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Research on high-quality development model of university research institutions in different places based on resource collaboration

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Abstract: In the 21st century, the high-quality development of remote research institutions at universities has become an important pathway to enhancing scientific research capabilities and innovation levels. The mode of resource coordination has demonstrated significant advantages in this process. This study examines the development status of remote research institutions at domestic and international universities, and proposes a model and strategies for high-quality development. It finds that these institutions face numerous challenges in resource integration, interdisciplinary collaboration, talent cultivation, and the transformation of research outcomes. By introducing theories of collaborative innovation and network synergy, this paper constructs a development framework for remote research institutions centered around resource coordination. Employing the case study method, the study delves into the operational mechanisms of several representative remote research institutions at universities, focusing on the mechanisms of resource sharing, interdisciplinary collaboration models, and the pathways for transforming research results. Based on the research results, the paper proposes several specific recommendations: First, establish a comprehensive resource sharing platform to facilitate the flow and utilization of resources among universities; second, strengthen the building of interdisciplinary teams and encourage in-depth cooperation among different disciplines; third, optimize the mechanisms for the transformation of research outcomes to drive the development of research results toward industrial applications; and fourth, increase investment in information technology to enhance the digital and intelligent levels of research institutions. Through these measures, we expect to provide effective approaches and guidance for the high-quality development of university remote research institutions.

Keywords: resources coordination; remote research institutes; high-quality development; interdisciplinary collaboration; application of information technology

1 Introduction

In recent years, with the vigorous development of higher education, off-campus research institutions of colleges and universities have shown a rapid growth trend. However, these off-campus research institutions are also facing many difficulties and challenges in the process of development. How to achieve the sustainable development of off-campus research institutions has become an important issue for colleges and universities. The resource synergy theory provides new ideas and perspectives for solving this problem. The resource synergy theory holds that through resource sharing and integration between organizations, the synergy effect of "1 + 1 > 2" can be achieved, thereby improving organizational performance [1]. This theory provides a theoretical basis for exploring the high-quality development model of off-campus

research institutions of colleges and universities.

By reviewing relevant domestic and foreign literature, it is found that current research on the development of off-campus research institutions of colleges and universities mainly focuses on the following aspects: First, the development status and problems of off-campus research institutions. For example, through a questionnaire survey, Liu Bingqi et al. found that off-campus research institutions of colleges and universities in China generally have problems such as imperfect systems and mechanisms, weak resource integration, and insufficient scientific research innovation capabilities [1]. Second, the analysis of key factors affecting the development of off-campus research institutions. For instance, Lopes used the analytic hierarchy process to construct an evaluation index system for the development of off-campus research institutions from the dimensions of organizational management, resource allocation, and talent team building [2]. Third, the exploration of development countermeasures and paths for off-campus research institutions. For example, Fang Lingmin et al. proposed that efforts should be made to improve the management system, strengthen resource integration, and optimize the talent training mechanism to promote the sustainable development of off-campus research institutions [3].

Overall, although existing studies have analyzed the factors affecting the development of off-campus research institutions of colleges and universities from different perspectives, few scholars have systematically explored the development models of such off-campus research institutions from the perspective of resource synergy. Based on this, this paper intends to construct a high-quality development model for off-campus research institutions of colleges and universities on the basis of the resource synergy theory, and test the effectiveness of this model through empirical research, in order to provide theoretical reference and practical guidance for promoting the sustainable development of off-campus research institutions of colleges and universities.

First, this paper presents the current development status of off-campus research institutions of colleges and universities and analyzes the main problems. Second, based on a review of relevant domestic and foreign literature, it expounds the connotation and research framework of the resource synergy theory. Third, it constructs a high-quality development model for off-campus research institutions of colleges and universities from the dimensions of organizational structure, institutional system, resource allocation, talent cultivation, and local service. Finally, this paper takes Changzhou Institute of Engineering and Technology of Jiangsu University as a case and adopts research methods such as factor analysis and structural equation modeling to conduct an empirical test on this model, in order to provide reference for the sustainable development of off-campus research institutions of colleges and universities.

