first is fragmented group; the second is SOEs' striking departure from main business due to ambiguous positioning; the third is dilemma in control and power delegation, and imbalance between centralization and decentralization. If these problems fail to be solved properly, the state-owned enterprises could not be improved fundamentally, and enterprise could not step into a virtuous circle. Therefore, the effective management and control of subsidiaries of state-owned enterprises, the establishment of scientific coordination and optimization models, and the construction of performance evaluation system have played an important role in the rational allocation of resources, the rational guidance of enterprise asset operation, the mobilization of enterprise enthusiasm and creativity, the establishment of evaluation incentive systems for organizations and employees, the improvement of national macro-control and the formulation of scientific and reasonable economic policies.

(2) Adapt to the global trend of enterprise development

Currently, market competition is increasingly fierce, the strategic goal of enterprises in developed countries has changed from the pursuit of profit maximization to the pursuit of enterprise value maximization. As Chinese enterprises constantly compete with others globally, they're presented with both opportunities and risks, thus competitive enterprises and competent operators are needed. This requires evaluation of the operating benefits for subsidiaries of the state-owned enterprises to reasonably determine their advantages in business development, so that the head office can allocate resources to subsidiaries in a more targeted way. At the same time, it also requires a scientific and comprehensive evaluation of the business performance of enterprises to improve efficiency and sharpen core competitiveness, giving Chinese enterprises an edge in global competition.

(3) Enhance the internal management of state-owned enterprises

In recent years, modern science and technology have been greatly applied in enterprise management. In order to better allocate resources, coordinate the development of various subsidiaries, and scientifically and fairly evaluate enterprise performance, state-owned enterprises need to use corresponding quantitative models and methods for analysis, which holds key to enhancing their internal management.

(4) Contribute to the change of enterprise management concept and development strategy

On the whole, state-owned enterprises in China are still adopting extensive development model. The business operators have focused their business and development on some single

indicators, which objectively encourages some enterprises to pursue one-sided short-term benefits such as scale, output value and profit, and they have neglected the long-term development benefit targets such as resource utilization efficiency, reserve of talents, technological innovation, and environmental improvement. The use of corresponding quantitative models and methods, optimization and coordination of the development among subsidiaries of state-owned enterprise, and reasonable evaluation of the enterprise's operating performance are conducive to correctly guiding and standardizing the enterprise's operating behavior and pursuing the path of enterprise value maximization.

1.5 The Main Work and Chapter Arrangement of This Thesis

This thesis analyzed the state-owned group's control mode and management mechanism for its subsidiaries, with the purpose of solving main problems occurred in the process of control, such as how to coordinate the cooperative relationship among the subsidiaries, how to evaluate the operating efficiency of subsidiaries and optimize the allocation of resources, how to evaluate the organizational performance and employee performance of subsidiaries so as to effectively motivate employees. For these challenges, the author put forward the corresponding evaluation system and methods.

Based on the above research contents, the chapters are arranged as follows:

Chapter 1 describes the research background, research approach, and significance of this thesis; it also describes the aim and objective, then summarizes the current situation of the related theories of state-owned enterprises groups' control over the subsidiaries, and it has gained a deep understanding of the process and significance of enterprise group control through analyzing the characteristics and limitations of various theoretical concepts.

Chapter 2 describes literature review related to the risk management and control of enterprise groups for the other researchers.

Chapter 3 mainly studies the control mode of the enterprise group. It considers and selects the control mode suitable for the enterprise's own development by combining several factors such as the state-owned enterprise group's own industry characteristics, development stage, organization scale, leader's style, human resources, enterprise culture and so on, this theory also applied in LH enterprise group.

Chapter 4 proposes a method for evaluating the performance of state-owned enterprise employees.

And this method combines the multi-factor, multi-dimensionality, and dynamic characteristics of the performance of state-owned enterprise employees to construct

performance evaluation index system for employees of state-owned enterprises with 6 input indicators and 6 output indicators which comprehensively covers all aspects of employee performance: Work performance, work ability, work potential, and work attitude. The established DEA basic model and super-efficiency DEA model of employee performance evaluation reflect that there is no need to set the weight of evaluation indicators, it can make a clear evaluation on the advantages and disadvantages of employee performance and provide the direction and degree of performance improvement. Then, an empirical analysis was conducted to evaluate the performance of 16 employees in LH energy group's wholly owned subsidiary A.

Also, it puts forward the importance of studying the efficiency evaluation and optimization among the various sector departments within the enterprise, proposes the application of data envelopment analysis (DEA) in the efficiency evaluation and optimization of various sector in subsidiaries of state-owned enterprises groups, and provides a new idea for control of decision makers in subsidiaries of enterprise groups

Chapter 5 first proposes the performance evaluation for the subsidiaries of state-owned group. On the basis of performance evaluation system with the balanced scorecard, a performance evaluation index system with abundant indicators for state-owned enterprises was established, and then performance evaluation was conducted on the basis of the fuzzy mathematics theory combined with the index weight determined by Delphi method and entropy weight method; Finally, an empirical analysis of the evaluation method from these two aspects was completed.

Chapter 6 firstly analyzes the importance of strengthening coordination and decision-making among various departments within the organization system of enterprise group; Second, on the basis of considering the cooperation among various functional departments, cooperation among sectors, the optimization of interoperability, and the availability of indicator data, the internal collaborative optimization system for the ownership of the state-owned group-owned enterprises was designed and optimized. On the basis of IAHP theory, a collaborative optimization decision-making model for the subsidiaries of state-owned groups was established, and with the combination of the general process of coordinated decision-making and the interval-level analysis method, the system structure and the decision-making system for the subsidiaries of state-owned group was optimized. Finally, on the basis of IAHP method, an empirical study of decision-making methods for the inter-departmental coordination among subsidiaries of state-owned groups was conducted.

Chapter 7 analyzes the problems existing in the risk control of state-owned enterprise groups in China through investigations. In response to these problems, the author tries to put forward strategies and suggestions for countermeasures from the internal and external

perspectives. Then by taking the LH state-owned group as an example, it conducted an empirical study on the strategies of risk control of state-owned enterprise groups and offered suggestions and strategies for the problems in risk control of LH enterprise groups.

Chapter 8 is the conclusion and future outlook respectively. The author summarized the research results and discussed the direction of future research on this topic

1.6 The Main Innovations of This Thesis

(1) Due to the relative independence of the various subsidiaries of state-owned enterprises groups and the differences in policy formulation, decision-making, market differentiation, and nature of work, the development and efficiency of each company vary and the overall development is imbalanced. The thesis works on solving the problem of the evaluation of the efficiency among the various sectors within the subsidiaries of state-owned enterprise group and has provided suggestions on efficiency optimization. Theoretically realizing the optimization of the overall development model of state-owned enterprise groups is a problem encountered by the Group. Based on the detailed analysis of data envelopment analysis, this thesis attempts to perform a series of work on the efficiency evaluation and future development model of the subsidiaries of state-owned enterprise, plans overall development model due regard to the corresponding indicators affecting the development of each department in practical work, expounds how to optimize weak DEA or non-DEA efficient enterprises, makes DEA decision for various sectors of enterprises, determines relative validity, and carries out overall quantitative optimization through the "projection principle" for the weak DEA and non-DEA effective sectors of enterprises. It has offered new ideas for corporate decision makers to understand, evaluate, improve, and optimize the efficiency of various departments.

(2) As a large system, the state-owned enterprise group must coordinate the relations among subsidiaries and its relationship with the group so that it can contribute better to the group's overall strategic goals, and stimulate the enthusiasm of each subsidiary. The main idea of this decision method proposed in this thesis is that each department of the company makes its own decisions independently, carries out multiple exchanges of information and adjusts its own decision-making scheme, and finally achieves a satisfactory solution and forms the overall optimization of the system, which means to establish an internal collaborative optimization decision model of the enterprise system for the subsidiaries of state-owned enterprise group based on the IAHP(interval analytic hierarchy process) theory. This method firstly recognizes that the autonomy of the departments is objective, and it provides a set of inter-departmental coordination mechanisms on this basis. In this mechanism, coordination was conducted with limited information exchange and strong

maneuverability, thus it provides a theoretical basis for the establishment of enterprise decision support system and enterprise decision making on the management level. This decision-making method has more practical significance in the increasingly decentralized corporate organizational structure. On the one hand, it fully mobilizes the enthusiasm of the relevant functional departments, and in the decision-making process, more factors can be considered and the effectiveness of decision-making results can be improved. On the other hand, difficulties in collecting information caused by the decentralization of the organizational structure have also been resolved, and substantial information can be processed locally and only a small amount of coordination information is transmitted between departments.

(3) This thesis tries to establish a performance evaluation system for subsidiaries of state-owned enterprise group that integrates the overall balance, comprehensive connection, and the combination of qualitative analysis and quantitative calculation. It uses the idea of fuzzy mathematics to combine the Delphi method and entropy weight method, this evaluation system and evaluation model provide managers of state-owned enterprise groups with a way to understand and improve the management of subsidiaries.

(4) This thesis analyzes the characteristics of the multi-cause, multi-dimensional, and dynamic characteristics of the performance of employees in state-owned enterprise, at the same time, based on the four aspects including employees' work performance, work ability, work potential and work attitude, a performance evaluation index system for state-owned enterprise employees was designed, and DEA basic model and super-efficient DEA model for the performance evaluation of employees from state-owned enterprise were established. The performance evaluation model of employees in state-owned enterprises should take benefits of enterprises into account, which means that the enterprise should evaluate whether the employee's performance matches the enterprise's investment. Different evaluation results can not only reflect aspects needed to be improved, but also the improvements made by the employee as a subject that accepts input. The research results can not only provide ideas for state-owned enterprises to formulate measures to improve their performance management status, but also provide basis for them to design a more reasonable salary system.

Chapter 2 Literature Review

2.1 Research Status of State-owned Enterprise Group Management and Control

In recent years, there are innumerable domestic and foreign researches on management of group companies. Despite that, most studies still focus on "management", and the "control" of enterprises is often neglected. In the view of traditional management theory, "control" is only considered as one of the five functions of "management" (planning, organization, command, coordination, and control).

However, the importance of "control" in reality has become increasingly prominent [2]. With the increasing size of the parent organization, the issue of how parent company can effectively control the subsidiary has become a real problem that needs to be solved in the company's business management, while the problem of "control" has also become a hot topic in the theoretical circle.

2.1.1 Western Research of Group Management and Control

The term "management and control" first appeared in the American business community in conjunction with budget control, cost analysis, and profitability research [3]. Early management and control emerged as a function of accounting management [4]. Later scholars studied issues related to management and control from the perspective of accounting and financial management, and they measured the effectiveness of enterprise management and control with the criteria of profit maximization or cost minimization [5].

Scholars abroad began to study the model of group control in the 1920s [6]. The initial research focused on corporate governance and organizational structure [7]. There was no systematic study of the group's control model [8]. In the 1930s, the famous American economist Means[9] discovered that there is an agency problem after the separation of management rights and ownership, that is, the hired senior management personnel may have motives and behaviors that infringe the interests of the owners[10], This will increase cost of company's control over management, leading to lower profits[11].

In the 1980s, many well-known companies in the United Kingdom collapsed, which sparked a series of discussion on corporate governance and the birth of several corporate governance committees and governance guidelines [12]. International economic and financial organizations actively promoted corporate governance. The Organization for Economic Cooperation and Development (OECD) formulated corporate governance guidelines. The International Securities Regulatory Commission has also established the Emerging Markets Committee and drafted a report on Corporate Governance in Emerging Market Countries. Since the beginning of the 21st century, the research on the Group's management and control

model abroad has grown more mature, the researchers are more systematic and broader. Topic such as corporate governance, organizational structure and internal control have been systematically studied, meanwhile some research results with important reference value have been obtained [13].

In 1972, Harold Koontz proposed a future-oriented enterprise feed forward control method for the problem of time delay in the management and control process [14]. The systematic approach to management and control complied with the management needs of large U.S. companies and consortiums after the Second World War. Especially after strategic planning and forecasting became the focus of management in the 1970s, management and control system was widely used as an important tool for strategic implementation [15]. Management and control system focuses on the consistency of goals and the availability of information, which deepen people's understanding of the nature of management and control [16].

After entering the 1990s, research on management and control began to pay attention to the environment and the uncertainties of the organization. Robert proposed that interactive management and control system can focus the organization's attention on the uncertainty of strategy [17]. With the rapid changes in the management and control environment, feedback from the management and control system have enabled the senior management of the organization to pay attention to solving issues encountered during organization development[18], and through timely adjustment, a new strategy for organizational development has been formed. The interactive control system can be seen as a strategic feedback system that attaches importance to the future and changes. The control referred in interactive control system is not only the control of strategy implementation, but also the control of strategy adjustment, and that is, "today's control" affects the "tomorrow's strategy", which still has important implication on daily enterprise management. Fisher combined the contingency theory with the management and control system to identify the contingencies affecting the management system and analyzed their impact on the control system and organizational performance [19].

Martinez and Jarillo systematically studied the literature on multinational corporations' control mechanisms from 1953 to 1988, they divided the organizational types of multinational corporation groups into decentralized federalism, centralized authority, and integrated networks, and at the same time, control mechanism was divided into two aspects, which are formally structured mechanisms and informally unstructured mechanisms. Different aspects have made useful contributions to the study of enterprise management and control mechanisms [20].

Goold and Campbell called centralized and decentralized management between parent companies and subsidiaries as the "Parenting Styles" and divided them into three types: financial control, strategic planning, and strategic control [21].

2.2 Research of Group Management and Control in China

Research of Group's management and control in China began relatively late. It actually started in the 1980s. However, the achievements and progress are impressive, especially during recent years, as the large scale enterprise groups in China continuously rising, researches on group management and control are generating more practical significance.

Ge Chen divided the group management model into four types: capital control type, administrative control type, participation control type, platform control type, and constructed three-stage model for parent-subsidiary company and which includes the feed forward control, core control, and feedback control [22].

Yuan Dongan focused on the analysis of the American model, the Japanese model and the Korean model of enterprise groups according to the different characteristics of management and control of enterprise groups in different countries; Zhang Wenkui who works in the Development Research Center of the State Council, took the large-scale enterprise group that has both the business department and the linear function management unit as the research object based on the parent-subsidiary company system, studied the relationship among the organizational structure design, organization structure, and management and control of the large-scale enterprise group, but there is no detailed classification of the group's control model.

Wu Shengzhu proposed that the group financial control system is an organic integrity formed by financial personnel control system, financial system control system, financial target control system, and financial information control system. The financial objective control is based on the financial goals of the group company, and it is a method of controlling the subsidiary companies through the development of a financial evaluation system [23].

Ye Sheng divided the group management model into capital control, strategic control, personnel control, culture-oriented control and other major control modes from the perspective of differences in control methods.

Wang Ruo and Zhang Yunfeng divided group's control model into three types: financial control, strategic control, and business control. Based on this, some scholars further classified the strategic control model in a relatively uniform centralized and decentralized management into "strategic implementation" and "strategic guidance". The former focuses on centralized management while the latter emphasizes decentralized management [24].

Zhang Yan believed that with the rapid development of the national economy and the inherent needs of companies that are stronger and bigger, cross-industry and cross-regional operation and management have become a distinctive feature of large-scale state-owned enterprise groups in the implementation of cross-industry, cross-regional. In the process of business management, group companies often need to control the human resources of their subordinate companies, which brings forward three types of human resources management and control models including direct management, supervision, and consultant, he also suggested the transformation of human resource management after analyzing the factors of each model in detail [25].

Wang Jipeng systematically and detailed described and elaborated on the research results of the group's management and control theory in the book *Group Management*. Wang Jipeng believed that the core issues of the group's management and control are model selection, organizational structure design, power and responsibility system and core management processes, performance evaluation, and so on[26].

Wang Ruiling conducted a research on the management and control model of Huarui Holdings Group's parent and subsidiary companies. He believed that the parent and subsidiary company's management control system of Huarui Holdings is an integrated management and control system consisting of strategic management control system, financial management and control system, and human resources management and control system [27].

Bai Wangang summarized the four basic types of management and control methods for enterprise groups: The simulated legal person management and control and boundary-spanning parent-subsidiary company management and control including licit parent-subsidiary company management and control, implicit parent-subsidiary company management and control, and office; and the in-depth research on management and control mechanisms and environment was also conducted. In addition, Bai Wangang also proposed that in operation process of group companies, the principle of "Systematic Perspective" and "Organizational Intelligence Quotient" should be introduced, and it is believed that the effective operation of the entire collectivized enterprise system should be realized through management and control, and finally "the external complexity should be dealt with through internal simplification and order" [28].

2.3 Conclusion

The description of the overall characteristics of the management and control system is relatively rare. The research achievements are mainly from the aspects of control execution procedure, control variables, or control method. Literature reports on the systematic study

of management and control problems at the enterprise group level are even rarer, with most existing studies being carried out only from the perspective of group management and control (such as connotation, organization, pattern, means, etc.), and systematic and comprehensive researches are insufficient.

Chapter 3 Theoretical Research and Study on Management and Control of State-owned Enterprise Groups

3.1 Theoretical Study of Enterprise Groups

3.1.1 Connotation of Enterprise Groups

3.1.1.1 Definition of Enterprise Groups

Enterprise groups can be defined in broad and narrow terms. In a broad term, enterprise groups refer to simple enterprise aggregation, which is the product of horizontal and vertical integration amongst enterprises and the combination of several enterprises in the same region, same department or cross-region, and trans-department. In a narrow term, enterprise groups refer to the enterprise consortium formed by the combination of property rights between enterprises. Nowadays, generally involved enterprise groups refer to the concept of enterprise groups in a narrow term. The most fundamental difference between broad and narrow terms of enterprise groups is whether the enterprise is based on property rights or not.

Generally speaking, an enterprise group is a group of wholly-owned, controlled or share-holding subsidiaries established with the continuous growth of a single enterprise, or a form of economic organization produced by an associated company.

3.1.1.2 Characteristics of Enterprise Groups

According to the view of traditional economics, typical economic organizations can be divided into two types: hierarchical organizations represented by enterprises and market organizations with price mechanism as its core. Allocation of social resources, the division of labor in social production, and transactions are completed in these two organizations. In addition to these two typical economic organizations, there are many intermediate forms of economic organizations in reality, one among which is enterprise group.[29]

Enterprise group can be seen as an interest aggregate established on the basis of modern enterprise system with capital as its linkage, shares interests and risks. Most of its members are joint stock limited companies and limited liability companies. The parent company usually carries out effective capital operation by means of flow, separation, combination, and optimal allocation to maximize the interests of the group.

As an intermediate economic organization, enterprise group aims to make use of the relative advantages of the market and the enterprise as much as possible. To achieve this goal, business groups have different characteristics from other economic organizations.

(1) Diversity

Business groups have diversity. The diversity of enterprise groups is represented by the diversity of core, connected to the diversity of organization and organizational structure.

(2) Regard property rights as the main link

Enterprise groups regard the property right as the main link, that is, taking the capital as the tie, and it belongs to the joint enterprise consortium of equity and property right formed by investment capital. The relationships among group members are holding and being controlled, participating and being owned.

(3) Multi-level

As indicated in Table 3-1, corporate groups can be divided into four levels, namely the core layer, fixed layer, half-fixed layer, and loose layer. The core layer is one or a few key enterprises with the core position of the group, and it can be a group company that has both the characteristics of the head office and the parent company. The fixed layer is a subsidiary that can be controlled by a group company, generally, the parent company of which owns more than 50% of shares; The half-fixed layer is composed of affiliated companies with the participation of others. The parent company holds a certain percentage of shares, but it has not yet been controlled. The group can only influence other party's operating activities to a certain extent: The loose layer is composed of enterprises with no fixed relationship, and while there is no controlling share relationship with the parent company, there may exist capital lending relationship.

Table 3-1 Four Layers of Enterprise Groups (Lin hao, 2015)

	Core layer	Fixed layer	Half-fixed layer	Loose layer
General management coordination of enterprise groups	Administrative management	It is mainly in property management and supplemented by financial management	Property management	Network relationships based on long-term contracts
Boundary definition of enterprise groups	Inner boundary of parent company	Outer boundary of parent company	Inner boundary of enterprise group	Outer boundary of enterprise groups

Although there are many terms and classifications for enterprise groups, they have common characteristics which mainly manifest as an economic organization with hierarchical enterprises. The companies that make up an enterprise group have an intrinsic and close economic and technological relationship which requires coordinated actions; Capital is the main link between the parent company and its subsidiaries [30].

3.1.2 Analysis of the Organizational Structure of Enterprise Groups

3.1.2.1 The Organizational Structure of the Enterprise Group

There are several typical forms of organizational structure: linear system, linear function system, business department system, matrix system and parent-subsidiary system, etc. [31]. In practice, the organizational structure of the enterprise is not pure, it is in a mixture of concentrated structural forms and thus we call it mixed organizational structure [32]. From the view of historical evolution, the structure of the linear system and the linear function system has no longer adapted to the actual situation of the enterprise. Therefore, this thesis only explains the division system, matrix system, parent-subsidiary system, and the mixed structure [33].

(1) Business division system

The so-called business division structure is an organizational form in which decentralized management is carried out within a company for departments with independent products and markets, independent responsibilities and interests. Division system is also called responsibility center system [34].

The division structure is not organized by functions or tasks, but organized by product, region or customer type. Each division has built its own U-shaped structure [35]. The business division is a collection of interconnected units with three characteristics: a unit responsible for products and market and has independent products and markets; a unit responsible for interests and has independent interests and accounting; a decentralized unit with sufficient power to operate independently [36].

The advantage of the divisional system is that it allows the top management to get rid of the specific daily management affairs, and it is beneficial to concentrate on making strategic decisions and long-term planning, as well as improving the flexibility and adaptability of the organization[37]; At the same time, the business division system also helps to cultivate and train comprehensive management talents; The defect of the business division system is due to the duplicated organization, which has caused a waste of management personnel: Due to the independent management of each business division, the exchange of personnel between business divisions is more difficult when the mutual support is poorer; The executives of

each business division tend to consider interests of their own departments and ignoring the entire organization.

(2) Matrix organization structure

The matrix organization structure is formed based on the vertical leadership system of the linear-functional organizational structure [38].

The advantage of the matrix system lies in the fact that it combines the division system and the linear system to a certain extent. In the matrix structure, working group is characterized by flexibility, and it can be organized or disbanded according to the project needs and its progress, which improves the efficiency of personnel utilization; However, in the matrix structure, the members of the working group have two bosses at the same time, and the chaos and conflict of power relations may lead to the disorder of management order. Therefore, the matrix system is more suitable for companies or fields which have relatively unclear boundaries with customers, and the responsibility and motivation don't need to be clearly defined, but more cooperative and coordinated enterprises will be needed, such as those focusing on research and development.

(3) The parent-subsidiary company system

The parent-subsidiary company system refers to the separation of certain business of a company to form a subsidiary with status of a legal person [39]. Under the parent-subsidiary organizational structure, core enterprises form a capital-linked enterprise group through sole proprietorship, holding, equity participation, or business collaboration, and these enterprise groups usually include core enterprises such as wholly-owned subsidiaries, controlling subsidiaries and participating subsidiaries, as well as loose external organizations such as business cooperation enterprises. Subsidiaries can also establish economic entities such as sub-subsidiary alone or with other subsidiaries or even with the parent company. Strictly speaking, though the parent-subsidiary company system is not an internal organizational model, it is still closely related to the internal organizational structure of the company, for example, a divisional enterprise can be easily separated into independent subsidiaries, and subsidiaries can also be incorporated into the parent company.

From the perspective of the parent company, the advantages of the parent-subsidiary company system are conducive to fully meeting the needs of the company's diversified strategy, producing the leverage effect, and reducing the risk of the parent company. From the standpoint of the subsidiary company, the advantages of the parent-subsidiary company system lie in the fact that the decision-making power of the subsidiary company corresponds to the decision-making responsibility, and it independently assumes the civil responsibility and operational risk, meanwhile, it responds quickly to the changes in the market. The

disadvantage of the parent-subsidiary system is that there is a certain degree of conflict between management and control and corporate governance. The parent company's management and control over the subsidiary generally needs to be realized through corporate governance, which has totally different mechanism and procedures from that of management and control. In addition, corporate governance also imposes many restrictions on transactions and management services between parent and subsidiary companies, thus it may result in higher management costs for the entire group company. At the same time, the subsidiary company may compete with the parent company for business and it is difficult to coordinate. If the subsidiary or parent company and subsidiary company are listed companies, the situation will be more complicated.

In conclusion, the comparison of the business division system, matrix system, and parent-subsidiary company system is shown in Table 3-2.

Table 3-2 Comparison of Three Organization Structures (Wang Pu, 2014)

Organization structure type	Characteristics	Advantage	Disadvantage	Scope of application
Business division system	Organized according to product, region or customer type	1. The management team can focus on strategic decisions and long-term planning. 2. Improve organizational flexibility and adaptability	1. Repeated organizations, waste of management staff; 2. It is difficult for the personnel of the business division to change jobs and they could not provide good support to each other; 3. Ignore the overall interest	Scaled and diversified company
Matrix system	The business division shall organize the business of the company as a unit, however, business division will accept the guidance, supervision, and even the authorized direct command of the company's functional department.	1. Personnel utilization rate; 2. The working group is flexible	May cause the confused management	Need more companies to have cooperation and coordination
The parent-subsidiary company system	Subsidiaries have legal status	1. Produce leverage effect 2. Reduce the risks of parent company; 3. Subsidiary companies have the same powers and responsibilities	1. It is different for the parent company to control the subsidiary company; 2. It may result in higher management costs; 3. The relationship between parent and subsidiary companies is difficult to coordinate	Multinational enterprise

(4) Mixed organizational structure

In reality, most enterprise groups are mixed organizations, that is, they are based on the parent-subsidiary company system, and at the same time, they have business divisions and linear functional units. The organization structure can be divided into two types [40]:

The first is that the parent company sets up a business division to manage all business, all or some of which may exist as a subsidiary as necessary. In this way, the top management of the parent company does not need to directly manage the subsidiaries, and it only needs to manage, coordinate and evaluate the business units.

Another type of the mixed organization structure is that part of the business exists in the form of business division of the parent company or the linear function management unit, while the other part of the business is in the form of a subsidiary with the status of a legal person. The parent company generally owns a subsidiary or has absolute or relative control over a subsidiary.

3.1.2.2 Factors that Affect the Organization Structure of Enterprise Groups

As indicated in Figure 3-1, there are four major factors that affect the organization structure of enterprise groups.

Strategy of Enterprise Group
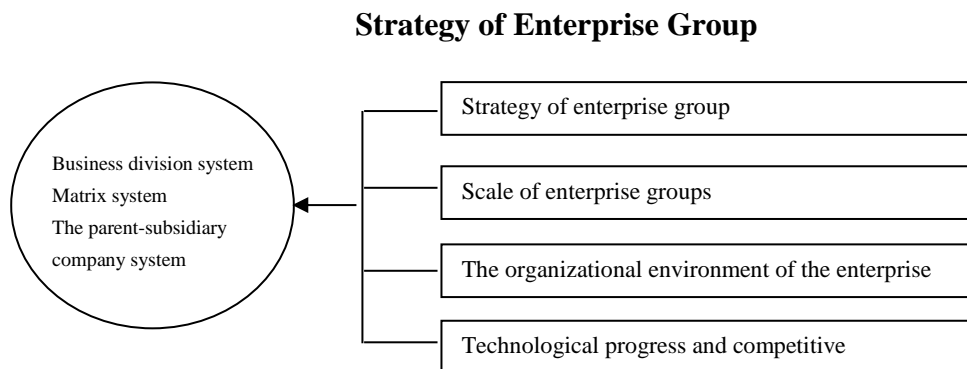
Figure 3-1 Organization Structure and Marketing Factors of Group Companies

① Strategy of enterprise group

The strategy of the enterprise group determines the organization structure and acts as a main influencer. The group strategy influences the organization structure by standardizing the organization structure of group through managers' strategic choices; Matching between organizational structure and strategy is a necessity for achieving enterprise goals; organization structures that are incompatible with the strategy will hinder the strategy from

being fully implemented; if the essence of the strategy changes, then organization structure will inevitably be greatly affected.

② Scale of enterprise groups

Generally speaking, the scale of the enterprise has a strong impact on organization structure. Smaller enterprises with a single business structure generally adopt the straight-line function. Compared to the enterprise with larger scale and more complicated business structure, linear function system is relatively rigid, and the business unit lacks sufficient decision power and response capability, thus business division system and parent-subsidiary company system are used more frequently.

③The organizational environment of the enterprise group

To a large extent, the organization structure of an enterprise group is affected by many factors from its internal and external environment. From different perspectives, corporate environment of the group companies can be classified differently. This thesis divides it into two major categories: external organizational environment and internal organizational environment. External organizational environment includes political and economic environment, social environment, industry environment, suppliers, and customers; the internal organizational environment includes level of group's head office and the level of subordinate companies. The head office level includes group strategy, holding level, group type, type of responsibility center, leadership style, etc., while the subsidiary level includes geographical distribution, importance and growth cycle, etc.

④ Technological progress and competitive environment

Advances in related technologies and changes in the competitive environment will also affect the organization structure of enterprise group. Technological progress, especially information technology, has been widely used in business management and it has impacted the organizational structure in a profound way. Flattening the organizational structure has become the goal pursued by many large companies. With fiercer competition, international competition in particular, the company's quick response and innovation ability have become the key to its long-term development. And quick response and the innovation ability demand enterprises to have a relatively decentralized organizational structure.

In addition, business characteristics, management tradition, and entrepreneurial style that enterprise group exhibit also influence its organization structure. What needs to be explained is that we have pointed out some of the factors affecting the organization structure, but it does not mean that each of these factors corresponds to a fixed organization structure. Hence, enterprise group's choice of organization structure is a result of the comprehensive analysis of these factors. The organization structure design concept of the contingency theory

believes that it is impossible to establish a universal management model, and there is no "best" management model, but only the "optimum" management model. The organization structure of the enterprise needs to be selected and designed according to different conditions.

3.1.3 Operational Mechanism of Enterprise Group

The objective of building an enterprise group is to uniformly manage and control the assets within the group through the capital ties in ways that the patent company gives full play of the overall advantages and obtains the best benefits. The advantage of an enterprise group lies in the parent-subsidiary company system which combines centralization and decentralization, extracts the benefit of single large enterprises and general enterprise consortium, avoiding the drawbacks of excessive centralization and excessive decentralization, coordinates actions according to the unified development strategy, as well as achieving the overall strategic objectives. Under this premise, each member enterprise has considerable autonomy and flexibility.

Enterprise group is an interactional and interconnected enterprise system formed by several sub-systems through the link of property rights. On the whole, it is the operation of the system of enterprise group. Ensuring the efficient operation and growth of this system is the core of enterprise group management and control. Research on the operating mechanism of the group company system helps deepen the internal management and manipulate rules between the parent company and the subsidiary company, so as to have better group management and control. Therefore, the first step to study the operation mechanism of group companies is to understand the motive behind formation.

3.1.3.1 Reasons behind the Establishment of Enterprise Groups

The formation of enterprise groups generally follows this path: The parent company of the group is established first, then the parent will invest in other newly established enterprise, purchased subsidiaries or related companies and equity companies to form an enterprise group.

The foundation of an enterprise group is the integration of its core companies. In essence, enterprise groups contain both the nature of an integrated organization and the nature of strategic alliances with member companies. Many scholars at home and abroad have researched the formation motivation of enterprise groups from different perspectives.

Liang Liang believed that the fundamental impetus for the integration of enterprise groups and strategic alliances is to pursue the maximization of the overall interests of the enterprise groups, especially the maximization of core enterprise interests while the maximization of

member enterprises' interests is the game result of long-term and short-term interests, as well as local interests and overall interests [41].

At present, the reason behind the establishment of enterprise groups is generally explained by the theory of transaction costs of economics. The analysis of transaction costs is actually only a static method, which cannot reveal the core reasons behind enterprise groups under dynamic conditions. Yuan Dongan introduced monopoly and competition factors as well as specialization factors into the motivation analysis of the enterprise group, and discussed the reason for the formation of enterprise groups from a dynamic perspective [42]. Tao Xiangjing and Sheng Zhaoyi believe that the study of the motives of enterprise groups is an important way to understand enterprise groups and an important theoretical basis for other related research, while externalities are the driving forces behind the formation of some types of enterprise groups in China [43]. The establishment of two economic game models will result in the formation of vertical enterprise groups, while externalities in horizontal industrial relations will lead to the formation of horizontal enterprise groups.

3.1.3.2 Analysis of the Links within Enterprise Group

The link of enterprise group is only a visualized expression. In fact, it refers to the law used in the enterprise group to establish the relationship between the group company and its member companies and the relationship among the member companies [44]. From the practice of foreign enterprise groups, the management and control links of enterprise groups are mainly divided into four types: The capital management and control link, contract management and control link, governance and control link, and business management and technology link that is the core for the management and control links, and they form a network of management and control links which connects and supports each other. Absence of each control link will have an important impact on the overall control and control effectiveness of the enterprise group.

In the management and control activities of enterprise groups, the parent companies should be based on capital link and integrate the configuration of contractual link, governance link, and business link to comprehensively design and develop the framework of the management and control systems between parent and subsidiary companies.

①Capital link

Among the links of enterprise group, the link of capital is the most important link, and it forms the basis of other links. The link of enterprise group reflects all the relationships among all member companies of the enterprise group. Many scholars believe that the equity link is the link of capital. Actually, capital link, not only in the form of equity link, has two

forms: the first is to establish property rights relationship by the financial participation of the core enterprise in another enterprise, and that is, linked by equity; the second is to form links through the core enterprises with solid strength to provide capital for the subordinate enterprises, and that is financing link. The relationship of property rights of the two is the most important [45].

Using equity as the link between a group company and its member companies or among member companies actually indicates the relationship of control or participation of a group company or a member enterprise based on its capital participation in another enterprise. The equity link is characterized by the fact that the enterprise group (parent company) is established through its ownership over the group member enterprises (subsidiaries).

The forms of financing links are various and they are in two main forms: First, the group's head office has an internal bank to conduct unified management and centralized operation of the funds of its subordinate companies, so as to maximize the effectiveness of funds, and sometimes to provide savings and loan preferences for the subordinate enterprises; Second, when the member company needs to apply for a loan from the bank, the group company can guarantee with its good financial reputation. For example, Erdos Group established internal bank and regarded it as the necessary place and control center for the capital flow of the group's wholly-owned and controlled enterprises, and the bank accounts of the wholly owned companies and holding companies are under the control of the internal bank who uses the overall financial budget leverage to monitor the cash flow, adjust the balance of funds, and maximize capital efficiency.

②Contractual link

The contractual linkage model is characterized by the use of contracts or agreements as a link between Group Company and its member companies. The establishment of enterprise group is achieved through contracts or agreements between Group Company and its members [46].

The form of contractual bond is very common among production enterprises, which allow the spreading of products within the group or enables large enterprises to provide component parts for small and medium-sized enterprises. The link is established by signing contract for the product variety, quantity, quality, price, time and place of delivery, etc. Contractual link is conducive to the specialized division of labor and collaboration of enterprise group. However, enterprise group with binding contracts as the link usually has poor cohesion and stability, and the group's head office has limited control over its subordinate enterprises. Thus, binding contract cannot well implement the group's overall strategy, make unified planning or carry out investment transformation for the group's overall development.

③Business link

Business link refers to the group's head office's improvement of the control system from the perspective of business strategy, implementation, monitoring, unified planning and its guidance of each subsidiary's business operation.

Business relationship among the members of the enterprise group can be divided into industrial relationship and capital relationship. The former refers to the relationship where each member of the enterprise group focuses on the production and sales within one industry or multiple industries, achieves unity and connection, realizes the group's business expansion and growth by relying on the up-and-down or horizontal extension of the industrial chain. The latter refers to the relationship where each member of the enterprise group uses a common investment entity—the parent company—as its core, and mainly relies on capital links to have equity transactions, capital loans, and other business relationships [47].

Through business links, enterprise group can achieve integration of multiple corporate subsidiaries on the basis of socialized production and specialized division of labor, which generates an industrial portfolio effect. A single enterprise will not be able to enjoy portfolio effect, disperse operational risk, and obtain scale economy.

④Technology links

Nie Zhengan believes that for industrial enterprises, technical relations are the fundamental linkage between them. As industrial enterprises are organizations of technology production, their structures are subject to inherent requirements of production technology. And technical relationship plays a key role [48].

The role of technological link is indicated in two aspects: First, the "expansion" of production technology will "proactively" promote the development of companies toward the enterprise group; Second, technical link will play a restrictive role in the formation of enterprise groups "afterward". For example, when enterprise establishes an enterprise group through mergers and acquisitions, it must consider its own technical structure and characteristics, and fully consider whether the technology of the target company can be incorporated into its own technical system. Generally, companies that have their own upstream and downstream product technologies may consider establishing a complete organic industrial chain through mergers and acquisitions.

The advantage of using technology as the link is that group companies have a high degree of technical dependence and will form a benefit-sharing mechanism and cohesion of the enterprise group accordingly.

3.2 Theoretical Analysis of Enterprise Group Management and Control

3.2.1 The Theoretical Connotation of Enterprise Group Management and Control

The operation and development of enterprise group is rooted in the operation of individual companies. However, complexity of internal structure of the enterprise group means that the management and control of enterprise group is more complicated than that of an individual enterprise, like the subject or the modes of management and control. In order to better understand contents of enterprise group management and control, this thesis will further study them by analyzing those of the individual enterprises.

3.2.1.1 Management and Control Contents of Individual Enterprises

Enterprise group is an economic organization composed of several enterprises with independent legal person status. Incorporated enterprise is the basic unit that constitutes an enterprise group, and it is also a basic component of the management and control of enterprise group.

Enterprise management and control is a process in which managers positively influence other members of the organization to implement organizational strategy according to organizational goals. According to the separation of ownership and management, the company formed an authorization mechanism under multi-level delegation agent. It also involves "general meeting of shareholders - the board of directors - senior managers - middle managers - lower-level managers, basic level employees" as the organization structure.

The functional subjects of enterprise management and control mainly refers to the board of directors and managers at all levels (high-level managers, middle-level managers, and low-level managers). The management and control entities are at different levels of corporate governance and control, they have the dual characteristics of control subjects and control objects. The board of directors is the permanent representative body of the shareholders' meeting of an enterprise, it is also the top management and control body of an enterprise, responsible for setting the management and control objectives of the enterprise and monitoring the implementation of the goals. Senior managers mainly refer to corporate managers who are responsible for the development of enterprise management and control systems and formulating specific control programs to regulate various control activities.

Under the unified framework specification of enterprise management and control, management and control entities work to ensure the normal operation and healthy growth of the enterprise through complicated interactions among entities at different levels. The management and control subjects at all levels focus on the implementation of the strategic goals of the enterprise, which enables the organization to maintain coordination and

consistency, so as to promote the coordinated operation and evolutionary growth of the system as a whole, and ultimately ensure the realization of the overall development goals of the enterprise.

An enterprise is a dynamic and complex system. The operation and growth of a single incorporated enterprise can be viewed as a process of system and evolution. The overall development strategy formulated by the enterprise is the fundamental goal of guiding the operation of the enterprise system. The enterprise management and control activities should be centered on the decomposition and implementation of the company's strategic objectives.

The main body of each level of the enterprise is around the decomposition of strategic goals, carrying out corresponding organizational setup, division of functions, task arrangements, and action plans to further form several functional subsystems (including strategic functional subsystems, financial functional subsystems, and human resource management, and the production of subsystems etc.). Each subsystem mainly relies on capital, business and other links to interact closely, so as to form a complex system with distinct levels, clear division of labor and orderly operation.

The highest goal of the enterprise system is the goal at the strategic level. Each subsystem has a sub-objective decomposed from the overall objective and realizes its own optimal control according to this objective. The control of the whole large system is realized by means of coordinating the subsystem. The operating mode is: Each level only controls – not directly – the activities at the next level, but only the control subsystem at the lowest level directly controls the operation of the system, thus system at the higher level mainly plays the role of planning and coordination. In this way, each member organization within the enterprise system becomes a benefit community with strategic consistency, resource sharing, business complementarity, and organizational coordination.

3.2.1.2 Characteristics of Enterprise Group Management and Control

（1） Strategic

The development of enterprise group mainly includes the development of business units and the improvement of the overall synergies of the group, which are the strategic issues for the group. But the development of a business unit depends on the appropriate authorization or decentralization of the parent company's investment-linked company, and improvement of the overall synergy effect of the group depends on the integration effect of the headquarters. These are closely related to the construction of the group's management and control system. Therefore, the establishment of a suitable group management and control system is a strategic issue in the development of enterprise groups.

（2） Systematic

The construction of the group's management and control system is a systematic project which requires consideration of many components and their interrelationships. These elements include the selection of the overall management and control model of the group, the positioning of the group's headquarters functions, the design of the group's overall organization structure, and the design of various functional control mechanisms. As a system, the management and control system is a cohesive entity that has the elements of dynamic connection. It has the openness and dynamic adaptability to external influence factors, and the correlation and integration of internal components. Therefore, the construction of the enterprise group's control system is a process that needs to be adapted to local conditions, system planning, and time adjustment.

3.2.1.3 Synergy Effects of Enterprise Group Management and Control

Synergy refers to the overall effect of "1+1 >2" resulting from close coordination and cooperation under the guidance of common interest objectives within each component of a system. Synergy is a leading factor in the collaboration of several members of the enterprise group. It enables each member company to form a benefit community centered on the parent company and realizes the growth and development of the entire enterprise group based on the benefit of each member company. Synergistic effect of enterprise group management and control mainly includes the following aspects:

(1) Strategic synergy

This refers to that each member of the company takes consistent action plans to achieve the established target under the guidance of the unified strategy formulated by the parent company and based on a high level of division of labor and cooperation. For example, the

parent company can break down the overall strategic goal into a number of detailed objectives which are completed by each subsidiary, and this can improve the operating efficiency of the enterprise on the basis of maintaining a high degree of consistency.

(2) Benefit synergy

This means that all members of the company have common development goals, that is, the ultimate goal of pursuing the maximization of group benefits. The parent company relies on the close ownership ties to closely unite all interest subjects, in addition, it carries out a high degree of unity and coordination on the strategic objectives and interests orientation, so as to achieve a high degree of fitting between the interests of all parties.

(3) Resource synergy

This means that under the unified management and coordination of the parent company, the internal resources of the group have been optimized and allocated in a way of sharing, which has produced the best utilization efficiency of resources. The parent company needs to scientifically plan and uniformly allocate resources such as funds, human resources and material resources for the entire enterprise group according to the strategic goals and the business needs of each enterprise member, so as to maximize resource allocation efficiency and utilization efficiency.

(4) Organization Synergy

This refers to that enterprise group arrange and organize portfolio operations through the unified organizational structure design and organizational management system as well as actively improve the efficiency of organization operation and reduce the cost of internal organization operation, so as to realize the close coordination and collaboration among members of the internal organization.

The synergy of enterprise group is to create more value for unit entity assets through the utilization of intangible asset within the group. Based on strategic synergy, benefit synergy, and organization synergy, enterprise group will have overall synergy effect and a synergy for the system that promotes its own growth and development.

3.2.2 Framework Analysis of Enterprise Group Management and Control System

3.2.2.1 System Perspective of Enterprise Group Management and Control

Enterprise group is an economic association composed of several legal persons, which is centered on the parent company-enterprise group, with the property right relationship as the main link.. It's a dynamic evolution and growth system by connecting each enterprise member through a variety of forms, such as wholly-owned, holding and equity participation. Each company member conducts business activities in multiple business areas under the guidance of a unified group strategy.

