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The Exploration and Practices of TusPark in Promoting Business Incubation and Industrial Development

Abstract

As a new platform for innovation, China's national university science parks gather a wealth of resources for innovation. They are not only the carriers of new knowledge, technologies and systems, but also that of new cultures. As one of the first batch of national university science parks in China, TusPark, which is backed by Tsinghua University with the active participation of varied entrepreneurial, R&D and financial institutions, has basically developed an ecological network for innovation that is distributed throughout the country. It has become an important platform for further transformation of the scientific and technological achievements of universities, as well as promoting the development of strategic emerging industries.

Focused on TusPark's functions and roles in advancing startup incubation and industrial development, this paper conducts an in-depth analysis of TusPark's developmental path, with research based on interviews conducted with people involved in TusPark's construction and operations, as well as reviewing the developmental history and models of global university science parks with international perspectives and extracting TusPark's unique developmental path and model. The aim of this paper is to analyse how TusPark, as the science park of China's top university, blazed a trail for business incubation and industrial development. The paper presents some typical cases and explains TusPark's major models for business incubation and industry cultivation. It also discusses the main factors of TusPark's success and explores its approaches for encouraging future development under new domestic and international circumstances.

Keywords: TusPark; TusHoldings; transformation of scientific and technological achievements; strategic emerging industry; multi-dimensional triple helix.

L'exploració i les pràctiques de TusPark en la promoció de la incubació empresarial i el desenvolupament industrial

Resum

Com a nova plataforma per a la innovació, els parcs científics universitaris nacionals de la Xina reuneixen una gran quantitat de recursos per a la innovació. No només són portadors de nous coneixements, tecnologies i sistemes, sinó també els de noves cultures. Com a un dels primers parcs científics universitaris nacionals de la Xina, TusPark, que compta amb el suport de la Universitat de Tsinghua amb la participació activa de diverses institucions empresarials, d'R+D i financeres, ha desenvolupat bàsicament una xarxa ecològica per a la innovació que es distribueix per tot el país. S'ha convertit en una plataforma important per a una major transformació dels assoliments científics i tecnològics de les universitats, així com per promoure el desenvolupament d'indústries emergents estratègiques.

Centrat en les funcions i els papers de TusPark en l'avanç de la incubació d'empreses i el desenvolupament industrial, aquest article realitza una anàlisi en profunditat del camí de desenvolupament de TusPark, amb investigacions basades en entrevistes realitzades amb persones implicades en la construcció i les operacions de TusPark, així com en la revisió de la història del desenvolupament i models de parcs científics universitaris globals amb perspectives internacionals i extreure el camí i el model de desenvolupament únics de TusPark. L'objectiu d'aquest article és analitzar com TusPark, com a parc científic de la millor universitat de la Xina, va obrir un camí per a la incubació d'empreses i el desenvolupament industrial. El document presenta alguns casos típics i explica els principals models de TusPark per a la incubació d'empreses i el cultiu de la indústria. També analitza els principals factors de l'èxit de TusPark i explora els seus enfocaments per fomentar el desenvolupament futur en noves circumstàncies nacionals i internacionals.

Paraules clau: TusPark; TusHoldings; transformació dels èxits científics i tecnològics; indústria estratègica emergent; multi-dimensional triple hèlix.

La exploración y las prácticas de TusPark en la promoción de la incubación empresarial y el desarrollo industrial