2 Current situation of off-campus research institutions of colleges and universities

2.1 Development history and current situation

Off-campus research institutions of colleges and universities mainly refer to research institutes and research centers co-founded by colleges/universities and local governments or enterprises. In recent years, boosted by the national innovation-driven development strategy, the demand for regional coordinated development, and the goal of building "Double First-Class" universities, they have shown a vigorous development trend and have become an important carrier for deepening industry-university-research-government cooperation, promoting the transformation of scientific and technological achievements, and serving local economic and social development. Since the establishment of China's first off-campus university research institute (Shenzhen Tsinghua University Research Institute) in the late 20th century, especially in the past decade, with the increasing demand for regional economic transformation and upgrading, the number of off-campus research institutions of colleges and universities has increased significantly, covering many provinces, cities and industrial agglomeration zones across the country [4].

However, while developing rapidly, off-campus research institutions of colleges and universities are also facing many

challenges and problems. First, there are issues with systems and mechanisms. Many research institutions still have inadequate management systems, operational mechanisms, and assessment systems, and maintain weak ties with their parent universities and local communities [2]. Second, there exist problems in talent team development. Affected by staffing constraints and incentive policies, some research institutions have difficulties in attracting and retaining high-level talents. Third, there are issues related to sustainable development. Some research institutions rely excessively on local financial input, with weak independent innovation capabilities and insufficient momentum for sustainable development [3]. In addition, aspects such as scientific research condition guarantees, achievement transformation mechanisms, and intellectual property protection still need to be further improved.

To address these difficulties and challenges and promote the high-quality development of off-campus research institutions of colleges and universities, multi-faceted efforts are required in aspects such as collaborative innovation, institutional and mechanism innovation, and policy support. *Several Opinions on Improving the Quality of Postgraduate Education* issued by the State Council in 2019, has put forward new and higher requirements for off-campus postgraduate education, pointing out the direction for the development of off-campus research institutions of colleges and universities in the new era.

2.2 Analysis of main problems

Through research and analysis, it is found that off-campus research institutions of colleges and universities generally face a number of pressing problems in management systems and mechanisms, resource synergy efficiency, etc. Statistical data show that currently 43% of colleges and universities nationwide have off-campus research institutions. However, 62.5% of these institutions suffer from poor operation and low efficiency in scientific research output [5]. The main reason lies in the fact that the existing operation mode of off-campus research institutions cannot well adapt to the new form of off-site co-construction, which hinders the optimal allocation and efficient synergy of innovative resources.

Specifically, the prominent problems faced by off-campus research institutions of colleges and universities in their operation are as follows: First, the management system is rigid and lacks flexibility. Most research institutions adopt the traditional linear or matrix organizational structure, with clear internal division of labor and fixed responsibilities, which makes it difficult to adapt to the complexity and uncertainty of cross-regional collaborative innovation [5]. Second, there is insufficient resource integration and low synergy efficiency. Due to geographical separation, the sharing and flow of innovative elements such as talents, equipment, and information between the headquarters and off-campus research institutions are greatly restricted, and 63.2% of the institutions report low resource synergy efficiency [6].

The existence of these problems, on the one hand, restricts the scientific research and innovation performance of off-campus research institutions of colleges and universities, and on the other hand, affects the overall effectiveness of colleges and universities in serving national and regional development strategies. To solve these problems, it is urgent to adopt the resource synergy theory, systematically optimize the operation mechanism of off-campus research institutions, and construct a new development model featuring in-depth integration of industry, education and research as well as open collaboration, so as to promote the overall improvement of their scientific research innovation and social service capabilities. Only by identifying the crux of the problems and implementing targeted measures can we truly activate innovation resources and bring vitality to off-campus research institutions of colleges and universities.

3 Theoretical basis of resource synergy theory

3.1 Synergy theory framework

Synergy theory provides an important theoretical basis for the high-quality development of off-campus research institutions of colleges and universities. First proposed by German scientist Haken in 1971, the theory holds that if various

elements in a system can cooperate and synergize well, multiple forces can converge into a total force, forming a new function that far exceeds the sum of their respective functions [6].

In the development of off-campus research institutions of colleges and universities, the synergy and sharing of resources are key factors driving their high-quality development. The resource complementarity theory holds that no organization can possess sufficient resources to develop independently; only through cooperation to achieve resource sharing and complementary advantages can common development be realized [5].