From the perspective of system composition, the enterprise group system is composed of several enterprise subsystems, and each sub-system mainly forms an interactive and interrelated parent-subsidiary system through the property right link. The operation and development of the enterprise group system are indicated in the development of the parent company system.

The parent company is the core system of the enterprise group system. It mainly relies on capital link to exert necessary influence on other enterprise subsystems, so as to ensure that each subsidiary company can become a system with a consistent strategy, reasonable structure, interest correlation and orderly operation, and this is how an enterprise group manages and controls. From the perspective of system operation, the management and control activities of the enterprise group are mainly represented by those of the parent company system. The growth of the enterprise group system is mainly reflected in the comprehensive evolution and growth of the parent-subsidiary company system in terms of the number of members, assets, operating income, market space, operational efficiency, and management capabilities.

The management and control of the enterprise group system is more complicated than that of a single enterprise. There are many characteristics of enterprise groups such as large scale, complicated organization structure, diversified operations, and cross-regional operations. Each enterprise member has many differences in terms of asset size, management level, and product production, which diversifies its organization, method, depth, and the path of management and control etc.

In order to effectively manage and control the operation and development of enterprise group, parent company must coordinate from the overall perspective of the parent company system, establish a unified system frame from the level of synergy, and conduct an overall study and construction on the objectives, contents, forms, mechanisms, organizations, models, systems and plans of group management and control, thereby making enterprise group management and control more systemic and comprehensive.

3.2.2.2. Analysis on the System Framework of Enterprise Group Management and Control

The overall characteristics of the management and control system is rarely described, whose main achievements came from the aspects of control execution procedure, control variables, or control method. The literature reports on the systematic study of management and control problems at the enterprise group level are even rarer, most of the existing documents have been studied from certain perspectives of group management and control (such as connotation, organization, pattern, means, etc.), and there is a lack of systematic and comprehensive research results. This thesis tries to find out some key elements that reflect the overall characteristics of the management and control system.

In terms of content composition, the enterprise group management and control system mainly includes the following subsystem modules:

(1)   Enterprise group management and control elements

From the perspective of system study, it is found that the management and control system is ultimately composed of various management and control elements, and these elements and their forms determine the system and structure of control.

According to theoretical basis and connotation of management and control system, the elements of management and control system can be summarized as ten generic types, as indicated in Figure 3-2:

① Control environment

Control environment refers to the environment that an organization faces when conducting management and control, which includes the organization's external and internal environment. The external environment includes the international environment, national politics, economy, social development environment, industry environment, regional environment, etc.; The internal environment includes the principles of integrity and moral values followed by the organization, the strategic choice of the organization, the division of organizational structure and authority, the establishment of a responsibility center, and human resource policies and practices.

② Control variables

Control variables are the key risk factors that affect the strategic goals of an organization. The realization of organizational goals mainly depends on the control of risk factors, value drivers and other key factors that influence organizational goals. Therefore, it is of utmost importance to improve internal management and control and identify key control variables, especially the risk control variables.

③ Control standards

Control standards refer to the basis for management and control of an organization, and it is the quantification of control variables. Control standards plan what the organization should do and to what extent. Control standards are the decomposition of strategic control objectives of an organization. Whether the control standards are correct or not will directly affect the effectiveness of management and control.

④ Information report

Information report refers to the measurement, recording, and reporting of information about activities in an organization. The information report reflects what the organization is doing. The relevance of information report in management and control is mainly reflected in the aspects related to control variables and control standards. The reliability of information report in management and control relies on its authentic reflection of organizational activities. Information report mainly includes accounting report, statistical   report and business report.

⑤ Implement evaluation

Implement evaluation refers to the assessment and evaluation of organizational operations. In fact, the implementation of evaluation is a process of comparing and analyzing information reports with control standards. Therefore, the status of the implementation of the evaluation depends on the quality of the control standards and the information report, and it also determines the effect of correcting the deviation. In the implementation of evaluation, it is essential to distinguish the subjective factors and objective factors, controllable factors and uncontrollable factors that cause the difference between practice and standard, so as to ensure the timeliness of performance evaluation.

⑥ Correction of deviation

Correction of deviation refers to the timely correction of the unfavorable differences between the implementation and the control standards during the assessment. The quality of control depends on correction of deviation, which is the key to ensuring control standards and management and control objectives. Meanwhile, it is also the fundamental factor that determines the quality of management and control.

⑦ Performance evaluation

Performance evaluation refers to the evaluation on the control results or performance of an organization's managers. The evaluation on business performance in management and control focuses more on managers or controllers. The principles of performance evaluation mainly include: combination of management achievement index evaluation and driving

factor index evaluation; combination of internal evaluation and external evaluation; combination of financial index evaluation and non-financial index evaluation.

⑧ Incentive mechanism

The incentive mechanism is to reward or punish the controlled objects according to the results of performance evaluation. Only when the effectiveness of management and control matches the remuneration of managers can the long-term and effective operation of management and control be guaranteed.
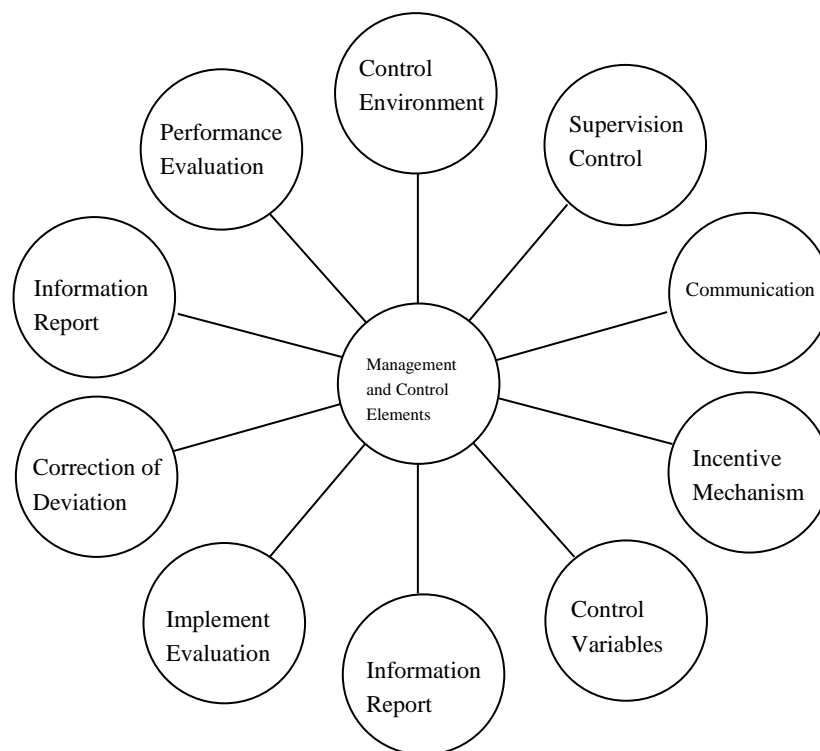
Figure 3-2 Schematic Diagram for the Ten Elements of Management and Control

⑨ Communication

Communication refers to the timely transmission or exchange of the above-mentioned management control elements, which is the basis and guarantee of management and control. Without determining the environment and the control variables, the control standard cannot be determined; without the communication of control standards and reports, it is impossible to perform evaluation and correct deviations.

⑩ Supervision control

Supervision control refers to supervising the implementation of management and control, an essential process of a complete control system. The absence of supervision and evaluation for the management and control, or the controller's neglect of control quality, will inevitably affect the performance and effectiveness of management and control. For example, the function of internal audit in internal control system is to supervise and control the control process of management and controller.

(2) Management and control mechanism of enterprise group

The management and control mechanism of enterprise group is the explanation of the inherent rules of group control. With the studies of the dynamic mechanism and power allocation mechanism of the parent-subsidiary control, the mechanism conducts the systemic analysis of the control mechanism of parent-subsidiary system based on the operation mechanism of parent-subsidiary system.

(3) Management control system of enterprise group

The management and control system of enterprise groups mainly studies the management and control methods of the group from the aspects of organizational control, functional control and system control of parent-subsidiary companies, and the operational characteristics of each control mode are analyzed from the perspective of practical operation.

(4) Management and control mode of enterprise group

The management model of the enterprise group is mainly based on the concept of management and control of parent-subsidiary companies' management and control, management control methods, management control depth, and operation mechanism, etc. to carry out comprehensive analysis, so as to systematically study the operation rules of group management and control.

(5) Management and control program of enterprise group

The management and control programs of enterprise group are mainly formulated from the perspective of the practice and application of enterprise group, and how the research and development of enterprise group can carry out practical program development and design from the management and control procedures and implementation content to guide the management and practice activities of the enterprise group.

(6) Management performance evaluation of enterprise group

The performance evaluation of the enterprise group management is mainly intended to evaluate the actual management and control performance of the enterprise group, and guide the formulation of the parent company's control plan based on the evaluation results.

3.2.3 Management and Control Mechanism of Enterprise Group

3.2.3.1 Understanding of the Management and Control Mechanisms of Enterprise Groups

The management and control mechanism of the enterprise group regards management and control as a complete system. It forms a complete enterprise group management and control system together with management and control organization, management and control mode, and the management and control including direction, motivation and restriction, which makes the management and control of enterprise group become an organic integrity [49].

The management and control system of the enterprise group consists of a management control mechanism, a management control system, a management control model, and management and control method. The four concepts are closely related but also different. In the literature on management and control of the parent-subsidiary company, there are many cases in which concepts are used interchangeably in order to avoid the mix of concepts. In this thesis, control forms which reflect the state of set decentralization including behavior control, output control, administrative management and market control are defined as control mode. From a corporate strategic perspective, strategies such as personnel, finance, and information are at the functional layer, and personnel, finance, and information are the operating elements of the company. Therefore, the form of control that reflects the status of the decentralized power from the perspective of functional elements is defined as a control measure. Strategic and cultural control can be attributed to both the management control model and the means from different perspectives.

The management and control mechanism is the hemimorphic adjustment that allows the management and control system to adjust by themselves. It's an adjustment mechanism that keeps the data within the specified limits. The management and control system is divided into two subsystems:

(1) The controlled object that is the controlled system which is mainly refers to the parent company of the group in the management and control of the enterprise group;

(2) The subject of control refers to the subsidiaries of the controlling group. The main body of management and control consists of three parts: deviation measurement agencies, decision-making agencies, and executive agencies. The management and control process is to connect the management and control subjects with the management and control objects through the information flow, that is, the management and control subjects convert the external role into a form that can directly act as the management and control object, so as to correct the deviations of the management control objects from the standard to realize the

control process of maintaining the stable state of the system, and the core of this process is a hemimorphic adjustment mechanism.

3.2.3.2 Relationship between Management and Control Mechanism and Mode

Management and control mode can be understood as the standard form of management and control, because the management objective is always a complex system, and it is difficult to find a universally applicable standard form. No matter how successful the management mode cannot be completely and mechanically copied, all reference expressions may be more accurate. Therefore, the management and control mode can be understood as a reference pattern.

There are both differences and connections between the control mechanism and the control mode. Specifically speaking, the management and control mode is the external performance of the management and control mechanism whereas the management and control mechanism is the specific content of the management and control mode. They are, in essence, two aspects of the same issue, or the correlation between the content and form.

The management and control mode reflects the management and control mechanism. The management and control mechanism is the summation and abstraction of the power distribution between the parent company and the subsidiary companies. The management control mode gives concrete content to this generalization and abstraction. Management control mechanisms can generally be classified into relative centralization, relative decentralization, and a combination of centralization and decentralization (or called relative equilibrium). The management and control model also reflects various types of power distribution.

3.2.4 Management and Control Method of Enterprise Group

The management and control measures of the enterprise group are the methods adopted by the head office to manage and control the subsidiaries of the group in order to realize the strategy of the group company. Different management and control modes are realized through specific management and control measures of the group company. From different perspectives, there are different classifications of enterprise group management and control methods. It can be divided into research and development, supply, production, sales and other management and control methods according to the production process of the enterprise; From the perspective of enterprise resources, it can be divided into financial affairs, strategy, human resources, performance, culture and other control measures. This chapter discusses

the management and control measures of enterprise group from the perspective of enterprise resources.

3.2.4.1 Financial Management and Control Methods

(1) The meaning of financial management and control

As a special form of economic organization, the financial management and control of enterprise groups has been paid great attention by scholars, and it is a hot issue in the study of enterprise management and control [50]. According to relevant scholars' researches on financial management and control of enterprise groups, the financial management and control of enterprise groups is defined as: The financial control of enterprise groups is based on the group head office as the main body of financial control, which is a management and control method to maximize the financial value of the group's subsidiaries by means of certain incentives and constraints under certain conditions.

Financial control of enterprise group includes budget control, capital control, internal audit, etc., and this indicates that the goal of financial management and control in the enterprise group is to maximize its value, rather than merely to control its compliance and effectiveness of financial activities in the traditional sense. It can be said that the management and control of the enterprise group is one of the key factors to achieve the group's strategic goals.

From the perspective of financial management and control, the financial management of enterprise group headquarters should establish the concept of "big finance" to give full play to the financing center, management center, investment decision center, profit settlement center and other basic functions of the financial department of the group company, so that the group's capital - controls - profit can obtain a virtuous circle of management system. In system, it should design a unified and efficient information system for control.

(2) The method of financial management and control

The financial management and control methods of enterprise group include budget control, capital control, and internal audit, etc.

① Budget control

Budget control is an internal management activity or process that quantifies and realizes the decision-making goals and resource allocation plans of enterprise groups. Budget control mainly includes the formulation of plans, establishment of budget standards, budget analysis reports, assessment and evaluation, etc. Budget control is a comprehensive control of enterprise's value flow, including the income, cost, profit and loss, capital, and cash flow of the enterprise. Budget control is not only a simple management method, but also a

management mechanism. The fundamental point of budget control is to replace daily management with budget and make budget an automatic management mechanism, as indicated in Figure 3-3.

② Fund management and control

Balanced and effective capital flow is the basis for the survival and development of enterprise groups. The so-called balanced flow of funds, refers to the inflow and outflow of funds through the appropriate coordination. For their long-term existence, enterprise must balance the flow of funds, and that is, the inflow is equal to the outflow. In fact, the enterprise capital is often in an unbalanced state, so it is necessary for the enterprise to strengthen the monetary fund control and make efforts to achieve a relative equilibrium in the imbalance.
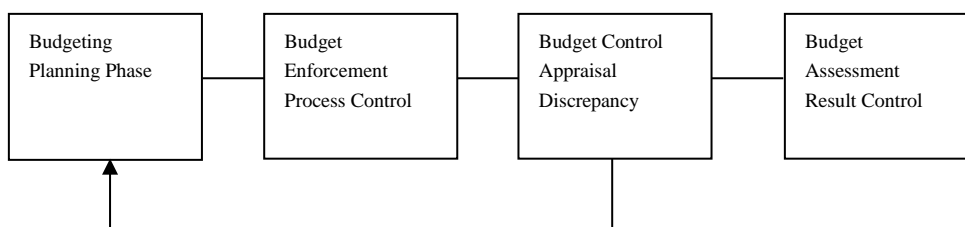
Figure 3-3 Implementation Process of Budget Control (Mangus Kald, 2015)

In the final analysis, the capital control mode of enterprise group is related to the right division of financial control, that is, whether each subsidiary has the decision-making right and management right of cash use or not. Specifically, capital management and control modes of enterprise groups include the unified income and expenditure mode, the allocated reserve fund mode, the settlement center mode and the financial company mode. The comparison of these four modes is shown in Table 3-3:

Table 3-3 Comparison of Monitoring Mode of Clearing

Mode Type	Arrangements rights for subsidiaries	Function of settlement center	Relationship with the group	Use Condition
Unified income and expenditure	Highly Centralized	Cash deposit	Group Internal Management	Preliminary stage of enterprise group
Allocation of reserve funds	Flexibility to a certain extent	Reimbursement centre	Group internal management	Preliminary stage of enterprise group
Settlement center	Combination of group and decentralization	Settlement center, cash center, control center, and loan center	Group internal management	Enterprise group development period
Finance company	Decentralization of authority	Financial center, information center, investment center	Independent legal person status, subsidiary of group	Maturity period of enterprise group

③ Internal audit

Internal audit plays an extremely important and special role in the operation and management of enterprise groups. The business objective of a group company is the common effort of all its constituent parts, and the composition of internal audit and other financial control links is the necessary condition for achieving the goal. Internal auditing is not only an important part of the internal control of an enterprise, but also a major force in the supervision and evaluation of other parts of internal control. Therefore, it must play an irreplaceable and positive role in strengthening internal control. In addition, in modern enterprise management, as the external environment changes, various risks increase, corporate governance strengthens internal reorganization, and the internal audit should also play a role in improving risk management and governance structure, which has given internal auditors more responsibility and mission.

Internal audit of enterprise group has two characteristics: First, it is the second line of defense for the control of the group over subsidiaries. Enterprise group budget control,

financial system control, financial director appointment system, financial process control, etc. are the first line of defense of the enterprise group. The internal audit of the enterprise group can evaluate the above control methods, and propose improvement measures and feedback to the controller. Second, internal audits of enterprise groups have also been added to the first line of defense, including pre-event, concurrent, and post-event internal audits.

3.2.4.2 Strategic Management and Control Measures

The strategic management and control of the enterprise group includes the strategic plan, strategic implementation plan, budget formulation, implementation and execution, and analysis and evaluation. The implementation process of enterprise group's strategic control is shown in Figure 3-4. The strategic plan includes planning and selection of strategy, which are two issues that must be addressed in strategic management and control.

The parent company of the group continuously adjusts its own strategy and then adjusts the company's strategy. The operation of the subsidiary companies may affect the strategy of the group's head office and the parent company will adjust its strategy, thus enterprise groups can form an effective cycle in strategic management.
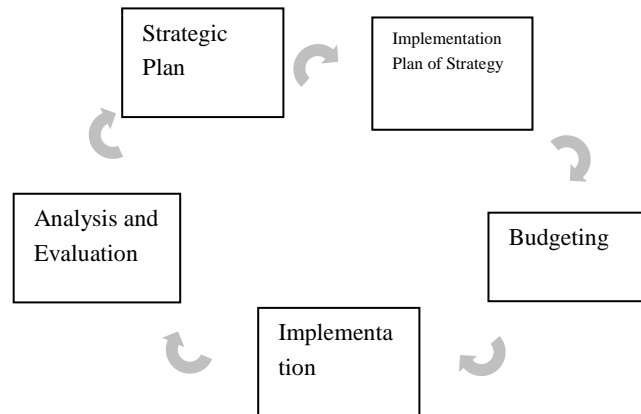
Figure 3-4 Implementation Process of Strategic Control

3.2.4.3 Management and Control Measures of Human Resources

Human resources management and control refers to the management and control of various activities such as recruitment, employment, training, and incentives for all types of personnel required by the enterprise group. The management and control mode of human resources of modern group companies mainly includes the following three ways from the perspective of centralization and decentralization [51]:

(1)   Direct management and control model of human resources

The direct human resources management and control model refers to the head office of the enterprise group as a comprehensive management center for human resources. It is responsible for the unified formulation of human resource development strategies, management systems, rules and regulations, and management processes, and monitors the implementation of subordinate enterprises while the subordinate enterprises are only responsible for specific implementation, with little or no differential improvement. Direct human resources management and control model belongs to highly centralized management and control model.

(2)   Regulatory management and control model of human resources

The supervisory human resources management and control model refers to the human resources department of the group's head office as the human resources policy monitoring center. It is responsible for supervising and guiding the development of human resources development strategies, management systems, rules and regulations, and management processes of subordinate enterprises, and providing policy and professional advice and suggestions. While subordinate enterprises independently implement human resource management practices, important management issues are subject to approval by the group company. Regulatory human resources management and control modes belong to the combination of the centralized and decentralized management mode.

(3)   Consultant-based management and control model of human resources

The consultant-based human resources management and control model refers to the human resources department of the group as the human resources consulting service center, which is responsible for providing the shared human resources service platform and professional human resource consulting consultants when subordinate enterprises independently formulate and implement human resource development strategies, management systems, rules and regulations, and management procedures. Consultant-based human resources management and control model belong to highly centralized management and control model.

3.2.4.4 Performance Management and Control Measures

Performance, also known as achievements and outcomes, it reflects the achievements or results of people engaging in an activity. Performance is one of the cores of management and control of an enterprise group [52]. An important criteria for measuring the success of enterprise group control is the performance of its subsidiaries. In the management and control

process of an enterprise group, performance control is both the means and purpose, and has always been a widely adopted management and control method.

In a narrow sense, performance management and control only includes performance evaluation; however, in a broad sense, the performance management control includes not only performance evaluation, but also the establishment of the performance evaluation system, the implementation of performance evaluation, and the application of performance evaluation results. The performance management and control of the head office over its subsidiaries refers to performance management and control in a broad sense, including the establishment of the performance evaluation system of the subsidiaries, performance evaluation implementation, and application of performance evaluation results (supervision, incentives, etc.). Performance control is not only an important means of enterprise group management and control, but also an ultimate goal.

This article uses the theory of Chen Zhijun's performance control of parent-subsidiary companies as reference, and divides the performance management and control of enterprise group into three types based on the management and control process [53]: Investment management and control, internal process performance management and control, and output performance control, as indicated in Figure 3-5. These three performance management methods interact and complement each other, and jointly form a complete performance control chain of the enterprise group.

The overall process of enterprise group's performance management and control

Input performance	—	Internal process performance management and	—	Output performance
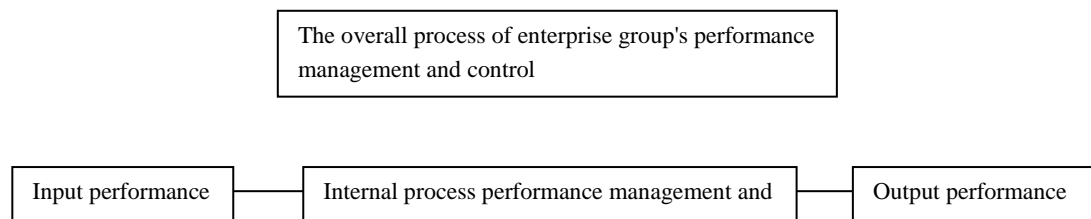
Figure 3-5 Enterprise Group's Performance Management and Control System Based on Control Process   (Chen Zhijun, 2016))

3.2.4.5 Cultural Management and Control Measures

Cultural management and control measures are very important. However, they are difficult to grasp, so for a long time, most enterprises have insufficient understanding of the functional meaning of cultural management and control measures. Currently, with the advancement of management science, the importance of cultural management and control methods has been increasingly recognized by corporate managers and scholars. In the future,

the management and control of enterprise groups should highly emphasize the use of cultural management and control measures [54].

There are two kinds of cultures within the enterprise group: First, the culture shared by enterprise groups; Second, the culture (culture of subsystem) of the subsidiaries within the group. The latter is the subculture of the former. In general, each enterprise group has its own unique business culture. However, the group's head office is the controller and its corporate culture is in an advantageous position, while the culture of the subsidiary is subject to the basic culture of the group's head office.

Cultural control refers to the head office's management of subsidiary companies based on company's vision and common belief. The characteristic of cultural control is the informal and restrained authority and power of control. The instructions given by the head office to its subsidiaries are not specific [55].

Cultural management and control can also become the main management and control measures of the group's head office under certain circumstances. The core of management and control is monitoring and evaluation. There are two phenomena that can be monitored and evaluated, which are behavior and results. When the results are easy to be measured and used effectively, the results can be used as a means of supervision and control. However, when the results are not easily measured and the behavior is not easily monitored, cultural control becomes a substitute for behavior and result control [56].

In the final analysis, the problem of centralization and decentralization is the problem of group management and control. The intensity of group cultural control is also closely related to the degree of centralization and decentralization that the enterprise group controls. The research of Chen Zhijun shows that under relative centralization, the parent company exerts the strongest cultural control over its subsidiaries, and under the independent management mode of relative decentralization, the intensity of cultural control is low[57]. When the head office of the group controls over its subsidiary companies more strictly, the corresponding cultural control process is also higher.

3.2.5 Risk Control Theory under Enterprise Group Management and Control

As enterprise group faces risks everywhere, risk control is another task that deserves attention in enterprise group management and control. In business management practices, corporate management and control include the control of risks, which is a higher-level and more comprehensive control activity. Risk control is an integral part of enterprise management and control. Enterprise management and control expands and refines risk control. Risk control is an integral part and the basis of enterprise management and control,

meanwhile, it also belongs to an important method for carrying out comprehensive enterprise management and control.

3.2.5.1 Connotation and Classification of Risks in Enterprise Groups

(1) The connotation of risks in enterprise group

At present, many scholars have studied the connotation of "risks", so according to their viewpoints as reference and defines the risk as: "The negative impact of future uncertainty on enterprise group."

(2) Characteristics of risks in enterprise group

The risk of enterprise group is objective and not based on the will of a person, so companies can't avoid it or even eliminate it on the basis of likes and dislikes. The risk of an enterprise group is relative and variable. The relativity of risk is that different entities have different understanding and affordability for risk events, and the same risk events have different effects on different entities. The risk of the enterprise group is controllable. Although the occurrence and degree of risk of the enterprise group are uncertain, the occurrence and result of the risk are always related to certain factors, and that is to predict and identify the probability of risk occurrence by scientific method for avoiding risks, or controlling the occurrence of risks and reducing the adverse effects.

(3) Classification of risks in enterprise group

There are many classifications of risks in enterprise group. Yet the author prefers the classification based on the types of risks, such as strategic risk, financial risk, market risk, operational risk, and legal risk.

3.2.5.2 Enterprise Group's Risk Control Theory

The risk control originated from the American economic crisis of 1929 when enterprise groups began to attach importance to the issues of risk control. At present, risk control has developed into a relatively independent area in the control of enterprise groups, which is of great significance to their survival and development.

(1) The relationship between management and risk control of enterprise group

In business management practices, corporate management and control includes the control of risks that is a higher-level and more comprehensive control activity. With risk control as its integral part, corporate management and control expands and refines it.. Apart from being the integral part and basis of corporate management and control, risk control also serves as an important method for carrying out comprehensive corporate management and control.

(2) The goals of risk control

In the risk control framework, it is necessary to analyze the corresponding risks according to different objectives such that the establishment of objectives has naturally become the first step of the risk control process, and has been determined as part of the risk control framework.

The COSO *Enterprise Risk Management - Integration Framework* pointed out that basic premise of enterprise group risk management is that each entity exists to provide value to its stakeholders. Risk management of enterprise groups enables managers to effectively deal with uncertainty, the risks and the opportunities brought by it, and to enhance their ability to create value. When enterprise group managers strive to achieve the optimal balance between growth, remuneration goals, and associated risks through the formulation of strategies and goals, and maximize the value of resources in the process of pursuing the objectives of the main body, the value can be maximized. .

(3) The subject of risk control

Regardless of theory or practice, risk control organizations do not have a fixed model. Larger enterprise groups, such as global multinational corporations, generally set up specialized risk control departments, whereas small business groups may have only one person to work for risks control in full-time or part-time.

(4) Risk control content

Successful enterprise group can break a comprehensive risk management project down into seven major components, including: Company governance - establish top-down risk management; hierarchical (department) management - business policy adjustments; portfolio management - think and act like a "fund manager"; risk transfer - transfer concentrated or ineffective risk out; risk analysis - develop the advanced analysis tools; data and technical

resources - ability to integrate data and systems; stakeholder management - improve risk transparency for key stakeholders .

(5) Risk control methods

The COSO *Enterprise Risk Management-Integration Framework* pointed out that management authorities choose risk response—avoid, bear, reduce, or share risk—a series of actions to control the risk within the risk tolerance and risk capacity of the subject.

3.3 Study on the Management and Control Mode of State-owned Enterprise Groups

3.3.1 Categories of Group Management and Control Modes

The management and control mode is a standard form and a reference style of management and control. According to strength and breadth of the control over its subsidiaries, management and control mode of the group company can be roughly divided into three categories: financial control mode, operation control mode, and strategic control mode.

3.3.1.1 Financial Control Mode

The financial control mode is largely characterized as a mode of decentralized control, where member companies are mainly managed and evaluated through financial indicators. The group company generally does not interfere with the specific business process of the subsidiaries, who determine their own development strategies while the parent company only increases or decreases the number of stocks according to the development status of the subsidiaries. Under this mode, the group's head office sets asset management as the core method for member companies, compares the operating results of the company's own published budgets and plans with those of its peer companies, and evaluates the financial performance of their operating performance. The financial management and control mode focuses only on the results. The main methods of control are generally financial control, corporate governance, and corporate mergers and acquisitions. This mode can be vividly described as "with concept but without practice"[58].

Hutchison Whampoa Limited is a classic example of financial control mode, employs more than 180,000 people, and operates a number of businesses in 45 countries, from ports and related services, real estate and hotels, retail and manufacturing, energy and infrastructure, to Internet and telecommunications services. The headquarters is mainly responsible for the operation of assets, as a result, not many functional officials at headquarters are primarily financial managers.

3.3.1.2 Operation Control Mode

Business running control mode is also called the operation control mode, the most centralized one among the three control modes, whose greatest feature is the emphasis on process control [59]. The parent company adopting this model has a business management department for it to manage the daily operation of the subordinate enterprises, and the department focuses on the unity and optimization of the management behaviors of member enterprises, the coordinated growth of the company as a whole, and the centralized control and management of the success factors of the industry. This type of control mode is mostly used by companies that engage in natural monopoly operations or large-scale commodity production. The control measures adopted include financial control, marketing or sales control, network or technical control, new business development control, and human resource management control.

In order to ensure that the headquarters can make decisions correctly and solve various problems smoothly, the group adopting the operation control mode will have a large number of staff in a large-scale headquarters. For example, GE adopted this control mode in 1984, as a result, there were more than 2,000 staffs in the headquarters. Until Jack Welch served as CEO, the mode was turned into a strategic control mode, which greatly reduced the number of staff officers at the headquarters. IBM can be said to be a typical example in this respect. In order to ensure the implementation of its global "on demand" strategy, all divisions are centralized by the headquarters and the plan is developed by the headquarters, while the subordinate units are responsible for ensuring implementation. This mode can be vividly described as "the combination of concept and practice".

3.3.1.3 Strategic Control Mode

The strategic control mode falls between the centralized mode and the decentralized mode, and emphasizes program control as its outstanding feature [60]. Under the strategic control mode, in order to ensure the group's overall interests and the maximization of the interests of the subordinate enterprises, the group's headquarters is responsible for the overall strategic planning, financial and asset operations, while all subordinate enterprises must formulate their own strategic plans and propose the corresponding business plans and budget plans which match with the strategic plan. In addition, the headquarters shall be responsible for approving the strategic operation plans of the subordinate enterprises and giving them additional valuable constructive proposals. Meanwhile, the budget approval shall be delivered to the subordinate enterprises for implementation.[61]

In order to ensure the realization of the objectives of the subordinate enterprises and the maximization of the group's overall interests, scale of the group's headquarters is not large, but it mainly focuses on comprehensive balance and comprehensive benefits of the group [62]. Such as balancing resource needs of various companies, coordinating the contradictions among subordinate enterprises, and promoting the "Borderless Corporate Culture", cultivation of senior executives, brand management, and sharing of best exemplary experiences. This mode can be vividly described as "the combination of concept and practice". Typical companies that use this regulatory mode include British Petroleum, Shell Oil, and Philips. At present, most of the world's group companies have adopted or will adopt this control mode.

3.4 The Principles and Environmental Factors that Influence the Selection and Control Mode of the Group

The group's management and control mode is a complex system that includes determining the company's governance structure, dividing the role of the head office and its subsidiaries, ranking the company's employees, selecting the company's organizational structure, determining the group's important resource management and control methods, and establishing a performance management system. The three types of group control modes have their own characteristics. There is no "best governance mode", and there is only a "suitable management mode" for an enterprise group at a certain period of time. When selecting management and control mode, it is necessary for the enterprise group to start from the specific conditions and take comprehensive consideration to determine the most suitable management and control mode. After all, the choice of management and control mode is the balance of "centralization" and "decentralization".

3.4.1 Selection Principle

① Maximize resource sharing and synergies between headquarters and subordinate business units;

② Maintain the balance of interests on the premise of ensuring the maximization of the common interests between the parent company and subordinate business unit;

③ Ensure the smooth and efficient operation of the business process between the headquarters of the group and its subsidiaries;

④ Keep the risk of the group company under control.

3.4.2 Influence Factors

3.4.2.1 External Environmental Factors

The external environment is the soil on which enterprises depend for their survival and development in society, where enterprise is ultimately a subsystem of the whole social system. Therefore, the management and control mode of enterprises is bound to be affected by the external environment. The so-called external environment refers to the external macro variables that an organization faces, such as politics, economy, society, technology, culture and so on. The external environment has a great influence on the selection of the management and control mode of parent-subsidiary Company. One of the important tasks for the selection is to enable enterprises to adapt to the needs of external environment. In general, the external environment can be analyzed from four aspects: politics, economy, society, and technology. For example, different countries have different legal provisions on the establishment and operation of enterprises while different cultural backgrounds lead to different corporate governance structures and business models, and technological progress constantly affects the organizational structure of enterprises and so on.

The uncertainty of the external environment is the most widely concerned when studying the external control of environmental variables. Duncan proposed two dimensions of external environment complexity and dynamics, which comprehensively summarized the overall characteristics of the external environment uncertainty[63]. Based on these two dimensions, the uncertainty of the environment can be divided into four types, see Table 3-4. The complexity of the environment refers to the number of environmental factors associated with the operation of the business and the interaction between these factors. If the external environmental factors that affect the enterprise are many, and each factor has an impact on each other, then the environment is complex; if the external environmental factors that affect the enterprise are less, and relatively independent of each other, then such an environment is relatively simple.

Environmental stability refers to the change of environmental factors in time. If environmental factors do not change or change slowly over a longer period of time, the environment is stable; if environmental factors change rapidly and are unpredictable, then the environment is unstable.

When choosing the control mode of the enterprise group, the external environment of the enterprise under its management must be taken into account. Due to the differences in industry, suppliers, customers and production technologies, the group is in a complex environment with high degree of uncertainty; Some groups are relatively stable, simple and less uncertain. Under the environment with high degree of uncertainty, the group often has opportunities to look for new products and market, at the same time, the organizational

structure of the group needs a higher degree of flexibility, so the group management and control system is suitable to adopt the decentralized management model.

Table 3-4 Categorization of External Factors (Duncan, 1972)

Stability	Simple + Stable = Low uncertainty 1. Low number of external factors 2. Factors remain constant or slow to change	Complex+Stable=Moderate uncertainty 1. A large number of external factors 2. Factors remain constant or slow to change
Uncertainty	Simple + Unstable = Moderate uncertainty 1. Low number of external factors 2.The factors change frequently, unpredictably, and produce reaction	Complex+Unstable = High uncertainty 1. A large number of external factors 2. The factors change frequently, unpredictably, and produce reaction
	Simple	Complex

3.4.2.2 Internal Environmental Factors

The primary task for an enterprise in effective management control is to achieve it through the design and reform of its governance structure, which must be adopted on the basis of a clear understanding of the internal environment of enterprises. Generally speaking, the internal factors affecting corporate governance structure are as follows:

(1) The position of a subsidiary in an enterprise group

For the core business subsidiary with high impact in term of operation condition on the performance of the parent company, relatively centralized management and control mode can be chosen in order to guarantee the parent company to have the power control; For the subsidiary of non-core business, the parent company can relatively weakened its control, so as to give full play to its operational activity and enhance the market reaction capacity.

(2) The stage of enterprise development

In the initial and growing period of the enterprise, the coordination and integration ability of the parent-subsidiary companies are not strong due to imperfect operation mechanism and unsound management system, therefore the use of relatively centralized management and

control can improve the management efficiency of enterprises and the control ability of subsidiaries. As the enterprise scales up and its management ability improves in a stable stage of development, it can adjust to adopt a relative decentralized approach to enhance the operating autonomy of the subsidiary.

(3) Dependence between parent and subsidiary companies

In terms of legal status, the parent-subsidiary companies are independent legal entities, and they are not a relationship of the higher and lower levels of administration. The parent company cannot directly interfere in the daily production and business activities of the subsidiary companies. Regardless of adoption of centralized or decentralized control mode, the parent company should exercise its controls over subsidiary companies through their governance structure, by delegating shares rights on behalf of the intention to carry out the parent company decisions. Therefore, the impact of parent-subsidiary dependencies should be taken into account when determining the control mode for it.

3.4.2.3 Strategic Factors

A.D.Chandler, a famous American management scholar, once put forward the view that "Strategy determines structure, and structure follows strategy". The organizational structure serves the organizational goals, because the establishment of control is ultimately intended to achieve the strategic goals of the group, the basis for establishing the management and control mode is to consider the strategic importance of subsidiaries, and understanding and implementing the strategic intention of the group is the cornerstone of group management and control. In order to achieve effective control, we must first identify the strategic objectives of the group and determine the objectives and direction of the development of the company. The impact of strategy on governance and organizational structures is analyzed as follows:

(1) Select the appropriate governance body according to the strategic planning requirements

The key influence of strategy on governance structure is the determination of appropriate governance body according to the requirements of strategic planning. The quality, ability, character and behavior pattern of the main body of governance should be adapted to the strategy of the group. It is necessary to determine the requirements for the governance body according to the strategic planning, including the concept, ability and behavior of the governance body, which are also the criteria for evaluating governance bodies.

(2) Strategy plays a decisive role in organization structure

Different strategic stages, management strategies, competitive strategies and competitive styles all affect the organizational structure of the group. Research shows that many large companies have gone through four stages of strategic development: Quantitative expansion, under-proliferation, vertical integration, and diversifying operation. Each stage has an appropriate organizational structure. In the strategic stage of quantitative expansion, enterprises expand the number of products or services in a region, corresponding to which, the organizational structure of enterprises is relatively simple, even only one office, performing simple production or sales functions. Enterprises at geographical proliferation strategy stage require the distribution of products or services to other regions for further development. When it comes to the organization structure, it is necessary to organize the offices distributed in different areas in a unified way, and then the problems of coordination, standardization, and specialization occur, which has resulted in a new organizational structure.

(3) Strategic importance of subsidiaries

Strategy determines the organization while organization influences the strategy. The organization structure serves the organizational goals, because the establishment of control is ultimately intended to achieve the strategic goals of the group, the basis for establishing the management and control mode is to consider the strategic importance of subsidiaries, and understanding and implementing the strategic intention of the group is the cornerstone of group management and control. In order to achieve effective control, we must first identify the strategic objectives of the group and determine the objectives and direction of the development of the company.

3.5 Selection and Design of Management and Control Modes

There is no best model for enterprise group management, but only the one that is most appropriate for its development at a specific stage. The essence of management and control is the art of centralization and decentralization. The key is how to balance the relationship between centralization and decentralization. In particular, state-owned groups should avoid falling into a situation of death and chaos. After the introduction to the control mode of the group, its selection principle, and the influencing factors, this thesis considers that the appropriate management and control mode are mainly selected from the following aspects.

3.5.1 Industry Characteristics

The requirements of management control vary with industries of different characteristics. In general, if the business operation is simple, there is no need for member enterprises to make too many customized business decisions or have the basic condition to realize the mode of centralized power control, however, for those industries that require member enterprises to make a large number of customized management decisions, the decentralized control mode should be emphasized.

3.5.2 Development Phase

As enterprises group develop, their needs for the management and control mode evolve. At the initial stage, enterprise groups are often simple manufacturers or sellers, all member companies are in the same business, and the management and control over each member enterprise can be copied to other member enterprises to varying degrees, thus the enterprise groups may consider implementing centralized management and control mode for member enterprises. As they expand, their development is characterized with diversified businesses. Each business has its own characteristics requiring different management and control modes to adapt, therefore, the group cannot implement a closer management and control model for the member enterprises, and decentralization control becomes inevitable. In the same way, relevant diversified groups can find a balance between centralization and decentralization.

3.5.3 Organization Size

The organization size determines the managerial extent and scope of the headquarters. In the initial development stage of the enterprise group, the member enterprises are relatively few, or basically distributed in the same area, in this case, if the enterprise group has enough personnel and ability, it can implement closer centralized control over the member enterprises.

As the enterprise group scales up, more and more affairs need to be managed and coordinated. It will affect the decision-making speed and quality if all decisions are made by the group headquarters, which requires the group headquarters to gradually delegate power and to shift to decentralized control mode. Take Vanke as an example, in initial development stage, Vanke implemented a centralized management and control model, where the investment management and decision-making power were separated, limited expert resources were concentrated at headquarters, and investment, personnel, capital and professional control of subsidiaries were reported to the enterprise group for decision making. However, with its rapid expansion, the sizes of regional subsidiaries were increasing. At the same time, more than 40 projects in more than 20 cities across the country need rapid response. Its reliance on the enterprise group to make decisions could not adapt to the increasingly competitive industry development, thus in 2005, Vanke made a major change in the mode of management and control, from the centralized mode to a decentralized mode.

3.6 Other Factors

In addition to the above three influencing factors, the selection of control mode will also be affected by such factors as leadership style, human resources, corporate culture, etc. As long as we grasp these factors through in-depth analysis, we can find the management and control mode suitable for their own actual situation, and realize the effective management and control of enterprise groups over member enterprises.

While taking into account the various factors mentioned above, we can also consider which group management and control mode is more suitable for our own enterprise from the following aspects: in term of the strategic importance of subordinate enterprises, it is necessary to centralize the management of subordinate enterprises; in term of the group headquarters' control of resources, the group headquarters has the ability to centralize the management of subordinate enterprises; in term of the development stage of subordinate enterprises, the group headquarters should not centralize the management of subordinate enterprises. After careful consideration of these three problems, the group management can also determine the selection of the group management mode.

To sum up, there are many factors that affect the selection of group management and control mode. Usually, these factors do not work alone, but infiltrate and influence each other, so there is not a standard model. Of course, it is possible to learn from the successful enterprise management mode, but we must combine their own actual situation with the external environment, so as to find out the most appropriate management mode.

The design and selection of group management and control mode should not stay at the theoretical level, but form an operable system that can put the management and control mode into practice. Effective selection and implementation of the control model take specific ways and measures as well as a series of supporting organizations, business process optimization, and technical means.

3.7 Conclusion

This chapter mainly introduced three management modes of enterprise groups: financial management and control mode, operation control mode, and strategic control mode. It also analyzed the main factors affecting the selection and control mode of the enterprise group, including internal environmental factors, external environmental factors, and strategic factors; it is also suggested that the enterprise group should select the most suitable management and control model in accordance with the industrial characteristics, the corporate development stage, the organizational scale, and other factors.

The research on relevant theories and enterprise groups in this chapter lays the foundation for the study of the full text.

