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Study on Tertiary Linkage Scientific Research Management Paradigm

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Abstract: Scientific research management is an important component of scientific research work. Its team innovation and organizational performance will directly affect the smooth progress of scientific research activities. Starting from the theory of high-performance work system, based on the project data analysis under the five-round review system of M University's national fund project, we will continue to improve the organizational efficiency, management efficiency and mechanical efficiency in scientific research management through the practice of tertiary linkage mode of scientific research management. The mission is to achieve the management objectives of optimizing the scientific research management process and maximizing the benefits of scientific research activities, and ultimately to optimize and improve the scientific research management, thus providing theoretical support and practical basis for universities in strengthening organized scientific research, and promoting the modernization of university governance capacity and governance system.

Keywords: Organized scientific research; High performance work system; Tertiary linkage; Five-round review.

1 Introduction

University scientific research plays a very important role in scientific and technological innovation. Its scientific research management is an important part of university scientific research activities. Its team innovation and organizational performance will directly affect whether scientific research activities can be carried out smoothly. The improvement of scientific research management is also the embodiment of the modernization of university governance capacity and governance system[1]. In scientific research management, project management is the core. In project management, it is mainly carried out as regards the National Social Science Fund project and the National Natural Science Fund project (hereinafter referred to as the National Fund project). They are the highest level, most authoritative and most competitive funded projects, and are also important quantitative indicators for the national "double first-class" construction, high-level university construction and discipline evaluation of the Ministry of Education. It is an important symbol of scientific research strength and scientific research organization capacity, and has an important demonstration and guidance role for scientific research[2].

This paper starts with the analysis of the data of the National Fund Project of M University, and under the practice of scientific research management in the tertiary linkage mode, M university continuously improves the organizational efficiency, management efficiency and mechanical efficiency in scientific research management, so as to achieve the management objectives of optimizing the scientific research management process and maximizing the benefits of scientific research activities, and finally achieve the optimization and improvement of the scientific research management, so as to provide theoretical support and practical basis for universities to strengthen organized scientific research.

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2 Tertiary Linkage Scientific Research Management Paradigm

2.1 High-performance work system and scientific research management practice

Since the 1980s, the High Performance Work System has attracted the attention of the western academic and business circles[3], and has achieved preliminary results in American enterprises. In recent years, its research has been gradually deepened, and its application field has also extended from enterprise management to team management, scientific research management and other fields. High-performance work system is the core content of strategic human resource management research. Based on previous studies, high-performance work system can be understood as a dynamic combination of human resource management practice that improve organizational performance by improving employees ability, attitude and motivation. This combination can have a synergistic effect on various performance results of the organization[4][5]. Research shows that high performance work system has a significant positive correlation with team performance. It can improve staffs work quality through staffs high participation, enhance the competitive advantage of the organization through effective integration of the organizational system, and improve the performance of the entire team[6]. According to the development laws of science and technology and higher education and the principles of management, university scientific research management can be defined as an organizational activity to achieve the best completion of scientific research projects by planning, organizing, controlling and summarizing the people, finance, materials, time, information and effects in university scientific research activities through all the stages of the scientific research process[7]. Scientific research management practice is also a combination of human resources management practice and cooperation between teams in terms of its essential attribute. In scientific research management practice, the high participation of scientific research management staff is constantly enhanced by giving full play to the high-performance work system. Through the effective integration of the organizational system, the self-management and teamwork competence of the team is highlighted[8], creating a continuous competitive advantage for the scientific research management team, realizing the effective combination of the internal team and the high-performance work system as well, so as to improve the overall performance of the scientific research team, and provide methodological support for improving the scientific research management[9].