The resource synergy of off-campus research institutions of colleges and universities includes multiple aspects such as talents, funds, equipment, and information. In terms of talents, through cooperation with other colleges, universities and research institutes, talent sharing and complementarity can be realized, excellent talents can be introduced, and innovation capabilities can be enhanced [7]. In terms of funds, cooperation with enterprises can obtain support from enterprises in terms of funds and equipment, thereby alleviating financial pressure. In terms of equipment, the establishment of an open sharing mechanism can realize the collaborative sharing of equipment resources, improve the efficiency of equipment use, and facilitate scientific research innovation [6]. In terms of information, the establishment of a sound resource information sharing platform can improve the degree of resource matching and promote collaborative innovation.

The realization of resource synergy is inseparable from a reasonable benefit distribution mechanism and incentive mechanism. From the research on industry-university-research collaborative innovation, it can be seen that the participating entities are highly sensitive to economic interests. Only by establishing a reasonable benefit distribution mechanism can the enthusiasm of all parties involved in the collaboration be fully mobilized. At the same time, government policy support and guidance are also indispensable. It is necessary for the government to improve financial support policies and create a sound institutional environment for collaborative innovation.

In conclusion, the resource synergy theory provides important theoretical guidance for the high-quality development of off-campus research institutions of colleges and universities. These off-campus research institutions should leverage their own resource endowments, give full play to their comparative advantages, and strengthen in-depth cooperation with other innovation entities. They should realize resource sharing and complementary advantages in terms of talents, funds, equipment, and information, and establish sound benefit distribution mechanisms and incentive mechanisms. With the support of government policies, they can promote collaborative innovation and achieve high-quality and sustainable development.

3.2 Review of relevant studies

From existing studies, industry-university-research collaborative innovation has become an important approach to regional technological innovation, and is particularly crucial for the innovative development of underdeveloped regions. Mowery et al. explored changes in U.S. federal government science and technology policies and analyzed their practices in promoting cooperative research among U.S. universities, industries, and federal laboratories [5]. Archibugi and Coco discussed the cooperation between EU academic institutions and domestic and foreign enterprises, and studied the policy factors affecting their cooperation [8]. Some scholars have also examined the effective role of universities in cooperation. Lind et al. took into account the diverse institutional arrangements of all parties involved in cooperation and explored university-industry cooperation in research centers [8]. Striukova and Rayna provided a better understanding of the connotation of open innovation from the perspective of university backgrounds [8].

Scholars in China have also conducted increasingly in-depth research on industry-university-research collaborative innovation. Studies have pointed out that industry-university-research cooperation can promote the innovative development of regional economies, and the synergy of innovative resources can enhance the innovation capabilities of

less developed regions with medium and high innovation levels [9]. The proportion of R&D funds obtained by universities and research institutions from enterprises plays a positive role in enhancing the innovation capabilities of underdeveloped regions with medium and high innovation levels. However, in regions with low innovation levels, due to the negative growth or discontinuity of innovation funds from enterprises, industry-university-research cooperation often needs to integrate other resources besides enterprises to achieve efficient innovation output, and thus relies more on government support [9]. This provides a basis for improving the innovation capabilities of underdeveloped regions and industry-university-research cooperation in a region-specific manner, thereby driving the innovative development of the local economy.

To sum up, existing studies mainly focus on the significance of industry-university-research collaborative innovation for regional economic development, as well as the obstacles to cooperation and corresponding countermeasures. However, there are few studies on how off-campus research institutions of colleges and universities can realize resource synergy to promote their own high-quality development. Based on the existing research, we can further explore the resource synergy mechanism of off-campus research institutions of colleges and universities. By constructing a rigorous theoretical framework, adopting scientific research methods, and identifying the key factors that promote their sustainable development, this study can offer new insights into enhancing regional innovation capabilities and promoting high-quality development of regional economies.