Chapter 4 The Performance Evaluation of State-owned Enterprises' Employees Based on Super-efficiency DEA Model

In the 21st century, human resources are regarded as the most important driving force for economic development. Tan Shu et al. proved that a very important factor in economic growth is the improvement of human quality. The research results of the World Bank also show that besides advanced equipment and technology, a country or enterprise must also pay attention to the coordination and matching of human resources.[64]

In order to attract, cultivate, and retain the needed talent, a company must establish a complete compensation system and a competition mechanism that stimulate the enthusiasm and creativity of employees, and create a work environment conducive to personal development [65]. After more than 10 years of development, China's state-owned enterprises have gradually established a compensation system that meets their own situations, but there are still many problems, which Zhang Yirong thought mainly are [66]:

(1) The mechanism for market-determined remuneration has not yet been formed, and the inconsistence between the remuneration of employees and the market price still exists. A survey of Ministry of Labor and Social Security in China indicates that most state-owned enterprises have the phenomenon of "one is excessively high, the other is excessively low" in terms of wage level at present, in other words, the salary of employees in general positions is higher than that of the labor market, but wages of employees in key positions such as professional and technical posts and management posts are generally lower than those in the labor market. On the one hand, it is difficult for the company to retain and introduce the talent needed. On the other hand, the "exit" of enterprises is blocked, and they cannot lay off the employees as they want to. The survival of the fittest and the market selection mechanism for the enterprise staff cannot be actually established.

(2) Remuneration cannot fully reflect the relative value of employees within the company. In the state-owned enterprises, the ranks of administrative posts, the levels of educational qualifications and titles, and the length of service play a decisive role in determining wages. However, insufficient understanding of the value and importance of different positions leads to the serious phenomenon of equalitarian "Communal Pot" or promotion according to status, and this has compromised the internal equity of enterprises and the working enthusiasm of employees in important positions.

(3) The salary system is still relatively simple, if employees cannot be promoted to management positions, their wages and bonuses will generally stagnate at a fixed level. The conflict is outstanding especially for enterprises with relatively concentrated professional and technical personnel, and the lack of incentives for professional and technical personnel over a long time has resulted in the loss of the professional and technical backbone after many

years of training, and swayed the stability of the company's professional and technical personnel.

(4) Salary is not fully linked with performance appraisal. Most companies fail to widen the income differences entirely based on the performance of their employees, thus the phenomenon of equalitarian salary is exists. Some companies lack a clear assessment target, or have assessment goals but do not attach importance to the collection of daily assessment information. Performance appraisal is based on the subjective impression of the appraisers, so that the performance appraisal results often deviate greatly from the actual performance of the employees. In the form, the basis for bonus distribution lacks credibility, which affects the incentive effect and reduces employee satisfaction.

In order to solve these problems, enterprises should establish a fair, equitable, and effective evaluation system. As an effective management tool, performance evaluation plays an important role in evaluating and motivating employees, enhancing the vitality and competitiveness of state-owned enterprises, promoting the development of state-owned enterprises, and improving their market position. It is the core of human resource management in state-owned enterprises [67].

The accuracy and rationality of employee performance evaluation depend on whether the designed evaluation index system is scientific and whether the evaluation method is appropriate. Lai Ruixing et al. established a performance evaluation system including 15 items for the workshops and department heads from the four aspects including the annual work experience, work attitude, work ability, and peer and subordinate evaluation[68]; Wang Xiaoshuo established a performance evaluation index system with 13 indicators including understanding ability, coordination ability and team cooperation spirit, and established a fuzzy comprehensive evaluation model for management staff performance[69]. Nie Jingtao et al established an index system that includes salary, research and development ability, work ability, and leadership, and they also established a multi-criteria decision model for employee performance evaluation based on satisfaction[70]; Yang Shaomei established a performance evaluation index system consisting of 11 indicators including work quality, work responsibility, and knowledge application from the aspects of work ability, morality, and knowledge, at the same time, used the analytic hierarchy process to construct a comprehensive evaluation model, and carried out empirical study on the performance of employees in state-owned enterprise[71].

The research of the above scholars has made some contributions to employee performance evaluation. However, some problems in the evaluation of employee performance in state-owned enterprises have not yet been well resolved, such as the lack of clear evaluation criteria and objective metrics, the design of evaluation index is detached from the job responsibilities,

the content of evaluation lacks clear pertinence, and the evaluation results lack guidance to performance improvement. In addition, few evaluation results have been put in application.

Based on the relevant literature, this thesis combines the multi-factor, multi-dimensional, and dynamic characteristics of employee performance in state-owned enterprises and constructs for state-owned enterprise employees a performance evaluation index system with six input indicators and six output indicators. And these indicators comprehensively cover all aspects of employee performance: work performance, work ability, work potential, and work attitude. The system reflects not only work performance of employees, but also the overall quality of employees, and combines long-term incentives with short-term incentives. And the designed evaluation indicators have reflected the idea of combining quantitative analysis and qualitative analysis. In addition, the DEA method, which has been widely used in various fields to solve the relative efficiency evaluation problem, is applied to employee performance evaluation. The established basic DEA model and super-efficiency DEA model for employee performance evaluation can make definite evaluation on the merits of the employee performance without setting weights to evaluation indicators, and provide the direction and extent for performance improvement.

This thesis evaluated the performance of employees in state-owned enterprises from the perspective of enterprises, that is to say, it analyzed whether the output of employees in various aspects matches the input of enterprises after the necessary investment. The evaluation results reflect not only the aspect that the enterprise needs to adjust as an investor, but also the aspect of improvements made by the employee as a subject that accepts input. This research method can not only provide ideas for state-owned enterprises to formulate measures to improve performance management, but also provide a basis for companies to design more reasonable compensation systems.

4.1 Performance Management Process

4.1.1 Concepts of Performance Management

Performance management begins with performance assessment. As early as the 19th century, Robert Owen introduced performance evaluation into Scotland, hence he was regarded as the Father of Personnel Management. Since the 1980s, many scholars have put forward many different viewpoints on the connotation of performance management. Performance management connects individuals with the purpose of the organization for supporting the process of the organization's overall goals. Performance management improves the performance of individuals by tapping into their potential, and improves corporate performance by combining individual goals with enterprise strategy. Michael

Armstrong (1994) argued that performance management is an agreement between an individual and management on goals, standards, and competencies required, a management process based on mutual understanding that enables organizations, groups and individuals to achieve better work outcomes. Performance management is a step-by-step approach to identify, measure and assess the information about the performance level of an individual's work so that the organizational goals can be realized. Since organizations and individuals are inherently inseparable under an established premise, the performance management system can only position the individual behaviors of the organization members on the premise of positioning the organization. Wu Xin believes that performance management refers to achieving the goals of the organization through the continuous open communication process to form the expected benefits and output of the organization's goals and promoting the team and individuals to make actions that are conducive to achieving goals [72].

Based on the above points of view, this thesis argues that performance management is the management of the various elements of the performance realization process, and a management activity based on the corporate strategy. Performance management is a kind of management activity through the establishment of enterprise strategy, goal resolution, performance evaluation, and the use of performance results in daily business management activities to motivate employees to continuously improve their performance and eventually achieve organizational goals and strategies. In the process of performance management, special emphasis should be placed on two-way and continuous communication between managers and employees.

4.1.2 Performance Management Process

Performance management is a complete system, where all aspects of management are not only closely linked, but also in a cyclical process, thus it is a continuous and constantly correcting process. As shown in Figure 4-1.

① Performance plan

The starting point of the performance management process is to determine the target plan and establish the performance standard. The performance target plan is mainly based on the realization of the strategic target.

Performance planning is a two-way communication process in which managers and employees need to reach a consensus on the objectives of employee performance. On the basis of consensus, employees need to make corresponding commitments to their work goals. The common input and participation of managers and employees is the basis for performance management.
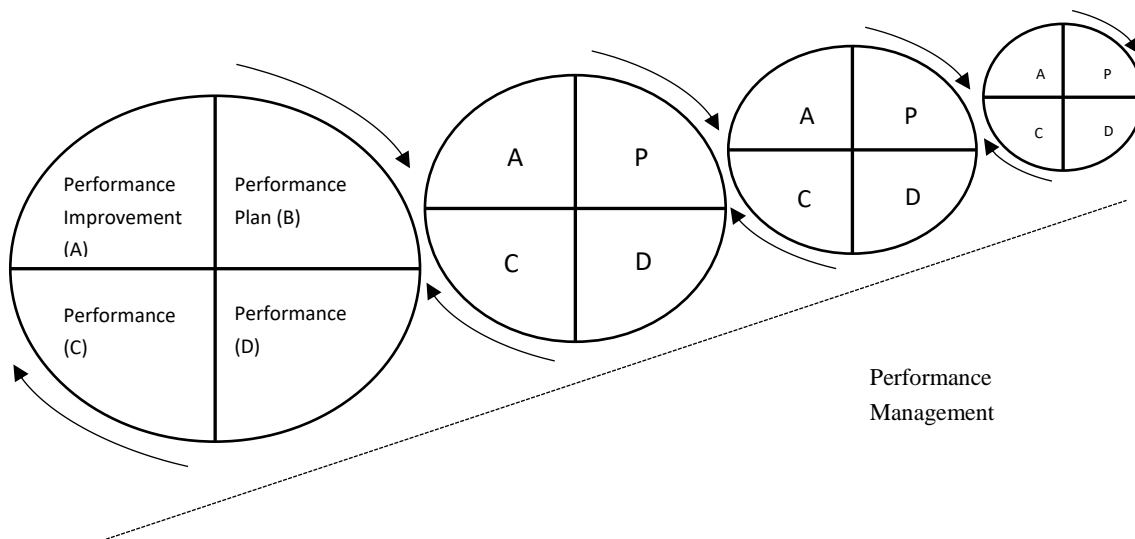
Figure 4-1 Flow Chart of Performance Management

（**Armstrong, 1994**）

② Performance appraisal

Performance appraisal is usually conducted at the end of a certain period when according to the prepared plan, the manager evaluates the achievement of the employee's performance goals. Performance appraisal is based on the agreed performance indicators at the beginning of the performance period.

③ Performance feedback

After employee performance evaluation, managers should have conversations with employees. Feedback information about employee performance during the assessment process will be provided through conversations, so that employees could understand their current performance and what managers expect of them, and recognize the areas to be improved; at the same time, employees can also present their difficulties in achieving performance goals and request guidance and assistance from higher management.

④ Performance improvement

In the communication process for performance feedback, both employees and managers often reach a consensus on the results of the evaluation and the areas that need improvement, and select an area to start the improvement. This means the beginning of a new performance management cycle.

4.1.3 The Practical Significance of Performance Management

(1) Promote management and business process optimization

In performance management, managers at all levels will try to improve the efficiency of handling matters from the perspective of the whole company or a department, and through continuous adjustment of the above four aspects, gradually improve the operational efficiency of the organization so that the management and business processes have been gradually optimized while improving the organizational performance.

(2) Ensure the realization of the organization's strategic goals

The business manager of a well-developed company usually breaks down the company's annual business objectives, assigns to each department and forms the annual performance targets of each department, while the breaking-down of core indicators for each department to each post has become the key performance indicators of each post, thus managers and staff at all levels will fully express their opinions during the formulation of annual business goals. In this way, the overall goals of the company can be broken down, at the same time, employees at all levels participate in the formulation of goals, therefore, it lays a good mass foundation for the realization of the target at all levels and helps the final realization of the organizational goal.

4.2 Construction of the Employee Performance Evaluation System

4.2.1 Purpose of Employee Performance Evaluation

The performance evaluation of employees has always been associated with salary and closely related to the immediate interests of employees while performance evaluation has become the most direct and effective means to arouse the enthusiasm of employees. Performance evaluation shoulders the important mission of reflecting the employees' work performance and determining their salaries. Its rationality directly affects the stability of the company. The most direct purpose of evaluating employee performance is to provide an objective and fair picture of employee performance during the evaluated period.

4.2.2 Content of Employee Performance Evaluation

The content of employee performance evaluation is usually divided into: work performance evaluation, work ability evaluation, and work attitude evaluation. In addition, in order to achieve a certain goal of human resource management, job potential evaluation is also included in the daily performance evaluation system. The above four aspects do not exist

in isolation, they are linked with each other to achieve a specific management purpose and form an overall performance evaluation system. As shown in Figure 4-2.

(1) Work performance evaluation

Work performance is the result of an employee's actual work during a specific period of time. The process of performance evaluation is the process of using pre-established target levels to measure employee job performance results. With such evaluation process, it can not only evaluate the performance of employees at all levels, but also prompt employees at all levels to improve their work in a planned way in order to meet the target requirements.

If isolated from the employees' work, work performance evaluation would be impossible, because the evaluation is based on results of the employee's work or performance. In general, employees' performance is evaluated in terms of quantity, quality, efficiency, and innovation, see Table 4-1.
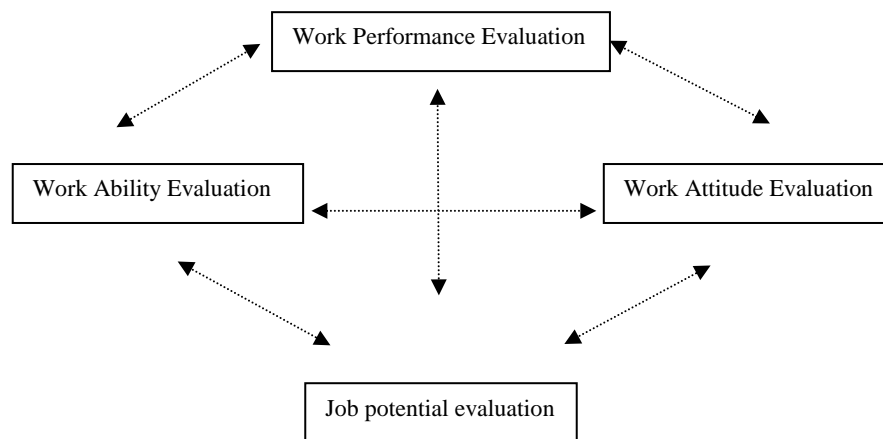
Figure 4-2 Content of Employee Performance

Table 4-1 Dimension Table for Employee's Performance Evaluation

Evaluation Dimension	Definition
Quality	Whether the result of work completion is correct and timely, and whether it is consistent with the planned goal.
Quantity	The workload and progress of the completed task.
Efficiency	The time and expense involved in completing the work.
Innovation	Apply new methods to improve the results of the work undertaken.

Whether for managers or employees, work performance evaluation is very necessary. Corporate managers want to control the business process through performance evaluation and promote employees' efficiency; Employees hope that their work performance can be objectively reflected through evaluation, so that they can improve the work and personal ability constantly.

(2)   Work Ability Evaluation

The work ability evaluation refers to the evaluation of the evaluated employee's ability reflected in the work. For example, when an emergency occurs during work, whether the employee has a high capacity to make an accurate judgment; whether the employee has the ability to coordinate various relationships or not; whether the employee could clearly express the information needed by customers.

Because in some cases, employees may successfully complete their work due to accidental factors. On this occasion, if you only evaluate the work performance of employees, you may make a higher evaluation. The purpose of performance management is to achieve the long-term development goals of the company. Therefore, merely evaluating work performance cannot play an effective role in guiding employees' behaviors for a long time. This requires that performance evaluation should also evaluate the staff's work abilities. In general, employees' work abilities include the following three aspects: first, common sense and professional knowledge; second, the skills; third, work experience.

Compared with work performance evaluation, work ability evaluation is more difficult. Since performance is relatively easy to measure while ability is internalized in employees, it is difficult to quantify and compare so that the evaluation of employees' working ability can be carried out by direct ability assessment, or by some intermediary indicators, see Table 4-2.

Table 4-2 Dimension Table for Employee's Work Ability Evaluation

Evaluation Dimension	Definition
Common sense, professional knowledge	Employees should have the knowledge needed to handle the tasks they undertake, and this dimension is usually measured by the level of academic qualifications.
Skills	Employees have the skills needed to deal with the tasks they undertake. This dimension usually uses the time and content of the training they receive.
Work experience.	The number of years that employees engage in related work.

(3) Job potential evaluation

The potential mentioned here refers to the ability that employees have but have not yet exerted in their work. The job potential evaluation is intended to understand the potential of employees through various means and to find out the reasons for hindering their development so as to better develop the potential of employees and encourage them to transform their potential into practical work capabilities.

The under-performance of employees' working ability may be caused by the following reasons: on the one hand, employees in the enterprise have not got the job opportunities to show themselves. Every employee has strengths, when placed in an unsuitable position, the work performance may be affected. On the other hand, it may be that the superior's guidance or instruction is wrong, which affects the performance of employees' ability. Of course, to enable employees to fully tap the existing capabilities at work, they must also develop necessary capabilities. Otherwise, employees may not be able to perform their full capabilities due to the lack of knowledge or skills in certain areas.

Companies can usually use the following three aspects of information to evaluate the potential of employees: the evaluation results of employees' work ability, the relevant working years, and various qualification certificates. The evaluation of potential should not

be separated from the evaluation of employees' working ability, and the enterprise evaluates the potential of employees through objective and relatively stable conditions such as their working years and relevant qualification certificates, the evaluation cycle of which is generally longer than the daily performance evaluation cycle. The results of employee potential evaluation can provide more objective evidence for various personnel decisions such as job rotation.

(4) Work Attitude Evaluation

As we know, different work attitudes usually produce different work results. Evaluating the work attitude of employees in performance evaluation can encourage employees to create better job performance with a good work attitude. At the same time, it should also be recognized that a good working attitude does not ensure that employees can fully exert their work ability. Therefore, to enable employees to fully exert their work ability, it also needs other human factors and external variables, such as the rationality of work design, the atmosphere of the workplace, and the external environment of the company. The relationship among work attitude, working ability and work performance is shown in Figure 4-3.
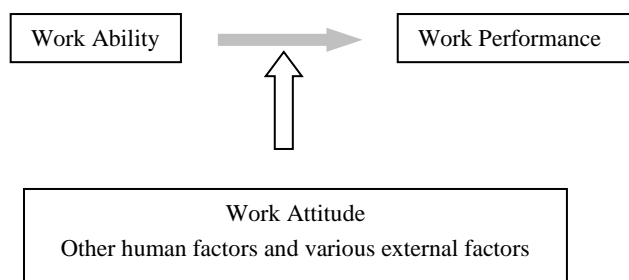
Figure 4-3 The Relationship Chart of Work Attitude, Work Ability and Work Performance

The work attitude of employees plays an extremely important role in transforming their work ability into work performance. Therefore, it is an important means to promote employees' achievement of performance goals by guiding employees to improve their work attitude through evaluation of work attitudes. The assessment of work attitude is usually conducted from the following four dimensions, see Table 4-3.

Table 4-3 Dimension Table for Employee's Work Attitude Evaluation

Evaluation Dimension	Definition
Coordination	Having collective spirit and organizational concepts
Enthusiasm	Actively participating in the improvement of the work program; Putting forward valuable suggestions
Sense of responsibility	responsible for the work and undertaking the responsibilities in the work
Awareness of self-	Efforts to improve self abilities and challenge the higher goals

The evaluation of employees' work attitudes is different from the evaluation of work ability. The attitude evaluation does not consider the rank, or ability of the employees, but only evaluates whether employees work hard and whether they have higher awareness of self-improvement in their work.

4.2.3 Effect of Employee Performance Evaluation Results

(1) Promoting employees' work performance and work ability

The results of performance evaluation can be used to improve employees' work performance and job skills. By finding out employees' difficulties in completing their work and gaps in their work skills, staff development plans and training plans can be formulated accordingly.

(2) Providing the basis for employee bonuses and salary raise

The results of performance evaluation can fairly measure the employees' contributions to the company, and in this way, employees' bonuses and salaries can be adjusted.

(3) Promoting reasonable arrangements of staff positions

The evaluation results of employee performance can explain to a certain extent whether the employees adapt to the existing positions, so that the corresponding personnel changes can be determined according to the degree of employee performance higher or lower than the standards, and the qualified employees can be arranged in suitable positions.

4.2.4 Evaluator's Error in Employee Performance Evaluation

In order to objectively and impartially evaluate the employees' performance, both the evaluator and the evaluated employee must meet higher requirements. For evaluators, they are required to be relatively objective in the evaluation; for the evaluated employees, since their immediate interests will be closely linked with the results of the evaluation, they hope to be evaluated in a more fair manner. However, it is not realistic for the evaluator to be completely objective because the evaluator's personal feelings will play a greater role in the evaluation process and inevitably incorporate some subjective factors; it is also not realistic to design a performance evaluation system that satisfies all employees, because any evaluation system may make some employees feel relatively unfair. In the evaluation process, there will be a variety of evaluator errors which cannot be completely avoided, but can only be reduced by some measures.

    (1)   Halo effect

The American psychologist Thorndike found out from the results of psychological experiments that an evaluator tends to act on a subjective impression when assessing a person so that the evaluation result tends to be higher or lower, and this phenomenon is named halo effect. It shows that in the evaluation process, the evaluator is often influenced by one highly rated indicator of the evaluated person and tends to overestimate other indicators, and vice versa.

    (2)   Logical error

Logical error is the error caused by simple reasoning when the evaluator evaluates some elements with logical relations. The essential difference between the halo effect and the logic error is: The former's error only works among the index characteristics of the same evaluated person, and in performance evaluation, it will appear when evaluated each indicator characteristic of the same person, while the latter has nothing to do with the person being evaluated, and it is generated for the reason that the evaluator thinks that there is a consistent logical relationship between evaluation indicators.

    (3)   Leniency and severity errors

Leniency error refers to the evaluator's unreasonably high evaluation toward the evaluated person. This error may affect the enthusiasm of employees and cause negative feelings of demotivation. The above two errors can be controlled by the following two methods: First, control the distribution of evaluation results, which requires a certain percentage of "excellent", "good", "qualified" and "failed" employees; Another method is to reduce the fuzzy definition of the evaluation indicator itself, so that the evaluator will conduct the evaluation according to a clear rating standard.

(4) Central effect

The central effect means that the evaluator may make evaluations that are neither too good nor too bad for all person evaluated to avoid the extremes of evaluation, and unconsciously, move toward the middle level of all evaluators. Such performance evaluation obviously cannot distinguish the person evaluated. It can neither provide help for the formulation of management decisions nor provide pertinent advice on personnel training.

(5) Recency error

Recency error is also known as recency bias, which means that the evaluator only evaluates the person based on their recent performance. This means that the performance of the evaluated person in the final stage of the evaluation period determines their performance during the whole period, especially when the person evaluated have achieved good results or have made mistakes recently, this will cause the evaluator make too high or too low evaluation.

4.2.5 Control Measures for Evaluator Errors

(1) Train evaluators

Through training, evaluators are made fully aware of the existence of various errors so that they can consciously reduce these errors. At the same time, the evaluators are required to learn through training to consciously collect the factual basis needed in the evaluation process and correct their attitudes.

(2) Clearly define evaluation indicators and standards

With clearly defined performance evaluation indicators and standards, the evaluators can make pertinent evaluations according to definitions of the indicators to be evaluated, so as to avoid compromising the evaluation on overall performance with improper views on a particular inspection of the performance.

(3) Select the appropriate evaluation method.

Each evaluation has pro and con. For example, although the ranking method can effectively reduce the central effect, if the performances of the evaluated are all excellent, the ranking method tends to cause the evaluator to be psychologically unbalanced. Therefore, appropriate evaluation methods should be selected according to the specific conditions such as the evaluation object and the evaluation purpose.

(4) Determine a reasonable evaluation period.

The selection of evaluation period has an important impact on the evaluation results. The evaluation period should not be too long, or too short. Since one of the objectives of employee performance evaluation is to promote the improvement and development of employee work, if the evaluation period is too long, it is neither conducive to finding and correcting problems in a timely manner, and not conducive to the implementation of incentive measures; however, if the evaluation period is too short, the merits and demerits of the evaluated may not be fully demonstrated, which is not conducive to achieving the purpose of evaluation.

4.2.6 Matters Needing Attention in Employee Performance Evaluation

(1) The attention of the top management

Performance evaluation is a work that requires mobilizing all of the company's resources. Without support from top management, performance evaluation will inevitably fail to achieve good results. Therefore, top management should be aware of their important role in the establishment and implementation of employee performance evaluation systems, and give full support to specific executive departments.

(2) Establish an open feedback mechanism

In many companies, employees were initially enthusiastic about performance evaluation, which usually would not last long. The important reason for this situation is that the performance evaluation system has not been established with a feedback mechanism. If employees do not see the significance of performance evaluation, they will not actively participate in the entire process of performance evaluation.

(3) Link performance evaluation results with remuneration

The evaluators and the evaluated of some companies do not attach importance to performance evaluation, merely regarding it as certain formality, the most important reason of which is that the results of performance appraisal do not directly affect the immediate interests of employees. The performance evaluation can only exert its true value when the enterprise has established a link between the results of employee performance and their salaries.

4.3 Employee Performance Evaluation System for State-owned Enterprises

4.3.1 Characteristics of State-owned Enterprises' Employee Performance

The employee performance of state-owned enterprises is characterized with multiple factors, multi-dimensionality, and dynamism. Understanding the factors and characteristics that affect the employee performance of state-owned enterprise has important guiding significance for designing a scientific and reasonable performance evaluation index system.

(1) The multiple causes of employee performance

The performance of employees in state-owned enterprises is the result of their working environment, their own ability level and incentive factors provided by enterprises. Among them, the work environment is an external factor that affects employee performance, which mainly includes the internal environment and the external environment. The internal environment, which consists of internal organizational structure, rules and regulations, corporate culture, employee workplace facilities and equipment, directly affects the performance of employees. The external environment consisting of social economic conditions, market competition intensity, and labor market conditions will have an indirect impact on employee performance. The ability level of employees will directly influence the performance of their duties. The level of ability is related to personal intelligence, education degree, experience and other factors. Meanwhile, the training of employees can also improve their working ability and work performance. Incentives mainly refer to the enthusiasm of the employees' work determined by the internal environment of the company and the work attitude of the employees. Incentives are the psychological basis for ensuring employees to create good performance, which depends on the characteristics of employees' needs, values, etc., among which the demand structure has the greatest impact. Among the various incentive measures, the distribution of salary and bonus and job adjustment that are related to performance are the most direct incentives.

(2) Multiple dimensions of employee performance

Employee performance includes the fulfillment of job responsibilities, the quality and efficiency of work tasks, and many other aspects. As state-owned enterprises in China continue to raise their knowledge levels and knowledge requirements, the overall quality and knowledge level of the employees of state-owned enterprises is developing to a higher level. Under this trend, employee performance reflects multi-dimensional characteristics. Although employees' direct completion of work tasks at their posts constitutes a major aspect of their performance, when measuring employee performance, the work efficiency of employees, communication and collaboration with other colleagues, and the sense of teamwork and cooperation of employees also need to be considered.

(3) The dynamism of employee performance

The dynamism of employee performance is mainly reflected in the fact that performance content changes with the development of state-owned enterprises and the adjustment of employees' work content. With changes in the socio-economic situation, market competition, as well as the internal environment of the state-owned enterprises, the levels of employees' capabilities and incentives taken by companies, employee performance will change accordingly. Therefore, these dynamism should be reflected in designing the index system of employee performance evaluation.

4.3.2 Principles of Constructing Performance Evaluation Indicator System for Employees in State-owned Enterprises

(1) Reflecting work performance and comprehensive quality concurrently

The evaluation index system must not only reflect the work performance of employees, but also reflect their overall quality. There is a complementary relationship between work performance and the overall quality of employees. The overall quality is the basis for employees to create work performance. At the same time, the work performance is a direct reflection of the overall quality of employees in their work. If the comprehensive quality of employees is improved, it will directly promote employees' performance.

(2) Combination of long-term and short-term incentives

One of the purposes for employee performance evaluation is to motivate employees to improve their performance, and the employee performance consists of short-term performance and long-term working ability. The purpose of the so-called short-term incentives is to improve current performance; the purpose of long-term incentives is to improve the overall quality and ability of employees.

(3) Combining qualitative indicators with quantitative indicators

When designing the evaluation index system, qualitative indicators should be combined with quantitative indicators, and quantitative measures should be applied to certain qualitative indicators. The posts of employees in state-owned enterprises can be divided into two categories according to their nature: One category is non-management staff, such as manufacturing workers, office workers, etc.; the other category is management positions, such as employees engaged in planning, finance, strategy and other related work. The former's work performance is easy to quantify and easy to set quantitative indicators; work performance of the latter is difficult to quantify and usually described by using qualitative indicators. However, in order to be able to use quantitative mathematical methods to evaluate

the status of the evaluated subjects reflected by each indicator, it is necessary to quantify the qualitative indicator points in some way.

4.3.3 Employee Performance Evaluation Index System of State-owned Enterprises

(1) Staff performance evaluation index system

Based on the above principles, this thesis designs a performance evaluation index system for state-owned enterprise employees based on the four aspects of employee performance evaluation, work ability evaluation, job potential evaluation, and work attitude evaluation, as shown in Table 4-4.

Table 4-4 Staff Performance Evaluation Index System

Input indicators		Output indicators	
Index names	Expression	Index names	Expression
Wages	I_1	Degree of task completion	O_1
Post level	I_2	Quality of the completed tasks	O_2
Training costs	I_3	Complete efficiency of work task	O_3
Education	I_4	Team awareness and cooperation	O_4
Working years on the current post	I_5	Communication skills	O_5
Work experience.	I_6	Coordination ability	O_6

Among the input indicators, the four indicators including salary level, training cost, current job duration, and work experience are all quantitative indicators while the job level and education level, although belonging to qualitative indicators, they can be easily quantified. Positions in state-owned enterprises can be divided into four levels: The first-line basic level staff, basic level management staff, middle-level management staff, and senior management staff, whose indicator values are set as: 3, 5, 7, and 9. The qualifications of employees can be divided into the following categories according to the educational qualifications of China: junior college graduate, undergraduate, master, and doctor, their indicator values are also set as 3, 5, 7 and 9.

In the output indicators, except for the completion index of the work task, which is a quantitative indicator, the remaining five indicators are qualitative indicators. The same method is used to quantify the five indicators: Each indicator is scored by employees themselves and between employees and superiors. The score range is 1-100, and the final score value of the performance quality of the work task and the completion efficiency of the work task is equal to the weighted value of the evaluation subject score of the three parties with the weight of 10%, 10% and 80%, respectively. The final score values of the team awareness and cooperation spirit, communication ability, and coordination ability index are equal to the weighted value of the tripartite evaluation subject scores of 10%, 40%, and 50%, respectively.

(2)   Instructions for data acquisition of employee performance evaluation indicators

The evaluation values of the specific indicators set in the employee performance evaluation index system will come from different evaluation subjects during the evaluation, and the data used in the models to be built later in this chapter are the comprehensive scores given by the evaluation entities, see Table 4-5.

Table 4-5 Summary of Data Preprocessing for Employee Performance Evaluation Indicators

Evaluation Date _

Name of the evaluated	Evaluation index (input)						Evaluation index (output)					
	I_1	I_2	I_3	I_4	I_5	I_6	O_1	O_2	O_3	O_4	O_5	O_6
1												
2												
3												

Person responsible for data processing:

Input evaluation indicators of the evaluated person in the above table are directly provided by the relevant person in charge of the human resources management department, as shown in Table 4-6.

Table 4-6 Data Table of Employee Performance Evaluation Input Indicators

Name of evaluator	Evaluation index (input)					
	Wages	Post level	Training costs	Educati	Working years on	Work experience
1						
2						
3						
Data provided by:						

Data Instruction:
Corresponding values to all the post levels:
Front-line basic level staff   Basic level management staff Middle level management staff Senior management staff
3   5   7   9
Corresponding values to all the education levels
Junior college   Bachelor's degree   Master's degree   Doctoral degree
3   5   7   9

The final numerical values of the evaluation indicators of the evaluated in Table 4-5 are derived from the evaluation values of the indicators by the employees themselves, between the employees, and by the superiors, as indicated in Table 4-7.

Table 4-17 Data Table of Employee Performance Evaluation Output Indicators

Name of the evaluated person: Evaluation Date										
Evaluator		Evaluation index (output)								
Name	Job title	Degree of work task completion	Weights	Quality of work task completion	Efficiency of work task completion	Weights	Team awareness and cooperation	Communication skills	Coordination ability	Weights
1	(superior)		100%			80%				50%
2	(self)	—	—			10%				10%
3	(Employees at the same level)					10%				40%
Weighted rating										
Data processed by										
Data instruction:										
1. The scores of the six indicators are all between 1 and 100; The degree of the work task completion is directly determined by the superior.										

(3) The performance evaluation index system constructed in this paper for employees of state-owned enterprise has the following characteristics: On the one hand, the evaluation system covers all aspects of employee performance, including work performance, work ability, job potential, and work attitude. All aspects have set corresponding indicators for evaluation so as to provide a more comprehensive reflection of employees' performance over a certain period. On the other hand, in order to reflect the matching evaluation of investment and output in employee performance evaluation, it not only sets indicators reflecting the input of enterprises and employees themselves, but also sets indicators reflecting the output of employees, which provides a clear direction for enterprises to improve their management and employees to improve themselves.

4.3.4 Process Design for Employee Performance Evaluation of State-owned Enterprises

(1) Evaluation period

The evaluation period of employee performance of state-owned enterprises runs from the beginning to the end of each fiscal year. Evaluation work begins at the end of the previous fiscal year and ends within the first month of the new fiscal year.

(2) Evaluation department

The employee performance evaluation in state-owned enterprises needs the participation and cooperation of all departments and employees. Since the employee performance evaluation results will be linked to the salary of each employee, the Department of Human Resource Management in the enterprise shall be responsible for organizing the annual employee performance evaluation.

(3) Evaluation process design

The employee performance evaluation in state-owned enterprises can be completed according to the process shown in Figure 4-4.

4.4 Introduction to Evaluation Models

Data Envelopment Analysis (DEA) was originally developed by A. Chames, W.W. Cooper and E. Rhodes in 1978. It is an approach using linear programming techniques to conduct effective evaluation on relative efficiencies of homogeneous economies of multi-indicator inputs and multi-indicator outputs. The basic idea is: Each evaluation object is regarded as a decision-making unit (DMU), a number of DMUs constitute evaluation groups. The evaluation and calculation are performed by setting the weights of the input and output indicators as variables to determine the effective production frontier, and whether DMU is DEA effective is determined by the distance between each DMU and effective production frontier, and the reasons for non-DEA effective or DEA weak efficiency as well as the direction and degree of improvement can be pointed out. The advantage of this method is that it can evaluate different dimension indicators, without artificially determining the weight of each indicator, and it has a strong objectivity. But there are also obvious drawbacks: When multiple DMUs have relative efficiency, they cannot be re-sequenced. In response to this defect, Anderson et al. made improvements to the basic model, and in 1993, proposed a super-efficiency DEA model. The basic idea is: when evaluating the k_0 DMU, the input and output indicators of the DMU are replaced by a linear combination of input and output indicators of all other DMUs so that the DMU is excluded while the DMU is included in DEA basic model. Therefore, effective sequencing of evaluation objects can be achieved.

| Human resources management department organizes employee performance | The end of last fiscal |

Data collection

| Some of the index values of the evaluated person are directly provided by the | The score provided by the superior leader on the evaluated person's | The score provided by the evaluated person themselves on their own | The score provided by the peer on the evaluated person's corresponding index |

Organize and summarize

Final evaluation value of each indicator for employee performance

Use the model to implement the evaluation

Performance evaluation results of each employee

Feedback of evaluation

Formulate performance management improvement plan

At the end of the first month of the current fiscal year

Figure 4-4 Flow Chart of Employee Performance Evaluation in State-owned Enterprises

4.4.1 DEA Basic Model

There are n DMUs of the same type, that is, each DMU has s types of inputs and t types of outputs. x_{ir} represents the input of the i-th input index of the r-th DMU and y_{jr} represents the output of the j-th output index of the r-th DMU. The efficiency calculation of the k-th DMU can be transformed into the following linear programming:

$$s.i. \begin{cases} \min\theta \\ \sum_{r=1}^{n} \lambda_r x_{ir} + s_i^- = \theta x_{ik} \\ \sum_{r=1}^{n} \lambda_r y_{ir} - s_j^+ = \theta y_{ik} \\ S_j^- \geq 0, S_j^+ \geq 0, \lambda_r \geq 0 \end{cases} \quad \dots\dots\dots\dots\dots\dots\dots (1)$$

Where, S_i^-, S_j^+ are slack variables. θ is the efficiency value of the k-th DMU that satisfies $0 \leq \theta \leq 1$.

When , the k-th DMU has DEA efficiency, indicating that the DMU has both technical efficiency and scale efficiency. From a technical point of view, in the operation process of

DMU, the resources have been fully utilized, all inputs have reached the best combination, and the best output effect has been achieved. The scale efficiency means that the operation of DMU is in the best state of returns to scale.

When θ^k=1, there is at least one S_i^{-k}>0, (i=1, 2,…s), or at least one S_j^{-k}>0, (j=1, 2,…t) , then the DMU is weak DEA efficiency. If S_i^{-k}>0, that is to say S_i^{-k} of inputs of the i-th input index are not fully utilized; If S_j^{+k}>0, that is to say there is a difference of S_j^{+k} between the j-th index input and the maximum output. Therefore, at this time, the operating activities of the DMU do not have technical efficiency and scale efficiency at the same time.

When θ^k<1 , DMU is not DEA effective, namely, the operation activities of DMU are neither technical effective nor scale effective.

4.4.2 Super-efficiency DEA Model

When the kth DMU efficiency is calculated, the problem can be transformed into the following linear programming:

$$
s.i. \begin{cases} \min\theta \\ \sum_{r=1,r\neq k}^{n} \lambda_r x_{ir} + s_i^- = \theta x_{ik} \\ \sum_{r=1,r\neq k}^{n} \lambda_r y_{ir} - s_j^+ = \theta y_{ik} \quad \cdots\cdots\cdots\cdots\cdots\cdots..(2) \\ S_j^- \geq 0, S_j^+ \geq 0, \lambda_r \geq 0 \end{cases}
$$

In this model, the maximum proportional value of a DMU that increases its input and maintains relative efficiency, is called the super-efficiency value of the DMU, which is also used to distinguish the efficiency of the relatively effective DMU. The super efficiency value may be greater than 1. The efficiency value of the invalid DMU in the super-efficiency DEA model is the same as the efficiency value of the ineffective DMU in the DEA basic model.

4.4.3 Advantages of Using the DEA Model to Evaluate Employee Performance

Using the DEA model to evaluate employee performance has the following advantages. First, it does not require artificially setting the weight of performance evaluation indicators, so that the influence of subjective factors on the evaluation result is effectively reduced and the objectivity of the evaluation result is guaranteed. Second, according to the effective production frontier of the solution results, the direction and degree of improvement of the evaluation object can be obtained, which provides a basis for enterprises to formulate measures to improve employee performance; Third, the use of the super-efficient DEA model overcomes the deficiencies in which multiple relatively effective evaluation units cannot be further distinguished, thus, a clear division can be made on the performance of employees, which is conducive to the design of a reasonable merit-based pay scheme.

4.5 Application of Super Efficiency DEA Model in Employee Performance Evaluation in LH Energy Group

To illustrate the application of the DEA model to the employee performance evaluation in state-owned enterprises, this section intends to evaluate the performance of 16 employees in a division of A Limited Company, one of the wholly owned subsidiaries of the LH Energy Group.

4.5.1 Establish Index System

Based on the above-designed index system, the evaluation results of self-assessment, peer review, and superior evaluation of employees in the department are integrated to obtain the evaluation values of the corresponding indicators of 16 employees, as indicated in Table 4-8.

Table 4-8 Performance Evaluation Indexes of 16 Employees in a Department

Staff/Index	Assessment Index (Inputs)						Assessment Index (Outputs)					
	I_1	I_2	I_3	I_4	I_5	I_6	Q_1	Q_2	Q_3	Q_4	Q_5	Q_6
1	2903	3	600	5	3	3	100	79	84	96	68	87
2	4667	5	2400	5	8	9	70	94	88	76	90	99
3	1918	3	1900	3	2	2	96	64	69	91	85	69
4	5992	7	2900	5	4	9	75	97	83	82	91	95
5	4417	7	1700	5	6	10	76	93	90	97	83	80
6	6174	5	800	7	8	8	90	69	67	93	97	74
7	7292	7	700	9	3	3	97	74	81	95	69	95
8	2524	3	600	3	4	6	98	91	84	92	87	94
9	1895	3	500	3	1	2	74	91	62	83	70	77
10	5012	5	2700	7	9	9	87	79	85	93	94	82
11	3683	3	600	5	3	4	96	72	60	92	83	62
12	2316	3	500	3	7	7	94	95	68	87	66	61
13	5211	7	1200	5	5	5	95	80	89	97	88	84
14	6782	9	2200	5	12	14	95	92	70	89	82	75
15	6028	7	2600	9	7	7	94	70	92	96	89	76
16	7691	9	1700	7	4	5	90	82	86	87	64	95

4.5.2 Modeling and Solving

According to formula (1) and (2) in 4.4, the basic DEA evaluation model and super-efficiency DEA evaluation model of the employee performance of the department are established, respectively. This thesis uses software DEA-Solver and EMS to solve the above models, respectively. The results are shown in Table 4-9, Figure 4-5, and Table 4-10.

Table 4-29 Results Obtained from DEA Basic Model for Employee Performance Evaluation

DMU	Score	11 S-(1)	12 S-(2)	13 S-(3)	14 S-(4)	15 S-(5)	16 S-(6)	O1 S+(1)	O2 S+(2)	O3 S+(3)	O4 S+(4)	O5 S+(5)	O6 S+(6)
1	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
2	0.6519	402	0	865	0	1	0	34	4	0	23	2	0
3	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
4	0.6895	1645	1	1161	0	0	2	25	3	0	19	0	1
5	0.6661	233	1	481	0	0	1	29	8	0	4	11	22
6	0.8362	2349	1	0	3	2	0	19	32	27	10	0	31
7	0.9037	4003	3	0	4	1	0	0	32	0	9	15	1
8	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
9	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
10	0.6505	622	0	894	1	2	0	19	15	4	7	0	16
11	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
12	1.0000	0	0	0	0	0	0	0	0	0	0	0	0
13	0.7798	1392	2	0	0	1	0	13	33	0	15	11	20
14	0.6003	1596	2	744	0	2	2	2	0	10	2	0	11
15	0.5097	187	0	0	0	0	0	22	19	0	15	3	20
16	0.5767	1850	1	0	0	1	0	15	35	0	27	34	8
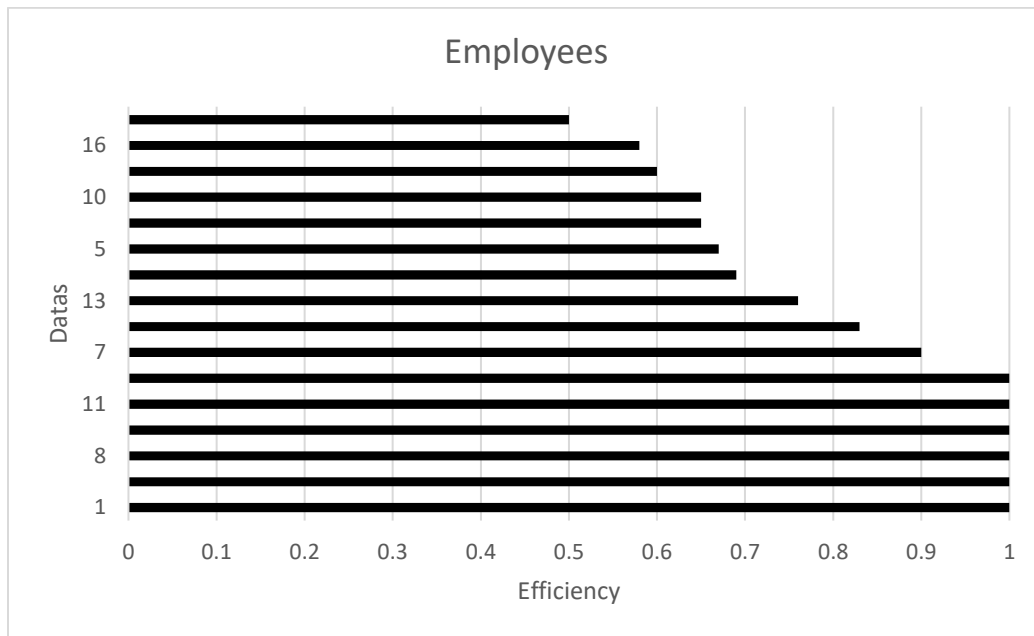
Figure 4-15 Employee Performance Evaluation Results

Table 4-10 Results Obtained from Super-efficiency DEA Mode for Employee Performance Evaluation

DMU	Score
1	123.76%
3	129.73%
8	130.81%
9	318.18%
11	106.65%
12	118.35%

When using the super-efficiency DEA model for evaluation, the score of the weak DEA effective decision-making unit does not change, so only the evaluation results of the six DEA effective decision-making units under the model are listed here.

