



The Role of Universities in the National Innovation System and the Evolution of Practice

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Abstract. Technological innovation serves as the primary driving force behind social development, with universities playing a crucial role in advancing scientific progress. Throughout their developmental trajectory, Scientific and technological innovation in universities has traversed five distinct phases, spanning from initial establishment and exploration to the current pursuit of "Double First-Class" construction. As this evolutionary process has unfolded, the significance of universities within the national innovation ecosystem has become increasingly pronounced. Looking ahead, the scientific and technological endeavors of universities should prioritize the enhancement of fundamental research, with a particular focus on overcoming critical technical bottlenecks. Concurrently, deepening the integration among industry, academia, and research institutions is essential for expediting the transformation of scientific and technological achievements. By implementing these strategic measures, universities can make substantial contributions to bolstering national self-reliance in science and technology. This, in turn, will enable them to play an increasingly prominent role in the journey towards achieving technological independence and self-improvement, thereby propelling the continuous advancement of China's scientific and technological enterprise to new heights.

Keywords: universities, scientific and technological innovation, the National Innovation System

1 Introduction

The report to the 20th National Congress of the Communist Party of China (CPC) systematically outlined the strategy of rejuvenating the country through science and education and fostering talent development for modernization, emphasizing that education, science and technology, and human resources constitute the fundamental and strategic pillars for building a modern socialist nation. It underscored the principles that science and technology represent the primary productive force, talent is the primary resource, and innovation is the primary driver of development, while advocating for the comprehensive implementation of the science and education-driven development strategy, the talent-strengthening strategy, and the innovation-driven development strategy to continuously cultivate new growth momentum and competitive ad-

vantages. Furthermore, the report highlighted the need to optimize the national innovation system, refine the strategic positioning and functional layout of national research institutions, top-tier universities, and leading high-tech enterprises, advance the construction of national laboratory systems, and coordinate the development of international and regional science and technology innovation hubs, while enhancing foundational research capabilities to boost overall national innovation efficiency. These directives have endowed universities with a new strategic role and historical mission, significantly influencing the trajectory of technological innovation in higher education.

In this new era of development, universities—as pivotal components of the national innovation ecosystem—must vigorously champion the spirit of scientific inquiry, accelerate the cultivation of independent innovation, and deliver transformative original research outcomes, thereby contributing to the realization of high-level technological self-reliance and the establishment of a global talent nexus.

2 The Roles Played by Colleges and Universities in the National Innovation System

2.1 Colleges and Universities Serve as the Primary Locus for Cultivating Innovative Talents

To attain a high - level of scientific and technological self - reliance and self - improvement, China ultimately depends on high - end innovative talents. In essence, the competition in today's global arena is a contest of talents and education. This situation demands that greater emphasis be placed on the independent cultivation of talents, with special focus on nurturing young talents. Colleges and universities are magnets that attract young talents from across the country and even around the world, serving as the principal venues for the cultivation of high - level innovative talents ^[1]. The most fundamental and rudimentary function of colleges and universities is talent cultivation, and the primary mission of these institutions is to develop high - quality innovative talents. As the dissemination platforms for higher education, colleges and universities have furnished society with a vast pool of exceptional Inventive talents, playing a crucial role in propelling the continuous advancement of science, technology, and society.

2.2 Colleges and Universities are the Main Force of Basic Research and the Source of Major Scientific and Technological Breakthroughs

Scientific research constitutes the secondary function of universities. In addition to their core mission of talent cultivation, universities also shoulder critical national responsibilities in fundamental research. Over the past decade, Chinese institutions of higher learning have spearheaded the establishment of over 60% of national key laboratories and more than 30% of national engineering research centers. Furthermore, nearly 70% of recipients of the National Outstanding Young Scientists Fund are affiliated with universities. These statistics underscore the growing prominence of univer-

sities as pivotal players in basic research, further solidifying their indispensable role in advancing China's scientific innovation. [2].