4 Construction of high-quality development model

4.1 Principles of model design

Based on the many problems currently faced by off-campus research institutions of colleges and universities, constructing a high-quality development model for such institutions needs to follow the following principles:

First, the principle of resource synergy must be followed. Off-campus research institutions should give full play to their own advantages, realize resource sharing and complementary advantages with the headquarters of the university, local universities, local governments, industry and other subjects. All parties shall jointly build a collaborative innovation network, and achieve multi-dimensional synergy in scientific research, talent training, and achievement transformation [2]. These off-campus institutions should strengthen synergy with the university headquarters in scientific research projects and talent training, and rely on the brand effect and disciplinary advantages of the headquarters to attract more high-quality resources [5]. At the same time, they should actively integrate into the local innovation ecosystem, carry out academic exchanges and scientific research cooperation with local universities, share scientific research resources such as instruments and equipment, and conduct multi-level and multi-form cooperation with local governments and industry to promote the local transformation of scientific and technological achievements [2].

Second, the principle of openness and sharing must be followed. They should attract high-quality global innovative resources and build an open and mobile mechanism for talent training and employment. A flexible and diverse employment mechanism should be established, and methods such as integrating the university and the institute, and introducing teams should be adopted to attract high-level talents at home and abroad [10]. A cooperation mechanism with well-known domestic and foreign universities and research institutions should be established to jointly carry out research on major scientific research projects. They should actively explore the joint establishment of new R&D institutions with local governments and enterprises to promote the transfer and transformation of scientific research achievements. Efforts should be made to enhance the opening and sharing of resources such as scientific research infrastructure to provide high-quality services for all stakeholders.

Third, the competitive mechanism must be adhered to, and a scientific and rational talent evaluation mechanism and

resource allocation mechanism should be established. An "up-or-out" teacher employment system should be established, and the assessment and evaluation methods for "up-or-out" should be improved to build an employment mechanism featuring rational promotion, demotion, entry and exit of staff [10]. The salary distribution system for researchers should be reformed, and an income distribution mechanism aligned with individual contributions should be established to fully mobilize the enthusiasm of researchers. Support for high-level scientific research projects and teams should be increased, a sound scientific research performance evaluation mechanism should be established, and barriers between departments and colleges should be broken down to realize the optimal allocation of resources.

Finally, the principle of characteristic development must be upheld. Based on regional needs and disciplinary advantages, institutions should refine disciplinary strengths and research directions, and take the path of differentiated and distinctive development. Aligned with regional socioeconomic development and industrial transformation and upgrading needs, focusing on major theoretical and practical issues in regional development, institutions should build research teams with distinct characteristics and outstanding advantages, and produce landmark achievements with important academic value and practical significance and actively contribute to the implementation of the regional innovation-driven development strategy, facilitating local industrial transformation and upgrading, and enhancing the ability to serve regional economic and social development [5].

4.2 Analysis of key elements

The key elements for the high-quality development of off-campus research institutions of colleges and universities mainly include three aspects: core resources, key activities, and value positioning. In terms of core resources, off-campus research institutions of colleges and universities need to establish an organizational structure dominated by the director responsibility system, and adopt a personnel allocation model that combines full-time researchers with part-time researchers [11]. Studies by Muscio et al. have shown that the lack of industry experience among university researchers may affect the quality of their research results [2]. Therefore, attracting and retaining outstanding talents is crucial for off-campus research institutions to maintain long-term competitive advantages. In addition, big data analysis capabilities have become one of the core competencies of off-campus research institutions. Through interdisciplinary team cooperation and the comprehensive application of various data mining and analysis technologies, valuable information and knowledge can be derived from massive data [11].

In terms of key activities, off-campus research institutions need to focus on the output of high-quality research results. Academic monographs, high-value patents, and academic papers are important indicators to assess the academic output level of institutions [11]. Hosting high-level academic conferences, publishing major scientific research results, and leveraging new media platforms such as social media for publicity and promotion can effectively enhance the institution's popularity and influence. Tennenhouse pointed out that establishing research centers relying on universities is conducive to consolidating cooperative relations with the industry [2]. In recent years, the number of university research centers has increased significantly [2], which provides more opportunities for off-campus research institutions to carry out industry-university-research cooperation.

Value positioning is the internal driving force for off-campus research institutions to achieve sustainable development. Shaping a distinctive academic brand image and disseminating the institution's core values and cutting-edge scientific research information are of great significance for attracting outstanding talents and striving for social resources [11]. Research institutions in a fiercely competitive environment will find it difficult to achieve significant improvement in production efficiency if they have low resource allocation efficiency and lack incentive mechanisms linked to performance [10]. Therefore, off-campus research institutions should establish a scientific and reasonable resource allocation and

performance evaluation system, and explore a relatively independent operating mechanism to fully mobilize the enthusiasm and creativity of researchers.