Resumen

Como nueva plataforma para la innovación, los parques científicos universitarios nacionales de China reúnen una gran cantidad de recursos para la innovación. No sólo son portadores de nuevos conocimientos, tecnologías y sistemas, sino también de nuevas culturas. Como uno de los primeros parques científicos universitarios nacionales de China, TusPark, que cuenta con el apoyo de la Universidad de Tsinghua con la participación activa de diversas instituciones empresariales, de I+D+i financieras, ha desarrollado básicamente una red ecológica para la innovación que se distribuye por todo el país. Se ha convertido en una plataforma importante para una mayor transformación de los logros científicos y tecnológicos de las universidades, así como para promover el desarrollo de industrias emergentes estratégicas. Este artículo, centrado en las funciones y el rol de Tuspark en el avance de la incubación de empresas y el desarrollo industrial, realiza un análisis en profundidad del camino de desarrollo de Tuspark. Con investigaciones basadas en entrevistas realizadas con personas implicadas en la construcción y las operaciones de TusPark, así como en la revisión de la historia del desarrollo y modelos de parques científicos universitarios globales con perspectivas internacionales, y así extraer el camino y modelo de desarrollo únicos de TusPark. El objetivo de este artículo es analizar cómo TusPark, como parque científico de la mejor universidad de China, abrió un camino para la incubación de empresas y el desarrollo industrial. El documento presenta algunos casos típicos, y explica los principales modelos de TusPark para la incubación de empresas y el cultivo de la industria. También analiza los principales factores del éxito de TusPark, y explora sus enfoques para fomentar el desarrollo futuro en nuevas circunstancias nacionales e internacionales.

Palabras clave: TusPark; TusHoldings; transformación de los éxitos científicos y tecnológicos; industria estratégica emergente; triple hélice multi-dimensional.

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Introduction

In 1951, Stanford University created the first high-tech park in the world – the Stanford Research Park (Zhan and Zhu 2021). Since then, it has successively incubated a large number of enterprises and industries with far-reaching influence worldwide and has created tens of thousands of job opportunities, promoting the development of productivity and bringing about profound changes in varied modes of production, economic structures, ideologies and social systems. This pioneering move proved the significant role of university science parks in enhancing the strengths of universities' scientific research, promoting the transformation of scientific and technological achievements, upgrading industries and promoting regional economic development. Soon thereafter, various countries and regions around the world raced to follow suit, beginning to set up science parks in various forms. After over 60 years of development, there are currently more than 1,000 large-scale university science parks recognized worldwide. Distributed in the United States, Europe, Asia, South America and other countries and regions (Xu 2021), they have created a variety of management models involving government, universities, business enterprises, and foundations. Typical examples include the Stanford Research Park, Cambridge Science Park, Tsukuba Science City, Singapore Science Park, and Tsinghua Science Park (TusPark).

China began to explore the construction and development of university science parks in the 1980s. The main difficulties and challenges of building a university science park at that time included: 1) There was no successful precedent in China from which to learn the functions, operation models and management systems for science parks; 2) There was neither talent nor teams readily available; 3) There was no funding or budget available from the state, local government or university. Consequently, TusPark overcame these difficulties by organising

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experts in sci-tech innovation and entrepreneurship, city planning and other areas to formulate strategic plans for the university science park, forming a planning and construction committee that consisted of members of government, university employees and a management team, as well as setting up a commercial construction holding company. These initiatives, which seemed quite ground-breaking and innovative at the time, put the establishment and development of the university science park on the right track from the outset.

Thanks to more than 30 years of unremitting efforts and practices, China has seen the establishment of many university science parks, which have achieved remarkable results in promoting the transformation of the scientific and technological achievements of universities, the incubation of high-tech enterprises, and regional economic development. They have constituted a significant force for universities to contribute to social development. On the one hand, they have expanded spaces for the development of disciplines that are advantageous for these universities consolidated their leading positions and promoted reforms in these universities' programs, settings and curricula so as to be better geared toward their developmental needs. On the other hand, by focusing on industrial development and relying on the advantages of the universities' technologies and talents, they have innovated the industry-university-research-application model of cooperation, attracting a large amount of venture capital to establish new businesses. They have also directly promoted the healthy and rapid development of the regional economy, becoming an important source of university and regional development and innovation.