2.2 Management system based on tertiary linkage mode

Management is divided into three levels in management study, namely, top management, middle management and first-line management[10]. At present, the scientific research management mode of universities in China is generally divided into three levels: schools (scientific research management departments), secondary units (departments, research institutions), research groups or researchers; scientific research management tasks and functions form a pyramidal institutional system and functional business system through horizontal division and vertical division[11]. The management efficiency includes three levels, namely, the organizational efficiency of the decision-making level, the management efficiency of the management level and the mechanical efficiency of the executive level[12]. Due to the constant changes of scientific research policies and demands of various scientific research activities with the development of economic and social changes, relevant policies have not been transmitted to the next level in time, resulting in information asymmetry between the subject and object of scientific research management, resulting in the failure of the secondary units to make effective decisions, resulting in low organizational efficiency, management efficiency and mechanical efficiency, and the failure to achieve management objectives[13]. Therefore, to ensure the efficiency of scientific research management, it needs the interaction between the three levels. M University has established a vertical tertiary linkage management team system under the tertiary linkage mode, which is under the macro guidance of university leaders, scientific research managers, scientific research presidents and scientific research secretaries. Each functional department shall appoint a scientific research coordinator to form a horizontal management team with the Scientific Research Department connecting all functional departments. M University adheres to the working concept of innovation+management+service, focuses on serving the connotation construction, innovates the working mode, and makes scientific research services meticulous. Centering on the working idea of school leading, college main body, and teacher main force, it vigorously promotes the innovation of scientific research management, perfects the scientific research management system, and constructs a scientific tertiary linkage scientific research management system and mechanism.

2.3 The five-round review system of national fund projects

In order to improve the application quality of national fund projects and the project initiation rate, M University actively explores the high-quality development mode of scientific research, focusing on collaborative cooperation and

fine management. It promotes the in-depth development of the universitys scientific research, with the management of national fund projects as the vital point and the quality improvement as the guidance. The five-round evaluation system of the National Fund has also been written into the Fourteenth Five-Year Development Plan of the University by M University. As a scientific research management system, it is clearly required to be carried out and implemented throughout the university to promote the implementation of organized scientific research management and achieve high-quality development of the universitys scientific research. During the application period of the National Fund Project, M University, as the decision-making level, carried out the top-level design for the application of the National Fund Project through the five-round review system, and the scientific research management department of the University, as the management level, coordinated and organized the five-round review work. As the executive level, the secondary units, research groups and scientific research personnel carry out preliminary preparation for the school deployment. They organize teams, select topics, design demonstration, and polish the application forms in multiple rounds to continuously improve the quality of the application forms. Through the tertiary linkage mode, the NSFC project has realized the high participation of the whole staff from the school, the scientific research management department, the secondary college to the research group, from the staff of the scientific research management department, the scientific research secretary of the secondary college to the scientific research staff, and improved the performance and competitive advantage of the whole team through the effective integration of the organizational system, laying a solid foundation for the improvement of the application quality.

3 Data Analysis of M University

Since 2018, M University has carried out organized scientific research management. Through the tertiary linkage model, it has regularly held meetings as regards scientific research work to schedule all secondary colleges to improve their enthusiasm and participation. From the data analysis of national fund projects in recent years, whether from the total number of national fund projects or the number of major national fund key projects, M University has achieved quantitative accumulation and qualitative breakthrough, the category structure of national fund projects has achieved continuous optimization, and the project types and multiple disciplines have achieved zero breakthrough.

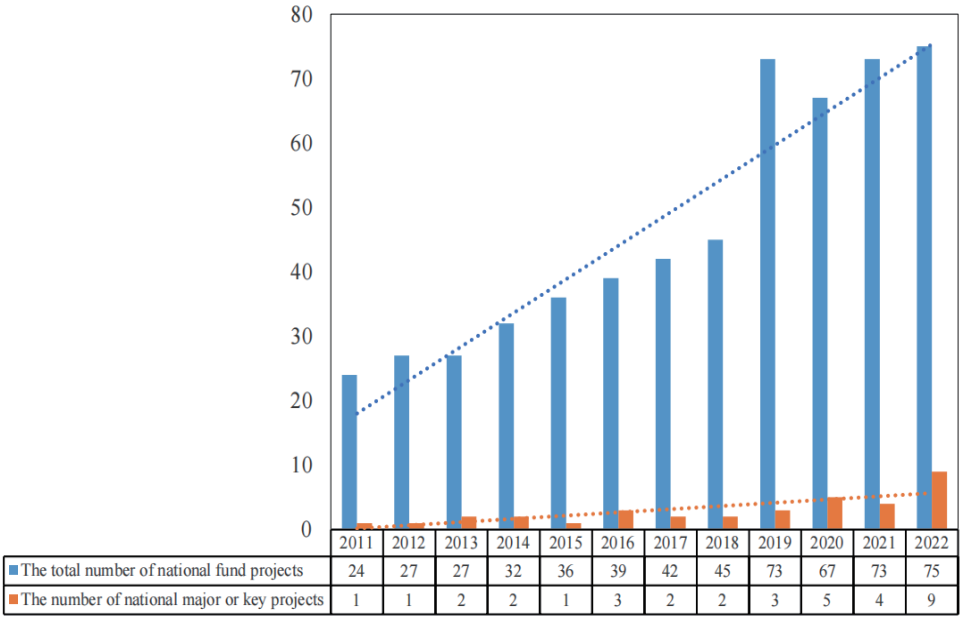
3.1 Application and establishment objectives based on MBO