4.5.3 Analysis of Evaluation Results

According to the scores of the evaluation units and the values of the slack variables shown in Table 4-9, it can be estimated that : Among the 16 employees, the performance evaluation results of 6 employees are DEA efficient, that is, the input for these employees achieves the best combination and the output is in the best condition, and the 6 employees are employee 1, 3, 8 ,9, 11, and 12; The performance evaluation results of the remaining 10 employees are all non-DEA efficient, that is, the inputs in these employees have not reached the optimal combination and their outputs have not reached the best status. The 10 employees are ranked 7,6,13,4,5,2,10,14,16,15 according to their performance from good to bad. At the same time, the direction and degree of employee performance improvement can be derived, which to a certain extent, provides managers with reference for appropriate management measures. For example, through numerical analysis of the slack variables in employee 2's performance evaluation results, it can be concluded that the employee did not make good use of the company's input in salary, training, and work experience, thus the employee's completion degree of work tasks, work quality, team spirit, cooperative spirit and communication skills need to be improved. Obviously, the DEA basic model cannot be used to further evaluate 6 employees who are DEA efficient.

As the evaluation results shown in Table 4-10, the application of the super-efficiency DEA model solves the problem that the effective evaluation unit of DEA cannot be further distinguished. From the scores, it can be concluded that the performance of the 6 employees with DEA efficiency from good to poor is 9, 8, 3, 1, 12 and 11.

4.6. Performance Evaluation and Optimization of Various Sectoral Enterprises of the State-owned Enterprise Group

4.6.1 Selection of Evaluation and Optimization Methods

In order to solve the performance evaluation and optimization of various sectoral enterprises of state-owned group, a powerful mathematical model and method is required to quantitatively analyze it, while the Data Envelopment Analysis (DEA) is a very suitable method for such purpose.

As an excellent model with characteristics of fewer indicators, high sensitivity and high reliability, DEA model has been favored and adopted by more and more experts and scholars and since it was put forward in 1978 (such as Charnes and Cooper 1985; Seiford and Thrall,1990). Moreover, it has absorbed the core competence theory in other disciplines such as econometrics and advanced mathematical statistics to perfect its own model, and through

the establishment of "production frontier", compared the returns to scale and relative efficiency of each decision so as to determine the optimization of overall efficiency.

Recent research advances in the study of DEA models were the publications of three articles in September 2004 by Gattoufi in the Journal of the Operational Research Society, Socio-Economic Planning Sciences magazines, which are about the latest investigation on DEA research. Gattuofi and others set forth the publication and scope expansion of DEA articles and magazines from 1978 to 2001, and found that the numbers of DEA articles and magazines had been increasing year by year, and the number of countries and regions applicable to DEA had also been increasing year by year. This was particularly true between 1999 and 2001. It can be seen that as an excellent research planning model for decision-making efficiency, DEA model had been given more and more attention and its application field had been gradually expanding with the passage of time.

As an excellent evaluation tool, DEA only need to determine the clear input and output, and the efficiency comparison of each evaluation unit can be obtained. It is very convenient for its users, but at the same time we should also note: In practical operation, DEA is often limited due to its assumed rigidity, and for these defects, we should develop and extend various DEA models such as C^2R, BC^2, FG and ST models, in addition to confidence region model and super-efficiency DEA model. However, the DEA models used in China are limited to 10 or so models such as CCR, BCCs, cost efficiency and Malmquist index. In fact, the DEA models have reached more than 140 types. The space for DEA applications is still vast. It is also very important to introduce new innovative theories into Data Envelopment Analysis (DEA). We are delighted to see that many experts and scholars are devoting themselves to the research in this field, and are looking for new and effective theories and methods of performance evaluation techniques. In practice, we can comprehensively apply data envelopment analysis and other methods to solve different specific problems, and establish a synthetic evaluation and evaluation optimization model based on practical problems, which can advance the theory of data envelope analysis and at the same time plays an extremely important role in its development and theoretical innovation, and will surely bring about high practical value.

4.6.2 Research on DEA Modeling

4.6.2.1 Overview of Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a non-parametric frontier efficiency analysis method developed by A. Charnes and W.W. Cooper on the basis of "relative efficiency evaluation". This method is often applied to the management and evaluation of production and life,

efficiency and decision-making among corporate departments. The data envelopment analysis is used to estimate the effective production frontier on the basis of a set of input-output observations. It can be used to determine whether the corresponding point of the evaluated decision unit is on the frontier of the production possibility set (production frontier). Therefore, DEA method can be used to study the relative efficiency evaluation of various schemes, and currently has become an effective analysis tool in the fields of management science and systems engineering. It evaluates a group of "sectors" or "units" with multiple inputs and outputs (called Decision Making Unit (DMU), which is mainly realized through mathematical programming. A large number of DMUs are used to form evaluation sets, analyze and compare the relative efficiency, and based on the observed data of DMUs, whether each DMU is DEA efficiency is determined so as to determine the "effective production frontier". According to the distance between each DMU and the efficient production frontier, the DEA efficiency of DMUs is determined, besides, projection method can be used to point out the direction and extent of the reasons for non-DEA effective or weak DEA efficient of DMU.

Generally speaking, the data envelopment analysis is suitable for synthetic evaluation of multi-output and multi-input efficiency. It can give a definite evaluation of efficiency by calculating the effective value of each evaluation unit with mathematical programming model based on the input-output data and evaluating whether it is DEA efficiency or weak DEA efficiency. It has the absolute advantage in dealing with the effectiveness evaluation of multi-output and multi-input.

Because DEA characteristically does not need any weight hypothesis, compared with other decision prioritizing methods such as Analytic Hierarchy Process or Delphi that would require construction of judgment matrix or assumption of weights, it avoids the interference of subjective factors and effectively simplifies the calculation and reduces the errors, which has become the biggest advantage of data envelopment analysis. In addition, because it is not dimensionally considered, its application in practical production and life and decision analysis is very wide and convenient, and we can also use DEA projection method to give reasons for non DEA efficiency or weak DEA efficiency and the direction and the extent of improvement. It has very clear economic management significance and provides clear management information for the competent authorities of enterprises.

The DEA method does not synthesize the data directly, so the optimal efficiency index of the decision making unit is independent of the dimension selection of the input index value and the output index value. It is not necessary to do dimensionless processing (of course, it can be done) before modeling with DEA method. When the magnitude order of each of

input and output indicators is large, we can usually standardize the evaluation indicator for the convenience of programming solution.

With its fewer indicators, high sensitivity and reliability, the decision method of Data Envelopment Analysis (DEA) can be used to analyze the indicators which cannot be priced or whose weight cannot be easily determined. And each indicator to be measured can appear in its original form, does not need to unify the units, greatly simplifies the measurement process, guarantees the integrity of the original information, and avoids the subjective influence of the artificial determination of the weight. The DEA can comprehensively evaluate the relative efficiency of the same type of units with multi-indicator input and multi-indicator output, and does not need any functional hypothesis between variables. It is especially suitable for the evaluation and comparison between units of the same nature (Athanassopoulos and Giokas 1997: Athnaassopoulos and KkarZais 1997: Athnaassopoulos and My lono Poulus, 1997). These advantages have allowed DEA method to be widely used in all kinds of organizations, individuals, enterprises and institutions. These areas of application include education, health care, banking, life insurance, the military, auditing, market research, retail trade, organizational effectiveness, transport, housing rental and manufacturing, etc.The industries involved relate to all aspects of the national economy and people's livelihood. At present, its application fields are still expanding.

4.6.2.2 Establishment of DEA Model

Description of the problem solved by Data Envelopment Analysis: There are n departments or units, called n evaluation units, and each evaluation unit has m kinds of "inputs" (indicating the department's consumption of "resources") and P kinds of "outputs" (indicating the amount of effective information after the department consumes "resources"), which are denoted with different economic indicators. Thus, an evaluation system with multiple indicator inputs and multiple indicator outputs for n evaluation units is constituted, as shown in Figure 4-6: $DMU_j(j=1,2,...,n)$

$$v_1 \quad 1$$
$$v_2 \quad 2$$
（Input）
$$\vdots \quad \vdots$$
$$v_n \quad m$$

$$
\begin{matrix}
x_{11} & x_{12} & \dots & x_{1n} \\
x_{21} & x_{22} & \dots & x_{2n} \\
\vdots & \vdots & & \vdots \\
x_{m1} & x_{m2} & \dots & x_{mn}
\end{matrix}
$$

$$
\begin{matrix}
y_{11} & y_{12} & \dots & y_{1n} \\
y_{21} & y_{22} & \dots & y_{2n} \\
\vdots & \vdots & & \\
y_{m1} & y_{m2} & \dots & y_{pn}
\end{matrix}
$$

$$1 \quad u_1$$
$$2 \quad u_2$$
（Output）
$$\vdots \quad \vdots \quad \vdots$$
$$p \quad u_p$$
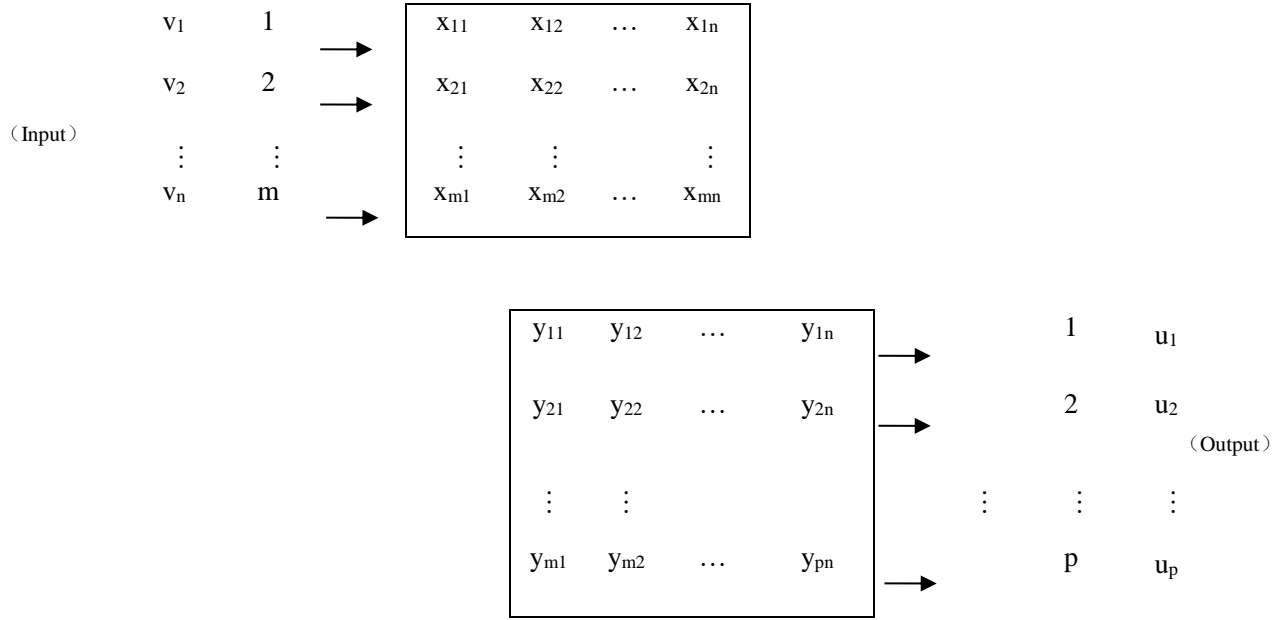
Figure 4-6 Evaluation System for n Evaluation Units

Where:

x_{ij} denotes the *i*-th input index of the evaluation unit, DMU$_j$, $x_{ij} > 0$

y_{rj} denotes the *r*-th input index of the evaluation unit, DMU$_j$, $y_{rj} > 0$.

v_i denotes the weight coefficient of the *i*-th input index, $v_i \geq 0$;

① Determination of the DMU of *N* similar evaluation units.

The determination of evaluation unit DMU is the first step to solve the decision problem with DEA method. We should note that when selecting DMU, we should select homogeneous units, that is, the selected departments and industries have the same nature as the overall evaluation objectives, and roughly equal degree of influence. At the same time, the input and output indicators of each selected department must be the same, otherwise the DEA cannot be calculated. Comparative evaluation between sectors with equal conditions and equal status. In the practical process, we can use the knowledge of other disciplines to classify and evaluate, such as clustering analysis in statistics for grouping judgment and evaluation.

② Selection of input-output indicators

As the DEA method does not have strict requirements for input and output price information, the weights of input and output variables are generated with mathematical planning on the basis of sample data, independent of human subjective factors. Therefore, it is suitable for evaluating the production efficiency of decision-making units with multiple inputs and outputs. Scientifically and rationally selecting input and output indicators is very important for the effective use of the DEA model. According to the basic variables of the function, the input-output indicators of different industries should be selected and measured from different directions and perspectives. However, in practical operation, we should pay attention to many problems in selecting input-output indicators, such as the data authenticity, reliability, availability, and the impact of the index data on the overall objective decision. In view of this, we should learn from the knowledge of other disciplines, such as hypothesis testing in statistics to help us identify the effectiveness of indicator selection and so on.

③ Selection of the model type (commonly used $C^2 R, BC^2$)

In actual process of multi-sector decision-making and development model optimization, DEA has various kinds of models such as C^2R, BC^2, FG and ST to address different aspects and different directions of problems. In actual practice, we usually involve C^2R and BC^2.

C^2R model:

v_i represents the weight coefficients of the i-th input-index $v_i \geq 0 (i=1,2,...,m)$, u_r represents the weight coefficients of the r-th output-index, $u_r \geq 0 (r=1,2,...,p)$, x_{ij} and y_{rj} represent the component weights of $x = (x_{1j}, x_{2j},..., x_{mj})^T$ and $y = (y_{1j}, y_{2j},..., y_{rj})^T$. We can get the data such as historical data and statistical data with various methods, but they must satisfy the prerequisite of accuracy. v_j and u_r are index weight coefficients. In the evaluation system shown above, assume the weight coefficient vectors of input index and output index are $v = (v_1, v_2,..., v_m)^T$ and $u = (u_1, u_2,..., u_p)^T$ respectively. For evaluation unit DMU, its efficiency evaluation index is

$$h_j = \frac{\sum_{r=1}^{p} u_r y_{rj}}{\sum_{i=1}^{m} v_i y_{ij}} (j=1,...,n)$$

We would like to know the effectiveness of an evaluation unit in all evaluation units, that is, whether the efficiency of this evaluation unit is "optimal" compared to other DMUs? We set up a model to evaluate it.

The most basic C^{2}R model is:

$$
P = \begin{cases}
\max h_0 = \dfrac{\displaystyle\sum_{r=1}^{p} u_r y_{rj_0}}{\displaystyle\sum_{i-1}^{p} u_i y_{ij_0}} \\[4ex]
s.t. \dfrac{\displaystyle\sum_{r=1}^{p} u_r y_{rj}}{\displaystyle\sum_{i-1}^{p} u_i y_{ij}} \leq 1(\mathrm{j}=1,2,...,\mathrm{n}) \\[4ex]
v_i, u_r \geq 0(\mathrm{i}=1,2,...,m; r=1,2,...,\mathrm{p})
\end{cases}
$$

Matrix form: $P = \begin{cases}
\max h_0 = \dfrac{u^T y_0}{v^T x_0} \\[3ex]
s.t. \dfrac{u^T y_j}{v^T x_j} \leq 1(\mathrm{j}=1,2,...,\mathrm{n}) \\[3ex]
v \geq 0, u \geq 0
\end{cases}$

Among them, we can see: Efficiency $h_1 = \dfrac{Input}{Output} = \dfrac{u^T Y_1}{v^T X_1} = \dfrac{\displaystyle\sum_{r=1}^{p} u_r y_{rj}}{\displaystyle\sum_{i=1}^{m} v_i y_{ij}}(\mathrm{j}=1,...,\mathrm{n})$, u_r is a

measure, or weight, of the *r*-th type of output. C^{2}R model is the most basic DEA model, and in evaluating any evaluation unit, it is actually carried out relative to other evaluation units, so the DEA efficiency evaluation performed with this model is an evaluation of relative efficiency.

Since it is a fractional programming, we can use the Charnes-Cooper transformation.

Make: $t = 1/(v^T x_0), \omega = tv, \mu = tu$

Transform the model into a linear programming problem for convenient solution.

Because the C²R model obtained is a linear programming model, the dual model can be used to solve the problem conveniently. The relaxation variables s^+ and s^- are introduced, and then make $-\lambda_j^T = \lambda_j$, they can be transformed into :

$$D_\varepsilon = \begin{cases} \min V_D = \theta \\ s.t. \\ \sum_{j=1}^{n} x_j \lambda_j + s^- = \theta x_0 \\ \sum_{j=1}^{n} x_j \lambda_j - s^+ = \theta x_0 \\ \lambda_j \geq 0 (j=1,...,n) \\ s^-, s^+ \geq 0 \end{cases}$$

where relaxation variables $s^- = (s_1^-, s_2^-, ..., s_m^-)^T; s^+ = (s_1^+, s_2^+, ..., s_p^+)^T$

The difficulty of P model and D model in judging DEA efficiency is to find the optimal solution of the above mentioned conditions. In order to solve this problem, the C²R model of non-Archimedes infinitesimal ε is introduced, which is improved by perturbation method.

$$D_\varepsilon = \begin{cases} \min[\theta - \varepsilon(\hat{e}^T s^- + \hat{e}^T s^+)] = V_D(\varepsilon) \\ s.t. \\ \sum_{j=1}^{n} y_j \lambda_j + s^- = \theta x_0 \\ \sum_{j=1}^{n} y_j \lambda_j - s^+ = y_0 \\ \lambda_j \geq 0 (j=1,...,n) \\ s^- \geq 0, s^+ \geq 0 \end{cases}$$

This is the C²R model in the standard DEA evaluation system that we use in the actual operation. In the actual operation, we can calculate with it, and obtain the effectiveness of each evaluation unit.

④ For each evaluation unit, the corresponding model is solved, and the validity evaluation value is obtained.

We have obtained the dual model of C²R linear programming model, and added the relaxation variables s^+ and s^-, so we can easily get the solution by linear programming. In the practical operation, the solution we will use is s^+ and s^- through the results of these variables,

we can analyze the effectiveness of DMU of each evaluation unit, that is, analyze the efficiency of each evaluation unit. θ

Under the model:

Weak DEA efficiency: If the optimal solution of the linear programming problem satisfies: $V_D=1$, then the evaluation unit DMU is weak DEA efficiency.

DEA efficiency: If the optimal solution of the linear programming problem satisfies: $V_D=1$, and each of its optimal solution, satisfies $S^+ = S^- = 0$, then the evaluation unit DMU is DEA efficiency. At the same time, we should note that in the actual calculation, it is difficult to find an effective solution.

⑤ Analyze its economic and management significance and make adjustments

DEA model has a wide range of applications and significance in actual production and life. It estimates the possible set T according to the reference set of input and output quantities, and determines which decision activities of the decision making units are relatively effective. That is, how to maintain the same output and reduce the input quantity in the same proportion. If the input load cannot be reduced in the same proportion, that is, the optimal solution of (D) satisfies : $V_D=1$, then it is an effective production and living activity.

Analysis of scale returns: The so-called scale returns refer to the ratio of the relative percentage of the output increment to the relative percentage of the input increment. In the actual operation, our judgment method is:

When $\dfrac{\sum\limits_{j=1}^{n} \lambda_j^0}{\theta^0} = 1$, DMU$_{j0}$ is the return on scale that remains unchanged;

When $\dfrac{\sum\limits_{j=1}^{n} \lambda_j^0}{\theta^0} < 1$, DMU$_{j0}$ is the scale return that increases proportionally;

When $\dfrac{\sum\limits_{j=1}^{n} \lambda_j^0}{\theta^0} > 1$, DMU$_{j0}$ is the scale returns are diminishing proportionally;

Optimize the DEA decision results with the projection principle:

According to the "projection principle", when comparing and optimizing the efficiency among different sectors, $(\hat{x}_0, \hat{y}_0)$, the projection of (x_0, y_0) corresponding to the decision making unit, where $\hat{x}_0 = \theta^0 x_0 - s^{0-}$, $\hat{y}_0 = \theta^0 y_0 - s^{0+}$ actually constitutes a new DEA

decision making unit, and the decision making unit is on the production frontier. In other words, $(\hat{x}_0, \hat{y}_0)$, as an efficient DEA efficiency a decision making unit can obtain, theoretically, it gives the optimizable theoretical range (x_0, y_0) to be optimized to $(\hat{x}_0, \hat{y}_0)$. The optimizable range of inputs and outputs. The adjustment value of input x_j is $\theta_{x_j} - s^-$, and the adjustment value of y_j is $\theta_{y_j} - s^+$. Based on this, we can calculate the optimization value quantitatively.

Although DEA model has the characteristics of wide range of use, few indices, high sensitivity and reliability, in the practical application, we should pay attention to the following matters:

First, when we determine the DMU, we should ensure the homogeneity of the selected evaluation objects, that is, the selected department should have the same input-output indices, and the selected department or industry, is of the same nature relative to the overall evaluation objective, and the degree of influence is roughly equal.

Second, although DEA model can provide efficiency comparison and optimization among different departments, for the departments with same $\theta = 1$, that is, the departments of same DEA efficiency, it is impossible to give its accurate comparison. Its specific comparison method will be studied in the later research process.

4.6.3 Application of DEA Method in Evaluation Optimization of Subsidiaries or Affiliated Enterprises

4.6.3.1 The Main Idea of Intersectoral Development Model Optimization

In fact, a large modern enterprise is a large system, which is made up of multi-sectors with their specific connections and combinations. These are the corporate subsystems constituted by the functional departments, but at the same time, we also notice that various functional departments as subsystems also have their own specific objectives, status and market conditions. Although the goal of the subsystem is to serve the goal of the system, of subordinate nature, this does not mean that the objectives and development patterns of subsystems are always consistent with the objectives of the system. It is certain that the development speed and mode of some subsystems will not be consistent with the overall development of enterprises.

As a result of their respective independence and differences in policy making, decision-making, market and the nature of the work, the development speed and efficiency of the departments will not be at the same pace, and the overall development is not coordinated.

For large enterprises as a whole, it is bound to cause obstacles to the realization of the overall objectives, and to reduce the overall operational efficiency. And the continuous development of such situation will inevitably affect the realization of the overall objective of the enterprise.

The causes of this situation are manifold. Different conditions of each sector, different market environment, different national macro policies, and changes in external conditions or even differences in the nature of inter-sectoral work will lead to mismatch of efficiency and development speed. DEA decision optimization model is an effective method to solve this problem.

Here, the main ideas of DEA decision optimization are: By making DEA decision on the enterprises of each sector, the relative validity is determined, and the whole quantitative optimization of the enterprises with weak DEA efficiency and non-DEA efficiency is carried out with the "projection principle". Because DEA decision has the characteristics of few indices, high sensitivity and high reliability, it can objectively evaluate its relative effectiveness. Eventually, a relatively satisfactory result can be obtained after systematic optimization.

4.6.3.2 General Process of Optimizing Development Model with DEA

It is relatively simple to use DEA decision making method in the process of optimizing development model of subsidiaries or affiliated enterprises. It can be divided into the following seven steps:

Determine the purpose of the evaluation → select the decision-making unit → establish the input and output indicator system → select the DEA model → perform the DEA evaluation and analysis → adjust the input and output indicator system → obtain the synthetic evaluation conclusion and auxiliary decision. This is the general process of optimizing the development mode with DEA model. According to these steps, we can use DEA model to perform general optimization of the development mode. At this point, we should note: When the result of DEA decision evaluation and analysis is not satisfactory, we should adjust the index system of input and output. We can use the knowledge in statistics or other disciplines to select the index which has a great influence on the overall goal. This shall be adjusted on the basis of the adjustment until it is satisfied.

4.7 An Empirical Study of DEA on the Application of the Management and Control Optimization of State-owned Enterprises

4.7.1 Basic Data

According to the "Analysis and Research on the Supervision of State-owned Enterprises of Shandong SASAC", this thesis obtains eight kinds of enterprises belonging to the state-owned group of Shandong SASAC. Total assets, liabilities, owners' equity, operating income, total profits, total assets, total liabilities, owners' equity, operating income, total profits, total assets and liabilities of coal, iron and steel, automobile and machinery manufacturing, transport, trade, investment, gold and pharmaceutical and chemical industries in 2017 Six indicators of net profit. See tables 4-11.

We use statistical methods, such as t-test and F-test, according to the data we get. A variety of data selected for the eight categories of ownership enterprises have practical significance and have a greater impact on the development of six data DEA decision optimization models, we would not go into details here. Our goal is to make DEA decision optimization decision based on each index. We define input metrics: Total assets, liabilities and owner's equity. Output indicators: Operating income, gross profit and net profit. According to the actual data, the DEA decision model selected is the C^2R model of the non-Archimedean infinitesimal ε, that is, the perturbation method. This thesis analyzes the efficiency and effectiveness of each group company, statistics which block enterprise is DEA efficient and weak DEA efficiency, and gives their θ, s^+, s^- through the projection principle, the adjustment value is given, that is to say, by reducing income in proportion or improving by management, the output or efficiency can be increased, and finally the purpose of DEA effectiveness can be achieved. Analysis of its significance in economic management, help decision makers to carry out results analysis and auxiliary decision-making. This is of great significance to measure the efficiency of enterprises in Shandong Province, to optimize the efficiency of some plate enterprises, to optimize the development model of enterprises, and to optimize the development model of state-owned group companies, which can be widely used in a variety of production or service management, and has a strong practicability and applicability.

Table 4-11 Six Index Data of Eight Major Ownership Enterprises under the State-owned Assets Supervision and Administration Commission of Shandong Province

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Coal-mining Category	1798.60	1151.74	646.85	1136.78	135.77	99.98
Iron and steel category	1178.08	820.45	357.63	900.57	38.19	24.69
Automobile and machinery manufacturing	1028.71	623.09	405.62	833.33	78.97	65.58
Transportation category	1173.75	833.78	339.96	158.17	22.53	15.52
Commerce & Trade category	324.17	267.77	56.40	226.25	13.34	9.60
Investment category	395.65	228.74	166.91	68.30	8.49	7.41
Gold product category	174.16	116.45	57.71	254.03	9.72	6.56
Pharmaceutical and chemical industry category	133.54	68.52	65.02	97.71	7.42	6.24

From Table 4-11, we can clearly see that: Because of the obvious differences in the levels of the selected data, the eight major categories of enterprises mentioned above, coal, iron and steel, automobile and machinery manufacturing, and transportation, do not differ significantly in the six indicators selected. However, they are far better than those of trade, investment, gold and pharmaceutical, chemical and industrial enterprises, and there are no differences among the four major categories of enterprises in these six indicators. Therefore, the eight selected indicators can be clearly divided into two categories: coal, iron and steel, automobile and machinery manufacturing and transportation enterprises are the first category, and coal, iron and steel, automobile and machinery manufacturing and transportation

enterprises are the second category. In the actual operation, due to the difference of purpose, we divide the DEA calculation process into two parts:

Part I: The two kinds of enterprises are respectively used to optimize the DEA decision, and the two kinds of enterprises are defined as large scale enterprises and small scale enterprises, respectively. Based on this, we can get the relative efficiency evaluation of each enterprise in each part of the enterprise. To get which enterprises should be relatively less efficient than other enterprises to move the shadow principle, its theoretical adjustment value is given through improving the management methods and means so that the output or efficiency is increased. Finally, the purpose of DEA efficiency is achieved.

Part II: By combining the two parts of enterprises together, that is, the eight major categories of enterprises carrying out DEA operations at the same time, we can get the relative efficiency among the eight major categories of enterprises. Not only can we get which enterprises are relatively less efficient than other enterprises, and make adjustments similar to the first part, we can also compare the relative efficiency between large-scale enterprises and small enterprises. The relative efficiency of resource allocation and market integration between large-scale and small-scale enterprises is analyzed, and it varies in some indicators, which will lay a theoretical and data foundation for reforming the development model of large and medium-sized state-owned enterprises in the future.

4.7.2 Application of Super-efficiency DEA Method in Comparison of Benefits between Enterprises

Relative indicators for large-scale enterprises: By collating, we get tables 4-12:

Table 4-12 Relative Indicators for Large Scale Enterprises after Consolidation

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Coal-mining Category	1798.6	1151.74	646.85	1136.78	135.77	99.98
Iron and steel category	1178.08	820.45	357.63	900.57	38.19	24.69
Automobile and machinery manufacturing	1028.71	623.09	405.62	833.33	78.97	65.58
Transportation category	1173.75	833.78	339.96	158.17	22.53	15.52

Here we see that the order of input and output of each index is large, in order to facilitate the solution of linear programming problem, we can improve the standardized treatment of each evaluation index.

1. Calculation of the average value of unit i $\bar{Z}_j$, $\bar{Z}_j = \dfrac{1}{10}\sum_{i=1}^{10} Z_{ij}$

2. Calculate the standard deviation of unit i S_j, $S_j = \sqrt{\dfrac{1}{10}\sum_{i=1}^{10}(Z_{ij} - \bar{Z}_j)^2}$

3. Order: Standardized indicators are specified $Z_{ij}^{''} Z_{ij}^{''} = \bar{Z}_j / S_j$

The standardized indicator data is reclassified as a new table. As a new input and output index, the DEA model is used to optimize the index.

As a result, a standardized relative indicator for large-scale enterprises can be obtained, as shown in Table 4-13:

Table 4-13 Standardized Data on Relative Indicators for Large-scale Enterprises

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Coal-mining Category	6.055386	6.08161	5.2493656	3.125132	3.1013	2.9605
Iron and steel category	3.966268	4.332277	2.9022658	2.475765	0.8723	0.7311
Automobile and machinery manufacturing	3.463381	3.29014	3.2917178	2.290915	1.8038	1.9419
Transportation category	3.95169	4.40266	2.7588689	0.434827	0.5146	0.4596

We introduce the method in 4.2.2, that is, C^2R model or perturbation method in DEA decision model. This thesis analyzes the efficiency and effectiveness of each group enterprise, statistics which group enterprise is DEA efficient and weak DEA efficiency, and gives their θ, s^+, s^-. For the next step of optimization, the data are detailed in Table 4-14 below:

Table 4-14 Standardized Data on Relative Indicators for Large-scale Enterprises

	θ	$S1^-$	$s2^-$	$S3^-$	$s4^+$	$s5^+$	$s6^+$
Coal-mining category	1	0	0	0	0	0	0
Iron and steel category	1	0	0	0	0	0	0
Automobile and machinery manufacturing	1	0	0	0	0	0	0
Transportation category	03157	0.2429	0.3809	0	0.0838	0	0.0317

Through the DEA efficiency obtained in the table, we can know: Coal, iron and steel, automotive and mechanical manufacturing enterprises are equal to 1, so it is at least weak DEA efficiency, we also see that the three types of enterprises s+ and s- are all 0, which means that they are DEA efficient decision evaluation unit. It shows that in 2009, the operation of these three types of large-scale plate enterprises is relatively efficient, the operation mode is reasonable, the development model is good, and other enterprises are worth learning from the way and method. I will not go into details here. In contrast, the value of transportation and transportation enterprises is 0 ~ 3157 < 1. Even less than 0.5 shows that transportation enterprises are neither DEA weak efficiency nor DEA efficiency.

At the same time, we can see from the principle of the C^2R model that the size value of the sectoral enterprises represents the input-output efficiency. The smaller the value is, the smaller the efficiency of the plate enterprise is and the greater the efficiency is. For the less than 1 sectoral enterprise, we can not only reduce the input in proportion, but also improve the level of operation management through improvement. The improvement of technical equipment and other methods are strengthened to increase the output, and finally to achieve the effectiveness of DEA. For this example, the zero value of transportation enterprises is too small to 1, which shows that the development of transportation enterprises is relatively inefficient compared with several other major departments. It can be predicted that its operation mode has problems, the development momentum is not good, and some state-owned enterprise groups are at a disadvantageous position in the competition of traffic and transportation market. To this end, we should improve the level of operation and management,

strengthen investment in equipment technology and so on. Specifically, we should choose which of the six indicators to invest in, and improve the number of goals, which is the role that "projection principle" plays.

The following quantitative improvements are analyzed: By using the "projection principle", the input and output values of each indicator are calculated. In this case, the DEA analysis of large-scale enterprises, $\theta < 1$ enterprises only transportation enterprises. Through the theory of "the principle of projection", we can see that: The relaxation variable that needs to be improved is called for. 2429, 0.3809, 0.0838, < 0.0317, not 0. That means: Total assets, total liabilities, operating income and net profit still have variable room for improvement, which should be greatly improved in the next year. We can optimize the DEA efficiency of transportation enterprises through the change of these variables, adjust the value of input x_j to $\theta x_j - s^-$, and the value of output y_j to get $\theta y_j + s^+$.

From this we can conclude that theoretically the indicators can be changed to:

Total assets: (0.3157*3.95169-0.2429) *Sj=298.464

Total liabilities: (0.3157*4.40266-0.3809) *Sj=191.1225

Business income: (0.3157*0.434827+0.0838) *Sj=80.41101

Net profit: (0.3157*0.4596+0.0317) *Sj=5.971246

Namely: through analysis and calculation, we can optimize the four indicators s^+ and $s^- \neq 0$ that don't satisfy the DEA efficiency by "projection principle", and we can get a relatively effective DEA evaluation unit. The practical level of the target evaluation unit is given. Through this method, we can make quantitative preparation for the decision makers of state-owned group enterprises, which paves the way for the department or even the whole group enterprise to optimize the development model of the next stage. In this case, we can improve the relative efficiency of transportation enterprises and prepare for the next stage of development.

The second part is the DEA efficiency calculation of the relative indicators of small scale enterprises, including trade, investment, gold and pharmaceutical and chemical enterprises.

Relative indicators for small-scale enterprises: By collating, we get the following as shown in Table 4-15:

Table 4-15 Relative Indicator Data for Small-scale Enterprises after Consolidation

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Commerce & Trade category	324.17	267.77	56.4	226.25	13.34	9.6
Investment category	395.65	228.74	166.91	68.3	8.49	7.41
Gold product category	174.16	116.45	57.71	254.03	9.72	6.56
Pharmaceutical and chemical industry category	133.54	68.52	65.02	97.71	7.42	624

Like large scale enterprises, we have standardized treatment of each evaluation indicator. As a result, we can obtain the relative indicators of the standardized small-scale enterprises, as shown in Table 4-16:

Table 4-16 Standardized Data on Relative Indicators for Small-scale Enterprises

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Commerce & trade category	3.0282	3.3102	1.21199	2.8331	5.98	7.3198
Investment category	3.6959	2.8277	3.58676	0.8553	3.8059	5.65
Gold product category	1.6269	1.4396	1.24014	3.181	4.3572	5.0019
Pharmaceutical and chemical industry category	1.2474	0.84704	1.39723	1.2235	3.3262	4.7577

Similar to large scale enterprises, we use the method introduced in 4.2.2, that is, C^2R in DEA decision model. Model or perturbation method. This thesis analyzes the efficiency and effectiveness of each sectoral enterprise, statistics which sectoral enterprise is DEA efficient and weak DEA efficiency, and gives their , and . θ , s^+ , s^- For the next step of optimization, the data are detailed in Table 4-17 below:

Table 4-17 Efficiency and Effectiveness Data for Large-scale Enterprises

	$\boldsymbol{\theta}$	S1-	s2-	S3-	s4+	s5+	s6+
Commerce & trade category	1	0	0	0	0	0	0
Investment category	0.4338	0	0	0	0.7023	0.2389	0
Gold product category	1	0	0	0	0	0	0
Pharmaceutical and chemical industry category	1	0	0	0	0	0	0

Through the DEA efficiency obtained in the table, we can know: Trade, gold and pharmaceutical and chemical enterprises are equal to 1, so it is at least weak DEA efficiency. We also see that the S+ and S- of these three kinds of enterprises are all 0, which means that they are DEA effective decision evaluation units. It shows that in 2017, the operation of these three types of large-scale sectoral enterprises is relatively efficient, the operation mode is reasonable, the development model is good, and their ways and methods are worth learning for other enterprises. I will not go into details here.

On the other hand, the value of investment enterprises is 0.4338 < 1. Even less than 0.5 shows that investment enterprises are neither DEA weak efficiency nor DEA efficiency. At the same time, through the principle of C^2R model in the data envelopment analysis, we can know that the value represents the input-output efficiency of the sectoral enterprise. The smaller the value 0 is, the smaller the efficiency of the sectoral enterprise is and the greater the efficiency is. For the sectoral enterprise with < 1, we can not only reduce the input in proportion, but also improve the level of operation management. The improvement of technical equipment is strengthened, other methods are used to increase the output, and

finally the effectiveness of DEA is achieved. For this example, the value of 0.4338 for investment enterprises is too small to 1, which shows that the development of transportation enterprises is less efficient than several other small sector enterprises. It can be predicted that there are problems in its operation mode, the development momentum is not good, and some investment enterprises of state-owned enterprise groups are temporarily at a disadvantageous position in the market competition. To this end, we should improve the level of operation and management, and strengthen the investment in science and technology intelligence, and so on. Specifically, we should choose which of the six indicators to invest in and improve the number of goals, which is the role that "projection principle" plays.

The following quantitative improvements are analyzed: By using the "projection principle", the input and output values of each index are calculated. In this case, the DEA analysis of large-scale enterprises, $\theta< 1$ enterprises only transportation enterprises. Through the theory of "the principle of projection", we can see that: the relaxation variable that needs to be improved is $S_4^+ = 0.0838$, $S_5^+ = 0.0317$. That means: For investment enterprises, there is still variable room for improvement of total operating income and profits, which should be greatly improved in the next year. We can optimize the DEA efficiency of investment enterprises by changing these variables, adjust the input value x_j to $\theta x_j - s^-$, and adjust the output value y_j to the method of $\theta y_j + s^+$ to get the theoretical optimal value.

From this we can conclude that theoretically the indicators can be changed to:

Business income: (0.4338*0.8553+0.7023) *Sj=85.7162

Total profit: (0.4338*3.8059+0.2389) *Sj=4.2162

Namely: Through analysis and calculation, we optimize the two indicators (indicators of s^+ and $s^- \neq 0$) which do not satisfy DEA efficiency by "projection principle", and get a relatively effective DEA evaluation unit. The practical level of the target evaluation unit is given. Through this method, we can make quantitative preparation for the decision makers of state-owned group enterprises, which paves the way for the department or even the whole group enterprise to optimize the development model of the next stage. In this case, you can improve the relative efficiency of investment enterprises and prepare for the next stage of development.

4.7.3 Application of 3-super-efficiency DEA Method in Overall Optimization of Eight Categories of Enterprises

Two parts of enterprises are combined to carry out operations, that is, eight categories of enterprises are combined at the same time for DEA efficiency operations. Two parts of the enterprise integrate a total of six indicators for overall optimization.

The evaluation indexes are processed with standardized $Z_{ij}^{'} = \bar{Z}_j / S_j$. As a result, we can get the standardized

The relative indicators of each enterprise are indicated in Table 4-18 below:

Table 4-18 Standardized Data of Six Major Indicators for Eight Categories of Enterprises

Category	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Coal-mining category	3.1837	3.0874	3.2556	2.8595	3.1698	3.0783
Iron and steel category	2.0853	2.1993	1.8	2.2653	0.8916	0.7601
Automobile and machinery manufacturing	1.8209	1.6703	2.0415	2.0962	1.8437	2.0191
Transportation category	2.0777	2.2351	1.7110	0.3979	0.526	0.4779
Commerce & trade category	0.5738	0.7178	0.2839	0.5691	0.3114	0.2956
Investment category	0.7003	0.6132	0.84	0.1718	0.1982	0.2281
Gold product category	0.3083	0.3122	0.2905	0.639	0.2269	0.202

Pharmaceutical and chemical industry category	0.2364	0.1837	0.3273	0.2458	0.1732	0.1921

Table 4-19 Efficiency and Effectiveness Data for Eight Categories of Enterprises

	θ	S1⁻	s2⁻	S3⁻	s4⁺	s5⁺	s6⁺
Coal-mining category	1	0	0	0	0	0	0
Iron and steel category	0.5994	0	0	0	0	0	0.0459
Automobile and machinery manufacturing	1	0	0	0	0	0	0
Transportation category	0.3069	0	0	0	0.1974	0	0.03
Commerce & trade category	1	0	0	0	0	0	0
Investment category	0.3078	0.0098	0	0.0279	0.065	0.0101	0
Gold product category	1	0	0	0	0	0	0
Pharmaceutical and chemical industry category	0.9505	0.0378	0	0.1075	0	0.0068	0

In the same way as the above method, we use the method introduced in 4.2.2, that is, the model or perturbation method in DEA decision model. This thesis analyzes the efficiency and effectiveness of each sectoral enterprise, statistics which sectoral enterprise is DEA efficient and weak DEA efficiency, and gives their θ, s^+, s^-. For the next step of optimization on the basis of volume, the data are detailed in Table 4-19.

Through the whole DEA efficiency operation, we find that the operation results obviously vary with the enterprise scale. When the DEA efficiency operation is carried out according to the enterprise scale, there is only one department of the enterprise with $\theta < 1$ in each part. In the integration of all departments of enterprises after DEA efficiency calculation, we found that the effectiveness of the original enterprise is still weak, the efficiency of the two departments do not meet the requirements. This is very normal, on the basis of the original enterprise sector, the new entry into the effective enterprise sector, will inevitably lead the effectiveness of some departments of the original enterprise to the weak effectiveness of the enterprise.

Through the DEA efficiency obtained in the table, we can know: Coal, automobile and machinery manufacturing, commerce and gold enterprises are equal to 1, so it is at least weak DEA efficiency. We also see that the four categories of enterprises s^+ and s^- are all 0, which shows that they are all DEA effective decision evaluation units. It shows that in 2017, the operation of these four types of large-scale group enterprises is relatively efficient, the operation mode is reasonable, the development model is good, which are worth learning for other enterprises. I will not go into details here. On the other hand, the four types of enterprises are less than 1. Even if the value of transportation and investment enterprises is not more than 0.5, it shows that transportation and investment enterprises are not DEA weak efficiency, much less DEA efficiency. At the same time, through the data envelopment analysis of the principle of C^2R model, we can see that the value of the size of the group enterprises expressed the input-output efficiency. The smaller the value is, the smaller the efficiency of the group enterprise is, and the greater the efficiency is. For the group enterprise with < 1, we can not only reduce the input by 6, but also improve the management level of the transportation company. The improvement of technical equipment is strengthened, other methods are used to increase the output, and finally the effectiveness of DEA is achieved. For this example, The value of transportation and investment enterprises is really too small relative to 1, which shows that transportation and transportation enterprises and two other group sector enterprises have developed inefficiently compared with several other small sector enterprises. It can be predicted that its operation mode has problem, the development momentum is not good, and some state-owned enterprise groups are at a disadvantageous position in the competition. To this end, we should improve the level of operation and management, strengthen the investment in science and technology intelligence and so on. Specifically, we should choose which of the six indicators to invest in, and improve the number of goals, which is the role that "projection principle" plays.