As of 2019, China boasts 115 national university science parks, including 65 in the eastern region, 23 in the western region, 14 in the northeastern region, and 12 in the central region, covering 26 provinces, autonomous regions and municipalities and more than 140 colleges and

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universities (Torch High Technology Industry Development Center of the Ministry of Science and Technology of China, 2020). In particular, the Yangtze River Delta and the Beijing-Tianjin-Hebei region have the largest number of such parks; they cover 5.996 million square meters, have incubated 9,483 businesses with 123,000 employees, and have completed the incubation of 12,052 enterprises in total, which paid 1.427 billion yuan in taxes in 2019. By linking the sources of innovation, strengthening the sources of entrepreneurship, boosting the sources of talents, and breeding the sources of industry, China's national university science parks started from scratch and have since grown into comprehensive platforms for incubating high-tech enterprises, training innovative and entrepreneurial talents, and serving social and economic development (Xu 2021).

I. Establishing the Background and Functional Positioning of TusPark

As an institution of higher learning that is a leader in scientific and technological development and innovation in China, Tsinghua University gradually realized in the early 1990s that universities needed to engage directly with society and transform their scientific and technological achievements with a view toward social development and progress, though their campuses should be quiet places for scholarship. Therefore, Tsinghua University proposed the concept of functional zoning in education, which is to retain its own teaching and research functions while also gathering industry-, technology-, and market-oriented activities around the campus. That was also the original intention of building TusPark. In 1993, Tsinghua University formally put forward the concept of creating TusPark to align with its general goal of becoming a world-class university. In August 1994, the TusPark Development Center (the predecessor of Tus-Holdings Co., Ltd., hereafter referred to as TusHoldings) was set up to begin the

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construction of TusPark. Later, TusHoldings took full responsibility for managing and operating TusPark.

TusPark's main site covers an area of 25 hectares, with a total built area of 770,000 square meters. TusPark was defined with three main functions - "transforming scientific and technological achievements, cultivating innovative talents and incubating startups." Taking these three functions as its mission (Wang 2015), TusHoldings has successfully built a global innovation service network with over 300 incubators, science parks, and science cities as carriers after 20-plus years of exploration and practice. It has integrated many innovative resources from government, industry, university, research, finance, intermediaries, trade and media, and has incubated many of the world's leading independent and innovative technologies and enterprises that have grown into leaders in their respective industries.

II. Main Achievements and Typical Cases

(1) Main Achievements

In terms of industry-university-research cooperation and the transformation of scientific and technological achievements, TusPark has successfully commercialized a number of technologies such as the nano-imprinted LED graphic substrate technology, the core technology of heavy-duty gas turbines and the integrated gasification combined cycle for coal, as well as the technology of utilizing coal-fired flue gas desulfurized waste residue to improve saline-alkali soils. It also helped Zhongqing Yangming Solar Photovoltaic Technology Co., Ltd., GigaDevice, Beijing U-Precision Tech Co., Ltd. and other enterprises successfully apply for 19 national-level projects in 2013. Moreover, TusPark joined forces with local governments to introduce and support faster transformations of advanced technological achievements and successfully helped Kunshan City to build a small nucleic acid industrial cluster. In 2003, the

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Kunshan municipal government and the TusPark branch located in Kunshan jointly invited Peking University Professor Zicai Liang to Kunshan to carry out an exploratory survey. By 2007, Zicai Liang was chief scientist of the first key project on smallnucleic acids supported by the "863 Program (National High-tech R&D Program)" and had settled his startup company - Suzhou Ribo Life Science Co., Ltd. in the Kunshan High-tech Zone. In this context, a number of small nucleic acid companies and expert laboratories were set up in Kunshan and put into operation. In 2008, the first domestic small nucleic acid industrial base was built in the Kunshan High-tech Zone. In 2015, the Kunshan Small Nucleic Acid and Biomedicine Industrial Park was established, reliant on the prior construction of the small nucleic acid industrial base. In 2017, the small nucleic acid industrial base was approved to be a distinctive industrial base by the national Torch Program.