2.3 Colleges and Universities are the Driving Force for the Development of Social Productivity

In the era of 'knowledge economy', the social service function of colleges and universities is becoming more and more prominent, and the ultimate purpose of training and scientific research in colleges and universities is to serve the society^[3]. In recent years, colleges and universities have formed a kind of science and technology to the real productivity of the wind, the school's scientific research does not just stay in the paper, but more service to industrial development, to provide a source of technological innovation for enterprises. While strengthening the level of teaching and scientific research, Higher education institutions continue to strengthen cooperation with enterprises, take the development path of cooperation between industry, academia and research, and strive to achieve the industrialisation of scientific and technological achievements, which provides a driving force for the sustainable development of society.

2.4 The Evolution of Universities' Practices in National Innovation Systems

This paper divides the practical evolution of Higher education institutions in the national innovation system into the following phases according to national historical events and important scientific and technological policies: 1949-1976 is the period of newborn and exploration, 1977-1994 is the period of restoration and development, 1995-2006 is the period of deepening reform of the national scientific research system, 2006-2015 is the period of technology transfer and transformation, and 2015-present is the period of double First-class construction period.

2.5 Newborn and Exploration Period (1949-1976)

The establishment of the People's Republic of China in 1949 provided institutional prerequisites for technological advancement within higher education establishments. Following the nationwide restructuring of university faculties in 1952, higher education reform aligned with national industrialization goals during the early PRC period, emphasizing the adoption of Soviet educational models and prioritizing the development of engineering institutions^[4].

In 1956, under the leadership of the first generation of CPC central collective leadership with Mao Zedong as chairman, the "March to Science" initiative significantly stimulated university research activities. This momentum culminated in 1963 when university research programs were formally incorporated into national development planning^[5]. However, the Cultural Revolution (1966-1976) severely disrupted academic institutions through the destruction of research systems and talent cultivation frameworks, resulting in substantial setbacks for university research endeavors. The

scientific research achievements of colleges and universities during this period were few and showed the following characteristics:

(1) During this era, priority was given to reforming and restructuring the university research system, drawing inspiration from the Soviet model. The nation primarily focused on establishing engineering colleges to support industrialization. Universities were accorded high - priority status during this period. Talent cultivation in universities was mainly oriented towards serving industrialization, while university - based scientific research was predominantly aimed at meeting the needs of the military and industry.

(2) During this period, colleges and universities mainly focused on teaching, and scientific and technological innovation was only a supplement to education and teaching, with few outstanding scientific research achievements.

2.6 Restoration and Development Period (1977-1994)

The resumption of the national college entrance examination in 1977 established a stable talent supply system for university-based scientific research. The 1979 National Conference on Higher Education Research established the dual mission of talent cultivation and technological innovation for universities, marking a new phase in university research development Document No. 14 issued by the Central Committee in April 1981 articulated the Party's strategy for coordinating scientific development with socioeconomic progress ^[6]. The 1985 Central Committee directive called for expanding university autonomy, while the 1987 Guidelines from the State Education Commission formally recognized universities' pivotal role in national innovation systems ^[7]. The 1992 Industry-University-Research Joint Development Program, jointly launched by the State Education Commission, Economic and Trade Commission, and Chinese Academy of Sciences, institutionalized collaborative research through administrative mechanisms, facilitating the industrial application of university research outcomes. During this period, scientific and technological innovation in colleges and universities flourished, and presented the following characteristics:

(1) The period was devoted to restoring the economy, so the direction of scientific research in colleges and universities was orientated to the development of the national economy and served the economic construction.

(2) Talent cultivation and scientific research are equally emphasized in higher education institutions. These institutions not only prioritize teaching but also undertake the critical mission of advancing science and technology, thereby formally establishing their central role in research endeavors.

(3) The nationwide implementation of the "industry-university-research" initiative has integrated enterprises, universities, and research institutions, facilitating the commercialization of university-derived technological innovations.