The following quantitative improvements are analyzed: By using the "projection principle", the input and output values of each indicator are calculated. In the DEA analysis of large-

scale enterprises in this case, the enterprises with < 1 are iron and steel, transportation, investment and pharmaceutical and chemical enterprises. Through the theory of "the principle of projection", we can see that: The relaxation variable that needs to be improved is the relaxation variable whose s_i is not 0 as indicated in the above table. That means: For these four categories of enterprises, there is still a lot of variable room for improvement, and in the next year, these four categories of enterprises should make great efforts to improve these indicators. We can optimize the DEA efficiency of these four categories of enterprises by changing these variables, and adjust the value that the input amounts x_j to $\theta x_j - s^-$, the method of adjusting the value of the output amounts y_j to the method of $\theta y_j + s^+$ to obtain the theoretically reachable optimal value.

From this we can conclude that theoretically the indicators can be changed to:

Iron and steel category

Net profit: (0.5994*0.7601+0.0459) *Sj=16.29

Transportation category:

Business income: (0.3069*0.3979+0.1974) *Sj=127.018

Net profit: (0.3069*0.4779+0.03) * Sj=5.741

Investment category:

Total assets: (0.3078*0.7003-0.0098) * Sj=116.236

Owner's equity: (0.3078*0.84-0.0279) *Sj=45.831

Business income: (0.3078*0.1718+0.065) *Sj-46.882

Total profit: (0.3078*0.1982+0.0101) *Sj=3.046

Pharmaceutical and chemical industry category:

Total assets: (0.9505*0.2364-0.0378) *Sj=105.572

Owner's equity: (0.9505*0.3273-0.1075) *Sj=40.444

Total profit: (0.9505*0.1732+0.0068) *Sj=7.343

Business income: (0.4338*0.8553+0.7023) *Sj=85.7162

Total profit: (0.4338*3.8059+0.2389) *Sj=4.2162

Namely: Through analysis and calculation, we optimize the two indicators (indicator of s^+ and $s^- \neq 0$ indicator) which do not satisfy the DEA efficiency by "projection principle", and get a relatively effective DEA evaluation unit. The practical level of the target evaluation

unit is given. Through this method, we can make quantitative preparation for the decision makers of state-owned group enterprises, which paves the way for the department or even the whole group enterprise to optimize the development model of the next stage. In this case, you can improve the relative efficiency of investment enterprises and prepare for the next stage of development. This is organized into the following tables 4-20:

Table 4-20 Relative Efficiency of Four Categories of Enterprises

	Total assets	Total liabilities	Owner's equity	Business income	Total profit	Net profit
Iron and steel category						16.29
Transportation category				127.018		5.741
Investment category	116.236		45.831	46.882	3.046	
Pharmaceutical and chemical industry category	105.572		40.444		7.343	

Namely: By changing the four indicators which do not satisfy the DEA efficiency through the "projection principle", a relatively effective DEA evaluation unit can be obtained. The types of indicators which can be improved and optimized as well as the amount of optimization achieved in theory are given. Through this method, we can make quantitative preparation for the decision makers of state-owned group enterprises. It can effectively improve the relative efficiency in the future development model of enterprises in the four sectors.

4.8 Conclusion

In this way, we get the relative efficiency among the eight major categories of enterprises. We not only get which enterprises are DEA effective and which are DEA ineffective, but also compare the relative weight of the efficiency of these enterprises with that of other enterprises, and make the corresponding adjustment in theory. It provides a powerful quantitative basis for the decision makers of state-owned group enterprises to reform the development model in the future.

More importantly, with this DEA model, we compared the efficiency between large and small enterprises, and draw conclusions as follows: Shandong SASAC state-owned large and medium-sized enterprises have maintained a relatively balanced development, where the development efficiency of each of the two enterprise sectors is slightly smaller than that of other enterprises. And the number θ is similar, which shows that in terms of relative efficiency of development, the large enterprises and the small and medium-sized enterprises are about the same. This shows that under the unified leadership of the State Assets Supervision and Administration Commission of Shandong Province, the economic development of Shandong Province tends to be balanced and stable, and the momentum of development is good. But while they have maintained a good momentum of development, we also see some problems, for example, the pharmaceutical and chemical industry enterprises have already been very close to 1, and the DEA efficiency of pharmaceutical and chemical enterprises is very high. Only a little adjustment will be needed to achieve the effectiveness of DEA.

For transport and investment enterprises: In the first part, when large enterprises and the small and medium-sized enterprises are analyzed by DEA respectively, the DEA is not effective for sectoral enterprises (that is, enterprises in these two sectors), the values of which are 0.3157 and 0.4338 respectively in the second part of the analysis. Their values are 0.3069 and 0.3078 respectively, relatively smaller and relatively lower than the first part, which fully shows that their efficiency is really relatively smaller compared with that of other plate enterprises, and needs to be improved. Moreover, through the comprehensive DEA analysis of the efficiency of the eight major sectoral enterprises, it is not difficult to understand that the value is becoming smaller.

Compared with the multi-decision units, the relative efficiency of the small number of decision-making units must be relatively high. The results of this example also fully verify the data envelopment analysis in practical work. This paper analyzed and researched on the supervision and control of state-owned enterprises of Shandong SASAC in 2017, and has obtained data on its eight major categories of enterprises, including coal, iron and steel, automobile and machinery manufacturing, transportation, commerce, investment, gold and

medicine and chemical industry. This paper analyzed the relative efficiency and the theoretical values of the eight sectoral enterprises in 2017, and with its practicability and applicability, it will benefit the decision-making and policy formulation of Shandong SASAC and its various sectors, and lay a theoretical and practical foundation for large and medium-sized state-owned enterprises to reform the development model in the future.

Based on the analysis of the multi-cause, multi-dimensional and dynamic characteristics of the performance of state-owned enterprise employees, this paper combines the employees' work performance, work ability, job potential and work attitude in four aspects, and designs the performance evaluation indicators for the employees of state-owned enterprises. In the system, a basic DEA model and a super-efficiency DEA model for the performance evaluation of employees in state-owned enterprises were established. It also evaluated the performance of 16 employees in a certain division of the LH Energy Group's wholly-owned subsidiary A.

Its different evaluation results can reflect the aspect that the enterprise needs to adjust as an investor, as well as the improvements made by the employee as a subject that accepts input. The research results not only provide ideas for state-owned enterprises to formulate measures to improve their performance management status, but also provide basis for them to design a more reasonable compensation system. In addition, it should be noted that since the DEA model evaluates the relative efficiency of the evaluation unit, the scope set by the indicator value will affect the overall level of employee performance, and the value range of each indicator should be reset in further study as necessary.

At the same time, this paper introduced the research background of Data Envelopment Analysis (DEA) and the current development and research, and elaborates on its application and significance in the efficiency evaluation of enterprise groups. The Data Envelopment Analysis (DEA) theory was introduced in details, especially the model and its application. Through the brief "projection principle" and its application, the results of Data Envelopment Analysis were optimized, and the numerical value that can be improved theoretically was obtained. This paper briefly introduced the whole process of coordination and optimization, which made this paper more practical and applicable. It opened up a new way for enterprise decision makers to understand how to evaluate, improve and optimize the efficiency of different departments of the enterprise. Based on the actual data of Shandong enterprises in 2017, this paper evaluated and optimized the efficiency of various departments with DEA method, made an empirical analysis as well as the theoretical and economic analysis of the actual situation.

Chapter 5 Performance Evaluation and Its Optimization for Subsidiaries of State-owned Enterprise Groups

With the gradual improvement of China's market economic system, both the government management function and the enterprise supervision mechanism are undergoing changes. In accordance with the requirements of establishing a modern enterprise system, most state-owned enterprises began to have independent legal person status, which means that the state no longer has full control over the development of enterprises and instead it implements indirect management over ownership of the enterprises through investment, and the enterprises gradually become competitive market entities responsible for their own management decisions, profits and losses.

In order to promote the correct decision-making and effective management of the company's business operators, it is required to regularly and scientifically evaluate the company's operating conditions, management level, and the formation and maintenance of its core competitiveness. Therefore, scientific evaluation of the operating performance of state-owned enterprises has become an urgent requirement for the transformation of government functions and corporate supervision mechanisms.

At the same time, in the increasingly fierce competition, state-owned enterprise groups constantly eliminate some inefficient departments and branches that are harming the overall interests of enterprises, and then a competitive economic organization system, which has an impact on the national economy and people's livelihood, has been formed to adapt to the market economy. Under this background, enterprise decision makers are inevitably faced with the requirements that subsidiaries of the state-owned enterprise improve the internal efficiency of the company, strengthen the links between various internal departments, enhance the relationship between the enterprise and the market as well as its external relations, and evaluate the efficiency of production and management services in various sectors of state-owned enterprises. Therefore, the enterprise group should not only evaluate the efficiency of each section, but also need to give the directions and goals for their optimization, in the course of which only through quantitative analysis can the problems of enterprise efficiency evaluation and overall optimization be solved in a real sense.

The following parts will analyze the above two problems and establish the corresponding models.

5.1 Performance Evaluation for Subsidiaries of State-owned Group

The accuracy of performance evaluation results is usually affected by three factors: whether the design of the performance appraisal indicator system is reasonable, whether the appraisal method is appropriate, and whether the indicator data are accurate. Some literature[73] pointed out that in the performance evaluation of state-owned enterprises, there are problems such as the unconsidered opportunity cost of equity capital, single assessment method, and simple technology; other literature[74] introduced the current performance evaluation systems: the performance evaluation system based on the Balanced Scorecard and the one based on economic rent of ability; some literature[75] also established for China National Offshore Oil Corporation a comprehensive performance evaluation system, which includes four vertical aspects: financial efficiency, asset operation, debt paying ability and development ability, and three horizontal levels: quantification indicators, orientation indicators and reference indicators. For determination of indicator weights in the evaluation system, the related literature [76] mainly expounds the application of mathematical methods such as fuzzy mathematics theory, analytic hierarchy process, entropy weight method, the Delphi method, etc. in the process of indicator weight determination.

According to the performance evaluation system based on Balanced Scorecard, this thesis establishes a performance evaluation indicator system for state-owned enterprises by enriching specific indicators of various indicators. Based on the theory of fuzzy mathematics and combined with Delphi method and entropy weight method, the indicator weights are determined so as to conduct the performance evaluation.

5.1.1 Theoretical Basis of Enterprise Performance Evaluation

Principal-agent theory, stakeholder theory and strategic management theory are the theories that have extended significant impacts on corporate performance evaluation.

(1) Principal-agent theory

Under the modern enterprise system, the ownership of the enterprise is separated from the right of management, and the owner grants the management the decision-making and executive rights to by making a contract, so that the management can engage in economic activities on behalf of the owner [77]. As a result, the principal-agent relationship is formed [78]. According to the stipulations of the contract, the agent should maximize the interests of the principal when making business decisions, but the information asymmetry between the principal and the agent often results in obvious differences in their pursuits of objectives for corporate legal governance: The principal wants to maximize the value of the company, while the agent may pursue the appreciation of his own value and the maximization of his own

interests [79]. As a result, the agent may consider more about the short-term interests of the company for his personal gains but give up those plans which are beneficial to the long-term development of the company. In such circumstances, the principal must guide the agent to work for his or her best interests by taking some measures. If the medium and long-term performance of an enterprise is used as an assessment standard to measure the performance of the agent, it can effectively constraint agent's attempts and behaviors to "consider for personal gains". Therefore, it shows that enterprise performance evaluation is an inevitable action for the owner to supervise, restraint and control the management under the principal-agent relationship.

(2) Stakeholder theory

According to the stakeholder theory, modern company is a contractual consortium composed of various stakeholders, thus the management's decisions should be based on the interests of all stakeholders in the company [80]. For an enterprise, stakeholders refer to all entities and individuals that can affect or be affected by the enterprise, including principals (shareholders, creditors, etc.) who have an economic relationship with the enterprise as well as enterprise employees, corporate customers, society, and government. The role of stakeholder theory for corporate performance evaluation is: Enterprise should reflect the expectations of different stakeholders in formulating a performance evaluation indicator system. The competitiveness of an enterprise depends on whether it can meet the expectations of different stakeholders. However, the expectations of different stakeholders are different. Therefore, it is necessary to design a performance evaluation system that can effectively measure whether the needs of different stakeholders are satisfied and balanced.

(3) Strategic management theory

The term "strategic management" was first proposed by American scholar Igor Ansoff in the book *From Strategic Planning to Strategic Management* in 1976[81]. The subsequent research on strategic management has always been a hot topic in the field of corporate management. Strategic management includes the process of strategic planning and strategy implementation. Strategic planning is the planning for realizing the company's strategic goals and is the long-term development direction of the company; Strategic implementation is the implementation of the phased tactical objectives of the enterprise serving for its strategic target, and a phased realization of the company's goals. For its research, there are broad and narrow senses on the macroscopic level. Strategic management in a broad sense refers to the use of strategies to manage the entire enterprise, the main representative of which is Igor Ansoff; strategic management in a narrow sense refers to the management of corporate strategy formulation, control and correction, the main representative of which is the American scholar Steiner[82]. In a narrow sense, strategic management theory has a more

direct impact on the performance evaluation system, mainly in the four stages of the performance evaluation process: the construction stage of the performance evaluation indicator system where appropriate performance evaluation indicators are designed by analyzing the key success factors of strategic objectives; the stage of process control and management where the performance evaluation criteria should be determined when formulating strategic system and program, and the performance evaluation indicators should be decomposed into departments or individuals; the appraisal and evaluation stage where a comparative analysis is conducted between the results of strategic implementation and the target performance; the results application stage where the strategy is revised based on the results of evaluation.

5.1.2 Balanced Scorecard Evaluation System

(1) Introduction of the balanced scorecard

The balanced scorecard was the result of a research project carried out by the Nolan Norton Institute in 1990 involving 12 companies for one year. The 12 companies participating in this program belonged to the manufacturing and service industries, including high-tech, heavy industry and other industries. This study mainly discussed the organization of future performance evaluation systems so that the company's operating performance can be simultaneously recognized by the company's shareholders, employees, and customers. In this plan, they developed a set of methods that could turn strategies into actions, and transform strategic indicators into the strategy management tool, namely the "balanced scorecard" method. This method is a comprehensive performance management system that can implement the organizational strategy and objectives, and at the same time, attach importance to the results and the process. The balanced scorecard approach covers the financial objectives and the factors that contribute to the conversion of these financial goals into performance, and allows managers to look at the overall performance of the company from different perspectives in pursuing corporate financial performance. At the same time, the performance drivers for the company's future growth can be monitored at any time.

The balanced scorecard system emphasizes the coordination and balance between different performance areas [83], and the excellent performance in a particular area often fails to compensate for the poor performance of other areas. Its most prominent characteristic is to link the company's vision, mission, and development strategy with the company's performance evaluation and evaluation system, and transform the company's mission and strategy into concrete goals and evaluation indicators. The balanced scorecard system is based on the company's strategy and integrates various measurement methods into an organic whole that both includes financial indicators and supplements financial indicators through

customer satisfaction, internal business processes, and learning growth business indicators. These business indicators are the starting factors of financial indicators. The Balanced Scorecard diagram is shown in Figure 5-1.

(2) Indicators of the balanced scorecard system

The balanced scorecard is a comprehensive performance assessment system. In addition to the traditional financial measurement indicators, it also involves three new assessment areas: Customers, internal operations and learning growth [84].

① Financial perspective

The measure for evaluating corporate performance from a financial perspective is how the company can better meet the needs of shareholders. The most basic demand of shareholders busying shares is to realize capital gains through their investment. Therefore, the setting of financial evaluation indicators should reflect whether the company's strategy and its implementation contribute to profit increase. Typical financial goals involve profit, growth, and shareholder value. The selection of financial indicators should also take into account the company's life cycle, the requirements of strategic objectives on financial performance and other factors [85].
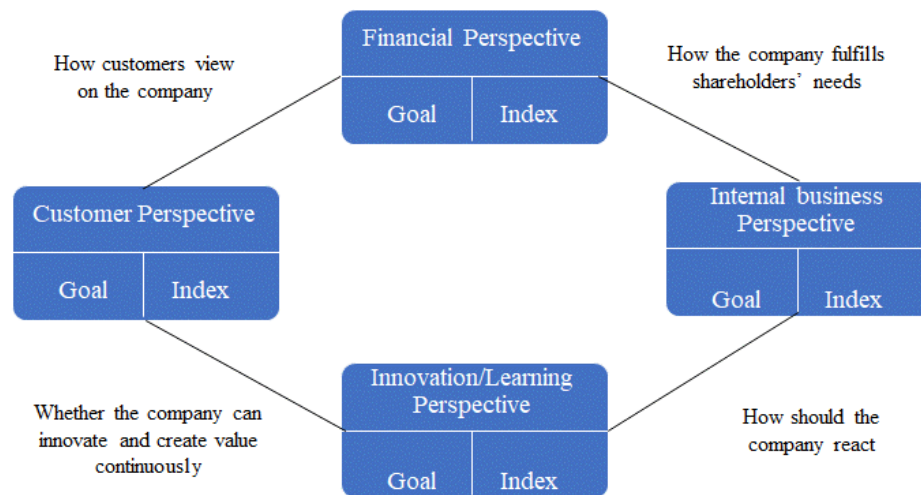
Figure 5-1 Schematic Diagram of the Balanced Scorecard (Yves, 2010)

② Customer perspective

Balanced scorecard method requires that indicators should truly reflect various factors associated with the customer. There are usually four types of things that customers are concerned about: Time, quality, performance, service and cost. In order for the balanced

scorecard approach to work, a company should define the goals that time, quality, performance, service and cost should achieve, and then transform these goals into specific assessment objectives [86].

③　Perspective of internal business operation

It is important for the evaluation indicators to be based on customers provided that the company's internal operational goals are guaranteed. Excellent customer performance comes from the processes, decisions, and behaviors that occur in the organization. Internal business operations refers to the key internal business activities that the company can meet with customer needs. The internal assessment indicators of the balanced scorecard should come from business processes that have the greatest impact on customers, including factors such as cycle time, quality, staff skills and productivity.

④　Perspective of innovation and learning

Corporate abilities to innovate, improve, and learn are directly related to corporate performance. Only by continuously developing new products, providing customers with more value and improving operation efficiency can companies enter new markets, increase revenue, and continue to grow so as to increase shareholder value.

(3)　Application of the balanced scorecard in performance evaluation of state-owned enterprises in China

Since the balanced scorecard method appeared in 1992, it has been widely used in European and American companies. Statistics show that more than 80% of the Fortune Global 500 are using the BSC evaluation method. Many state-owned enterprises in China also applied the balanced scorecard evaluation method. For example, SINOTRANS, one of the 179 state-owned large-scale enterprise groups directly under the State-owned Assets Supervision and Administration Commission, began the pilot work of the balanced scorecard evaluation within the Group since 2001. Since 2003, among its secondary subsidiaries, the Group has fully implemented the balanced scorecard evaluation system.

Fan Songlin and Li Wenjuan introduced the value contribution model of Baosteel Steel Pipe Co., Ltd. constructed with the theory of economic value added and the balanced scorecard[87]. The model includes four aspects of the balanced scorecard evaluation system, which are divided into financial factors and non-financial factors. Non-financial factors are divided into user factors, internal process factors, and learning and innovation processes. At the same time, the literature points out that this model not only effectively measures financial indicators, but also quantifies non-financial indicators, and truly satisfies customer needs with minimal cost so as to increase the overall value of the company's operations.

And many experts and scholars have studied application of the balanced scorecard evaluation system in the performance evaluation of state-owned enterprises. Fu Guangyou mentioned that when the Balanced Scorecard evaluation system was used in the performance evaluation of state-owned enterprises, it was very important to find out the key success factors, but it was found in its application to practical problems that it still lacked scientificity in identifying the relevant key success factors in the evaluation system of the balanced scorecard [88]. In addition, he also pointed out that the Balanced Scorecard was not a standardized evaluation template suitable for all enterprises or the whole industry. It appeared to evaluate the company from the aspects of finance, customers, internal business processes and learning and growth, but it actually required each enterprise to set the Balanced Scorecard evaluation system with its own emphasis. In addition, he pointed out that the issue of determining the weight of performance indicators is also worth exploring. Yao Yue, Yang Wangui, Jiang Yanzhang, and Yang Lan pointed out that introduction of the balanced scorecard system to certain state-owned enterprises in China could comprehensively evaluate the enterprise performance[89]. Their research also showed that in designing performance evaluation system for state-owned enterprises with the balanced scorecard evaluation system, first, the quality of state-owned enterprise's accounting information should be fully considered for scientific sake; Second, the evaluation system should include the social contribution level of state-owned enterprises; Third, the company's safety production issues and environmental protection issues should also be included in the evaluation to examine the company's safety and environmental awareness; In addition, different companies have different backgrounds and strategic tasks, and even the same goals may be measured by different indicators. When the balanced scorecard evaluation system is used in state-owned enterprises, their objectives of the four levels should be different from the measurement indicators of other enterprises. Wei Hongmei applied the Balanced Scorecard evaluation to the case of Exxon Mobil Corporation [90]. The study found the preconditions and principles for the balanced scorecard evaluation system to be used by state-owned enterprises as follows: The company's strategy could be broken down into layers; the causal relationship between the four aspects of the Balanced Scorecard could be found; management rules and regulations in line with the implementation of Balanced Scorecard should be in place; employees at all levels should be competent for their job.

Some problems need attention for the application of the Balanced Scorecard in the performance evaluation of state-owned enterprises. The opinions of scholars such as Fu Guangyou, Yao Yue, Yang Wangui, Li Yazhe, and Wei Hongmei are mainly expressed in the following points: the status of China's under grade quality of accounting information should be fully considered for designing scientific performance evaluation indicators; According to the special nature of China's state-owned enterprises, the indicators of corporate

social responsibility should be designed to effectively evaluate the contribution of state-owned enterprises to society when Balanced Score Card is used in the performance evaluation of state-owned enterprises in China. The status of environmental protection of state-owned enterprises should be evaluated, the balanced scorecard for performance evaluation of state-owned enterprises should be designed with indicators for environmental protection; Although the balanced scorecard evaluates a company's performance from four aspects, it is not a fixed template and each company should focus on its own characteristics.

5.1.3 Design of Performance Indicator System for Enterprise Organization

5.1.3.1 Design Principles

Whether the design of the performance evaluation indicator system is reasonable or not extend a direct impact on the accuracy of evaluation results. The design of performance evaluation indicators usually follows three principles: the rationality of the indicator setting, that is, the information reflected by the indicator can meet the requirements of the design goal; Comprehensively reflecting the objects, that is, the designed indicator system can fully reflect the information of the evaluated object; The availability of indicator data, which means that the data of indicators can be obtained directly or quantified by some method.

The performance evaluation system of state-owned enterprise is expressed by breaking down the long-term development strategy of the company from top to bottom and converting them into quantifiable indicators, to communicate as far as possible the strategy to employees at different job levels so that the basic level employees and senior managers can act in a unified manner.

① Overall balance

The design of the performance evaluation system for state-owned enterprises should consider the overall balance, and design secondary indicators from four perspectives: financial perspective, customer perspective, internal business process perspective, and learning growth perspective. Each of these four aspects has its distinct emphasis, and at the same time, they have close causal relationship which reflects the idea of seeking the overall balance and harmony of enterprises. The balance contained in the performance evaluation system is reflected in the balance between financial and non-financial evaluations, the balance between long-term and short-term goals, the balance between external and internal requirements, and the balance between management and operating performance.

② Comprehensive relationship

The four evaluation perspectives of the performance evaluation system for state-owned enterprises have the relationship of sequential safeguard and promotion. "Learning and growth" is the long-term, basic, and process-based key success factor that can guarantee and promote "internal business processes"; "Internal business processes" are the key to improving corporate performance, and compared with learning and growth, it is a semi-basic, indirect and process-based key success factor which can guarantee and promote "meeting customer needs"; "Meeting customer needs" is the quick effective, direct, and process-based key success factor that can guarantee and promote "financial performance"; "financial performance" is the result-based key success factor of the enterprise that is the most direct and important performance indicator of the enterprise management.

③ Combining qualitative analysis with quantitative calculation

The design of the performance evaluation system for state-owned group enterprises is based on the reading of relevant literature, and uses repeated qualitative analysis and two quantitative analysis methods including the Delphi method and the entropy weight method, and finally, establishes a more reasonable performance evaluation system.

5.1.3.2 Design scheme

Following the basic principles of the performance evaluation system and highlighting the characteristics of the performance evaluation system obtained through analysis, this paper referred to the balanced scorecard performance appraisal system from four aspects: financial affairs, customers, internal business processes and learning and growth, and established an evaluation system including 16 secondary indicators, as indicated in Table 5-1.

(1) Asset liability ratio

Asset liability ratio is an indicator that evaluates corporate performance from a financial perspective. This indicator has become a financial leverage factor which reflects the percentage of creditors' funds in the total assets of the company and the extent to which the corporate assets guarantee the rights of creditors. Under good conditions in production and operations, the positive effects of financial leverage can be used to gain more profits. However, if the company's operating conditions are not good and its financial strength cannot guarantee the security of debt repayment, the financial leverage may play a negative role and aggravate the financial situation.

Smaller asset liability ratio indicates stronger long-term solvency of the company. With relatively high business risk, companies will usually choose a relatively low asset liability ratio to reduce financial risks; with low business risk, companies will usually choose a higher asset liability ratio to increase shareholders' returns. As the asset-liability ratio plays a role

of financial leverage, different stakeholders have different requirements for this indicator. From the perspective of creditors, the lower the debt ratio the better. When the asset liability ratio is low, the ratio of the capital provided by creditors to the total capital of the enterprise is low, and the possibility of insolvency is low. Since the risks of the enterprise is mainly borne by the shareholders, this is very beneficial to the creditors; From the perspective of shareholders, it is an ideal state to maintain the asset-liability ratio at a relatively high level, which can give full play to the positive role of financial leverage; From the perspective of operators, they hope that the asset-liability ratio will remain within a reasonable range, make full use of borrowed capital to create profits for the enterprise and reduce financial risks as many as possible.

  (2) Operating cost ratio

The operating cost ratio is an indicator for evaluating corporate performance from a financial perspective. This indicator reflects the relationship between operating costs and operating income in business operations. According to the value of this indicator, both the level of profitability of the company's business operations and its ability to control operating costs as well as its management level can also be evaluated.

Smaller operating cost ratio indicates lower price for the company to pay for gains and greater profitability.

Table 5-1 Performance Evaluation Indicator System for the Subsidiaries of State-owned Group

First-level indicators		Secondary grade index		
Name	Expression	Name	Expression	Calculation formula
Financial perspective	a_1	Asset liability ratio	a_{11}	(total liabilities / total assets) * 100%
		Operating cost ratio	a_{12}	(Operating cost/operating revenue)*100%
		Net profit margin on sales	a_{13}	(net profit/operating revenue)*100%
		Return on total assets	a_{14}	(Total profit before interest and taxes/total average assets) * 100%
Customer perspective	a_2	Growth rate of operating revenue	a_{21}	(Operating revenue of report period - operating revenue of base period)/Operating revenue of base
		Contribution ratio of operating revenue	a_{22}	(Operating revenue of subsidiaries/Operating revenue of parent company) * 100%
		Profit rate of main business	a_{23}	(Main Business Profit/Main Business Net Revenue) * 100%
Internal business perspective	a_3	Current ratio	a_{31}	Current assets / current liabilities
		Quick ratio	a_{32}	Quick assets/current liabilities
		Cash ratio	a_{33}	(cash + short-term investments) / current liabilities
		Turnover of fixed assets	a_{34}	(Main business revenue/net value of fixed assets)*100%
		Total asset turnover ratio	a_{35}	Prime operation revenue/total average assets
Learning and growth perspective	a_4	Net asset growth rate	a_{41}	(Net assets of report period - net assets of base period) / net assets of base period * 100%
		Net profit growth rate	a_{42}	(Net profit of report period - net profit of base period)/Net profit of base period *100%
		Total asset growth rate	a_{43}	(Total assets of report period - total assets of base period) / Total assets of base period * 100%
		Growth rate of debt	a_{44}	(Total liabilities of report period - total liabilities of base period) / Total assets of base period * 100%

(3) Net profit margin on sales

Net profit margin on sales is an indicator that evaluates corporate performance from a financial perspective. As the initial basis for corporate profits, this indicator reflects the proportion of the company's net profit to operating income.

Generally speaking, the higher the net profit margin on sales, the stronger the company's profitability.

(4) Return on total assets

Return on total assets is an indicator that evaluates corporate performance from a financial perspective. This indicator shows the level of the company's total assets gains, which fully reflects the profitability of the company and the output of the investment. In-depth analysis of this indicator can strengthen the enterprise's attention to asset management and promote the enterprise to improve the income level of unit assets.

Larger indicator value of the return on total assets indicates better proportion of enterprise input and output, and the higher overall operating efficiency of enterprise's total assets.

(5) Growth rate of operating revenue

The growth rate of operating revenue is an indicator for evaluating corporate performance from the perspective of customers. This indicator is an important indicator to measure the operating status of the company and its market share as well as to predict the development trend of its business operations. Sustained and stable business income is the foundation and development conditions for the company's survival.

Higher growth rate of operating income indicates greater growth rate of its operating income and greater market potential; If the value of this indicator is less than zero, it indicates that the company's products or services or market may have problems.

(6) Contribution ratio of operating revenue

The operating income contribution ratio is an indicator for evaluating company performance from the perspective of the customer. This indicator is the proportion of the operating income of the subsidiary to the total revenue of the parent company.

Higher indicator value of the operating income contribution ratio indicates greater contribution of the subsidiary to the parent company.

(7) Profit rate of main business

The profit rate of main business is an indicator for evaluating corporate performance from the perspective of customers. This indicator refers to the ratio between the profit and the net income of main business over a certain period of time, which indicates the amount of the

main business profit that can be brought by each unit of the enterprise income, and reflects the profitability of enterprises' main businesses, and is the main indicator to evaluate the economic benefits of enterprises.

The higher profit rate of the main business indicates that the prices of goods or services are scientific, the added value of products or services is high, the marketing strategy is appropriate, the market competitiveness of the main business is strong, and the profit level is high. Only when the main business of the company stands out, that is, the profit margin of the main business is relatively high, can it capture an advantageous position in the competition.

(8) Current ratio

The current ratio is an indicator of corporate performance from the perspective of internal business processes. This indicator shows how many current assets of the company guarantee for repayment of its current liabilities, and reflects the ability of the company to liquidate assets within one year to repay the current liabilities.

The greater the current ratio, the stronger the short-term solvency of the company, and the smaller the financial risk of the company's inability to repay the short-term debt due. However, if the indicator is too high, it means that the company's liquid assets are used excessively, which may reduce the profitability of funds.

(9) Quick ratio

The quick ratio is an indicator for evaluating corporate performance from the perspective of internal business processes. Since the inventory in current assets may not be realized or the realized value is far lower than its book value due to long backlog, etc., the deferred expenses generally will not generate cash inflows. Therefore, the quick ratio is calculated only through the ratio of the strongest component of liquid assets to current liabilities.

The greater value of quick ratio indicates greater guarantee for the company's future solvency. However, if excessively high value of this indicator indicates that the company has so many monetary assets as to reduce the profitability of funds.

(10) Cash ratio

The cash ratio is an indicator for evaluating corporate performance from the perspective of internal business processes. The cash ratio is the ratio of the amount of quick assets after deducting accounts receivable to the current liabilities. This indicator can best reflect the ability of companies to directly repay their current liabilities.

Similarly, greater value of the cash ratio indicates stronger solvency of the company for current liabilities. However, if this ratio is too high, it means that the company's current

liabilities have not been properly used; and excessively high amounts of cash assets can increase the opportunity cost of the company.

(11) Turnover of fixed assets

The turnover rate of fixed asset is an indicator for evaluating corporate performance from the perspective of internal business processes. This indicator reflects the degree of utilization of enterprise assets.

Higher value of the fixed asset turnover indicator indicates higher utilization rate of fixed assets by the company and better management.

(12) Total asset turnover ratio

The total asset turnover ratio is an indicator for evaluating enterprise performance from the perspective of internal business processes. This indicator is an important indicator for examining the operational efficiency of corporate assets and reflects the management quality and utilization efficiency of all corporate assets.

Higher value of the total asset turnover indicator shows faster turnover rate and higher utilization efficiency of assets.

(13) Net asset growth rate

The net asset growth rate is an indicator for evaluating corporate performance from the perspective of learning and growth. This indicator reflects the level of change in assets of an enterprise in the current year and also the accumulation of corporate capital.

Higher value of the index indicates greater capital accumulation, stronger capital maintenance and stronger ability in risk response and sustainable development.

(14) Net profit growth rate

The net profit growth rate is an indicator for evaluating corporate performance from the perspective of learning and growth. Net profit is the final result of the company's operating performance, the growth of which is the basic characteristic of the company's growth. The larger increase in net profit indicates that the company has outstanding business performance and strong market competitiveness. In the actual calculation, if the net profit of last year is negative, the net profit growth rate is the ratio of the difference between the net profits of the two years and the absolute value of the net profit of the previous year.

(15) Total asset growth rate

The total asset growth rate is an indicator for evaluating enterprise performance from the perspective of learning and growth. This indicator reflects the growth of the company's assets.

The higher the total asset growth rate, the faster the company's asset growth. However, the higher growth rate of assets is not necessarily good. Only when sales growth and profit growth exceed the growth of assets, the growth of asset size is appropriate and profitable.

(16)　Growth rate of debt

The growth rate of debt is an indicator to evaluate corporate performance from the perspective of learning and growth. This indicator reflects the growth of the company's liability scale. Company's operation with borrowed fund could have leverage to a certain extent.

The lower growth rate of the debt is not necessarily good, and with a certain relationship with the growth rate of the assets, higher debt growth rate may bring more benefits to the company.

The above performance evaluation system for state-owned enterprises was constructed based on considerations of the company's finances, customers, internal business processes, and learning and growth, so it can more comprehensively reflect the performance of enterprises during a specific period of time. Second, corresponding quantifiable indicators are set for all aspects examined, and these indicators can all be obtained from the company's annual financial statements, so as to lay the foundation for the objectivity and accuracy of enterprise performance evaluation results. In addition, classified performance evaluation indicators can help enterprises to formulate corresponding performance improvement measures based on the evaluation results.

5.1.4 Construction of Fuzzy Synthetic Evaluation Model

This paper proposes a fuzzy synthetic evaluation model constructed on the basis of fuzzy mathematics theories, Delphi method and entropy weight method, whose specific steps go as follows:

(1) Construction of fuzzy set (feature set and weight set)

Assume that feature set of the first grade indicators of evaluation indicator system (Table 5-1) is $A=\{a_1,a_2...,a_n\}$, W is the fuzzy set of importance degrees of A, then the weight set of each indicator of corresponding feature layers is $W=\{W_1,W_2,...,W_m\}$, where w_1 denotes the weight of the ith feature in A and satisfies $\sum_{i=1}^{m} w_i =1$

The feature set of the second grade indicator is $a_1=\{a_{i1},a_{i2},...a_{ij},...a_{in}\}$ （$i=1,2,...,m$; $j=1,2,...,n$ ）, the weight of indicator corresponding to its set of features is

$W_1=\{w_{i1},w_{i2},...w_{ij},...w_{in}\}$, $(i=1,2,...,m; j=1,2,...,n)$, where w_{i1} denotes the weight of the a_{ij}th feature in a_1 and satisfies $\sum_{i=1}^{m} w_{ij} =1$.

(2) Construction of fuzzy evaluation matrix

Assume that object of evaluation is $V= \{V_1, V_2, ... V_P\}$, the feature set of the corresponding first-order indicator layer is $a_1=\{a_{i1}, a_{i2}, a_{ij},... a_{in}\}$, a fuzzy mapping of the first-order indicator feature from V to a_1 is established to be $f:V{\rightarrow}f(a_i)$.

$$v_i{\rightarrow}a_{ij}=\frac{r_{i1}}{v_1}+\frac{r_{i2}}{v_2}+...+\frac{r_{mn}}{v_p}\ (i =1,2,...,m; j=1,2,...,n)$$

The fuzzy relation can be induced by f and denoted by the matrix as follows:

$$R_i = \begin{array}{c} \\ a_{i1} \\ a_{i2} \\ ... \\ a_{mn} \end{array} \overset{\begin{array}{cccc} v_1 & v_2 & ... & v_p \end{array}}{\begin{bmatrix} r_{i11} & r_{i12} & ... & r_{i1p} \\ r_{i21} & r_{i22} & ... & r_{i2p} \\ ... & ... & ... & ... \\ r_{mn1} & r_{mn2} & ... & r_{mnp} \end{bmatrix}}$$

Formula (5-1)

R_i denotes a fuzzy relation between evaluation object set V and index factor set a_i, and r_{ijp} denotes the membership of evaluation object v_P to the feature a_{ij} of the secondary grade index layer.

(3) Determination of index weights in the model

① Determination of the weights of the first grade indices

The weights of the first grade indicators are determined by the Delphi method. By Delphi method, a group of experienced experts are invited to comment on how to determine the weight of each indicator, and then to estimate the weight of each indicator by means of statistical average method. And its specific steps are as follows:

First, more detailed background information is sent to a certain number (n) of selected experts, each of whom is asked to estimate the weight of each objective independently, as shown in Table 5-2:

Table 5-2 Expert Scoring Results by the Delphi Method

Score \ Expert	Index a_1	a_2	...	a_m
1	w_{11}	w_{12}	...	w_{1m}
2	w_{21}	w_{22}	...	w_{2m}
...	...	...	...	...
n	w_{n1}	w_{n2}	...	w_{nm}

After calculating the sample mean of each indicator weight $\overline{M}(w_j) = \dfrac{1}{n}\sum\limits_{i=1}^{n} w_{ij}$ ($j=1,2,...,m$) and the deviation of each expert to the estimated value of each indicator weight $\Delta_{ij} = w_{ij} - \overline{M}(w_j)$, further analyze whether $\overline{M}(w_j)$ is reasonable or not, especially let the experts with larger deviations Δ_{ij} of estimate value fully express their opinions, and eliminate some errors in the estimated value.

Then, with the attached additional information, experts are invited to re-estimate the weight of each indicator and calculate the average value $\tilde{M}(w_j) = \dfrac{1}{n}\sum\limits_{i=1}^{n} w_{ij}$ and the variance $\tilde{D}(w_j) = \dfrac{1}{n-1}\sum\limits_{i=1}^{n}(w_{ij} - \tilde{M}(w_j))^2$ again. Repeat the above steps until the k-th step, where the estimated variance is less than or equal to the preset standard ε ($\varepsilon > 0$). Send the mean estimate $\tilde{M}(w_j)$ and $\tilde{D}(w_j)$ obtained from the k-th step to the experts, and ask them to give the final estimates of the objective weights and to give, at the same time, the "credibility" of the estimated values l_{ij} ($0 < l_{ij} < 1$), indicating the confidence given by the i-th expert on the j-th index weight value.

Finally, determine the final estimated value of objective function weight. Let $M_\lambda^i = \{i : l_{ij} \geq \lambda,\ i=1,2,...,n\}$, λ ($0 < \lambda < 1$), which is a preset criterion, then the final estimate of the j-th objective weight is $\overline{\omega} = \dfrac{1}{\left| M_\lambda^{(i)} \right|} w_{ij}^i$, $\left| M_\lambda^{(i)} \right|$ denotes the number of elements in $M_\lambda^{(i)}$.

In the process of determining the weight of each indicator by the Delphi method, the members of the expert group do not communicate directly among themselves and may change their opinions anonymously, so that various arguments can be fully expressed. While from the feedback questionnaires, the experts get collective opinions and the current situation as well as the arguments for or against various opinions, and make their own new judgments thereon, which constitute the anonymous interaction among experts. Finally, the use of statistical assessment methods for predicted results can cover the views of the entire group and thus find the mainstream opinion representing the experts.

② Determination of the weights of the second grade indicators

The weights of the second grade indicators are determined by entropy weight method. In information theory, entropy is a measurement of uncertainty. The smaller the entropy, the smaller the uncertainty. The greater the entropy, the greater the uncertainty. According to this characteristic of entropy, the discrete degree of the indicator can be judged by calculating the entropy value of the indicator. The greater the discrete degree, the greater the entropy value of the indicator. If the value fluctuation of each evaluation object is very large for a certain indicator, it shows that the discrete degree of the indicator is very large, and that the indicator plays an important role in the whole evaluation system.

The entropy weight method takes the ratio of the difference coefficient of entropy value of each indicator to the sum of difference coefficients of entropy values of indicators as the weight of the indicator. Because this method can offer an insightful perspective of the information contained in the original data, it effectively avoids the influence of subjective factors on the indicator weight. The weight of the secondary grade indicator of the corresponding first grade indicator in the performance evaluation indicator system proposed by this thesis is $W_l = \{w_{i1}, w_{i2}, \dots w_{ij}, \dots W_{in}\}$, and with the entropy weight method, the weight of each second grade indicator can be obtained by the following formula:

$$w_{ij} = \frac{1 + \dfrac{1}{\ln p} \sum_{\eta=1}^{p} r_{ij\eta} \ln r_{ij\eta}}{\sum_{j=1}^{n} \left(1 + \dfrac{1}{\ln p} \sum_{\eta=1}^{p} r_{ij\eta} \ln r_{ij\eta}\right)},$$

$(i=1,2, \dots, m; j = 1,2, \dots, n ; \eta=1,2, \dots, p)$………………….... Formula (5-2)

W_{ij} denotes the weight of the a_{ij}-th indicator in a_i, and satisfies $0 \le a_{ij} \le 1$, $\sum_{j=1}^{n} a_{ij} = 1$.

It can be seen from the above formula that, in the evaluation by entropy weight method, all the indicator values must be treated as positive numbers. In view of the characteristics of

the indicator system established in this paper, the following formula is used to process each indicator value.

$$r_{ij\eta}^{i} = \frac{r_{ij\eta} - \min(r_{ij.})}{\max(r_{ij.}) - \min(r_{ij.})} + \beta_{ij} \ldots\ldots\ldots \text{ Formula (5-3)}$$

$$(i=1,2, \ldots, m; j = 1,2, \ldots, n ; \eta=1,2, \ldots, p)$$

where max (r_{ij}) is the satisfaction value of the evaluation object in the a_{ij}-th indicator, and min (r_{ij}) is the most unsatisfactory value of the evaluation object in the a_{ij}-th indicator; β_{ij} is the adjustment coefficient, and if a_{ij} is a moderate indicator, assign 0.5 to β_{ij} and if a_{ij} is a positive or negative indicator, assign 1 to βij. Then the assigned values of β_{ij} in this indicator system are shown in Table 5-3.

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Table 5-3 List of the assigned values for indicator system *βij*

β_{11}	β_{12}	β_{13}	β_{14}	β_{21}	β_{22}	β_{23}	β_{24}
0.5	1	1	1	1	1	1	1
β_{25}	β_{31}	β_{32}	β_{33}	β_{41}	β_{42}	β_{43}	β_{44}
1	1	1	1	1	1	0.5	0.5

(4) Establishment of the fuzzy systhetic evaluation model

After constructing the fuzzy evaluation matrix R_i of a_i and determining the importance W_i of a_i, the fuzzy entropy weight evaluation is performed on each feature of $a_i=\{a_{i1}, a_{i2}, \ldots, a_{ij, \ldots,} a_{in}\}(i=1,2, \ldots, m; j = 1,2, \ldots, n)$.