In regard to the cultivation of innovative and entrepreneurial talents, first, the "Starting a New Business" program launched jointly by TusPark and Tsinghua University has trained nearly 200 entrepreneurial teams of students, and more than half of these have established companies. Through Tus Innovation Network, the "Dream Class" has made its way into dozens of colleges and universities in China. The innovation and entrepreneurship training carried out by TusStar has covered over 150 colleges and universities, and more than 60,000 students have received its training in total. Second, TusPark assisted Tsinghua University in the establishment of its innovative, creative and entrepreneurial practice platform - X-Lab. At present, more than 30,000 young students from Tsinghua and the wider society have participated in the various lectures, competitions, exchanges and practical activities organized by the Tsinghua X-Lab, and 1,500-odd projects in different stages of creative development, innovation and entrepreneurship submitted by Tsinghua students and alumni have joined the Tsinghua X-Lab. Projects stemming from these registered businesses have directly created more than 8,000 jobs. At the same time,

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through the cultivation of the Tsinghua X-Lab, the total amount of project financing for all the registered businesses has exceeded 3 billion yuan. Third, TusPark assists the Tsinghua Alumni Association in organizing the Tsinghua Alumni Creativity, Innovation and Entrepreneurship Competition, which has been held 6 consecutive times. It has served over 1,000 startups run by Tsinghua alumni in dozens of cities and has helped nurture a large number of entrepreneurial talents.

In terms of the establishment of a business incubation and innovation service system, in the past 20 years, the TusStar incubator which originated from TusPark has deployed more than 150 innovative incubation bases in 80-plus cities around the world, with an incubation space of over 400,000 square meters. It has incubated more than 10,000 businesses, creating an innovation ecosystem for high-tech startups (Wu 2010). At present, TusPark has established over 300 innovation network nodes around the world, serving more than 100 cooperative colleges and universities, over 10,000 high-tech enterprises, and nearly 30,000 college students. Among them, there are nearly 20 overseas scientific and technological innovation platforms, with 44 overseas innovation and cooperation projects worth nearly 7 billion yuan.

(2) Typical Cases

1. "Starting a New Business" Program to Cultivate New Types of Innovation and Entrepreneurial Talents

In 2011, Meng Mei, Director of TusPark Development Center and Honorary Chairman of TusHoldings, launched a practical program - "Starting a New Business"- for teams of students in Tsinghua who have started an enterprise. Just as TusPark has forged a different path from others, this program has created a singular new model for early business development. As for its highlights, first, it has its own trademark - "Chuangye Xing", logo, badge, and serial number

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for each team to receive continuous assistance from teachers. Second, it has its own community - "Chuangye Hang" for students to exchange ideas with one another. Third, it has its own funding - "Chuangye Henxing". The initial funding of 20 million yuan was provided by Highlander Chairman Wanqiu Shen for student research. Later, it was developed into seed funds.

What differentiates this program from others is its extensive connections with industry. The mid-term and final exam scores are not given by teachers, but rather evaluated by venture capitalists from the industry. This program is fairly selective in regard to the students it admits, setting a high threshold. The applicants must have started their own businesses and sign up in the name of an entrepreneurial team, and the founder or key figure of each team is required to come to class. Tsinghua University recruits 5,000 new graduate students per year, but only 50 of them are admitted to the "Starting a New Business" program per year, just 1% of the total graduate enrollment. Over the past three years, more than 40 teams have participated in this program, and a total of 10 teams have received investment funding. The largest investment to date exceeded 10 million yuan (Zhao 2016).

2. Incubation and Investment Always Keep Up with the Growth and Development of Enterprises - GigaDevice

The achievements of university science sarks will consequentially accelerate both the implementation and the operation of the knowledge economy (Xu and Mei 2003). With TusStar as its flagship incubator, TusPark has adhered to the principle of long-term service and is committed to creating an innovation ecosystem for high-tech startups. It has cultivated a large number of outstanding technology companies by means of "incubation + investment" (Luo 2005), as evidenced by the establishment and development of GigaDevice.

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Originating from the Tus incubator in 2005, GigaDevice is the first company in China that can provide SPI NOR Flashmemory chips in mass production, breaking the monopoly of foreign companies in the domestic market. In August 2016, GigaDevice was listed successfully on the A-share market.