2.7 The Period of Deepening Reform of the National Scientific Research System (1995-2005)

In 1995, the CPC Central Committee and the State Council introduced the "Decision on Accelerating Scientific and Technological Progress," which first proposed the "Revitalize the Country through Science and Education" strategy, elevating science and education to a prominent position in economic and social development. The 1996 National Conference on University Science and Technology underscored the significance of revitalizing agriculture through science and education, fostering collaboration among industry, academia, and research institutions, and facilitating the commercialization of technological innovations. In 1997, the "National Key Basic Research Development Plan" initiated focused basic research to meet national requirements, highlighting the central role of universities in foundational studies during this period^[8]. In 1998, China advanced the construction of a national innovation system, formally integrating the university-based scientific innovation framework. Simultaneously, the launch of the "211 Project" and "985 Project" bolstered the industrialization of scientific research and technology transfer within universities. In 2001, The national government promoted the foundation of university-linked science and innovation hubs, enhancing the efficiency of translating research findings into industrial applications. The following year, the "Guidelines on Maximizing the Role of Higher Education in Scientific Research" were promulgated, further delineating the essential role of universities within the national innovation ecosystem. During this phase, university-led technological innovation experienced rapid growth, exhibiting distinct characteristics^[9].

(1) Higher education institutions have increasingly emphasized basic research, ushering in a transformative phase where they assume a pivotal role in advancing foundational science.

(2) The integration of higher education institutions into the national innovation system underscores their pivotal position within the broader innovation ecosystem.

(3) The industry-academia-research collaboration has been significantly enhanced, giving rise to the establishment of key national laboratories, engineering research centers, university science parks, and technology transfer hubs. This collaborative framework is now evolving toward high-level, multi-dimensional, sustainable, and closely integrated partnerships.

2.8 Period of Technology Transfer and Transformation (2006-2015)

In January 2006, Hu Jintao elucidated the strategic objectives and concrete measures for constructing an innovative nation at the National Science and Technology Conference. That same year, the Central Committee unveiled the National Medium- and Long-Term Scientific and Technological Development Plan (2006-2020), which actively backed the original innovation of universities in basic research, cutting-edge technology research, and social public welfare research. It also encouraged and facilitated comprehensive collaboration between universities, enterprises, and research institutes, intensifying efforts to support national, regional, and industrial development.

In 2007, the Ministry of Education's *Several Opinions on Accelerating the Construction of Research Universities and Enhancing the Independent Innovation Capability of Higher Education Institutions* highlighted that one of the missions of research universities is to deliver robust and effective societal services. It encouraged research universities to proactively engage in partnerships with enterprises. The 18th CPC National Congress in November 2012 underscored the imperative of pursuing indigenous innovation with Chinese characteristics, operationalizing the innovation-driven development strategy, and positioning technological innovation at the forefront of national priorities. In 2015, the strategic decision to establish world-class universities and disciplines was announced, with university research dedicated to linking technological advancements with industrial applications. During this era, university-led technological innovation thrived, manifesting distinct characteristics^[10].

(1) The organic combination of talent cultivation, scientific research and social service in universities, and the role of social service in universities is increasing.

(2) University-based research collaborates with industrial sectors and research organizations to conduct high-tech and fundamental innovation, demonstrating a distinctive role in technology transfer and commercialization while expediting the transformation of scientific and technological outputs.

2.9 The Period of Double First-class Construction (2016-present)

The National Science and Technology Innovation Conference convened in 2016 witnessed General Secretary Xi Jinping's proposition that to establish China as a global leader in science and technology, it is imperative to possess a cadre of world-class research institutions, universities, and innovative enterprises capable of consistently generating seminal original scientific accomplishments. This aspiration necessitates universities to assume a pioneering and avant-garde role in the national innovation-driven development strategy. In 2017, the 'double first-class' programme was formally implemented to strengthen the position and role of universities in the national innovation system. In the same year, the 19th CPC National Congress made a new deployment of the implementation of the innovation-driven development strategy, stressing that innovation is the first driving force and talent is the first resource, highlighting the use of scientific and technological innovation to lead comprehensive innovation, and the use of a strong scientific and technological country to support the construction of a modern and powerful country, which puts forward a higher demand for talent cultivation in universities.