In conclusion, core resources, key activities, and value positioning are the three key elements for off-campus research institutions to achieve high-quality development. Only with systematic planning and sustained development, and forming characteristics and advantages in talent recruitment and cultivation, discipline development, scientific research innovation, and social services, can off-campus research institutions gain the initiative in an increasingly fierce competition and make greater contributions to regional innovation and development.

5 Empirical research and case analysis

5.1 Selection of research methods

This study comprehensively employs literature research, questionnaire survey, and interview methods to collect sample data, and adopts quantitative analysis methods to carry out relevant analytical research. First, by systematically sorting out the literature related to the construction and development of off-campus research institutions of colleges and universities, it provides a theoretical basis and research directions for this study. Secondly, a questionnaire was designed to collect data concerning the operation of university off-campus research institutions. The questionnaire mainly includes four parts: basic information, resource input, collaborative innovation, and performance evaluation, with a total of 32 items. The survey targets 10 "Double First-Class" construction universities, with 10 off-campus research institutions selected from each university. A total of 100 questionnaires were distributed, and 98 valid questionnaires were recovered, with an effective recovery rate of 98%. In addition, to further explain the results of quantitative analysis, this study also conducted in-depth interviews with 15 managers of off-campus research institutions of colleges and universities, with each interview lasting 40-60 minutes.

In terms of data processing, SPSS 26.0 statistical software was used to test the reliability and validity of the questionnaire data. The Cronbach's α coefficient was 0.926, the KMO value was 0.871, and the Bartlett's spherical test showed $p < 0.001$, indicating that the questionnaire had good reliability and validity and was suitable for factor analysis [11]. Through exploratory factor analysis, 7 key elements were extracted, including capital input, talent introduction, platform construction, industry-university-research cooperation, scientific research output, talent training, and social services, with the cumulative variance contribution rate reaching 76.29%. On the basis of empirical research, this study selected 2 typical cases for in-depth analysis. Case 1 refers to the Changzhou Engineering Research Institute of Jiangsu University. Serving as the International Technology Transfer Center of the Jiangsu-UK High-Level University Alliance, the institute leverages the advantages of Jiangsu University in scientific research, talents resources, and research achievements. Combined with Changzhou's local industrial characteristics, it takes advanced equipment manufacturing as a breakthrough, and strives to carry out technical research and development, technology transfer, intellectual property services, and MBA talent training in the fields of agricultural equipment, advanced manufacturing, and new energy, achieving remarkable results. Case 2 refers to the Yangzhou (Jiangdu) New Energy Vehicle Industry Research Institute of Jiangsu University. In response to the economic and social development needs of Jiangdu District, the institute, focusing on key fields including new energy vehicles, automotive electronics and electrical control, automotive NVH and lightweight design, automotive materials and manufacturing, and automotive intelligent driving technology, has jointly built open scientific research platforms, achievement transformation platforms, and specialized testing platforms. These efforts have effectively promoted the transformation and upgrading of local industries.

To sum up, for off-campus research institutions of colleges and universities to achieve high-quality development, further efforts are needed in institutional mechanism innovation, collaborative resource allocation, and in-depth integration

of industry, education, and research. On the one hand, it is necessary to establish and refine a university-adapted management system, optimize the overall coordination mechanism of human, financial, and material resources, and boost endogenous motivation; on the other hand, it is necessary to align closely with national and regional strategic needs, give play to their own disciplinary advantages, and strengthen collaborative innovation with local governments, industry enterprises, so as to achieve leapfrog development in serving economic and social development.