U_i denotes fuzzy evaluation vector of a_i, then the fuzzy evaluation model of the second grade indicator feature goes as follows:

$$U_i = (\mu_{i1}, \mu_{i2}, \cdots \mu_{in}) = W_i \cdot R_i = (w_{i1}, w_{i2}, \cdots w_{in}) \cdot \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1p} \\ r_{i21} & r_{i22} & \cdots & r_{i2p} \\ \cdots & \cdots & \cdots & \cdots \\ r_{in1} & r_{in2} & \cdots & r_{inp} \end{bmatrix} \ldots\ldots \text{ Formula (5-4)}$$

$$u_{i\eta} = \sum_{j=1}^{n} w_{ij} \cdot r_{ij\eta} (i = 1,2\cdots, m, j = 1,2\cdots, n, \eta = 1,2,\cdots, p)$$

The first grade indicator feature set is $A = \{a_1, a_2, \cdots, a_n\}, W = \{w_1, w_2, \cdots, w_m\}$ is a weight set of A, the total evaluation matrix is U, which is calculated by the following formula:

$$U = (u_1, u_2, ..., u_p) = W \bullet U_i = (w_1, w_2, ..., w_m) \bullet \begin{bmatrix} u_{11} & u_{12} & ... & u_{1p} \\ u_{21} & u_{22} & ... & u_{2p} \\ ... & ... & ... & ... \\ u_{n1} & u_{n2} & ... & u_{np} \end{bmatrix} \quad \text{...... Formula (5-5)}$$

The above is the fuzzy synthetic evaluation model established in this paper. By the principle of maximum membership, the evaluation results of each evaluation object can be obtained from the total evaluation matrix U.

5.1.5 Design of Performance Evaluation Process for Subsidiaries of State-owned Enterprises

(1) Evaluation process

The performance evaluation process for subsidiaries of state-owned group is shown in Figure 5-2.

(2) Evaluation cycle

Because all the indicators contained in the performance evaluation system in this paper require the corresponding data to be obtained from the financial department, and the annual financial statements can reflect the operating situation of the enterprise in a more comprehensive way, therefore, the evaluation cycle is set at one year and the performance of the enterprise is evaluated at the end of each accounting year.

(3) Subject of evaluation

The performance evaluation on subsidiaries of the state-owned enterprise group shall be carried out by the strategic research department with the assistance of the financial department of the corporate headquarters.
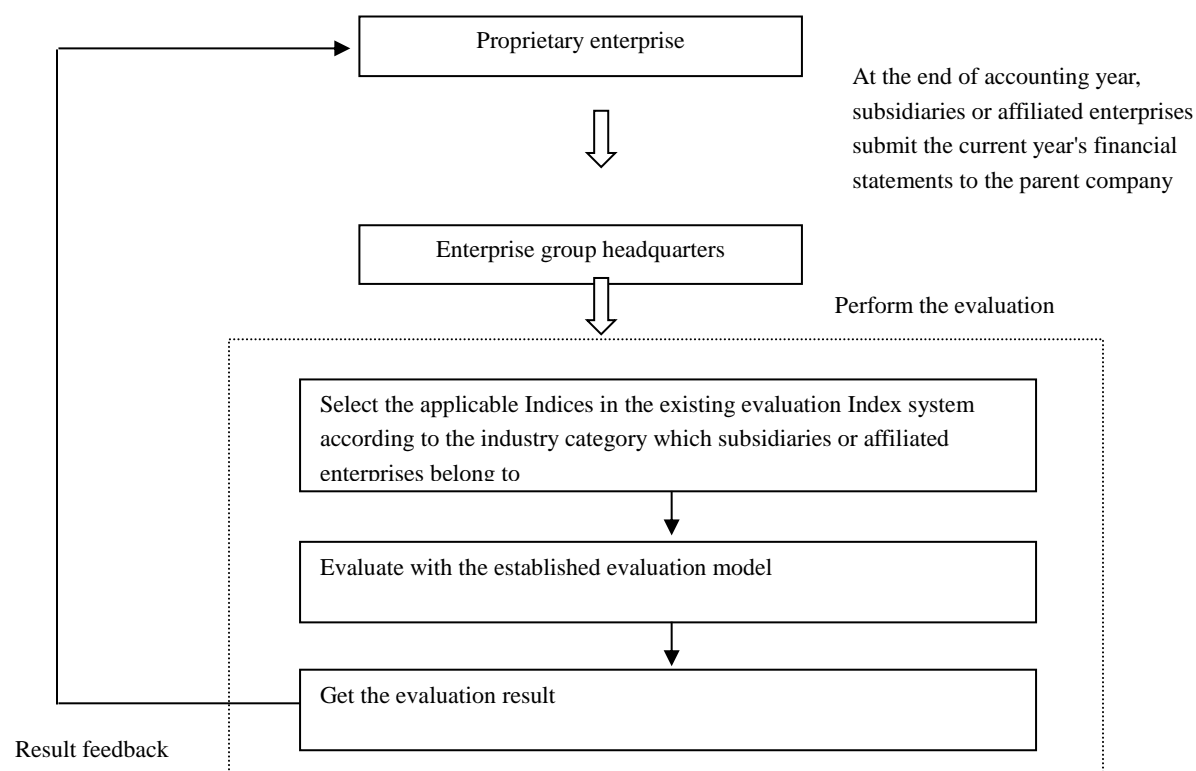
Figure 5-2 Flow Chart of Performance Evaluation on Subsidiaries or Affiliates of State-owned Enterprise Group

5.1.6 Application of Fuzzy Synthetic Evaluation in the Performance Evaluation on subsidiaries of LH Group

The performance evaluation indicator system for subsidiaries or affiliated enterprises of LH Energy Group is shown in Appendix 1 and Appendix 2. This section will carry out performance rating on the three sectors of subsidiaries and affiliated enterprises of LH Energy Group, respectively: Real Estate and Project Management Section, Biopharmaceutical Section and Hotel Management Section.

5.1.6.1 Performance Evaluation on Enterprises of Real Estate and Project Management Sector

The real estate and project management sector of LH Energy Group is shown in Figure 5-3.

Shandong Huaneng Real Estate Development Co., Ltd. with registered capital of 18 million RMB, is a wholly owned subsidiary of LH Energy Group. It is specialized in real estate development with the third class of real estate development qualifications issued by Construction Commission of Shandong Province. At present, the company develops and manages real estate projects mainly in Weihai City and Shouguang City. By now it has successfully developed the Shandong Huaneng Building and the Jinan Baiwang Shopping Mall in Jinan City; Tai'an Jinshan Residential Area; Huaneng City Garden and Weihai Xuefu Jiayuan projects in Weihai City.
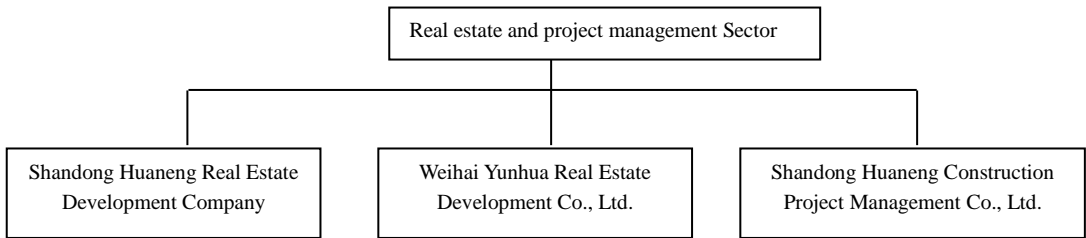
Figure 5-3 Enterprises of Real Estate and Project Management Sector

Weihai Yunhua Real Estate Development Co., Ltd. was established in 2001 and was acquired in November 2007 by Shandong Huaneng Real Estate Development Company, a wholly owned enterprise of LH Energy Group. In April 2008, the company was transferred with 100% equity for free to LH Energy Group as a wholly owned enterprise, and increased the registered capital from 10 million RMB to 50 million RMB. In May 2008, after selling part equity of the company, the LH Group held 51% of the stocks. The company is specialized in real estate development business.

Shandong Huaneng Construction Project Management Co., Ltd. is a wholly owned enterprise of LH Energy Group with registered capital of 3 million RMB. The company is mainly engaged in the construction and supervision of civil construction, municipal engineering and large thermal power plants, thermal power plants and others; it possesses two Class-A qualifications for housing construction engineering supervision and electrical engineering supervision.

(1) Determination of the weights of the first grade indicators

Six experts (including business administrators) from related fields are invited to score the importance of the first grade indicators of the performance evaluation indicator system designed in this paper and the score scale is 1-10, denoting progressive importance degrees in turn. The results are shown in Tables 5-4:

Table 5-4 Initial Analogue Scores for the Importance of the First Grade Indicators

Indices Experts Score	a_1	a_2	a_3	a_4
Expert 1	8	1	4	7
Expert 2	10	9	4	2
Expert 3	7	5	2	7
Expert 4	10	8	7	9
Expert 5	8	5	6	7
Expert 6	7	8	9	7

According to the steps of determining each indicator weight by the Delphi method, the first grade indicator weight set W= (0.37, 0.26, 0.12, 0.25) is obtained through calculation.

Although the balanced scorecard evaluation system emphasizes the balance between finance, customer, internal business process and innovation and learning, different enterprises should have their own focus. While the above weights reflect exactly this idea, in the performance evaluation on subsidiaries or affiliated enterprises of LH Energy Group, the group attaches the most importance to the financial performance of subsidiaries or affiliated enterprises, followed by customers, and innovation and learning, and finally, the internal business process. These evaluation weights are determined on the basis of fully considering the development stages of the affiliated enterprises and the overall strategy of the group. With the development of subsidiaries and affiliated enterprises and the overall strategy adjustment of the group, the weights will inevitably change.

(2) Determination of the weights of the second grade indicators

Related indicators of the enterprises of real estate and project management sector of LH Energy Group in 2017 as shown in Table 5-5

Table 5-5 Corresponding Indicators for the Enterprises of Real Estate and Project Management Sector

Secondary grade indicator	Company 1	Company 2	Company 3
a_{11}	69.06	61.61	36.62
a_{12}	76.37	85.53	80.95*
a_{13}	14.31	4.21	10.52
a_{14}	7.40	3.81	16.78
a_{21}	164.23	94.40*	24.56
a_{22}	7.38	19.51	2.00
a_{23}	23.63	12.36	94.45
a_{31}	1.29	7.35	2.39
a_{32}	0.82	3.10	2.39
a_{33}	16.54	137.16	143.37
a_{34}	39.92	91.64	9.11
a_{35}	0.40	0.64	1.20
a_{41}	19.86	6.58	21.61
a_{42}	319.02	205.5*	91.88
a_{43}	24.20	30.08	10.14
a_{44}	26.24	-67.34	-5.00

*The number with asterisk indicates the missing data, and this paper assigns to it the average value of the evaluation object, hereinafter the same.

According to formula (5-3), the pre-processed data is shown as Table 5-6.

Table 5-6 The Corresponding Indicators for the Enterprises of Real Estate and Project Management Sector after Pre-processing

Secondary grade indicator / Company Indicator value	Company 1	Company 2	Company 3
a_{11}	1.50	1.27	0.50
a_{12}	1.00	2.00	1.50
a_{13}	3.66	1.00	2.66
a_{14}	1.28	1.00	2.00
a_{21}	2.00	1.50	1.00
a_{22}	1.31	2.00	1.00
a_{23}	1.14	1.00	2.00
a_{31}	1.00	2.00	1.18
a_{32}	1.00	2.00	1.69
a_{33}	1.00	1.95	2.00
a_{34}	1.37	2.00	1.00
a_{35}	1.00	1.30	2.00
a_{41}	1.88	1.00	2.00
a_{42}	2.00	1.50	1.00
a_{43}	2.89	3.89	0.50
a_{44}	1.50	0.50	1.17

According to the formula (5-1), we can get

$$R_1 = \begin{bmatrix} 1.50 & 1.27 & 0.50 \\ 1.00 & 2.00 & 1.50 \\ 3.66 & 1.00 & 2.66 \\ 1.28 & 1.00 & 2.00 \end{bmatrix}$$ …….……..Formula (5-6)

According to the formula (5-2), we can by calculation obtain

W_1 = (0.10, 0.19, 0.53, 00.17)…………………………. Formula (5-7)

Similarly, it can be calculated

W_2 = (0.36, 0.33, 0.31) ……………………….……….Formula (5-8)

W_3=(0.17,0.22,0.24,0.19,0.18) ………………………   Formula (5-9)

W_4=(0.21,0.18,0.52,0.09) ……………………………   Formula (5-10)

(3) Calculation of total fuzzy evaluation matrix

The fuzzy evaluation models of the second grade indicator features are as follows:

$U_1 = W_1 \cdot R_1 = (2.51,1.22,2.10)$ …………………………..   Formula (5-11)

$U_2 = W_2 \cdot R_2 = (1.51,1.51,1.31)$ …………………………..   Formula (5-12)

$U_3 = W_3 \cdot R_3 = (1.07,1.86,1.60)$ …………………………..   Formula (5-13)

$U_4 = W_4 \cdot R_4 = (2.40,2.56,0.96)$ ………………………….   Formula (5-14)

The total fuzzy performance evaluation matrix of real estate and project management sector enterprises of LH Energy Group is as follows

$U = W \cdot U_i = (2.05,1.71,1.55)$ …………………………….   Formula (5-15)

(4) Evaluation result and analysis

Formula (5-7)-Formula (5-10) illustrate the weights of the specific indicators involved in the four aspects of the balanced scorecard system in evaluating the enterprises of real estate and project management sector. From a financial perspective, the weight of asset-liability

ratio is 0.1, the weight of operating cost is 0.19, the weight of net profit margin on sales is 0.53, and the weight of total asset return is 0.17; From a customer perspective, the weight of operating income growth rate is 0.36, the weight of contribution ratio of operating income is 0.33, and the weight of main business profit rate is 0.31; From the perspective of internal business processes, the current ratio indicator weighs 0.17, the quick ratio indicator weighs 0.22, the cash ratio indicator weighs 0.24, the fixed asset turnover indicator weighs 0.19, and the total asset turnover indicator weighs 0.18; From the perspective of learning and growth, the weight of net assets growth index is 0.21, the weight of net profit growth rate is 0.18, the weight of total asset growth rate is 0.52, and the weight of debt growth rate is 0.09.

Formula (5-11)-Formula 5-12 show the performances of the enterprises of real estate and project management sector in various evaluation perspectives. From the financial perspective, the performances of the three enterprises from good to bad are: Company 1, company 3, company 2; For performances of the three enterprises from the customer perspective, company 1 and company 2 are at the same relatively superior level, followed by company 3; From the perspective of internal business processes, the performances of the three enterprises from good to bad are: Company 2, company 3, company 1; From the perspective of learning and growth, the performances of the three enterprises from good to bad are: Company 2, Company 1, Company 3.

From the synthetic fuzzy evaluation vector of Formula (5-15), the performances of the three enterprises can be concluded as in a superior-bad order, respectively: Company 1, Company 2, and Company 3.

5.1.6.2 Performance Evaluation on the Enterprises of Biopharmaceutical Sector

Biopharmaceutical sector companies of LH Energy Group are shown in Figure 5-4.
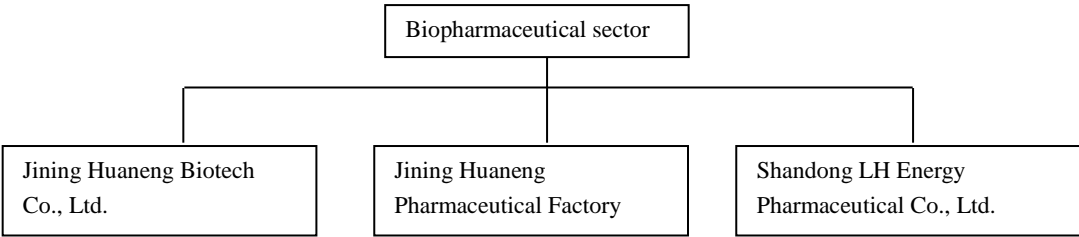
Figure 5-4 Enterprises of Biopharmaceutical Sector

Jining Huaneng Biotech Co., Ltd. has a registered capital of 10 million RMB, of which LH Energy Group holds 70% of the shares, and Jining Research Institute of Biotech Applications holds 30% of the shares. The company mainly produces health care products, and is mainly engaged in the production and sales Longxin oral liquid, Longxin jade liquor,

golden energy oral liquid, positive pressure tea and other health products. This company and Jining Huaneng Pharmaceutical Factory are two independent legal entities owned by the Group Company in the biopharmaceutical sector, but currently their administration bodies are the same.

With a registered capital of 1.14 million RMB, Jining Huaneng Pharmaceutical Factory is a wholly-owned subsidiary of LH Energy Group, and mainly produces pharmaceutical products. With its core technology of the imported extractive technique of lumbrokinase from Tsinghua University, the company has developed biological health products by adopting high-tech biotechnology, formed preliminarily three major product series of curing, rehabilitating and nourishing types for the treatment of cardiovascular and cerebrovascular diseases and become the largest earthworm research and development base in China. At present, Qilong capsules, Jiangmeiling capsules, Salviae Miltiorrhizae Shuxin Capsules, Sea Cucumber Capsules and other products developed by the company have a fairly high market share in China.

Shandong LH Energy Pharmaceutical Sales Co., Ltd. is an affiliated enterprise bought by Jining Huaneng Pharmaceutical Factory, a secondary enterprises of LH Energy Group. With a registered capital of 3.1 million RMB, the company, formerly known as Shandong Songhai Pharmaceutical Co., Ltd., is mainly engaged in sales business of Chinese patent medicines, chemical medicine preparations, biochemical drugs and others, and has the GSP certification granted by the pharmaceutical regulatory bodies. With approval of the Provincial Commission of State-owned Assets Supervison and Administration, the company was acquired in August 2008 by Jining Huaneng Pharmaceutical Factory, a wholly owned enterprise of the group company, and renamed Shandong LH Energy Pharmaceutical Co., Ltd.

(1) Determination of indicator weight

Related indicators of the enterprises of pharmaceutical sector of LH Energy Group in 2017 are shown in Table 5-7.

Table 5-7 Corresponding Indicators of the Enterprises of Biopharmaceutical Sector

Company Indicator value / Second grade indicator	Company 1	Company 2	Company 3
a_{11}	59.03	43.41	94.76
a_{12}	56.00	31.00	97.00
a_{13}	2.00	18.00	0.15
a_{14}	4.15	30.44	3.18
a_{21}	-31.79	1.85	755.82
a_{22}	2.00	5.00	13.00
a_{23}	2.00	18.00	0.15
a_{31}	0.39	1.75	0.98
a_{32}	0.29	1.42	0.65
a_{33}	11.00	6.00	20.00
a_{34}	*0.44*	15.13	101.85
a_{35}	0.23	1.29	4.51
a_{41}	1.48	75.25	13.83
a_{42}	-89.00	67.00	-11.00*
a_{43}	-14.83	-3.40	18.93
a_{44}	-23.00	-39.00	19.20

Table 5-8 Corresponding Indicator Values of the Enterprises of Biopharmaceutical Sector after Pre-process Treatment

According to Formula (5-3), the pre-processed data are shown in Table 5-8.

Company / Indicator value / Secondary grade indicator	Company 1	Company 2	Company 3
a_{11}	0.80	0.50	1.50
a_{12}	1.38	1.00	2.00
a_{13}	1.10	2.00	1.00
a_{14}	1.04	2.00	1.00
a_{21}	1.00	1.04	2.00
a_{22}	1.00	1.27	2.00
a_{23}	1.10	2.00	1.00
a_{31}	1.00	2.00	1.43
a_{32}	1.00	2.00	1.32
a_{33}	1.36	1.00	2.00
a_{34}	1.00	1.14	2.00
a_{35}	1.00	1.25	2.00
a_{41}	1.00	2.00	1.17
a_{42}	1.00	2.00	1.50
a_{43}	0.50	0.84	1.50
a_{44}	0.77	0.50	1.50

According to Formula (5-1), obtain

$$R_1 = \begin{bmatrix} 0.80 & 0.50 & 1.50 \\ 1.38 & 1.00 & 2.00 \\ 1.10 & 2.00 & 1.00 \\ 1.04 & 2.00 & 1.00 \end{bmatrix} \qquad \text{………..Formula (5-16)}$$

According to Formula (5-2), it can be calculated ……………………. Formula (5-17)

$$W_1 = (0.13 \quad 0.32 \quad 0.28 \quad 0.27)$$

Similarly, it can be calculated $W_2 = (0.32 \quad 0.35 \quad 0.33)$……………. Formula (5-18)

$$W_3 = (0.21 \quad 0.20 \quad 0.20 \quad 0.19 \quad 0.20)$$…………………………….. Formula (5-19)

$$W_4 = (0.33 \quad 0.38 \quad 0.15 \quad 0.14)$$……………………………………. Formula (5-20)

(2) Calculation of total fuzzy evaluation matrix

The fuzzy evaluation models of the second grade indicator features are as follows:

$$U_1 = W_1 \bullet R_1 = (0.13, \quad 1.49, \quad 1.38,)$$…………………………………. Formula (5-21)

$$U_2 = W_2 \bullet R_2 = (1.03, \quad 1.44, \quad 1.38,)$$…………………………………. Formula (5-22)

$$U_3 = W_3 \bullet R_3 = (1.07, \quad 1.49, \quad 1.74,)$$…………………………………. Formula (5-23)

$$U_4 = W_4 \bullet R_4 = (0.89, \quad 1.61, \quad 1.39,)$$…………………………………. Formula (5-24)

The total fuzzy performance evaluation matrix of the enterprises of biological sector of LH Energy Group is

$$U = W \bullet U_i = (1.04, \quad 1.51, \quad 1.50,)$$…………………………………. Formula (5-25)

(3) Evaluation results and analysis

Formula (5-17)-Formula (5-20) illustrate the weights of the specific indicators involved in the four aspects of the balanced scorecard system in the evaluation on enterprises of biopharmaceutical sector. From the financial perspective, the weight of asset-liability ratio is 0.13, the weight of operating cost ratio is 0.32, the weight of net profit margin on sales is 0.28, the weight of return on total asset is 0.27; From a customer perspective, the weight of operating income growth rate is 0.32, the weight of operating income contribution ratios is

0.35, and the weight of main business profit margin is 0.33; From the perspective of internal business process, the weight of current ratio index is 0.21, the weight of quick ratio index is 0.20, the weight of cash ratio is 0.20, the weight of fixed assets turnover ratio is 0.19, the weight of total assets turnover ratio is 0.20; From the perspective of learning and growth, the weight of net assets growth rate is 0.33, the weight of net profit growth rate is 0.38, the weight of total asset growth rate is 0.15, and the weight of debt growth rate is 0.14.

Formula (5-21) - Formula (5-24) show the performances of the enterprises of biopharmaceutical sector in various evaluation perspectives. From the financial perspective, the performances of the three enterprises from good to bad are: Company 2, company 3, company 1; From the customer perspective, the performances of the three enterprises from good to bad are: Company 3, Company 2, Company 1: From the perspective of internal business processes, the performances of the three enterprises from good to bad are: Company 3, company 2, company 1; From the perspective of learning and growth, the performances of the three enterprises from good to bad are: Company 2, company 3, company 1

From the synthetic fuzzy evaluation vector of Formula (5-25), the performances of the three enterprises can be concluded, respectively: Company 2, Company 3, and Company 1.

5.1.6.3 Performance Evaluation on Hotel Business Sector

There are three companies in hotel business sector of LH Energy Group, as shown in Figure 5-5.
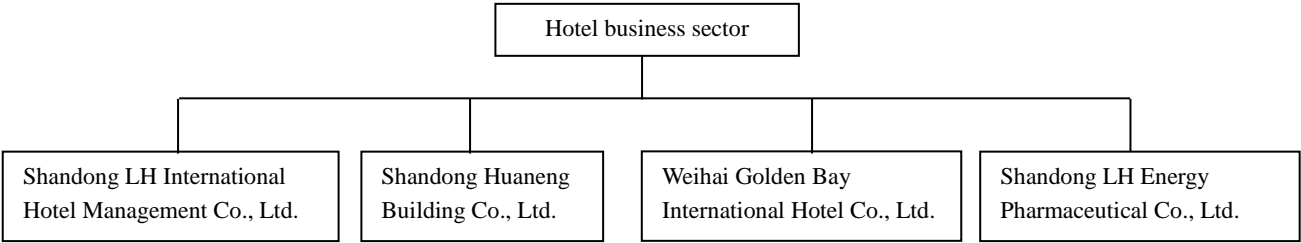
Figure 5-5 Enterprises of Hotel Business Sector

Shandong LH International Hotel Management Co., Ltd. is a wholly owned subsidiary of LH Energy Group. With a registered capital of 6 million RMB, the company is a specialized hotel management company which integrates hotel management, project investment, entrustment management, professional training and exhibition service, and denotatively expands the hotels industry sector of the group company mainly through acquisition, renting, trusteeship and other managerial means. Since this year, the company has rented and run a hotel in Linyi City, and run 3 hotels through trusteeship and lease in Weihai City.

Shandong Huaneng Building Co., Ltd. has a registered capital of 60 million RMB, among which LH Energy group holds 90% of the shares, and Shandong Huaneng Real Estate Development Company holds 10% of the shares. The building is a four-star tourist hotel integrating with guest rooms, restaurants, office rooms and conference rooms.

Weihai Golden Bay International Hotel Co., Ltd. has a registered capital of 88 million RMB, among which LH Energy group holds 25% of shares, Shandong Huaneng Building-an enterprise wholly owned by the group company holds for 35.23% of shares, and Weihai Jinfeng Real Estate Comprehensive Development Co., Ltd holds 39.77% of shares. The company is a five-star tourist hotel which integrates guest room rental, catering, entertainment and leisure.

With a registered capital of 57.29 million RMB, Qingdao Huaneng Building Co., Ltd. is mainly engaged in guest rooms, restaurants, housing rental, beauty salon, business center and other business.

(1) Determination of index weight

Related indicators of the enterprises of hotel sector of the LH Energy Group in 2017 are shown in Table 5-9.

Table 5-9 List of Corresponding Indicators for Enterprises of Hotel Management Sector

Secondary grade indicator	Company 1	Company 2	Company 3	Company 4
a_{11}	4.05	80.33	55.55	71.38
a_{12}	19.00	15.00	21.00	14.00
a_{13}	-6.00	-4.00	-3.00	0.40
a_{14}	-3.87	1.14	0.99	3.84
a_{21}	2.63*	-12.76	-6.81	27.46
a_{22}	1.00	8.00	7.00	5.00
a_{23}	-6.00	-4.00	-3.00	-0.40
a_{31}	14.71	0.83	1.09	2.21
a_{32}	13.47	0.80	0.94	0.86
a_{33}	310.00	58.00	51.00	5.00
a_{34}	39.08	0.21	0.21	0.56
a_{35}	0.52	0.13	0.17	0.17
a_{41}	-3.00	-2.45	-1.13	-0.25
a_{42}	-1463.00*	-249.00	-4048.00	-92.00
a_{43}	1.09	8.92	2.08	-0.14
a_{44}	86.73*	239.00	21.00	0.20

Table 5-10 The Corresponding Indicator Values of the Enterprises of Hotel Business Sector after Pre-processment

According to Formula (5-3), the pre-processed data are shown in Table 5-10.

Company / Indicator value / Secondary grade indicator	Company 1	Company 2	Company 3	Company 4
a_{11}	0.50	1.50	1.18	1.38
a_{12}	1.71	1.14	2.00	1.00
a_{13}	1.00	1.36	1.54	2.00
a_{14}	1.00	1.65	1.63	2.00
a_{21}	138	1.00	1.15	2.00
a_{22}	1.00	2.00	1.86	1.57
a_{23}	1.00	1.36	1.54	2.00
a_{31}	2.00	1.00	1.02	1.10
a_{32}	2.00	1.00	1.01	1.00
a_{33}	2.00	1.17	1.15	1.00
a_{34}	2.00	1.00	1.00	1.01
a_{35}	2.00	1.00	1.10	1.10
a_{41}	1.00	1.20	1.68	2.00
a_{42}	1.65	1.96	1.00	2.00
a_{43}	0.64	1.50	0.75	0.50
a_{44}	0.86	1.50	0.59	0.50

According to Formula (5-1), obtain

$$R_1 = \begin{bmatrix} 0.50 & 1.50 & 1.18 & 1.38 \\ 1.71 & 1.14 & 2.00 & 1.00 \\ 1.00 & 1.36 & 1.54 & 2.00 \\ 1.00 & 1.65 & 1.63 & 2.00 \end{bmatrix}$$ ....Formula (5-26)

According to Formula (5-2), it can be calculated ....Formula (5-27)
$W_1 = (0.16, \quad 0.27, \quad 0.27, \quad 0.31)$

Similarly, it can be calculated $W_2 = (0.28, 0.39, 0.32)$………………….. Formula (5-28)

$W_3 = (0.20, \quad 0.19, \quad 0.21, \quad 0.19, \quad 0.20)$……………………………. Formula (5-29)

$W_4 = (0.35, \quad 0.44, \quad 0.10, \quad 0.11)$…………………………………… Formula (5-30)

(2) Calculation of total fuzzy evaluation matrix

The fuzzy evaluation models of the second grade index features are as follows:

$U_1 = W_1 \bullet R_1 = (1.11, \quad 1.41, \quad 1.63, \quad 1.63)$…………………………….. Formula (5-31)

$U_2 = W_2 \bullet R_2 = (1.11, \quad 1.51, \quad 1.55, \quad 1.83)$……………………………. Formula (5-32)

$U_3 = W_3 \bullet R_3 = (2.00, \quad 1.04, \quad 1.06, \quad 1.04)$…………………………. Formula (5-33)

$U_4 = W_4 \bullet R_4 = (1.24, \quad 1.60, \quad 1.17, \quad 1.68)$…………………………. Formula (5-34)

Then the total fuzzy performance evaluation matrix of the enterprises of hotel business sector of LH energy group is as follows:

$U = W \bullet U_i = (1.25, \quad 1.44, \quad 1.43, \quad 1.63)$……………………………. Formula (5-35)

(3) Evaluation results and analysis

Formula (5-27)-Formula (5-30) illustrate the weights of the specific indicators involved in the four aspects of the balanced scorecard system in evaluating the enterprises of hotel business sector. From the financial perspective, the weight of asset-liability ratio indicator is 0.16, the weight of operating cost ratio is 0.16, the weight of net sales interest rate indicator is 0.27, and the weight of total asset return ratio indicator is 0.31; From the customer

perspective, the weight of operating income growth rate is 0.28, the weight of business income contribution rate is 0.39, and the weight of main business profit margin is 0.32; From the perspective of internal business process, the weight of current ratio indicator is 0.20, the weight of quick ratio indicator is 0.19, the weight of cash ratio indicator is 0.21, the weight of fixed assets turnover ratio indicator is 0.19, the weight of total assets turnover ratio indicator is 0.20; From the perspective of learning and growth angle, the weight of net assets growth rate indicator is 0.35, the weight of net profit growth rate indicator is 0.44, the weight of total asset growth rate indicator is 0.10, and the weight of debt growth rate indicator is 0.11.

Formula (5-31) - Formula (5-34) show the performances of the enterprises of hotel business sector from various evaluation perspectives. From the financial perspective, the performances of the four enterprises from good to bad are: Company 3 is at the same superior level as company 4, followed by company 2, and the performance of company 1 is the worst; From the customer perspective, the performances of the four enterprises from good to bad are: Company 3, company 2, company 1; From the perspective of internal business processes, the performances of the four enterprises from good to bad are as follows: Company 1, company 3, company 2 and company 4 are at the same poor level; From the perspective of learning and growth, the performances of the four enterprises from good to bad are: Company 4, Company 2, Company 1, Company 3

From the comprehensive fuzzy evaluation vector of Formula (5-35), the performances of the four enterprises can be obtained, from superior to poor: Company 4, company 2, company 3, company 1.

5.2 Conclusion

In this paper, the fuzzy performance evaluation model for state-owned group enterprises is established by combining the characteristics of overall balance, overall connection, qualitative analysis and quantitative calculation and using the Delphi method and entropy weight method for the managers of the state-owned groups to understand and improve the management of subsidiary enterprises.

Chapter 6 Analysis of Coordination and Decision-making among Subsidiaries of State-owned Enterprise Group

Since the reform and opening up, China's economy has been on a path of sustained and rapid development, and become an important part of world economy. Against this backdrop, the state-owned enterprises in China have gradually improved in practice.

As state-owned enterprise groups implement the diversified management strategies, some product lines that lack competitiveness are gradually eliminated, while some resources conducive to the development of the enterprise groups are effectively integrated, and the dominant positions of enterprise groups within the industries are on constantly rise. However, with the implementation of horizontal or vertical integration strategy, the decision makers of enterprise groups are inevitably faced with the problem of how to effectively strengthen the coordination between subsidiaries or departments within the groups in order to consolidate and develop their core competitiveness and internal cohesion.

The decision-making process of coordination between subsidiaries or departments of enterprise group has been characterized with complexity and poor symmetry of information and data. Therefore, in the process of inter-departmental coordination and decision-making, the quantitative factors are often impossible to complete. Usually, the decision makers can only use the method of subjective decision to determine the overall objectives of the enterprise and the tasks of each sector in the next period. The Analytic Hierarchy Process (AHP) is a combination of qualitative and quantitative methods that determines the relative importance of many factors in the hierarchy by comparing in pairs, and synthesizes the relative importance of people's judgment and the determined decision factors to carry on the overall sequencing. Its most important and basic idea is to make complex problems hierarchical and to consider the problem layer by layer. It provides quantitative basis for analysis and decision making and is widely used in analysis and evaluation.

However, with the increasing application of Analytic Hierarchy Process (AHP), its limitations are gradually exposed: When establishing judgment matrix, the data processed by AHP are "point" data or "rigid" data. But in actual decision-making process, it is often difficult for the decision-makers to make a clear judgment on the comparison of the two factors, where it might not be appropriate to use rigid point data. In management, because the information is not complete, the experts are often uncertain about their judgment. In this case, we use the interval AHP method that is using the interval number to replace the point value to form a judgment matrix, and then solve the weight vector and the comprehensive weight of interval number, and finally sequence them.

6.1 Research on IAHP Modeling

6.1.1 Brief Introduction to the Interval Analytic Hierarchy Process (IAHP)

（1）The difference between IAHP and AHP

By comparing IAHP and AHP, we can see that with the introduction of interval number judgment matrix, the construction of judgment matrix becomes more and more in line with human subjective judgment. The differences between IAHP and AHP decision making methods are also enlarged accordingly. In the process of theoretical research and practical operation, we can see that there are several main differences between IAHP and AHP.

① IAHP needs to construct interval number judgment matrix.

② The methods used to roughly solve the eigenvector are different.

③The introduction of k and m, to determine which interval number the matrix emphasizes. The k/m is the most important influence factor to solve the final eigenvector.

④ the difference of consistency test.

（2）Application scope of IAHP decision-making method

IAHP decision making method combines qualitative and quantitative methods and has the characteristics of hierarchical and broad judgment intervals. It is widely used in various decision-making fields and provides an effective mathematical model for decision-making. However, in the process of practical decision operation, we should pay attention to using experts or experienced hands to construct the judgment matrix, which can avoid both the difficulty to pass the consistency test and the distortion in the actual decision.

6.1.2 Establishment of IAHP Model

(1) Establishment of a hierarchy

Similar to the AHP method, the establishment of hierarchical structure is also the key to modeling and comprehensive ranking with IAHP, which is the first step to simplify the complex problems. When building the hierarchical model, we should first define the decision goal and accurately analyze the relevant influence factors. Build a hierarchical model in turn, until the final decomposition into the corresponding related factor criteria, that is, there should be a target layer, criterion layer, sub-criterion layer, program layer.

The whole calculation process of IAHP model is based on the establishment of hierarchical structure, and the relative importance of each sub-factor to the overall goal is taken as the

weight. It should be noted that each factor of the same layer should be graded in relation to the relative factors of the previous layer.

(2) Forming judgment matrix

  After the hierarchical structure is established, the judgment matrix should be established to scale out the local weights in each layer. It is a comparison of one factor in pairs with other factors in the same layer. By solving the largest eigenvalue and eigenvector of the matrix, we can get the weight ranking of each factor relative to other factors. In the calculation of IAHP, the relative importance scale of AHP method is still used.

  In the process of establishing judgment matrix by IAHP calculation, if A and B are considered to be between very important and absolute important, the comparative language scale is quantified by looking up Table 6-1, and the relative importance indicator is as follows: [7,9], according to which the judgment matrix can be constructed. In the process of practical operation, experts should be asked to make a careful comparison and scoring to make it more scientific and credible.

Table 6-1 Positive Reciprocal 1-9 Scale Table

Scale a_{ij}	Definition
1	i factor is as important as j
3	i factor is slightly more important than j
5	i factor is more important than j
7	i factor is more important than j
9	i factor is more important than j
2, 4, 6, 8	For the intermediate state between the above two judgments
Reciprocal	Importance of factor j compared with factor i

(3) Solve the weight of judgment matrix

  After establishing the judgment matrix according to the above first two steps, we can calculate the weight of the interval number. In this paper, the interval eigenvalue method is

used to solve the eigenvector of the interval number judgment matrix. We usually calculate interval number matrices by means of numerical matrices or vectors.

Note $A = (a_{ij})_{n \times n}$ as an interval matrix, that is $A^- = (a_{ij}^-)_{n \times n}$, also note:, $A^+ = (a_{ij}^+)_{n \times n}$, that is $A = [A^-, A^+]$. In the same way, for the interval vector $x = (x_1, x_2, ..., x_n)$, that is $x_i = [x_i^-, x_i^+]$, for the interval vector $x^- = (x_1^-, x_2^-, \cdots x_n^-)^T$, $x^+ = (x_1^+, x_2^+, \cdots x_n^+)^T$, and note $x = [x^-, x^+]$.

In addition: If: $A\lambda = X\lambda$, namely λ is the eigenvalue of A, x is the eigenvector of A. Then $A^- x^- = \lambda^- x^-$, $A^+ x^+ = \lambda^+ x^+$. And if λ^- and λ^+ is the largest eigenvalue of the corresponding matrix, then: x^- and x^+ and are the normalized feature vectors corresponding to λ^- and λ^+ respectively. $x = [kx^-, mx^+]$ is the corresponding full eigenvector of x, where k and m are all positive real numbers satisfying $0 \le kx^- \le mx^+$. The ratio between K and m is the judgment of experts that is closer to which importance in the scale of 1-9. According to the symmetry of the left and right endpoints of the weight vector, we can obtain the expressions of k and m. Assume:

$$k = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} a_{ij}^+}} \quad m = \sqrt{\sum_{j=1}^{n} \frac{1}{\sum_{i=1}^{n} a_{ij}^-}}$$, where we can get the calculation method of the weight of interval number.

The steps are as follows:

The interval judgment matrix is divided into two matrices: A^- and A^+ for calculation.

① Normalize the judgment matrix by column.

$$\overline{a_y} = \frac{a_y}{\sum_{i=1}^{n} a_{ij}}, i = 1,2,..., n; j = 1,2,..., n$$

② The normalized matrix is added by rows.

$$\overline{w_i} = \sum_{j=1}^{n} \overline{a_{ij}}, i = 1,2,..., n$$

And then normalize the vector $\overline{w} = (w_1, w_2,..., w_n)^T$, that is $w_i = \dfrac{\overline{w_i}}{\sum\limits_{i=1}^{n} \overline{w_i}}$, when:

$w = (w_1, w_2,..., w_n)^T$ is the eigenvalue to be solved.

Calculate the largest eigenvalue λ of the judgment matrix, then $\lambda = \sum\limits_{i=1}^{n} \dfrac{(Aw)_i}{nw_i}$; where: $(Aw)_i$ is the i-th element of the vector Aw. Obtain the eigenvectors x^- and x^+ of the two matrices.

③ From the expressions of k and m, $k = \sqrt{\sum\limits_{j=1}^{n} \dfrac{1}{\sum\limits_{i=1}^{n} a_{ij}^{+}}} \quad m = \sqrt{\sum\limits_{j=1}^{n} \dfrac{1}{\sum\limits_{i=1}^{n} a_{ij}^{-}}}$, obtain k and m,

and the corresponding weights of weight vectors $x = [kx^-, mx^+]$ can be obtained by introducing the formula.

④ After determining the corresponding weight values of n weight vectors, we use the form of center interval to represent the above interval, and select the greater influence factors to

sequence. Namely: $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$. Based on this, the weights of n targets can be determined and sequenced.

（4）Consistency test

Definition: If $\forall i, j, k$ all have $a_{ij} \cdot a_{jk} = a_{ik}$, A is called the consistency judgment matrix.

Test methods: I. Calculate consistency indicators: $C.I. = \dfrac{\lambda_{max} - n}{n-1}$. II. Calculate consistency

ratio:. $C.R. - C.I / R.I.$ Where the value $R.I.$ is

Dimension	1	2	3	4	5	6	7	8	9	10	11	12	13	14
RI	0	0	0.58	0.89	1.12	1.26	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58

When C.R. < 0.1, the judgment matrix satisfies the consistency, and the next operation can be carried out.

6.1.3 Matters Needing Attention

In general, it is a multi-level model. When building hierarchical structure and judgment matrix, there should be target layer, criterion layer, sub-criterion layer and scheme layer. When calculating the ranking weight of the previous indicator in each indicator system, the influence of the eigenvector $(x_1, x_2, ..., x_m)$ of the previous indicator on the next layer should be calculated. When calculating the hierarchical total sequence consistency indicator, the hierarchical total sequence random consistency indicator is $C.I. = \sum_{i=1}^{m} a_i C.I._{.i}$. When

$R.I. = \sum_{i=1}^{m} a_i R.I._{.i}$。 $C.R. = C.I./R.I. < 0.1$, the hierarchy total sort matrix satisfies consistency.

when the consistency is too low, correction judgment matrix should be adopted to correct and recalculate until the requirements are met.

When the consistency test of each judgment matrix is up to standard, and the total test is not qualified, we should start to reconstruct the judgment matrix with the largest C.R.

6.2 Process of Coordinated Decision

6.2.1 Main Thrust of Inter-sectoral Coordinated Decision

Modern enterprise group is a large system composed of many functional departments. These functional departments are called the subsystem of enterprise group. As a system, enterprise groups have their own specific goals, and different as their goals are, these goals are global, such as the pursuit of profit maximization, rapid expansion of enterprises and so on. While as subsystem each functional department also has its own specific goals, and the goals of the subsystem are subordinate to and serve the system goals. Of course, this does not mean that the objectives of the subsystems are always consistent with the overall objectives of the enterprise group. In fact, the objectives of the subsystems and the objectives of the groups are to a large extent not compatible with the objectives of the enterprise groups. The measures taken by various functional departments to achieve their own goals often damage the realization of the objectives of other departments or are restricted by other departments, and ultimately affect the realization of the overall objectives of the enterprise.

There are many reasons for this. For example, information asymmetry, conflicting objectives of the various subsystems, and so on. Traditional methods focus on the establishment of appropriate overall planning model, set up a reasonable global objective function, ignore the local objectives of each department, set up resource constraints, establish a goal programming model, and then solve the model, so as to determine the decision plan.