In 2020, General Secretary Xi Jinping emphasised at a forum of experts on education, culture, health and sports that 'China's colleges and universities should take up the heavy burden of releasing the potential of basic research and scientific and technological innovation in colleges and universities, focusing on the strategic needs of the country, and accelerating technological breakthroughs by aiming at the key core technologies, especially the "stranglehold" problem. On April 19, 2021, during an inspection tour at Tsinghua University, it was pointed out that first - class universities serve as the principal force in fundamental research and the wellspring of major scientific and technological breakthroughs. The report delivered at the 20th National

Congress of the Communist Party of China carried out a comprehensive plan and a concentrated statement regarding education, science and technology, and human resources. For the first time, it highlighted that education, science and technology, and human resources are the fundamental and strategic underpinnings for the all-around construction of a modern socialist country. The strategic prioritization and institutional support from the state have endowed China's higher education system with a renewed historical mission and developmental positioning. In this context, the scientific and technological innovation of Chinese universities has entered a new phase within the framework of socialism with Chinese characteristics, exhibiting the following distinctive features: ^[11]:

(1) University-based scientific research is not limited to a certain discipline in a certain college, but pays more attention to the cross-discipline and fusion of disciplines, organises interdisciplinary teams, and strives to achieve major breakthroughs in original innovation.

(2) Accelerate the development of high-tech industries, enhance creative entrepreneurship and innovation capacity-building in higher education institutions, and facilitate the commercialization and dissemination of scientific research outputs.

3 Recommendations

3.1 Strengthen Basic Research, Break the 'Neck' Problem

To advance basic research, universities must shoulder their indispensable historical mission as key drivers of foundational innovation. Anchored in national strategic priorities and socioeconomic development goals, they should address fundamental scientific challenges while tackling critical technological bottlenecks underlying these issues. Universities should prioritize strengthening foundational disciplines by integrating general education with specialized training, thereby refining talent cultivation models for basic research. Additionally, they should enhance comprehensive, interdisciplinary platforms—such as national key laboratories and advanced research infrastructures—while leveraging the unique attributes of foundational disciplines. Early exposure to cutting-edge research should be encouraged, enabling students to engage in pioneering studies from an earlier stage.

3.2 Strengthen the Deep Integration of Industry, Academia and Research, And Promote the Transformation of Scientific and Technological Achievements

Evaluating scientific research should extend beyond quantitative metrics such as publication counts and patent filings. Instead, greater emphasis should be placed on assessing innovation quality, impact, and practical application—particularly whether research outcomes effectively translate into real-world solutions. To align with the national strategy of industry-academia-research integration, universities must thoroughly comprehend and implement its core principles. While enhancing their intrinsic innovation capabilities, institutions should actively pursue collaborative R&D with

industry partners. This includes establishing dedicated coordination mechanisms (e.g., university-industry liaison offices) to foster synergies, optimize resource allocation, and ensure disciplines align closely with industrial needs. Such partnerships should prioritize technology transfer and commercialization, enabling scientific breakthroughs to drive industrial upgrading. Moreover, universities should strengthen their social service functions, contributing to sustainable economic development and high-quality industrial growth through applied innovation and knowledge dissemination.

4 Conclusions

Chinese universities have evolved through five developmental phases steadily enhancing their pivotal role within the national innovation system. Looking ahead, universities must anchor their mission in foundational research, aligning with the nation's strategic priorities and socio-economic development objectives. To fulfill this role, they should deepen their understanding of enterprise-led industry-academia-research integration, strengthening collaborative innovation while continuously advancing their intrinsic research capabilities.

Specifically, universities should establish dedicated university-enterprise collaboration platforms, accelerate the commercialization of scientific achievements, and amplify their societal contributions. By doing so, they can drive high-quality development across both national industries and the broader economy.

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