In 2005, GigaDevice founder Yiming Zhu returned to China from the United States to start his own business. He established Xinjijiayi Microelectronics Technology Co., Ltd. (later renamed GigaDevice) in the Tsinghua Overseas Students Pioneer Park with an investment of two million yuan from the lead investor, TusHoldings, who also found co-investors for the business This important angel investor funding helped put GigaDevice into corporate operation. In April 2007, GigaDevice was included in TusPark's first "Diamond Program", receiving support from universities, enterprises, governments and domestic and foreign resources provided by TusHoldings.

At the time of the global financial crisis in 2008, GigaDevice's capital chain experienced problems. TusHoldings once again became the lead investor, making an additional investment of more than 20 million yuan, and helped it obtain credit financing from financial institutions such as small-credit companies and banks, promoting its move from research and development to the market. This laid a solid foundation for GigaDevice to obtain Series B funding and complete the IPO. In September 2017, Guoxin Tus Fund joined with the China Integrated Circuit Industry Fund to invest in GigaDevice with the goal of promoting its development from being a leading private NOR Flash business in China to a national platform dedicated to driving the overall development of the country's digital storage industry.

At present, GigaDevice is a leading flash memory chip designer in the Chinese mainland and also the largest domestic MCU provider, ranking first in China and third in the world in terms

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of the market share in the SPI NOR Flash field. In June 2020, GigaDevice came out third in the "2020 Hurun China Top 10 Private Enterprises in Chip Design", with a valuation of 87 billion yuan.

3. Funds Assisting in the Transformation and Industrialization of Technological Achievements - Tus-Clean Energy

TusPark aims to accelerate the application and industrialization of scientific and technological achievements by building a platform for the transformation of scientific research results, integrating resources from multiple sources, and allocating funds to acquire businesses. Tus-Holdings' leading enterprise in its clean energy industrial cluster, -Tus-Clean Energy, is a typical case.

Tus-Clean Energy is a platform dedicated to the transformation of scientific research results in the clean energy field. It relies on the strong advantages of Tsinghua's industry-university-research cooperation and its management of a clean energy technology industry fund. So far, it has formed a complete strategic plan for working in the three major business sectors of clean heat, clean electric power, and clean motive power, becoming the clean energy group with the broadest business scope and the most comprehensive technology chain in China.

Focusing on high-grade, high-precision, and advanced technology, Tus-Clean Energy Group has made unremitting efforts to tap into the technological resources and strengths of Tsinghua University, as well as other universities, scientific research institutions, and specialized companies. It has also allocated capital, business and other elements based on technology, so as to achieve the final successful commercialization of scientific research results. On the one hand, clean energy funds have been set up for capital support, including the seed fund established in cooperation with Tsinghua X-Lab, the clean energy angel fund created with

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TusStar Ventures, the overseas angel investment fund created with Tus TGN, and the VC fund and various sector funds established with Tsing Capital. On the other hand, these funds are utilized to purchase traditional and thermal power companies, and to build power stations, with the goal of gradually applying the enterprise's technology via these companies and platforms.

At present, Tus-Clean Energy owns two clean energy sector funds - Tus-Jianshi and Tus-Zefeng - and has successfully launched the Tus-Ruixing equity investment fund of 2.62 billion yuan, providing both technology and financing services for the development of the energy sector. This has also given a strong impetus to the research and development of energy technology, providing a wide range of application platforms for funding.

Following this model, Tus-Clean Energy has integrated advanced technologies at home and abroad to promote the transformation of scientific research results overseas. It has carriedout technological and capital cooperation projects with the United States, Finland, Brazil, Switzerland, Germany, France, the United Kingdom, Israel, Malaysia, Kenya and other countries and regions. According to the resource endowment and energy demand of different countries, the cooperation is carried out at different levels in order to accelerate the overall development of the international industry. Up to now, photovoltaic, biomass, wind power and several other projects have been launched abroad in succession.