Drucker, the father of modern management, put forward the theory of management by objective(MBO)[14], which is widely used in the practice of enterprise management. Among them, the objective assessment is an effective measure to implement management by objectives, and M University also applies it to the scientific research management. As one of the important contents of the scientific research management, the objective assessment is formulated according to the scientific research development plan in the medium and long-term development plan of the university. The implementation of specific tasks and measures will be achieved through further decomposition of scientific research objectives, so as to strengthen scientific research objectives and ultimately promote the realization of the overall objectives of the university. Therefore, in the late stage of application and after the official release of the National Fund Program, M University will conduct data analysis on the number of tasks and completed numbers set at the beginning of the year, and feed back the data to the secondary colleges. Through data analysis and comparison, the advantages and disadvantages of each secondary college will be pointed out. Through the analysis of data such as the completion of national fund project application and project approval tasks, per capita project approval, and national project approval in the past five years of the secondary college, it is vital for the universitys scientific research management work. Targeted scientific research management policies are made, and the university carries out the point-to-point scientific research management coordinating service of one college, one characteristic according to different colleges and disciplines.

3.2 Data analysis during the 12th to 14th Five-Year Plan period

Through the research management practice of tertiary linkage in the past five years, M University has made outstanding achievements in national projects, breaking through the expected goals. Through the analysis and comparison of the data from the 12th Five-Year Plan to the 14th Five-Year Plan, the total number of national fund projects and major or key projects from 2011 to 2022 has been counted as shown in Figure 1. Taking the five-round review for the implementation of three-level linkage as the dividing point, the number of national projects of M University has been significantly improved in both quantity and quality since 2018 , and the number of national projects has been increasing continuously in the past

decade. Especially after 2018, after the implementation of organized scientific research management, there has been a leap from 45 in 2018 to 73 in 2019. After 2019, the number of projects approved has been maintained at a high level, and the scientific research management performance is very outstanding. During the 13th Five-Year Plan period, M University has undertaken 17 national major or key projects, far exceeding the construction goal (5) of the 13th Five-Year Plan. The whole university has won 274 national projects, achieving the construction goal (50 per year) of the 13th Five-Year Plan, and far exceeding the construction goal of the 13th Five-Year Plan scientific research plan. The total number of national fund projects approved in 2019 was 73, with a year-on-year increase of 62.22%. In 2022, the number of national major or key projects was 9, with a year-on-year increase of 125%.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
The total number of national fund projects	24	27	27	32	36	39	42	45	73	67	73	75
The number of national major or key projects	1	1	2	2	1	3	2	2	3	5	4	9

Figure 1: The number of national fund projects and major or key projects of M University(2011-2022)

3.3 Data analysis based on the structure of national fund projects

One of the important indicators to measure the quality of projects is the project approval rate. According to the analysis of the structure of the project approval rate, the project approval rate can be divided into key projects, general projects and youth projects, etc. From the perspective of disciplines, the project approval rate can be divided into management, applied economy, theoretical economy, etc. The National Natural Science Fund projects can also be classified according to the Department of Management Sciences, the Department of Life Sciences, etc. For this reason, we compare the project approval rate of the youth projects and general projects of the National Fund with strong representativeness and funding taking up for more than 80%, as shown in Table 1. Under the tertiary linkage scientific research management system, M University has implemented the five-round review system of national fund projects. Whether it is the National Social Science Fund or the National Natural Science Fund, its average project approval rate is higher than the national average project approval rate, especially the National Social Science Fund. The average project approval rate reaches 26.5% and 25.1% from 2019 to 2020, which is more than 10 percentage points higher than the national average project approval rate. When analyzing the structure of national fund projects, it can be found that the project approval rate of general projects is higher than the national average level, but the project approval rate of youth projects is unstable and has a continuous downward trend. In 2022, the national natural science project approval rate of M University is only 12.14%, which is still five percentage points lower than the national average level. This shows that M University has a lot of room in the introduction and cultivation of young scholars. Based on the discipline characteristics of M University, the application of national natural science projects is mainly concentrated in the department of management, and the number of applications and projects approved has reached more than half of the whole university. Therefore, we have conducted a comprehensive