This method is undoubtedly a scientific and effective method, an important basis of decision-making science, and also an important theoretical cornerstone of decision support system research. However, when faced with the decentralized organization and the decisions in contradiction with the specific objectives of some departments, it will inevitably give rise to a decrease in the working enthusiasm of the departments, inefficient production and services and other obstacles to the development of enterprises.

In order to avoid such a situation, the main ideas for this paper to adopt decision approach are: Each department of the enterprise first independently formulates its own decision scheme, then carries on many information exchanges and adjusts their decision scheme, finally achieves the satisfactory solution, and realizes the system overall optimization. In this method, each department adjusts the parameters of its decision model, and after many interactive dynamic processes, finally obtains the optimized decision results that all parties are satisfied with.

6.2.2 General Model for Coordinated Decision-making between Functional Departments

Assuming that there are n departments involved in coordinated decision-making, each with information autonomy, the optimization model is a single-objective optimization model (or a multi-objective model that can be transformed into a single-objective model), the global decision vector is $I = (\eta_1, \eta_2,...,\eta_n)$ where $\eta_i (i = 1,...,n)$ is the global decision variable, n is the decision number, and $\mu_{i+1} = |\eta_{i+1} - \eta_i|$ is the difference between the interdepartmental decision steps in the decision-making process.

6.2.3 General Process of Coordinated Decision-making between Functional Departments

The final purpose of coordinated decision-making among the functional departments of enterprises is to find a scheme to satisfy all departments. That is, there is no decision goal made by the superior department, which causes dissatisfaction among some departments due to their own special reasons or the overall fairness, so as to result in the decrease of work efficiency and the degree of inter-departmental cooperation and reduce production and service efficiency. For example, when formulating a fund allocation programme, that is, how the state-owned group should allocate the funds to the various sectors, so that the departments will be more satisfied with the funds allocation programme if the plan can be fully completed rather than complain about their own difficulties or fairness and other circumstances. Or each department plan objective coordination plan that is how to formulate the production or target quota plan in the next period, so that some departments will not think their quota poses too

much pressure on them. In the process of coordination, all departments should take the interests of their departments as the priority, that is to say, a department will lead the AHP ranking allocation, prioritize allocation for its own department slightly over others, and finally reach a relatively satisfactory allocation plan for each department.

The coordination principles are: (1) In the process of coordination, the differences between various departments should be reduced continuously, that is, the coordination process is convergent. If the process of coordination is becoming more and more divisive, that is, the process of coordination diverges, then this situation should be given up. This paper guarantees the convergence of the results is to properly increase the weight of the last round of inconsistent results in the next cycle. (2) It is to determine the conditions in which all departments can be satisfied, that is, how to determine the final satisfactory results. The method of choosing satisfactory solutions in this paper is to compare the results of the two allocations before and after, in order to determine whether it is less than the established acceptable optimal coordination difference.

The process of multisectoral participation in coordinated decision-making is described below:

① system initialization. Assuming that there are n departments, the candidate order of each department can be arranged in a predetermined order, and a sufficiently small positive ε acceptable to each department is set to be the difference in the optimization and coordination process acceptable to all departments.

② choose the first department to make the decision, and give the decision result η_i. Then choose the next department decision, and again give the decision results of each department η_{i+1}.

③ $\mu_{i+1} = |\eta_{i+1} - \eta_i|$

④ compare the distribution results μ_{i+1} with the minimum ε acceptable to each department: If $\mu_{i+1} < \varepsilon$, then the coordination process is completed, find the solution that makes each department satisfied; If $\eta_j \geq \varepsilon$, so select the next department and re-make the decision. $i = i+1$; And before the next round of coordination, we should appropriately increase the weight of the last round not in line with the department, to ensure the convergence of the coordination process.

⑤ if i=n, all departments have been fully coordinated, it is impossible to find a coordination plan that will satisfy all departments, and coordination ends with failure.

This is the process of building a decision system model with information technology based on coordination, which is widely used in the field of information technology. Based on its scientific and normative nature, this paper applies it to the coordination of decision-making among departments. The essence of this coordination process is: There are a lot of methods for coordinated decision for selected sectoral departments, and this thesis selects interval Analytic Hierarchy Process (AHP), then makes decision by replacing the decision department step by step, and finds out whether all the sectors are satisfied by certain constraints, that is, whether the decision-making process is over.

There are two criteria to be satisfied in this thesis:

① whether μ_{i+1} is less than ε, that is, whether it satisfies the gradual convergence of the coordination difference in the process. If μ_{i+1} cannot satisfy the gradual reduction, or if the quantized divergence is gradually becoming larger, then the decision vector is divergent, the reasons for and solutions to such problems must be found.

② Whether *i* is equal to n. that is, whether all departments that need coordination have been coordinated. If all of them have been coordinated, that is, i=n, under this margin ε, it is impossible to find a solution that will satisfy all sectors. The solution in this paper is: Appropriately increase ε, that is, appropriately increase the minimum difference acceptable to various departments, then the coordinated decision based on IAHP method is carried out.

And it should be noted that in the process of selecting ε, the size of ε is more critical. The excessively large ε will shorten the coordination process, and inevitably cause excessively large gap among various departments. The excessively small ε might satisfy various departments, but the coordination process will be too long, or even can not appear satisfactory solution. Therefore, it depends in the actual operation process.

6.3 Empirical Study of IAHP in LH Group's Coordinated Decision-making Investment

6.3.1 Basic Data

According to the "Analysis and Research on the Supervision of State-owned Enterprises of Shandong SASAC", this thesis obtains eight categories of enterprises belonging to the state-owned groups of Shandong SASAC. Total assets, liabilities, owners' equities, operating income, total profits and net profits of coal, iron and steel, automobile and machinery manufacturing, transport, trade, investment, gold and pharmaceutical and chemical industries in 2017.

6.3.2 Question Assumptions and Indicator Layers

③ In the next quarter, the SASAC of Shandong Province is to allocate a sum of funds to the enterprises under its jurisdiction to promote the implementation of its accelerated development strategy in the next quarter. Through preliminary observation, it indicates that the real estate development sector enterprises from the above four aspects are far better than other sectors. Consideration could therefore be given to allocating its funds separately to support its next phase of rapid and stable development. Real estate development sector enterprises are not within the scope of consideration. The problem becomes the reasonable allocation of the remaining funds to hotel management, coal logistics, biopharmaceutical, new finance pawn and project management. To promote its development in the next quarter, the funds allocation is required that the amount of funds allocated to enterprises in various sectors enable all departments to be satisfied with the allocated amounts, including the amounts of their own and other sectors, provided that the normal development in the next stage is ensured, and there should not be a decline in the overall productivity of state-owned enterprise groups or a decline in inter-sectoral synergy among sectors due to the dissatisfaction of some departments with the allocation plan.

④ For this problem, the coordinated decision-making for subsidiaries of state-owned enterprise group as discussed in this thesis with the IAHP method can be performed. Start with a hierarchy diagram, as shown in Figure 6-1.
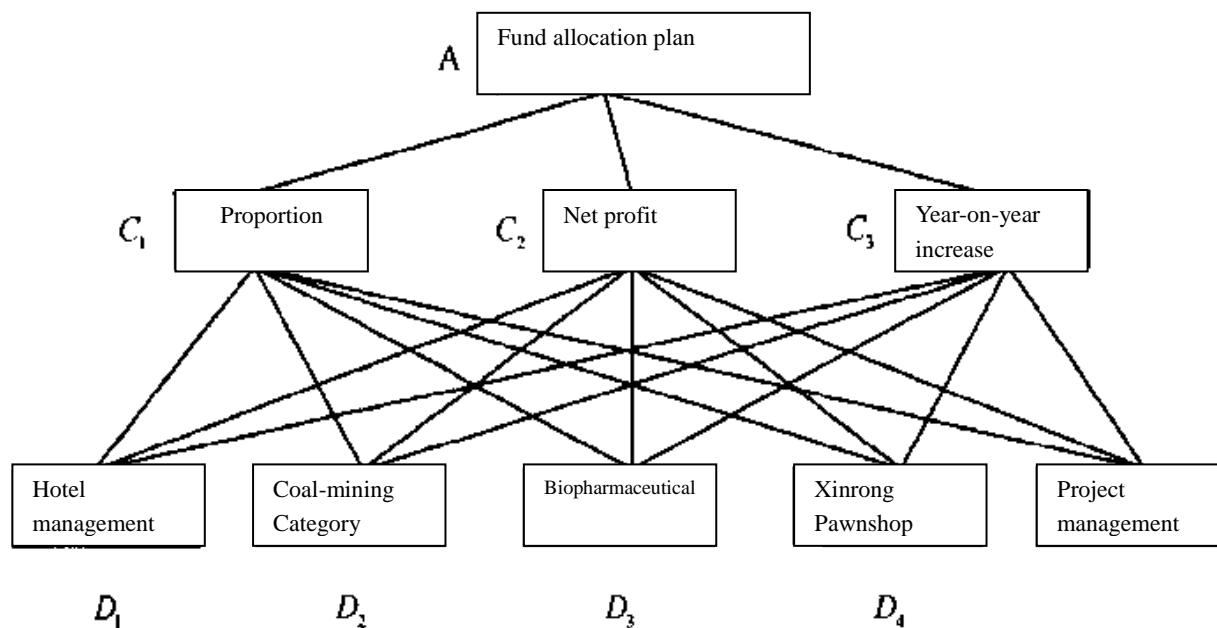
Figure 6-1 Indicator Hierarchy of State-owned Group Enterprise's Subsidiaries

In order to allocate state funds to various departments in a reasonable manner and avoid dissatisfaction of some departments with the funds allocated we construct three criteria at the criterion layer in the construction hierarchical diagrams：C1 is proportion, C2 is net profit and C3 is year-on-year growth. Any criterion include five sectors of departments，which are hotel management, coal logistics, biopharmaceutical, new finance pawn and project management. The task is to use the IAHP method and the general process of inter-departmental coordination decision-making to coordinate the decision-making, so that these five sectors of enterprises can realize the reasonable allocation of funds under the hierarchy structure through a reasonable funds allocation plan.

6.3.3 Establishment and Analysis of Evaluation System

Assume that the Shandong SASAC is allocating 10 million funds in next quarter to these five sectors of enterprises, and according to the general process of synergy optimization, set the minimum ε acceptable to various sectors to be 1 million. Then optimize according to the above mentioned process and the given table.

①n=5, ε=1 million

② Select the hotel management sector as the leading department, and carry out IAHP ranking and distribution. The relative judgment matrix developed by hotel enterprises is

A—C	C1	C2	C3
C1	(1,1)	(3,5)	(2,4)
C2	(1/5,1/3)	(1,1)	(1,3)
C3	(1/4,1/2)	(1/3,1)	(1,1)

Obtain:

$X^- = (0.627, 0.206, 0.166)$, $X^+ = (0.587, 0.233, 0.180)$.

The k and m are: k=0.902,m=1.082.

Accordingly, according to $m(A_i) = \frac{1}{2}(kx_i^- + mx_i^+)$: the total eigenvector of the third order judgment matrix is (0. 6, 0. 219, 0. 173).

That is: When IAHP distribution is dominated by the hotel management section, the importance of proportion, net profit and year-on-year growth to the enterprises of the hotel

management section, account for 60%, 21.9% and 17.3%, respectively. This is the condition for the final total sort.

The construction of such judgment matrix is reasonable. If the judgment matrix is constructed on the hotel management section, for proportion, net profit and year-on-year growth, the performances of the proportion and the year-on-year growth are far better than those of other industries, so when building a judgment matrix led by hotel management sector enterprises, the weights of these two indicators will be added to increase their own advantages over other sectors accordingly.

C1—D	D1	D2	D3	D4	D5
D1	(1,1)	(1,3)	(2,4)	(3,5)	(3,5)
D2	(1/3,1)	(1,1)	(1,3)	(3,5)	(3,5)
D3	(1/4,1/2)	(1/3,1)	(1,1)	(2,4)	(2,4)
D4	(1/5,1/3)	(1/5,1/3)	(1/4,1/2)	(1,1)	(1,2)
D5	(1/5,1/3)	(1/5,1/3)	(1/4,1/2)	(1/2,1)	(1,1)

Obtain through calculations:

x^- = (0.386, 0.274, 0.176, 0.087, 0.076), x^+ = (0.379, 0.286, 0.186, 0.8, 0.068). The k and m are: k=0.851, m=1.139.

Thereafter, according to $m(A_i) = \dfrac{1}{2}(kx_i^-, +mx_i^+)$, the total eigenvector of the fifth order judgment matrix is (0.38, 0.28 ~ 0.181 ~ 0.083 ~ 0. 071).

Namely: When IAHP distribution is dominated by the hotel management section, based on the criterion of proportion, the distribution proportions of hotel management, coal logistics, biopharmaceutical, new financial pawn and project management should be as follows: 38%, 28%, 18.1%, 8.3% and 7.1%.

The construction of such judgment matrix has its rationality. If the judgment matrix is constructed on the hotel management section, the hotel management sector will surely increase its own weight over other sector in order to increase its competitive advantage over other sectoral enterprises, and even for similar indicators, the hotel management sector is bound to increase its weight relative to those of other departments in order to increase its own advantage and compete for a better share in final funds allocation, which is the main reason why this paper adopts such a coordinated decision-making process.

C2—D	D1	D2	D3	D4	D5
D1	(1,1)	(1,3)	(1/3,1)	(1,2)	(2,3)
D2	(1/3,1)	(1,1)	(1/5,1/3)	(1/4,1/2)	(1,2)
D3	(1,3)	(3,5)	(1,1)	(1,3)	(3,5)
D4	(1,1)	(2,4)	(1/3,1)	(1,1)	(2,4)
D5	(1/3,1)	(1,2)	(1/5,1/3)	(1/4,1/2)	(1,1)

Through calculations obtain:

$x-$= (0.213,0.099,0.35,0.238,0.099), x^+= (0.22,0.101,0.359,0.218,0.101).

The k and m are: k=0.832, m=1.13.

Accordingly, according to $m(A_i) = \frac{1}{2}(kx_i^- + mx_i^+)$, the total eigenvector of the fifth order judgment matrix is (0.213, 0.098, 0.349, 0.223, 0.098).

Namely: When IAHP is assigned under the leadership of the hotel management section and based on net profit criterion, the assigned proportions of hotel management, coal logistics, biopharmaceutical, new finance and pawn and project management should be: 21.3%, 9.8%, 34.9%, 22.3% and 9.8%, respectively.

The rationality of the construction of judgment matrix has been stated in the C1-D matrix and will not be restated.

C3—D	D1	D2	D3	D4	D5
D1	(1,1)	(3,5)	(2,3)	(2,3)	(1,2)
D2	(1/5,1/3)	(1,1)	(1/4,1/2)	(1/4,1/2)	(1/6,1/4)
D3	(1/3,1)	(2,4)	(1,1)	(1,2)	(1/5,1/3)
D4	(1/3,1)	(2,4)	(1,2)	(1,1)	(1/5,1/3)
D5	(1,2)	(4,6)	(3,5)	(3,5)	(1,1)

Through calculations obtain:

x^-= (0.308, 0.057, 0.127, 0.127, 0.38), x^+= (0.294, 0.053, 0.147, 0.147, 0.36).

The k and m are: k=0.817, m=1.048.

Accordingly, according to $m(A_i) = \frac{1}{2}(kx_i^-, +mx_i^+)$, the total eigenvector of the five-order judgment matrix is (0.28, 0.051, 0.129, 0.129, 0.344).

Namely: When IAHP assignment is led by the hotel management section based on the year-over-year growth criteria, the assigned proportions of hotel management, coal logistics, biopharmaceutical, new finance and pawn, and project management should be as follows: 28%, 5.1%, 12.9%, 12.9%.,34.4%.

The rationality of the construction of judgment matrix has been stated in the C1-D matrix and will not be restated.

Set simultaneous A-C matrix/C1-D matrix, C2-D matrix and C3-D matrix. Perform total sorting based on the hotel management sectoral enterprises.

	C1	C2	C3
	0.6	0.219	0.173
D1	0.38	0.213	0.28
D2	0.28	0.098	0.051
D3	0.181	0.349	0.129
D4	0.083	0.223	0.129
D5	0.071	0.098	0.344

Through comprehensive ranking and calculation, obtain:

W= (0.323, 0.198, 0.207, 0.121, 0.124),

Consistency check: Total C.1=0.018 and R, I.=1.12, total C.R.=0.016 < 0.1. The matrix satisfies the consistency, that is, the overall satisfies consistency. The established matrix is true.

Namely: In the case of IAHP decision allocation led by hotel management section and based on the joint criteria of proportion, net profit and year-on-year growth, the assigned proportions of hotel management, coal logistics, biopharmaceuticals, new finance pawn and project management should be: 32.3%, 19.80%, 20.7%, 12.1% and 12.4%, respectively.

The test passed, so: The 10 million assigned by SASAC, if the hotel management section is chosen as the dominant one, will be allocated through IAHP ranking and assignment to hotel management, coal logistics, biopharmaceutical, new finance pawn and project management

3.23 million, 1.98 million, 2.07 million, 1.12 million and 1.24 million RMB Yuan, respectively.

Through the construction and gradual calculation of the judgment matrices which are superior to other sectoral enterprises, it clearly indicates that the results of IAHP coordinated decision-making led by the hotel management sector tend to increase the funds allocation of the hotel management sectoral enterprises. The 3.23 million RMB is much higher than that in other sectors. This is only natural but bound to lead to dissatisfaction, uncoordinated cooperation and ultimately inefficiencies among other departments as well as failure for rapid and steady growth of production efficiency. Therefore, according to the general process of coordinated optimization in this paper, the next step of coordinated optimization should be carried out.

Then the IAHP ranking and assignment is carried out led by the coal logistics section. The relative judgment matrix of the coal logistics enterprises is as follows.

A—C	C1	C2	C3
C1	(1,1)	(1,2)	(3,5)
C2	(1/2,1)	(1,1)	(3,5)
C3	(1/5,1/3)	(1/5,1/3)	(1,1)

Through calculations, obtain:

$x^- = (0.49, 0.392, 0.117)$, $x^+ = (0.494, 0.394, 0.111)$.

The k and m are: k=0.905, m=1.089.

Accordingly, according to $m(A_i) = \frac{1}{2}(kx_i^- + mx_i^+)$, the total eigenvector of the third-order judgment matrix is (0.491, 0.392, 0.114).

Namely: When IAHP assignment is led by coal logistics section, the importances of the proportion, net profit and year-on-year growth to the enterprises of coal logistics sector, account for 49.1%, 39.2% and 11.4%, respectively. This is the condition for the final total ranking.

The construction of the judgment matrix has its rationality. If the judgment matrix is constructed from the coal logistics sector, among the proportion, the net profit and the year-on-year growth, the performance of the proportion is much better than that of other sectors. Therefore, when the coal logistics -management-sector-enterprise-led judgment matrix is

constructed, the weight of this indicator will be increased to enhance its own advantage over other sectors.

Cl—D	D1	D2	D3	D4	D5
D1	(1,1)	(1/3,1)	(1,3)	(3,5)	(3,5)
D2	(1,3)	(1,1)	(2,4)	(3,5)	(3,5)
D3	(1/3,1)	(1/4,1/2)	(1,1)	(2,4)	(2,4)
D4	(1/5,1/3)	(1/5,1/3)	(1/4,1/2)	(1,1)	(1,2)
D5	(1/5,1/3)	(1/5,1/3)	(1/4,1/2)	(1/2,1)	(1,1)

Through calculations, obtain:

x^- = (0.274, 0.386, 0.176, 0.087, 0.076), x^+ = (0.286, 0.379, 0.186, 0.08, 0.068).

The k and m are: k=0.851, m=1.139.

Accordingly, according to $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$, the total eigenvector of the fifth order judgement matrix is (0.28, 0.38, 0.181, 0.083, 0.071)

Namely: When the assignment of IAHp is led by coal logistics sector and based on the proportion criterion, the assigned proportions of hotel management, coal logistics, biopharmaceutical, new finance and project management should be: 28 %, 38%, 18.1%, 8.3% and 7.1%, respectively.

The construction of such judgment matrix has its rationality. If the judgment matrix is constructed with the coal logistics sector, the coal logistics sectoral enterprises will surely increase their weights relative to those of other sectoral enterprises in order to enhance their competitive advantage over other sectoral enterprises, and even for similar indicators, the coal logistics sectoral enterprises are bound to increase their weights relative to those of other departments in order to increase its own advantage and compete for a better share in final funds allocation, which is the main reason why this paper adopts such a coordinated decision-making process.

C2—D	D1	D2	D3	D4	D5
D1	(1,1)	(1/5,1/3)	(1/6,1/4)	(1/5,1/3)	(1/4,1/2)
D2	(3,5)	(1,1)	(1/3,1)	(1,2)	(1,3)
D3	(4,6)	(1,3)	(1,1)	(1,2)	(3,5)
D4	(3,5)	(1,2)	(1/2,1)	(1,1)	(2,4)
D5	(2,4)	(1/3,1)	(1/5,1/3)	(1/4,1/2)	(1,1)

Through calculations, obtain:

x^-= (0.06, 0.219, 0.35, 0.261, 0.11), x^+= (0.051, 0.244, 0.337, 0.252, 0.116).

The k and m are: k=0.842, m=1.115.

Hence, according to $m(A_i) = \frac{1}{2}(kx_i^- + mx_i^+)$, the total eigenvector of the five-order judgment matrix is (0.054, 0.228, 0.335, 0.25, 0.111).

Namely: When the assignment of IAHP is led by coal logistics sector based on net profit criteria, the proportions of hotel management, coal logistics, biopharmaceutical, new finance and project management sectoral enterprises should be as follows: 5.4%, 22.8%, 33.5%, 25% and 11.1%.

The construction rationality of judgment matrix has been stated in the C1-D matrix and will not be restated.

C3—D	D1	D2	D3	D4	D5
D1	(1,1)	(2,4)	(1,3)	(1,3)	(1/4,1/2)
D2	(1/4,1/2)	(1,1)	(1/3,1)	(1/3,1)	(1/6,1/4)
D3	(1/3,1)	(1,3)	(1,1)	(1/2,1)	(1/5,1/3)
D4	(1/3,1)	(1,3)	(1,2)	(1,1)	(1/5,1/3)
D5	(2,4)	(4,6)	(3,5)	(3,5)	(1,1)

Through calculations, obtain:

x^-= (0.189, 0.753, 0.11, 0.127, 0.499), x^+= (0.22, 0.081, 0.124, 0.141, 0.434).

The k and m are: k=0.883, m=1.116.

Hence, according to $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$, the overall feature vector of the fifth-order judgment matrix is (0.206, 0.078, 0.118, 0.135, 0.463).

Namely: When the assignment of IAHP is led by the coal logistics sector and based on the year-on-year growth criteria, the assigned proportions for hotel management, coal logistics, biopharmaceuticals, new financial pawn, and project management sectoral enterprises should be: 20.6%, 7.8%, 11.8%, 13.5% and 46.3%.

The rationality of the construction of the judgment matrix has already been described in the C1-D matrix, and will not be restated.

Set simultaneous A-C matrix, C1-D matrix, C2-D matrix, and C3-D matrix. Carry out a comprehensive ranking based on the coal logistics sectoral enterprises.

	C1	C2	C3
	0.491	0.392	0.114
D1	0.28	0.054	0.206
D2	0.38	0.228	0.078
D3	0.181	0.335	0.118
D4	0.083	0.25	0.135
D5	0.071	0.111	0.463

Through calculations, obtain:

W= (0.182, 0.285, 0.234, 0.154, 0.131),

Total C.I.=0.021, R, I.=1.12, total C.R.=0.019<0.1.

The matrix satisfies the consistency, that is, generally satisfies consistency. The matrix is true.

Namely: In the case of IAHP's decision-making assignment led by the coal logistics sector and based on the combined criteria of proportion, net profit, and year-on-year growth, the assigned overall proportions of hotel management, coal logistics, biopharmaceuticals, new financial pawn and project management should be: 18.2%, 28.5%, 23.4%, 15.4% and 13.1%

The test passed, so: The 10 million allocated by the SASAC, if the hotel management section is selected to lead the IAHP rank allocation, should be allocated to hotel management, coal

logistics, biopharmaceuticals, new financial pawn and project management, 1.82 million, 2.85 million, 2.34 million, 154 million and 131 million RMB Yuan of funds.

Through the construction and the gradual calculation of each judgment matrix superior to other sectoral enterprises, it clearly indicates that the results of the IAHP's coordinated decision-making with the coal logistics sector as the dominant factor tended to increase the allocation of funds to the coal logistics sector. Its allocated fund of 2.85 million RMB Yuan is higher than those of other departments. This is an inevitable result but will inevitably lead to dissatisfaction, incoordination and low coordination efficiency among various departments as well as failure for rapid and steady growth of production efficiency. Therefore, the next step of coordinated optimization should be carried out according to the general process mentioned in this paper.

Calculate $|\mu_{i+1}, \mu_{i+1}| = |\mu_{i+1} - \mu_i|$ of each department, obtain the differences μ_{i+1} between the five departments are 1.41 million, 0.87 million, 0.27 million, 0.33 million, and 70,000, which indicate: In the coal-logistics-dominated AHP ranking and assignment, the difference of hotel management departments is too much, which is greater than the optimized minimum difference of 1 million acceptable to the sectoral enterprises. The degree of satisfaction is too low and adjustments need to be made.

Select another sector of enterprises to make the next adjustment.

Then the biopharmaceutical sector is used as the leading IAHP allocation, and the biopharmaceutical companies' relative judgment matrix is

A—C	C1	C2	C3
C1	(1,1)	(3,5)	(2,4)
C2	(1/5,1/3)	(1,1)	(1,3)
C3	(1/4,1/2)	(1/3,1)	(1,1)

Through calculations, obtain:

$x^- = (0.627, 0.206, 0.166)$, $x^+ = (0.587, 0.233, 0.18)$.

The k and m are: k=0.902, m=1.082.

Hence, according to $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$, the overall feature vector of the third-order judgment matrix is (0.6, 0.219, 0.173).

Namely: When IAHP assignment is dominated by biopharmaceutical sector, the importance of proportion, net profit and year-on-year growth to the biopharmaceutical sectoral enterprises account for 60%, 21.9% and 17.3%, respectively. This is the final condition of the total ranking.

The construction of such judgment matrix is reasonable. If the biopharmaceutical sector is used to construct the judgment matrix, among the three indicators of proportion, net profit and year-on-year growth, the performance of net profit is much better than that of other sectors. Therefore, the bio-pharmaceutical sector will increase the weight of this indicator so as to increase its own advantage over other sectors.

C1—D	D1	D2	D3	D4	D5
D1	(1,1)	(1,2)	(1,3)	(4,6)	(4,6)
D2	(1/2,1)	(1,1)	(1,3)	(4,6)	(4,6)
D3	(1/3,1)	(1/3,1)	(1,1)	(3,5)	(3,5)
D4	(1/6,1/4)	(1/6,1/4)	(1/5,1/3)	(1,1)	(1,2)
D5	(1/6,1/4)	(1/6,1/4)	(1/5,1/3)	(1/2,1)	(1,1)

Through calculations，obtain::

$x^- = (0.352, 0.306, 0.209, 0.071, 0.063)$, $x^+ = (0.347, 0.303, 0.23, 0.065, 0.055)$.

The k and m are: k=0.861, m=1.135.

Hence, according to $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$, the overall feature vector of the fifth-order judgment matrix is (0.348, 0.303, 0.221, 0.067, 0.058).

Namely: When the IAP assignment is led by the biopharmaceutical sector and based on the proportion criterion, the proportions of hotel management, coal logistics, biopharmaceuticals, new financial pawn and project management should be: 34.8%, 30.3%, 22.1%, 6.7% and 5.8%.

The structure of such judgment matrix is reasonable. If the bio-pharmaceutical sector is used to construct the judgment matrix, the bio-pharmaceutical enterprises will increase their weights relative to other sectoral enterprises to increase their competitive advantage over other sectoral enterprises. Even for previously similar indicators, bio-pharmaceutical sectoral enterprises will increase the corresponding weight to increase their own advantages compete

for better share of funds allocation, which is the main reason why this paper adopts such a coordinated decision-making process.

C2—D	D1	D2	D3	D4	D5
D1	(1,1)	(1/4,1/2)	(1/8, 1/6)	(1/6,1/4)	(1/4,1/2)
D2	(2,4)	(1,1)	(1/6,1/4)	(1/5,1/3)	(1/2,1)
D3	(6,8)	(4,6)	(1,1)	(1,3)	(4,6)
D4	(4,6)	(3,5)	(1/3,1)	(1,1)	(3,5)
D5	(2,4)	(1,2)	(1/6,1/4)	(1/5,1/3)	(1,1)

Through calculations, obtain:

$x^- = (0.051, 0.094, 0.447, 0.302, 0.105)$, $x^+ = (0.046, 0.096, 0.438, 0.311, 0.109)$.

The k and m are: k=0.875, m=1.112.

Hence, according to $m(A_i) = \dfrac{1}{2}(kx_i^-, +mx_i^+)$, the overall eigenvector of the fifth-order judgment matrix is (0.048, 0.094, 0.439, 0.305, 0.107).

Namely: When the IAP assignment is led by the biopharmaceutical sector and based on the net profit criterion, the proportions of hotel management, coal logistics, biopharmaceuticals, new financial pawn, and project management sectoral enterprises shall be: 4.8%, 9.4%, 43.9%, 30.5% and 10.7%.

The rationality of the construction of the judgment matrix has already been described in the C1-D matrix, so it will not go into details here.

C3—D	D1	D2	D3	D4	D5
D1	(1,1)	(5,7)	(1,3)	(2,4)	(1/4,1/2)
D2	(1/7, 1/5)	(1,1)	(1/5,1/3)	(1/4,1/2)	(1/8, 1/6)
D3	(1/3,1)	(3,5)	(1,1)	(1,3)	(1/5,1/3)
D4	(1/4,1/2)	(2,4)	(1/3,1)	(1,1)	(1/7, 1/5)
D5	(2,4)	(6,8)	(3,5)	(5,7)	(1,1)

Through calculations, obtain:

$x^- = (0.221, 0.047, 0.134, 0.087, 0.511)$, $x^+ = (0.241, 0.042, 0.158, 0.097, 0.461)$.

The k and m are: k=0.897, m=1.095.

Accordingly, according to $m(A_i) = \dfrac{1}{2}(kx_i^- + mx_i^+)$, the overall feature vector of the fifth-order judgment matrix is (0.231, 0.044.147, 0.092, 0.482).

Namely: when the IAHP assignment is led by the biopharmaceutical sector and based on the criteria for year-on-year growth, the proportions for hotel management, coal logistics, biopharmaceuticals, new financial pawn, and project management enterprises should be: 23.1%, 4.4%, 14.7%, 9.2% and 48.2%.

The rationality of the construction of the judgment matrix has already been described in the C1-D matrix, so it will not go into details here.

Set simultaneous A-C matrix, C1-D matrix, C2-D matrix, and C3-D matrix. Carry out a comprehensive ranking based on the coal logistics sector.

| | C1 | C2 | C3 |
	0.6	0.219	0.173
D1	0.348	0.048	0.231
D2	0.303	0.094	0.044
D3	0.221	0.439	0.147
D4	0.067	0.305	0.092
D5	0.058	0.107	0.482

Through calculations, obtain:

W= (0.26, 0.21, 0.254, 0.123, 0.142)

Total C.I. = 0.018, R, I. = 1.12, total C.R. = 0.017 < 0.1.

The matrix satisfies consistency, that is, it generally satisfies consistency. The matrix is true.

Namely: when the IAHP decision-making assignment is led by the bio-pharmaceutical sector and based on the combined criteria of proportion, net profit and year-on-year growth, the assigned proportions of hotel management, coal logistics, bio-pharmaceuticals, new financial

pawn, and project management sectoral enterprises should be: 26%, 21%, 25.4%, 12.3% and 14.2%

The test passed, so: the 10 million RMB Yuan allocated by SASAC, if bio-pharmaceutical section is selected to lead the IAHP ranking and assignment, the hotel management, coal logistics, bio-pharmaceuticals, new financial pawn and project management are allocated with 2.6 million, 2.1 million, 2.54 million, 1.23 million and 1.42 million RMB Yuan, respectively.

Through the construction and the gradual calculation of each judgment matrix superior to those of other sectoral enterprises, it clearly indicates that the results of the IAHP coordination and decision-making dominated by the biopharmaceutical sector tend to increase the allocation of funds for biopharmaceutical sectoral enterprises. The allocation of 2.54 million RMB Yuan is higher than those for the other three sectors. This is an inevitable result and will inevitably lead to dissatisfaction, incoordination of cooperation and a low level of coordination and efficiency among various departments as well as failure for rapid and steady development of production efficiency. Therefore, the next step of coordinated optimization should be carried out according to the general process of coordinated optimization in this paper.

Calculate $|\mu_{i+1}, \mu_{i+1} = |\mu_{i+1} - \mu_i$ of each department, and obtain the differences μ_{i+1} between the five departments are 0.78 million, 0.75 million, 0.20 million, 0.31 million, and 0.11 million RMB Yuan. It indicates that: Through the three-step calculation and two-step adjustment and under the IAHP ranking and assignment dominated by the bio-pharmaceutical sector, the differences among all the sectoral enterprises are smaller than the acceptable optimized minimum difference of 1 million and a satisfactory allocation plan for each sectoral enterprise is obtained, that is, the hotel management, coal logistics, bio-pharmaceuticals, new financial pawn and project management are allocated with 2.6 million, 2.1 million, 2.54 million, 1.23 million and 1.42 million RMB Yuan of funds, respectively. In this case, all departments can be satisfied with the amounts of funds allocated, including those of their own and other sectors, and there will be no decline in production efficiency of the whole state-owned enterprise group or in the synergy among sectoral departments due to dissatisfaction of some sectors with the allocation plan.

In the process of coordination, since a minimum quantity ε of the optimization process that all sectoral departments are satisfied with is set in advance, provided that the optimized difference is less than the preset ε, it can be asserted that all departments satisfy with the optimization process. In this case, the biopharmaceutical sector has been allocated 2.54 million RMB Yuan of funds, which is higher than all sectoral enterprises, but it also indicates that among the funds of all departments, the allocated funds of the first three sectors are

basically on average, those of the latter two are on average. In addition, the balances between various departments gradually decreases in coordition process, and the coordination results converge. Such results are acceptable and satisfactory. In the coordination process, the coordination margins of all sectoral departments are all smaller than the preset ε, which meets the coordination process requirements. This proves that in the actual production and life, the interval AHP method has a certain feasibility of coordinated decision-making.

6.4 Conclusion

Through the above analysis, it can be concluded that in the process of system reform and development, the subsidiaries of state-owned group enterprises in Shandong Province may measure decisions, especially for internal allocation system and task assignment on the basis of the above analysis, which is very powerful in terms of practicality, applicability and operability, and provides a new perspective for leadership decisions of subsidiaries of state-owned enterprise groups.

Decision makers of enterprises, especially state-owned enterprise group generally manage many more subordinate sectoral departments due to the larger enterprise scale, and accordingly, are increasingly faced with issues of coordinated optimization among various departments, which is a common occurrence in actual production and life of subsidiaries of state-owned enterprise group and private enterprises, and plays a decisive role. Therefore, in actual production and life, more attention should be paid to the application of various coordinated decision methods in corporate governance and coordinated development of various departments. For example, the Delphi method and the interval AHP method mentioned in this article were used to address this situation with a strong scientific and practical operationally. In the course of coordinated decisions, the decision-makers of an enterprise can design the interval judgment matrix based on the actual situation, and invite experienced experts to make practical judgments, although there is a certain subjectivity to the department itself, but it does not deviate too much from the actual situation. Financial departments at all levels can also use this method in formulating allocation strategies or assigning tasks. Through soliciting the relevant opinions of each sectoral department, the minimum difference of the optimization process ε is determined on the basis of the actual situation. For example, the paper set ε to 1 million. In the process of decision-making, the enterprise leaders construct hierarchical rankings and judgment matrix, solve AHP and coordinate decision-making process according to the procedures discussed in this paper. Interval AHP coordinated decision-making for various departments has been widely used, and brought about irreplaceable benefits in allocating funds, assigning tasks and others. It is

hoped to provide corporate managers and decision-makers with some new ideas for management decision-making.

Chapter 7 Empirical Research on Risk Control Strategies Under State-owned Enterprise Group Control

Drawing lessons from the investigation by Chen Lijie and Ye Xiaozhong on the risk management system of large-scale enterprise groups in China, the author of this chapter conducted an empirical survey on the risk control of the LH enterprise group, a company controlled by Shandong Province, found problems in term of risk control existing in Chinese enterprise groups, and proposed corresponding risk control strategies [91].

7.1 Status Quo of Risk Control of State-owned Enterprise Groups

Some well-known international companies have failed due to serious problems arising in the process of management and risk control, such as the "Bahrain Banking Incident in the UK" and the "Aero Fuel (Singapore) Incident"[92]. These cases of failure have provided very valuable materials for the studies in China. Through analysis on several domestic and foreign cases of failure, the author believes that the enterprise groups as a whole should strengthen the following awareness:

First, establish a risk culture and strengthen risk awareness. As risk control is an enterprise's overall and long-term work, enterprise groups, especially state-owned enterprise groups, must rely on the cohesion of risk culture to promote all employees of the company to work together to withstand risks.

Second, improve risk control departments, and enhance risk control staffing. Improving risk control departments, includes organizational leadership and obligations of corporate governance structure, risk control functional departments, internal audit departments and legal affairs departments and other relevant functional departments and business units, and regulating the risk control responsibilities of the relevant departments.

Third, pay attention to major corporate risks and strengthen high-risk forecasting and monitoring. In production and operating activities, enterprises do not have to pay equal attention to every single risk, but focus on the major risks or high risks, in order to forecast and monitor in a scientific and reasonable manner to prevent the occurrence of the risk.

In order to understand China's state-owned enterprise groups in term of risk control, the author of this paper, on the basis of the existing research findings, focused on investigating the status quo of risk control in state-owned enterprise groups of Shandong Province and finally summed up the risk control status of Chinese state-owned enterprise groups[93].

7.1.1 Status Quo of Risk Control of State-owned Enterprise Groups in Shandong Province

(1) Basic situation of risk control

In 2012, pilot project of total risk management for Shandong province-run enterprises was first carried out in 8 province-run enterprises such as LX, YK, HJ, GS, ZK, LK, LG, and WC. In 2016, the total risk management was fully implemented across Shandong Province in 24 corporate headquarters and all levels of enterprises. In the process of comprehensive risk management, the board of directors of enterprise group was responsible for risk control decisions. Generally, a comprehensive risk management committee was established and the risk management office was responsible for the specific work. The group headquarters had full-time departments and full-time staff. Important subsidiary companies (secondary and third-tier companies) also set up full-time departments (generally risk management office or department) with full-time staff. The group headquarters had formulated risk management system, risk management process, and major risk response plans, and established risk management information base. Total risk management was generally actively involved in important business activities and management decisions in accordance with systems and work processes.

(2) Risk control measures taken

In summary, at present Shandong Province has taken following risk control measures for state-owned enterprise groups.

① Develop plans and programs to specify the direction for total risk management.

In accordance with the working idea of "integrated planning, stepwise implementation, fanning out from point to area, emphasizing practical results", a construction plan for total risk management system was formulated, and a total risk management system covering the entire group was established. Based on its industrial characteristics and risks, countermeasures have been formulated for each monitoring indicator and the corresponding person in charge has been identified. Related plans and specific measures are formulated for before, during and after the major risks.

② Establish and improve the organizational system and strengthen the organization of risk management.

A risk management committee or an audit and risk management committee was established to perform risk management duties and enabled the board of directors to play the central role in total risk management. The risk management department was set up to formulate the "total risk management measures" to clarify the responsibilities of all levels and departments of the company in risk management. A risk management liaison system was

established at all levels and departments to promote the effective implementation of risk management.

③　Strengthen the system construction and provide basic guarantees for risk management.

In accordance with their own characteristics, province-run enterprise groups have successively formulated a series of risk management systems and methods, which laid the foundation for promoting risk management. For example, LX Group has formulated 28 regulations including the *Total Risk Management System*, *Guidelines for Internal Risk Control*, and *Corporate Business Decision Making Methods*.

④　Closely focus on production and operation, and strengthen risk management measures.

SG Group conducts comprehensive and in-depth analysis of major risks such as mergers and acquisitions, crude fuel markets, and marketing management in terms of the causes and possible impact of risks, sets one or more quantitative key indicators for major risks and formulates control measures for risk events under major risks.

⑤　Emphasize the use of information tools to improve the efficiency and level of total risk management.

SG Group has independently designed and developed a risk management information system to build a risk management system platform suitable for SG operation system and professional management; YK Group and HJ Group's risk management information systems embody the idea of "three-level management and control" idea as well as the concept of "business-led and total involvement", and set up modules of "risk response", "precautionary warning", "risk report" and "comprehensive view" and others. The Group's headquarters and all its subordinate organizations will used the same information system for risk management.

⑥　Strengthen enterprise's internal control to ensure that the responsibility for risk management is implemented.

Continuously optimize corporate governance, improve and perfect the internal control environment; further standardize business processes and strengthen business activity control; the system should be sorted out at the headquarters of the Group and at the main subsidiaries. Based on the identified risk points, rules and regulations should be formulated and revised to increasingly perfect the Group's internal control system. Focus on strengthening control over corporate governance structure, authorization and approval, accounting system, asset protection, budget, risks, and auditing, and strengthen internal and external supervision and inspection to ensure that control measures are implemented.

⑦　Vigorously cultivate risk management culture and firmly establish risk awareness.

In the corporate risk management culture, various companies have formulated practical and effective measures in accordance with their actual conditions and have received very good results. For example, LK Group integrates risk management culture with corporate culture construction by organizing total risk management lectures.

(3) Major risks facing the enterprise group

Although the enterprise groups in Shandong Province adopted these types of measures in risk control, they are still faced with various risk due to the different internal and external environments, development history, and organizational structure. In 2016, the State-owned Assets Supervision and Administration Commission of Shandong Province organized province-run enterprises to identify and assess five major types of risks in strategy, investment, finance, market, operations, and law, and in the end, 24 province-run companies assessed major risks for the industry in 2016 and identified them as follows:

Investment risk: It refers to various uncertainties that lead to untimely or biased investment decisions in identifying investment opportunities, project feasibility studies, and deliberations in the decision-making process. This type of risk mainly involves 12 province-run companies.

Health and safety environment risk: It refers to various uncertainties of various health, safety and environmental accidents that cause losses or adverse effects to the company in production and operation process. This type of risks mainly involves 12 province-run companies.

Human resources risk: It refers to the uncertainties in the structure, quantity, training and remuneration of human resources that impact on the long-term development of the company in its rapid development. This type of risks mainly involves 12 province-run companies.

Strategic Management risk: It refers to the various future uncertainties that influence the realization of the strategic objectives in formulating, implementing, evaluating and adjusting strategies. This type of risk mainly involves nine province-run companies.

Group control risk: It refers to various uncertainties for corporate management and operating objectives due to the fact that the company has not established a proper management and control model or does not specify the scope and content of the parent company's management of the subsidiary company, and has not effectively managed the subsidiary company in funds, personnel, investment and financing, system construction, business activities, etc. This type of risk mainly involves 8 province-run companies.