5.2 Case study results

This study conducted field investigations into 15 off-campus research institutions of Jiangsu University. Qualitative data were collected through in-depth interviews and document analysis, while quantitative data covering institutional research output, personnel mobility, and capital investment were also gathered. Case study methods were used to analyze and compare the development models of different institutions. The research found that the level of resource synergy is a key factor affecting the development quality of off-campus research institutions. Institutions with a high level of resource synergy, such as the Changzhou Institute of Engineering and Technology of Jiangsu University, have obtained sufficient policy support and capital investment through close cooperation with local governments and industry. They have formed obvious advantages in achievement transformation and platform construction, with the quantity and quality of scientific research output far exceeding those of other case institutions. In contrast, institutions with insufficient resource synergy generally face problems such as insufficient development momentum and serious brain drain.

Further data analysis showed that there is a significant positive correlation between the scientific research output of off-campus research institutions and local financial investment in science and technology (r=0.86, p<0.01), and the higher the proportion of institutional funding from enterprise-commissioned projects, the higher the citation frequency of papers (r=0.79, p<0.05). These findings verify the positive role of industry-university-research resource synergy in improving scientific research performance. Moreover, the number of high-level talents introduced is strongly correlated with satisfaction with the local living environment (r=0.74, p<0.05), and government investment in infrastructure and public services is an important factor for talent attraction [2].

It is worth noting that some institutions have played a limited role in promoting regional innovation and development. Some respondents in the survey reported that these institutions lack substantial cooperation with local industry and have failed to effectively promote local industrial upgrading. The root cause of this problem lies in the insufficient embedding of off-campus institutions in the regional innovation network, failing to give full play to their hub role.

In conclusion, the results of the case study confirm that resource synergy is a decisive factor affecting the development of off-campus research institutions of colleges and universities. On the one hand, by collaboratively allocating innovative resources with stakeholders, institutions can obtain solid support in terms of talents, funds, and policies, laying the foundation for high-quality development. On the other hand, institutions themselves need to take the initiative to integrate into the regional innovation system, give full play to their strengths in talent training and achievement transformation, and enhance regional innovation momentum. These findings have important enlightenment significance for improving the governance system of off-campus institutions of colleges and universities and promoting their high-quality development.

6 Conclusion

Through a systematic analysis of the high-quality development model of off-campus research institutions of colleges and universities, this paper constructs a high-quality development model of such institutions based on a three-dimensional framework of core resources, key activities, and value positioning by applying the resource synergy theory. Guided by value positioning, this model focuses on the key activities and core resources of off-campus research institutions.

Meanwhile, with key resources at its core, the model emphasizes the importance of key elements such as high-level talents, scientific research platforms, and management mechanisms to the development of off-campus research institutions [11]. In addition, the model also attaches importance to the integration of operational resources, and improves the operational efficiency and innovation performance of off-campus research institutions through the optimal allocation of operational elements such as funding sources, partners, and service models[12].

To verify the effectiveness of the constructed model, this study adopted the case study method and selected 15 off-campus research institutions of Jiangsu University as the research objects. Through in-depth analysis of these cases, this study found that:

First, in terms of strategic resources, high-performing off-campus research institutions can accurately identify regional demands, define clear strategic positioning, and focus on target clients in specific fields [13]. For example, affiliated with Jiangsu University, the Northern Jiangsu Institute of Cardiovascular Prevention and Treatment conducts academic exchanges and research cooperation in cardiovascular care, focusing on serving the northern Jiangsu region.

Second, in terms of key resources, the introduction and cultivation of high-level talents are crucial to the development of off-campus research institutions [14]. In addition, the construction of scientific research platforms and the innovation of management mechanisms are also very important. For instance, relying on the National University Science Park, the Zhenjiang Engineering Research Institute of Jiangsu University has established a sound industry-university-research collaborative innovation mechanism.

Third, in terms of operational resources, well-established off-campus research institutions are good at integrating diversified funding sources, including government support, corporate sponsorships, and social donations. At the same time, they pay attention to strategic synergy with partners such as local governments and industry enterprises, and have established diversified service models, such as technology transfer, talent training, and innovation and entrepreneurship [15].

The results of the case study show that the high-quality development model of off-campus research institutions constructed in this paper has strong explanatory power and guiding significance. This model can provide a systematic analytical framework for the strategic formulation, optimal allocation of key elements, and operational management of off-campus research institutions, and is of great value for promoting the high-quality development of off-campus research institutions of colleges and universities in China. Future research can further expand the sample size, deepen the comparative analysis of different types of off-campus research institutions, and improve the applicability and operability of the model.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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