Table 1: Project approval rate of national fund projects of M University (2019-2022)

Years		2019	2020	2021	2022
National Social Science Fund	National average project approval rate	15.71%	14.41%	14.21%	14.16%
	Average project approval rate (M University)	26.25%	25.16%	20.00%	15.29%
	Average project approval rate of national youth projects	18.67%	15.56%	14.81%	/
	Average project approval rate of youth projects (M University)	20.00%	16.22%	14.71%	10.26%
	National average project approvalrate of general projects	15.39%	14.54%	14.57%	/
	Average project approval rate of general projects (M University)	37.50%	37.84%	27.91%	22.22%
National Natural Science Fund	National average project approval rate	17.35%	15.57%	16.61%	16.37%
	Average project approval rate (M University)	22.60%	16.13%	17.60%	17.65%
	Average project approval rate of national youth projects	17.90%	17.29%	16.22%	17.23%
	Average project approval rate of youth projects (M University)	21.67%	15.66	15.70%	12.14%
	National average project approval rate of general projects	18.98%	17.15%	17.43%	17.56%
	Average project approval rate of general projects (M University)	25.93%	20.00%	23.33%	27.42%

analysis of the project approval rate of the Department of Management Sciences, as shown in Table 2. Except that it reached 20.69% in 2019, the average project approval rate of M University in the Department of Management Sciences is lower than the national average level for the rest of three years. In 2020, due to the epidemic and other reasons, the funding rate of the National Natural Science Fund reached the lowest in nearly ten years. The funding rate of M University in the Department of Management Sciences reached the lowest, only 9.16%. In terms of the general project and youth project approval rate, it can still be seen that the youth projects of M University is still its weakness, far lower than the national level. Even though the number of national natural science fund youth projects exceeded general projects for the first time in 2021, the approval rate of youth projects in M University which are funded by Department of Management Sciences reached only 11.93%, far lower than its general projects. In 2022, the project approval rate of youth projects reached the lowest point in recent years, only 7.61%, nearly 10 percentage points lower than its general projects. Therefore, for scientific research management, the NSFC Department of Management Sciences and its youth projects are the focus of work in the next stage. It is vital to plan and carry out organized scientific research.

In order to evaluate the comprehensive scientific research capacity of each college, this paper uses the coupling coor-

Table 2: Project approval rate of NSFC Department of Management Sciences (M University) (2019-2022)

Years	Average project approval rate	Average project approval rate (M University)	Average general project approval rate	Average general project approval rate(M University)	Average youth project approval rate	Average youth project approval rate(M University)
2019	15.06%	20.69%	15.35%	24.24%	14.87%	19.28%
2020	15.39%	9.16%	15.39%	14.81%	14.91%	7.77%
2021	15.05%	13.99%	16.24%	20.59%	15.59%	11.93%
2022	15.40%	14.41%	17.15%	41.67%	15.42%	7.61%

dination model to analyze the total number of teachers under 45 introduced from 2016 to 2019 and the number of national social science funds and natural science funds approved by 2019. The implementation steps are as follows:

In order to avoid dimensional and order of magnitude differences in the indicator data, the extreme value method is adopted to standardize the primary data. The formula is as follows:

$$X_{ij}^{*} = \frac{X_{ij} - m_j}{M_j - m_j} \tag{1}$$

Where X_{ij}^{*} is the normalized value, X_{ij} is the original data, M_j and m_j is the maximum and minimum of the original data. The calculation formula of two system coupling is:

$$C = \sqrt{\frac{F(x) \times G(x)}{[F(x) + G(x)]^2}} \tag{2}$$

Where $C \in [0, 1]$, the higher the value of C, the more harmonious the direction of development and structure between the two will be. Because the coupling degree cannot objectively reflect the coordination development level of the two systems, this paper combines the coupling coordination degrees of the two indicators in the calculation of coordination model, and the formula is:

$$T = \alpha \times F(x) + \beta \times G(x) \tag{3}$$

$$D = \sqrt{C \times T} \tag{4}$$

According to the above steps, the coupling and coordination analysis of the total number of teachers under 45 introduced in 2016-2019 and the number of national social science funds and natural science funds approved by 2019 is carried out, and the results are shown in Table 3.

As shown in Table 3, the comprehensive scientific research ability of different colleges presents different results, among which MA College, FE College, E College, IE College and PM College have excellent coordination in introducing teachers under 45 and the number of national funded projects. That is, these colleges have a high level of comprehensive scientific research ability, while the five colleges of N College, FL College, TY Department, AD College and IJ Institute are in a state of extreme imbalance. The main problem is that none of these colleges has won national funded projects by 2019, and the overall scientific research level is relatively low, which needs further improvement. The scientific research level of other colleges is average. The number of teachers introduced and the number of national funded projects need to be further increased to help improve the comprehensive scientific research level of the colleges.

The four-year cumulative project approval rate is one of the important indexes to measure the scientific research level of the college. This paper further analyzes the relationship between the coupling coordination degree of the two indexes of the introduction of teachers under 45 and the number of national funded projects and the four-year cumulative project approval rate. As is shown in Figure 2, the coupling coordination degree and the four-year cumulative project approval rate of the five colleges of N College, FL College, TY Department, AD College and IJ Institute are all zero. On the one hand, it is confirmed that the coupling coordination degree can reflect the scientific research ability of the college to a certain extent. On the other hand, it also indicates that the scientific research level of the five colleges is very low. According to Figure 2, except M and L College, other colleges have a big difference between the number of teachers introduced under 45 and the number of national funded projects, the coupling coordination degree of them is positively correlated with the four-year cumulative project approval rate. It indicates that increasing the coupling degree between the number of teachers with outstanding scientific research and the number of national funded projects will further improve the project approval rate of the college.

Table 3: Analysis of the coupling and coordination degrees between the number of teachers under 45 and the number of national funded projects in the colleges (departments) of M University

Number	Colleges	Coupling C	Comprehensive evaluation index T	coupling and coordination degrees D	Coordination level
1	MA College	0.96	0.79	0.87	Excellent coordination
2	FE College	1.00	0.94	0.97	Excellent coordination
3	E College	1.00	0.81	0.90	Excellent coordination
4	IE College	1.00	0.79	0.89	Excellent coordination
5	PM College	1.00	0.83	0.91	Excellent coordination
6	ME College	1.00	0.57	0.75	Intermediate coordination
7	FT College	1.00	0.45	0.67	Primary coordination
8	F College	0.96	0.63	0.77	Intermediate coordination
9	IM College	0.99	0.40	0.63	Primary coordination
10	ML College	0.98	0.42	0.64	Primary coordination
11	A College	0.77	0.61	0.69	Primary coordination
12	FE College	0.98	0.19	0.43	Borderline imbalance
13	M College	0.86	0.23	0.44	Borderline imbalance
14	L College	0.79	0.29	0.48	Borderline imbalance
15	JSID College	0.87	0.07	0.26	Moderate imbalance
16	MSE College	0.91	0.19	0.42	Borderline imbalance
17	N College	0.00	0.12	0.00	Extreme imbalance
18	FL College	0.00	0.04	0.00	Extreme imbalance
19	TY Department	0.00	0.06	0.00	Extreme imbalance
20	AD College	0.00	0.04	0.00	Extreme imbalance
21	IJ Institute	0.00	0.00	0.00	Extreme imbalance