Resource guarantee risk: It means that the group does not have sufficient reserves of resources to meet the needs of enterprise development and may affect the sustainable development of the group. This type of risk mainly involves 8 province-run companies.

Cash flow risk: Such risks mainly arise when the group develops at rapid pace, launches too many new projects, finances through huge amount of loans with large pressure of interest payment and huge inventory, lacks the ability to quickly realize assets to pay short-term liabilities, and unreasonably allocates the overall structure of liquid assets, which has resulted in a large funding gap and a high debt-to-equity ratio. The tight funding chain may lead to slow progress of projects or even project failures, and a high debt-to-asset ratio may result in a large pressure on the group's debt repayment, adversely affect its operations, and may reduce the group's creditworthiness and increase the difficulty of fundraising. The reasons for this type of risks include the impact of the market environment, poor financing channels, and poor application of fund in land resources. These types of risks involve eight province-run enterprises.

(4) Measures to strengthen risk control ability of enterprise groups in Shandong Province

By combining the risk control theory with the current status of the state-owned enterprise groups in Shandong Province, the author believes that all enterprises in Shandong Province should, based on their own circumstances and the external environment, focus on the development strategy objectives, conduct an in-depth analysis of the risks identified and assessed, find out the causes of the risks, assess the scope and extent of the risk impact, and based on the risk preference and risk tolerance, determine the risk management strategy, and formulate corresponding risk response measures to ensure that the risks are under control. This article gives the following suggestions and countermeasures:

For strategic planning risks, start from the three links of strategic research, strategic planning, and strategic planning adjustment, and formulate control measures based on the risk control points of information collection, information analysis, strategy formulation, formulation of development planning, performance evaluation of strategic plan implementation and strategic planning adjustment, respectively.

For investment risks, improve the investment management process, and carefully demonstrate and evaluate each node of project reserve, project approval and initiation, project financing, project implementation and post-project evaluation; establish an investment risk monitoring mechanism to keep informed of the industry and overall economic performance, and be able to quickly respond to decision-makers; Strengthen risk awareness and strengthen risk education in the training of staff at all levels of the organization; improve post-investment evaluation process and systematically summarize the entire implementation process of project investment so as to identify deficiencies.

For industrial policy risks, set up specialized industrial policy research institutions; make full and timely communication with policy makers.

For control risks over subsidiary, further improve the corporate governance structure and management system of group company; in accordance with the requirements of the modern enterprise system, establish a scientific management and control model, clearly define the extent, depth, mode, authorization, supervision, assessment and feedback of the group headquarters' control over branches and subsidiaries from the aspects of strategy, finance, personnel and business; delegate to subsidiaries, improve corporate governance structure of subsidiaries, and give full play to the enthusiasm and initiative of subsidiaries; strengthen the appointment and supervision of top management personnel of subsidiaries and try to avoid alternate-appoint of parent and subsidiary companies.

For human resource risks, establish a sound corporate culture and set up correct valuesfor members; learn from the successful experience of competition for posts, improve the training system, and prepare job descriptions to promote employees' enthusiasm for learning and motivation; Improve the labor and personnel system, and strengthen the reward and punishment mechanism and personnel protection mechanism.

For risks such as tight capital chain and high debt-to-asset ratio, strengthen fund management of the group, design and implement a fund management system, and implement real-time monitoring of funds; strengthen the circulation of internal funds of the group and strengthen the adjustment of the internal funds of the group; strengthen the group's budget management.

7.1.2 Problems in the Risk Control of State-owned Enterprise Groups

Through the main investigation and analysis of the status quo of risk control of state-owned enterprise groups in Shandong Province, and drawing on the analysis results of existing scholars, the author of this paper believes that the state-owned enterprise groups in China have following problems in risk management and control:

(1) Awareness of overall risk management needs to be further strengthened

Although the risk awareness of various companies has been enhanced, many efforts have been made in risk management and great progress has been achieved, but there is still a wide gap in the understanding of risk management at all levels. Many companies merely regard risk management as a means to meet external regulatory requirements, but have failed to become a corporate conscious action.

(2) Total risk management and daily operation and management need to be organically integrated

The total risk management frameworks of various companies have basically been established, but are not sufficiently integrated with other management systems. At present, some companies have not yet formed a true combination of actual work and practical implementation in the process of risk assessment, management strategies and solutions, and early warning systems.

(3) The total risk management system needs to be further improved

Some enterprises lack risk management talents, and job assignments are insufficiently staffed; some enterprises' risk management responsibilities are not clear enough, and there are blind spots, especially, the risk responsibilities of various business units and departments need to be further refined; some units have a singular risk assessment method and their assessment results are not convincing.

(4) Total risk management needs to be further deepened

The construction of risk management systems for some units has only stayed at the headquarters level, has not been fully implemented across the group and the major risks identified and their response measures need to be truly implemented.

7.2 Countermeasures and Suggestions for Risk Control of State-owned Enterprise Groups

The choice of management and control modes for enterprise groups varies with their sizes and nature. Regardless of the type of management and control model adopted by the enterprise group, the parent company will inevitably encounter various risks in the process of managing the subsidiaries as well as the production and operation processes of the parent and subsidiary companies. They are only different in size and the impact on the enterprise group itself. How to scientifically predict risks, assess risks, and effectively control risks, and place them under its risk tolerance will be main issues for the companies to resolve [94].

7.2.1 Internal Risk Control Countermeasures in Enterprises

(1) Correctly choose control mode for parent and subsidiary companies

According to the degree of centralization and decentralization, the control modes can be divided into the management and control modes of relative centralization, centralization and decentralization, and relative decentralization. The enterprise group must consider its own characteristics, size, and other factors to choose the mode of management and control. How to correctly choose the control mode has already been previously described and will not be repeated here. Only when the enterprise group selects appropriate parent-subsidiary control model, can it monitor the subsidiaries on the premise of giving full play to the enthusiasm

and initiative of the subsidiaries, so as to prevent major risks or crises arising in subsidiaries in the operation process and affecting the survival and development of the entire group companies[95].

(2) Improve corporate governance structure

The following points need to be noted in order to improve the corporate governance structure in China:

① Strengthening the role of the board of directors

In the corporate governance structure, the board of directors is the core. The management level of the board of directors has a significant impact on the success or failure of the company. If the company's board of directors has problems, it may cause economic losses to the company, or even make the company bankrupt. Therefore, importance should be attached to the construction of the board of directors so that it can maintain its relative independence, give full play to its enthusiasm, and effectively manage the company; at the same time, it can also be properly supervised to avoid its abuse of power and affect the company's survival.

② Safeguarding the supervisory board of the company to effectively exercise supervision

Supervisors play a very important role in corporate governance. If they can fully exercise the rights granted by *the Corporation Law*, it is of great significance to safeguard the healthy development of the company and regulate the operation of the company. In order to ensure that the supervisors have sufficient professional knowledge and ability, the supervisors selected or appointed must possess professional knowledge and experience in law, finance, accounting and taxation, and have the ability to communicate extensively with shareholders and other company employees; introduce an independent supervisor system to prevent the company from being manipulated by the controlling shareholders and truly enable the board of supervisors to exercise its supervisory function; set up a system for investigating the responsibility of supervisors for misconduct.

(3) Improving risk control system

In the overall risk management, other functional departments and business units of the enterprise shall accept the organization, coordination, guidance, and supervision of the risk management functional department and the internal audit department, and mainly perform the following duties: ① Perform basic risk management processes; ② Study and put forward judging criteria or mechanism for the major decisions, major risks, major events, and important business processes of this functional department or business unit; ③Study and put forward major decision risk assessment reports of the functional departments or business units; ④Properly establish the risk management information system for this

functional department or business unit; ⑤Properly cultivate the risk management culture. ⑥Establish and improve the risk management internal control subsystem of the functional department or business unit; ⑦Handle other related work on risk management.

Enterprises with the necessary conditions can establish three defense lines for risk management, that is, all relevant functional departments, business units, and subsidiary companies are the first line of defense; risk management function department and risk management committee under the board of directors is the second line of defense; the audit committee under the internal audit department and the board of directors is the third line of defense.

The following points need to be noted in order to improve the risk control system:

①　The convener of the risk management committee shall be chaired by the chairman who does not serve as general manager; when the chairman is the general manager, the convener shall be an external director or an independent director. Members of the committee must have directors who are familiar with the company's important management and business processes, as well as directors with knowledge or experience in risk management supervision and legal knowledge.

②　The company shall establish an internal audit department, strengthen internal audit work, ensure the independence of internal audit department setup, staffing and work, and be responsible for the audit committee under the board of directors; the internal audit department shall, in conjunction with internal audit supervision, supervise and inspect the effectiveness of internal control, and have the right to report directly to the board of directors, its audit committee, and the board of supervisors on major defects in internal control discovered during the supervision and inspection.

③　The company must establish a corporate legal adviser system with general counsel as the core, and form a legal risk liability system where the decision-making layer of the enterprise takes the lead, the general counsel spearhead the work, corporate legal advisers provide business guarantee, and all employees take part in the process.

(4) Establishing a risk warning system

In the course of business operations, enterprises must establish a risk warning system to monitor risks, collect, analyze, and evaluate risks in a timely and complete manner to determine the size of the risks and the means of control so that the risks can be controlled.

①　Speed up the establishment and improvement of the financial system and strengthen supervising the information disclosure of state-owned enterprise.

Chinese enterprises should explore financial early-warning systems that are more applicable to their own companies, and improve their evaluation indicators according to their own circumstances, and timely forecast and reflect the company's financial status. Emphasize the role of non-financial indicators and qualitative indicators in early warning analysis. Non-financial indicators and qualitative factors can serve as indicators of the company's future financial status or degree of financial crisis.

② Establish an information collection and delivery mechanism and improve the enterprise risk analysis mechanism.

A good risk early warning and analysis system can scientifically and effectively predict various risks that may occur in a company. To prevent the occurrence of a crisis in advance, it must be able to collect enough information and data. This information data includes both internal data and data of external market, and market conditions. The most important thing in the information system is to form a channel for information collection and transmission, so that the information system can accurately and timely acquire relevant information and data in order for the risk management personnel to analyze, evaluate and prevent crisis.

③ Establish a corporate risk response strategy.

After the company conducts risk analysis and assessment, it should immediately formulate a risk response strategy: through the combination of manual and automatic control, preventive control and discovery control, and using appropriate control measures, the risk is controlled within the tolerance.

(5) Improving internal audit supervision system

Internal audit is an important content of the internal control environment and is a major component of the internal control system of an enterprise. It helps to promote internal self-repair and improvement of the internal control system. Specific work includes:

① Identify the status of internal audit

Internal audit is an indispensable link in corporate governance in a modern enterprise system. It is an important means to promote the establishment of a sound corporate governance structure, standardize management, legalize operations, enhance market competitiveness, and grow bigger and stronger. Enterprises should establish an audit committee under the board of directors, which should be positioned as the company's internal supervisory leadership and the third line of defense for enterprise risk control.

② Improve institutions and strengthen audit team building

It is necessary to establish an internal audit department that meets the requirements of corporate governance, improve the audit system, regulate the operation, clarify the status of

the internal audit department in risk control and internal control, and establish relationships with the board of directors, managers, and audit committees to ensure the independence and authority of their operations.

(6) Improving performance evaluation system

The performance evaluation of employees has always been associated with salary, and closely related to the immediate interests of employees, and it has become the most direct and effective means to mobilize the enthusiasm of employees. Performance evaluation shoulders the important mission of reflecting the work performance of employees and determining the salary of employees. Its rationality directly affects the stability of the company. The most direct purpose of evaluating employee performance is to provide an objective and fair picture of employee performance during the evaluation period.

For business managers, they should do as follows: ① The attention of the top management. Performance evaluation is a work that requires the use of all the company's resources. The top management should give full support. ② Establish an open feedback mechanism. In many companies, the initial employees' enthusiasm for performance evaluation is relatively high, but it usually will not last long. The important reason for this situation is that the performance evaluation system failed to establish a feedback mechanism for performance evaluation. If employees do not see the significance of performance evaluation, they will not actively participate in the entire process of performance evaluation. ③ Link performance evaluation results with remuneration. When establishing a performance evaluation system, an enterprise should establish a link between the employee performance evaluation results and their salaries, so that the performance evaluation can exert its true value.

The main bodies responsible for evaluation should be trained and managed: ① Through training, evaluators will correctly understand the performance evaluation system and fully understand the existence of various kinds of errors in performance evaluation, so that they can consciously reduce these errors in order to correctly evaluate the working status of employees. At the same time, through training, the evaluators learn to consciously collect the factual basis needed in the evaluation process and correct their attitudes. ② Clearly define evaluation indicators and standards. With clearly defined performance evaluation indicators and standards, the evaluators can make pertinent evaluations according to the meaning of the indicators to be evaluated, so as to avoid improper views on the performance of an evaluator and affecting its overall performance. ③ Select the appropriate evaluation method. Each evaluation method has its advantages and disadvantages. Therefore, appropriate evaluation methods should be selected according to the specific conditions such as the evaluation object

and the evaluation purpose. ④ determine a reasonable evaluation period. The choice of evaluation period has an important impact on the evaluation results. The evaluation period should not be too long nor too short.

(7) Establishing accountability system

When enterprises develop risk control systems, the establishment of risk control institutions, the clear division of functions, the specialization of risk control personnel, and the scientific methods of risk prediction and assessment are important, and the accountability system also plays a decisive role in operation of the entire risk control system. Therefore, enterprise groups should attach importance to establishing and improving the accountability system.

7.2.2 Corporate Countermeasures for External Risk Control

(1) Supervision of government functional departments

The government authorities should learn from mature and advanced regulatory experience abroad, further study and formulate relevant regulatory requirements, guide the enterprise group to establish a sound and comprehensive risk management system, and prevent major risks for the enterprise group from a macro perspective.

(2) Participation of social intermediary agencies

Although a comprehensive risk control system has been set up internally and three lines of defense have been established, it is impossible for companies to rely on their own efforts to control risk bases due to the limitations of internal controls and the constraints of human, financial, and material resources. Therefore, companies need to use external forces to help them achieve effective risk control, and law firms and accounting firms are the best choices for corporate risk control cooperation.

7.3 Empirical Analysis of Risk Control under State-owned Enterprise Groups

As a large state-owned enterprise under the administration of the State-owned Assets Supervision and Administration Commission of Shandong Province, the LH Enterprise Group engages in five major industries, including hotels, real estate, bio-pharmaceuticals, financial pawn, and logistics trade, and it is a typical representative of state-owned enterprises in China. Therefore, this paper takes the LH Group as an example to conduct an empirical analysis of risk management under the control of state-owned enterprise groups.

In recent years, with the changes in the external environment such as the international financial turmoil, the national economic situation, and the industrial structure, many

uncertainties have been brought to the operation and management of LH Group companies. Under this background, the Group has actively carried out risk management, but there are still many drawbacks. The author of this paper tries to put forward some strategies and suggestions for the problems existing in the group.

7.3.1 Risk Control Organization Settings

LH Enterprise Group has established a total risk management organization system in accordance with the "*Guidelines*" of the State-owned Assets Supervision and Administration Commission of the State Council and the "*Guidelines of Total Risk Management for the Province-run Enterprises*" by the State-owned Assets Supervision and Administration Commission of Shandong Province. The parent and subsidiary companies respectively establish a comprehensive risk management committee and corresponding working organization. The total risk management committee of the parent company shall be appointed by the parent company, and the total risk management committee personnel of the subsidiary company shall be appointed by the subsidiary company, and the list of persons shall be reported to the parent company for the record. The parent company's total risk management committee conducts business guidance, supervision and management of the subsidiary's total risk management committee. The parent company's total risk management committee is responsible for reviewing risk management strategies and major risk solutions, and carrying out risk identification, evaluation, monitoring, and control of the group's major production and operation projects. The subsidiary's total risk management committee strictly enforces the risk management and control procedures formulated by the parent company, and regularly submits risk prevention and control work reports to the parent company as required; for major investment and financing projects, major project transformations and major operating contracts, the subsidiary company shall report to the parent company for approval according to regulations, and a risk assessment report shall be issued when necessary.

7.3.2 Group Management System

The group management and control system refers to the group organization system that uses property rights as a link, takes the LH enterprise group (parent company) as the core, and the subsidiary company (subsidiary) as the main member. The parent company designs and manages the organizational structure and operating mechanism of the parent company's management and control system, and promulgates it in the form of a basic management system. Both parent and subsidiary companies have the status of a corporate legal person, each of which enjoys an independent corporate property right, independently exercises civil

rights, assumes civil liability, and independently manages and assumes its own profits and losses with all its legal person property, and assumes responsibility for maintaining and adding value to the capital invested by shareholders.

The parent company's board of directors consists of three professional committees for comprehensive budget management, total risk management, and performance evaluation. It is responsible for overall budget management, total risk management, and performance assessment of the group. The role of the full budget management committee is: for the production and operation and investment and financing business, all aspects of budget preparation, implementation, regulation, analysis, assessment and supervision shall be fully covered and the whole process shall be managed. The role of the total risk management committee is: major risks in the investment, production, operation, and restructuring of the parent company and its subsidiaries are identified, assessed, monitored, and controlled. The role of the performance evaluation committee is: formulate an assessment method for all members of the group and supervise their implementation; the main work performances of the parent company's management, managers, and subsidiaries are evaluated.

7.3.3 Risk Control Implementation

According to the relevant requirements of the "*Guidelines for Total Risk Management of the Province-run Enterprises in Shandong Province*" by the State-owned Assets Supervision and Administration Commission of Shandong Province, LH Enterprise Group Company has put forward work objectives and plans for the construction of a total risk management system in a timely manner in accordance with its actual needs. It listed total risk management as a key task for the company in 2016. With the assistance of a risk management consulting company, LH Enterprise Group officially launched a construction project for total risk management and information system, whose objectives and final assessment results of the project are as follows:

(1) Risk assessment objectives: Improve the risk awareness and theoretical level of all LH enterprise groups, unify the risk management language, and cultivate the LH enterprise group's own risk culture; Identify risks in the development and operation of LH enterprise groups, form a risk event library for the current status of LH enterprise groups, and provide support for future work; Prioritize risks and draw a risk map of the LH Enterprise Group headquarters; A comprehensive analysis of the current risks faced by the LH Enterprise Group is conducted to identify the important characteristics of the risks, identify significant risks, propose management improvement suggestions for major risks, and implement relevant responsible agencies.

(2) Analysis of risk assessment results

① Overall risk status of LH Corporate Group Headquarters

　　The LH Enterprise Group conducted comprehensive risk identification and assessment for five major categories of first-class risks. A total of 68 risk events were identified, 26 categories of secondary risks were selected and sorted out, and the evaluation of risk events and the statistics of the evaluated models were adopted, and the final evaluation grades of 26 secondary risks were obtained. The risk classification and numbering of LH Enterprise Group is shown in Table 7-1.

Table 7-1 LH Enterprise Group Risk Classification

Primary risk number	Primary risk	Secondary risk number	Secondary risk
ZL	Strategic risk	RCBZ	Talent protection risk
		CYZC	Industrial policy risk
		CYGH	Industrial Development Risk
YY	Operational risk	XXBM	Information confidentiality risk
		SBGL	Equipment management risk
		CLGL	Vehicle Management Risk
		XXXT	Information System Risk
		WYGL	Property Management Risk
		TZGK	Investment Control Risk
		SCKF	Market Development Risk
		AQGL	Safety Management Risk
		JXKH	Performance assessment risk
CW	Financial risk	FZJG	Debt structure risk
		CRZ	Financing risk
		KJHS	Accounting risk
		ZCGL	Asset Management Risk
		YSZK	Accounts receivable risk
		CBGL	Cost Management Risk
		SWGL	Tax Management Risk

Continued (Table 7-1)

Primary risk number	Primary risk	Secondary risk number	Secondary risk
		DWDB	External guarantee risk
		YSGL	Budget Management Risk
SC	Market risk	GJMY	International Trade Risk
		HLL	Exchange rate & interest rate risk
FL	Legal Risk	HTGL	Contract Management Risk
		FLSS	Legal proceedings risk
		YZGL	Seal management risk

② LH Corporate Group Headquarters Risk Map

Through risk identification, risk analysis and risk assessment, the risk importance hierarchy of the 26 kinds of risks of the LH Enterprise Group headquarters were finally obtained. The risk importance hierarchy represents relatively high risks in all important aspects of the company's current situation and are the urgently needed risks under the current management and control level. It can be used as an important basis for company decision making.

By analyzing the data of risk identification and risk analysis, this paper draws a risk importance hierarchy of the 26 risks of LH Enterprise Group headquarters, as shown in Figure 7-1 and Figure 7-2.

③ LH Corporate Group Risk Evaluation Results

By analyzing and judging the various risk events of LH Group, and using the risk profile as a tool for display, LH Enterprise Group has sorted out the current overall risk status of the company and the management level of various risks, and identified significant risks for the future development of the group company: Investment control risk, liability structure risk, legal litigation risk, industrial development risk, and industrial policy risk.

The risk of investment control belongs to operational risk, which refers to the risk of investment project failing to meet investment expectations due to incomplete investment procedures, inadequate investment decision-making basis, and inadequate monitoring of the investment process. The risk of investment control also includes the management and exit difficulties of investment projects caused by historical issues.

The liability structure risk belongs to financial risk and refers to the unreasonable level of liabilities and structure of the group company, which affects the rapid and steady development of the company group, such as the unreasonable structure of long and short-term debts and short-term long-term debts.

The risk of legal proceedings is a legal risk and refers to the risk of legal proceedings caused by various commercial disputes in the course of business management, causing major economic losses to the company and implicating the responsible person of the company to bear corresponding legal liabilities.

The risk of industrial development is a strategic risk, which refers to the uncertainty of the development plan of the group company due to the factors such as its own historical reasons, the environment in which the industry is located, and the external regulatory assessment requirements.

The risk of industrial policy belongs to strategic risk and refers to the uncertainty of the group company's development in business operations caused by the launching of national or local industrial policies.

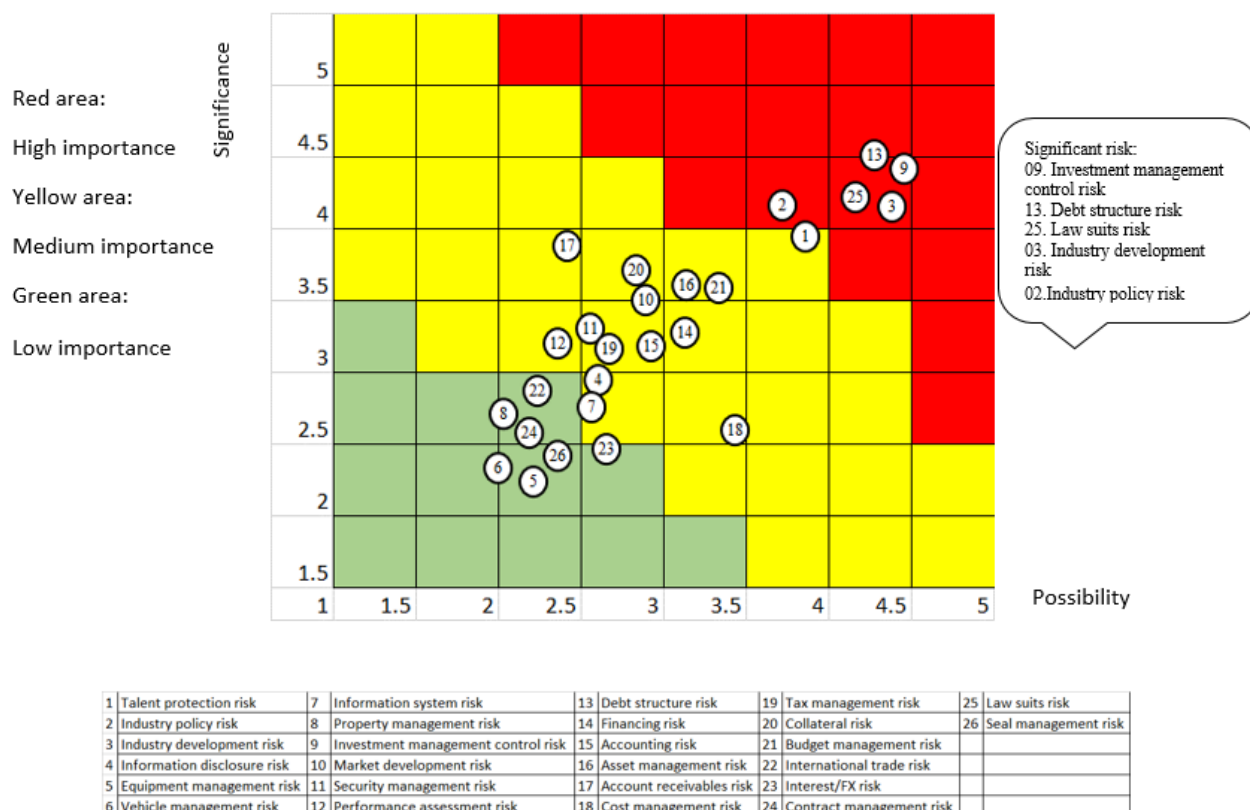| 1	Talent protection risk	7	Information system risk	13	Debt structure risk	19	Tax management risk	25	Law suits risk
2	Industry policy risk	8	Property management risk	14	Financing risk	20	Collateral risk	26	Seal management risk
3	Industry development risk	9	Investment management control risk	15	Accounting risk	21	Budget management risk		
4	Information disclosure risk	10	Market development risk	16	Asset management risk	22	International trade risk		
5	Equipment management risk	11	Security management risk	17	Account receivables risk	23	Interest/FX risk		
6	Vehicle management risk	12	Performance assessment risk	18	Cost management risk	24	Contract management risk		

Figure 7-1 Risk Importance Hierarchy of Group Headquarters

Hierarchy's Risk Name and Number

1	Talent protection risk	7	Information System Risk	13	Debt structure risk	19	Tax Management Risk	25	Legal proceedings risk
2	Industrial policy risk	8	Property Management Risk	14	Financing risk	20	External guarantee risk	26	Seal management risk
3	Industrial Planning Risk	9	Investment Control Risk	15	Accounting risk	21	Budget Management Risk		
4	Information confidentiality risk	10	Market Development Risk	16	Asset Management Risk	22	International Trade Risk		
5	Equipment management risk	11	Safety Management Risk	17	Accounts receivable risk	23	Exchange rate & interest rate risk		
6	Vehicle Management Risk	12	Performance assessment risk	18	Cost Management Risk	24	Contract Management Risk		

Figure 7-2 LH Group Risk Importance Hierarchy Atlas

7.3.4 Deficiencies in LH Enterprise Group Risk Control

(1) Deficiencies in investment risk control

The investment risk control mainly has the following deficiencies: First, investment decision-making procedures are not standardized, and investment decision-making information is not sufficient. Second, the process of investment monitoring is inadequate and investment projects deviate from their original intentions. Third, after the completion of the investment project, there is no mechanism for post-evaluation.

(2) Deficiencies in liability structure risk control

Reasonable liability is a necessary means for the development of an enterprise. According to its actual needs of development, it uses the funds of financial institutions to develop and expand its own industry and leverages the capital. At present, the group company's debt level is about 35%, and its performance is relatively conservative. It is mainly related to the profitability of the group company. In addition, the investment of short-term debt in long-term projects will affect the financial stability of the group company. This risk control has following deficiencies:

First, the investment of the group in long-term projects with short-term debt affects the stability of cash flow. On the one hand, it piles up the financial costs, on the other hand it also increases the risk of financial risks.

Second, the level of debt is low and the development performance is relatively conservative. The debt level of the hotel industry is generally maintained at around 50%. The group's business includes real estate, bio-pharmaceuticals and other sectors, and the corresponding level of liabilities should be higher, while the group's debt level is only about 35%, which affects the expansion of the group company.

Third, the structure of long-term and short-term debt is not reasonable enough, and there are short-term long-term debt investment, which affects the financial security of the group company. Finance planning of the group is closely related to production and investment. However, with its poorly defined long-term planning, the effective arrangement of the financial department for long and short-term debts was affected, in particular, the temporary application for capital needs, which leads to more short-term debts and fewer long-term debts.

(3) Deficiency in risk control of legal proceedings

At present, the group company has not done enough in legal risk prevention measures such as project approval and contract management. The mismatch between the rights and responsibilities of relevant person in charge of the conclusion and performance of contracts may lead to major legal disputes and lawsuits and cause major economic losses to the company. This risk control has the following deficiencies:

First, the review mechanism of project's decision-making is not sound enough to eliminate the hidden dangers of legal disputes for the later-phase project development. The flaws in the enterprise's decision-making mechanism, coupled with internal violations or poor execution of the management system lead to dysfunction of the risk-prevention mechanism, put the enterprise in a difficult situation when trying to resolve it later through legal proceedings.

Second, lack of legal awareness and legal knowledge. Although the group company has established a general counsel system, the legal awareness of leading cadres at all levels, especially the leadership level, is not strong enough, and the prevention of legal risks has not been incorporated into the daily operation and management, and legal disputes cannot be effectively prevented in advance.

Third, some leftover legal cases due to historic evolution. Most of the cases belong to external guarantees and external investments in the past, and with the absence of reverse guarantees, when the guaranteed party was unable to repay the debts, the group company was jointly and severally liable.

(4) Deficiency in risk control of industrial development

Due to historic evolution, the LH Enterprise Group formed an independent group company after being stripped of the service assets of original electric power system, and was placed under the Shandong Provincial SASAC. Its main development line has not been clear and the enterprise group has not formed effective integrating relationship among its subordinate corporate industries. The risk control has following deficiencies:

First, weak profitability of main business assets, and unfulfilled asset restructuring. As the predecessor of its assets is not engaged in an industry with strong profitability, the group company is faced with great difficulty in operation with prominent short board effect and heavy inherent burden. At the same time, it is even more difficult to realign its resources due to low relevancy of incorporated assets and independent operations among various sectors.

Secondly, the pursuit of profitability goals has resulted in a mismatch between its industrial development planning and actual operations. As a group company mainly engage in hotel business, the assessment requirements of the regulatory authorities also have a potential impact on the realization of its development plan.

Third, the lack of its own funds has limited its industrial integration. Its smaller total assets among province-run enterprises and lack of own funds have restricted its capabilities and conditions for industrial integration, especially investment in key industries, and caused to miss the fast track of development.

Fourth, with development planning lagging behind, the hotel sector as main business has affected the overall efficiency of the assets. The development of hotel industry has shown a trend of multiple models in recent years such as star hotels, hotel chains and business hotels, and witnessed the rise of large group management companies, while the development speed of the group company has been hampered by its overall planning and arrangement in hotel sector and insufficient integration between business modes.

(5) Deficiency in risk control of industrial policy

When national and local governments introduce relevant industrial policies, they usually start from a macro and overall perspective and comprehensively review the overall deployment. Therefore, the introduction of industrial policies may be favorable to specific enterprises, such as tax incentives, preferential policies for land, and may also be unfavorable, such as energy-saving and emission reductions, mergers and reorganizations. Based on the status quo of LH enterprise group company, the risk control has following deficiencies:

First, it could not effectively seize opportunities for development. Under the background of the national industrial restructuring, local governments have also accelerated the integration of industrial structure. This is conducive to the long-term development of the industry as a whole, but also conducive to the allocation of state-owned assets, but to the

company itself, opportunities and risks coexist. If the group company cannot seize the development opportunities, develop and grow in a limited period of time, it is likely to be acquired due to its small scale.

Second, the favorable industrial policies could not be fully used and given to full play due to lack of policy study. The group company involves in services, bio-pharmaceuticals, and other industries, and some of them are eligible for the state incentives and supports, whereas the series of preferential policies are in fact not fully utilized due to the lack of policy study.

Third, its failure to fully foresee the state's control policies on the real estate industry, has greatly affected the prospective earnings and development speed of the group company

7.3.5 Improvement Measures and Suggestions for LH Enterprise Group Risk Control

In response to the major risks of LH Enterprise Group, the author of this paper has proposed following measures:

(1) With respect to the problems in investment control, the group company need to strengthen the formativeness and scientific of the existing investment control while dealing with the leftover investment issues, and avoid the losses caused by blind investments, and address the problem with following specific measures:

First, strengthen the scientific procedures of investment decision-making and establish a standardized decision-making process. Establish and improve the company's investment management system, and sharpen the tools for investment verification. Major investment projects must be reviewed and assessed by the planning department, the Total Risk Management Committee, and the General Counsel, and finally submitted to the board of directors or the party and government associations for consideration and decision.

Second, for the projects to be invested, project-related information should be comprehensively collected, full argumentation and analysis should be undertaken, and comprehensive inspection and assessment of major investment decision-making projects must be in line with the company's overall strategic objectives, and full market research. Otherwise no project should be considered.

Third, properly dispose of the previous investment projects and remedial work, to minimize the loss of the group company. For the leftover investment projects, deal with them according to their conditions, if the operation could be improved, continue to provide relevant resources; for those impossible to make a profit and hamstringing the development of the group company, dispose of them in time to avoid further losses.

(2) In view of the existing liability structure of the group company, the risks brought about by the liability structure should be reduced through following measures:

First, formulate a clearer investment development plan, and through comprehensive budget management, provide the finance department with a clear and accurate fund demand plan so that the financial department can formulate a reasonable and scientific fund-raising plan; increase the communication between the business department and the finance department, and reasonably match the structure of long-term and short-term debts.

Second, prohibit the group company and its subordinate enterprises from investing short-term loans in long-term projects, and funds should be used rationally to avoid any impact on financial security. All subordinate enterprises should make full use of the group's financing platform to reduce financing cost, and at the same time establish a centralized management of the group's funds to increase the effective use of funds.

Third, reasonably and appropriately increase the debt level of the group company to provide sufficient funds for its development, and make use of financial leverage to increase and expand the capital and shares in the subsidiaries with good benefits and broad prospects, develop and grow its own enterprises.

(3) For its current legal lawsuit risks, the following specific measures should be taken:

First, improve the corporate governance system, strictly implement the decision-making process, cultivate the concept of operating according to law, reduce the number of related legal risks, and establish an open and fair decision-making mechanism. Prohibit external guarantees, and no one or any unit is allowed to guarantee security without argumentation and guarantee.

Second, establish and improve the general counsel system and raise the legal awareness of leaders at all levels. The corporate general counsel shall fully involve in the whole process of enterprise operation and management, earnestly strengthen the construction of the legal risk prevention mechanism, effectively play the role of gatekeeper as corporate general counsel on legal risks, and avoid the adverse impact of legal proceedings on the enterprise.

Third, timely track the progress of dispute cases, rationally use legal weapons to safeguard its own rights and interests. When the lawsuits arise, promptly understand the relevant laws and regulations with the joint help of the company's general counsel and external lawyers, collect beneficial legal evidence, actively prepare for protecting its own rights and interests, and do the utmost to reduce the losses company's economy and reputation.

(4) For its industrial development risk, first of all, it should start from the industrial orientation, define the development direction, concentrate on properly building and refining its own advantaged industry, and make effective connections between the industries. The specific measures include the following aspects:

First, based on its own resources, reposition the industry development plan. Further realign the development capabilities of the existing sectors, analyze the future development trend, determine the main business, and increase investment, refine and strengthen the main business, make full use of market-oriented means, learn from the advanced industry profit model, and increase the core competitiveness of main business.

Second, get rid of the non-key industries and invigorate the existing assets. Promptly clean up the sectors with weak profitability and smaller scale, concentrate the efforts on the investment in the main business, and centralize existing resources.

Third, strengthen the links between industries and enhance its ability to withstand risks. Increase the relevance of hotels, tourism and real estate sectors, build relationships between upstream and downstream industries, make full use of existing sectoral resources, and formulate corresponding development plans from a long-term perspective.

Fourth, actively communicate with the relevant departments of the provincial SASAC, and comprehensively consider the status quo of the main business of the group company, and appropriately lower the evaluation goals so as to realize the gradual optimization of the main business resources.

(5) For the industrial policy risks faced by the group company, measures for improvement include the following aspects:

First, increase investment in its own advantageous industries and enhance its overall management capabilities and efficiency. Industrial integration is the trend of the times while the group company has its own industrial advantages. For example, the biopharmaceutical subsidiary company of the group is now the largest research base of earthworm in China and has accumulated rich experience in the research and production of the industrial chain. The group company has accumulated a large number of talented staff and experience in the hotel industry, and combined with tourism project, the group company has begun to prepare for tourism real estate projects. While identifying the advantages of the above industries, increase investment to strengthen and refine the main business, and improve its own management. Rejuvenate the bad assets of the group company, transfer the assets to industries with obvious advantages and clearer profit prospective, and comprehensively improve the company's asset quality and scale.

Second, intensify the research and analysis of relevant national industrial policies. For the industries supported by the state, actively strive for corresponding preferential policies, such as national research funding, local land, and tax incentives. Actively take the advantages of the policy environment and the capital leverage, and through the means of mergers and reorganization, quickly develop and grow related industries.

Third, deepen the understanding of real estate macro control, prepare for the industry's winter, properly handle existing projects under construction and sales, maximize the recovery of funds, and use various financing channels to ensure stable and safe cash flow. Actively participate in affordable housing projects promoted by local governments, and at the same time, build tourism real estate projects by combining local tourism resources, and reduce the uncertainty in this area through the transfer of funds and risks.

7.4 Conclusion

In summary, the failures of these international companies resulted from serious problems arising in management and risk control. The author believes that enterprise group should act as a whole and establish a risk culture and risk awareness, improve risk control mechanism, pay attention to major corporate risks and strengthen risk early-warning as well as monitoring mechanisms. This study was conducted on the state-owned enterprise groups in Shandong province, even though there are risk management measures in place, the state-owned enterprises still need to strengthen their awareness of overall risk management. Comprehension gaps do exist between different managerial levels and firms only regard risk management as external regulation compliance rather than a corporate conscious action. Mechanisms of risk management and daily operations are still not fully integrated. Many firms do not have simultaneous risk assessment processes, risk management strategies and solutions. Firms often lack talented people for risk management, as a result, job descriptions are not lucid enough. Some departments do not have appropriate methods of risk assessment to address the real challenges that the enterprises are faced with. Generally, risk management is only a notion circulating at the headquarters, while at lower hierarchical management usually no risk precautions are taken.

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Chapter 8 Conclusion

As global economic integration deepens and enterprises scale up their business, the enterprise groups have become the mainstream of the companies' development form. Their subsidiaries have grown in size and increasingly diversified. Thus how to control its subsidiaries effectively has become an urgent challenge in practical operation for the parent company, especially for the state-owned enterprise in China. This thesis studies the management and control of state-owned enterprises in China, carrying certain theoretical and practical significance.

The research examined the theory and mechanism of management of state-owned enterprises and evaluation on employee performance. It also analyzed performance evaluation, coordination and risk control strategies of SOEs' subsidiaries. The dissertation had got the actual conclusion with meaningful value.

This thesis first examined the conundrum of effective cooperation between subsidiaries of different departments and the parent company for efficient allocation of resources. To tackle these two problems, the IAHP and DEA model were adopted to help group decision makers better measure the performance of employees and organizations. A novel method was developed for the decision makers.

This thesis used the Balanced Scorecard (BSC) tool as the main principle and combination of fuzzy mathematics and Delphi and entropy weight method as main methodology to assess the performance. The evaluation model provides a new perspective for the managers of state-owned enterprise groups.

This thesis has studied the multi-reason, multi-dimensional and dynamic factors. The super-efficiency DEA model which takes into account work performance, work ability, work attitude, job potential and other factors in the evaluation on employee performance was developed and tested. The study provides a guideline for improving performance and designing a more reasonable salary system.

For the risk control problem in state-owned enterprise, the thesis took the LH enterprise as an example to provide countermeasure and advice.

The thesis provides new ideas and methods for management and control of state-owned enterprises, and has an important reference value to the state-owned enterprises in China.

This thesis mainly researched on existing quantitative methods and models, as well as the management and control factors, and established evaluation models for management decision-making in the end. The research was still not perfect, and many issues remained to be resolved. The following issues will continue to be studied in the future:

(1) The Evaluation and Optimization of the Benefits among the Sectors of SOE Group

① The rigidity of the DEA hypothesis has resulted in many models since its development. However, few are used in China. Therefore, more attention should be paid to the application of DEA models, expanding the tool kit of DEA models to increase their practicality and applicability.

②Although the "projection principle" gives theoretical optimization goal, many factors limit its achievement in actual operation, such as policies, markets, emergencies and so on. In future optimization study, attention should be paid to the impact of external disturbances on the DEA model, especially the optimization model.

③ It is complicated for SOEs to optimize internal efficiency and development model. More attention should be paid to its application and method innovation in other reforming areas of SOEs.

(2) Coordinated decision-making among subsidiaries of SOEs:

①The combined qualitative and quantitative analysis of IAHP, characterized by a layered hierarchy and a broad range of judgments. With its wide adaptability it can be applied to various decision-making areas, and achieve better results through further research and application.

②Many problems remain to be solved in the IAHP methods. For example, in the preliminary consistency test, linear programming can be considered to in a preliminary consistency test, which requires further research in the future.

③The application of analytic hierarchy process models other than IAHP, such as fuzzy analytic hierarchy process. It will widen its application scope and increase practicality. It is of great significance to invigorate enterprises and departments in the fierce market competition.

④Further discussion on the system reform of SOEs. Inter-departmental coordination is only a minor task, and in future research, more attention should be paid to the application of other advanced decision-making methods in SOEs' system reform to enhance SOEs' competitive edge in domestic and international markets.

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Appendix

Appendix 1: LH Energy Group's Enterprise Performance Evaluation Form 1

LH Energy Group's Corporate Performance   Business Section _____   Year assessed _____
Evaluation Form (1)

Examination angle	Weights	Index name	Calculation formula	Index Weight	Index value			
					Subsidiary 1	Subsidiary 2	Subsidiary 3	…
Financial perspective		Asset liability ratio	(total liabilities / total assets) * 100%					
		Operating cost ratio	(Operating cost/operating revenue)*100%					
		Net profit margin on sales	(net profit/operating revenue)*100%					
		Return on total assets	(Total profit before interest and taxes / total average assets) * 100%					
Customer perspective		Growth rate of operating revenue	(Operating revenue of report period - operating revenue of base period)/Operating revenue of base period * 100%					
		Contribution ratio of operating revenue	(Operating revenue of subsidiaries / Operating revenue of parent company) * 100%					
		Profit rate of main business	(Main Business Profit / Main Business Net Revenue) * 100%					

Appendix 2: LH Energy Group's Ownership Performance Evaluation Form 2

LH Energy Group's Corporate Business section _____ Year assessed _____
Performance Evaluation Form (2)

Examination angle	Weights	Index name	Calculation formula	Index Weight	Index value			
					Subsidiary 1	Subsidiary 2	Subsidiary 3	…
Internal business		Current ratio	Current assets / current liabilities					
		Quick ratio	Quick assets/current liabilities					
		Cash ratio	(cash + short-term investments) / current liabilities					
		Turnover of fixed assets	(Main business revenue/net value of fixed assets)*100%					
		Total asset turnover ratio	Prime operation revenue/total average assets					
Learning and growth perspective		Net asset growth rate	(Net assets of report period - net assets of base period) / net assets of base period * 100%					
		Net profit growth rate	(Net profit of report period - net profit of base period)/Net profit of base period *100%					
		Total asset growth rate	(Total assets of report period - total assets of base period) / Total assets of base period * 100%					
		Growth rate of debt	(Total liabilities of report period - total liabilities of base period) / Total assets of base period * 100%					

LH Energy Group's Corporate Performance Evaluation Form (1) Business section   Year assessed