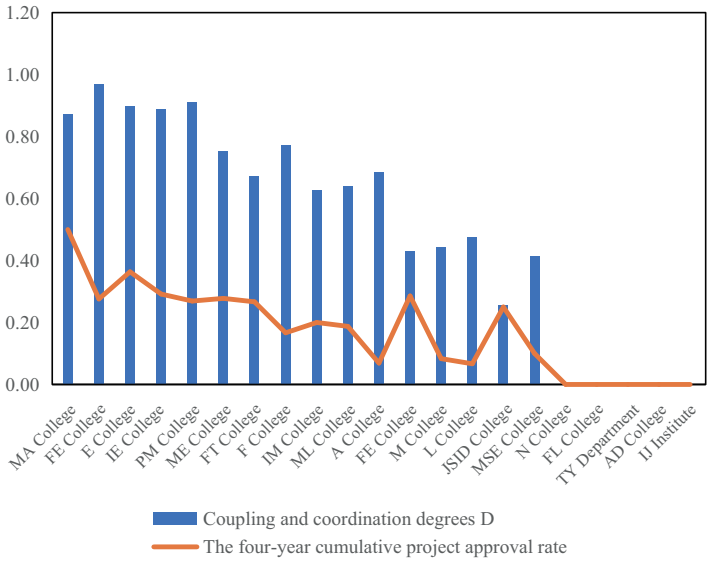


Figure 2: Comparative analysis of the coupling coordination degree and the four-year cumulative project approval rate of M University

4 Current Problems and Development Prospects of M University

4.1 Current problems

The main scientific research force of the school is concentrated on young teachers under 45. However, according to the above data analysis, the project approval rate of young teachers is far lower than the national level, and the cultivation

of young teachers scientific research ability needs to be further strengthened. Therefore, we have made statistics on the national funded projects of introduced teachers under 45 in the past four years since 2016-2019, and only 66 of the 312 newly introduced teachers have won the national project by 2019. There are still 246 people who have not obtained the approval of national projects, accounting for only 21.15%. The scientific research potential of young teachers is far from being tapped. It is difficult for young teachers to quickly change roles and improve scientific research level after entering the school. Teaching young teachers to maintain the continuity of scientific research has become one of the main tasks of the schools connotative development.

From the perspective of disciplines, colleges and teachers, the imbalance among the three is increasingly prominent. Some disciplines and colleges have no national funded projects for many years. From the statistics, it can be seen that there are 27 and over 20 young teachers respectively in E College and F College who have no projects, that 19 in E College and PM College who have no projects, and 25 young teachers in FE College who have no projects. From the perspective of the colleges, the national project approval of newly introduced talents is extremely imbalanced. Among them, the total number of teachers introduced by MA College in four years is 18, and 9 of them have funded projects. The cumulative project approval rate in four years is 50%, ranking first. The total number of teachers introduced by E College is 22, with a total of 8 funded projects. The cumulative project approval rate in four years is 36.36%, ranking second. The newly introduced talents from N College, FL College, TY College and AD College have no funded projects.

4.2 Development prospects and measures

At present, universities all over the country attach great importance to the introduction of high-level young talents. Meanwhile, we must increase the training of existing young teachers. Therefore, the scientific research management department coordinates with the personnel management department to recruit excellent young talents worldwide to apply for the National Natural Science Fund for Distinguished Young Scholars (overseas). They coordinates with the secondary colleges to carry out the Young Scholars Scientific Research Ability Improvement Plan, and invites the CheungKongScholars or experts to carry out academic activities every month. Secondary colleges actively organize the young teachers of the college to participate to improve their ability to apply for projects. During the winter and summer holidays, we invite top international professors to carry out methodological academic activities for young teachers of the college, and actively explore and cultivate potential young teachers.

The leaders of the college (department) are required to attach great importance to the application of national funded projects. They combine incentives and constraints, give full play to the management initiative of the college, and vigorously stimulate the scientific research enthusiasm of teachers. We form an efficient scientific research management system and establish a tertiary management system of the Scientific Research Department, the dean of the college and the scientific research secretary under the macro guidance of the university leaders. We hold regular scientific research meetings, dispatch secondary scientific research institutes, promote the preparation of the application of national projects, realize the flattening and networking of scientific research management institutes and promote the reform to delegate power, streamline administration and optimize government services in the scientific research field. Meanwhile, we give scientific researchers greater autonomy, and fully mobilize innovative talents as well as the enthusiasm of the team, constantly reducing the imbalance between disciplines, colleges and teachers.

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