III. Success Factors

For the past 26 years, TusPark has followed the development model of "Congregation, Polymerization, Focalization and Achievement" (Yang and Huang 2006) to integrate the eight innovative elements of government, industry, university, research, finance, intermediaries, trade and media. Remarkable development results have been achieved thanks to its consistent efforts to transform scientific and technological achievements, improve the service system for

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enterprise innovation, cultivate innovative and entrepreneurial students, and build a global innovation service network and the model of corporate operation under the guidance of the university.

1. The establishment of a Sound Service System for the Incubation and Innovation of Enterprises

In 1999, TusPark established Tsinghua Pioneer Park (the predecessor of TusStar Incubator) and formed a professional incubation service team with dozens of members committed to the transformation of scientific and technological achievements and the incubation of high-tech enterprises. To meet the service needs of businesses in different stages of development, it built a whole-chain vertical incubation system and a seven-step incubation model covering the full entrepreneurial lifecycle[1], as well as providing targeted counseling service and resources throughout the whole process, from entrepreneurship ideas to the listing of businesses. In response to the differing financing demands of technological enterprises in varied stages of development, a multi-level funding system has been established, including TusStar Angel Investment, Tus Ventures, Section Fund, and Buyout Fund.

2. Continuous Efforts to Promote Industry-University-Research Cooperation and the Transformation of Scientific and Technological Achievements

Relying on its own resources, TusPark has built a platform for the transformation of scientific research results, strengthened industry-university-research cooperation efforts, and integrated

[1]The "full-lifecycle seven-step incubation model" is an incubation service model that spans the entire entrepreneurial lifecycle: from developing an entrepreneurial idea to being listed on the stock market,. It takes entrepreneurs from the source of creativity, or the"dream class", to the "dream laboratory" for entrepreneurial practice, The “TusStar Camp” early incubation program offers its resources to the public with its , "Diamond Plan" that intensively cultivates selected projects, provides pre-IPO guidance, and finally leads the company to the global network. It provides tailor-made guidance and resources according to the different needs of companies at varied stages of development and accompanies the growth of these companies during every step of the process.

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technology, industry, finance and other resources to provide support for the transformation of Tsinghua University's technological achievements and to achieve the final successful commercialization and industrialization of scientific research results. Startup firms benefit from informal connections with faculty members and access to students (Motohashi 2013). Moreover, TusPark has also joined forces with local governments to introduce and support faster transformations of advanced technological achievements and has even helped local governments build several high-tech industrial clusters, such as the small nucleic acid industrial cluster and the OLED industrial cluster.

3. A focus on the Cultivation of Innovative and Entrepreneurial Students

University science parks are vital components of the national innovation system. They are an important base of independent innovation, an essential element of China's higher education system, as well as being an important platform for both industry-university-research integration and the development of innovative and entrepreneurial talent (Qin 2009). Since its inception, TusPark has always regarded the cultivation of innovative and entrepreneurial students as one of its primary tasks, and thus has explored three talent training paths. First, since 2011, it has run the "Starting a Startup" program together with Tsinghua University to cultivate entrepreneurial teams comprised of students. Second, it assisted Tsinghua University in setting up Tsinghua X-Lab, an innovative, creative and entrepreneurial practice platform designed to help students learn and carry out creative, innovative and entrepreneurial activities. Third, it assists the Tsinghua Alumni Association in organizing the Tsinghua Alumni Creativity, Innovation and Entrepreneurship Competition to give in-depth support to Tsinghua alumni and students in developing their creative, innovative and entrepreneurial practices.

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4. The Formation of its Own Industrial Clusters, Beneficial to its Development

So far, TusHoldings, the builder and operator of TusPark, has formed five strategic emerging industry clusters, featuring environmental protection, clean energy, healthcare, the digital economy, and new materials. Based on these industrial clusters, TusPark has set up a number of innovative service platforms, including the Clean Energy Accelerator, Clean Energy Research Institute, Environmental Industry and Technology Research Institute, Digital Economy Research Institute and New Material Industry Research Institute, in order to promote the continuous improvement of its innovative services and to attract similar industrial projects to settle in TusPark.

5. Emphasis on its Internationalization Strategy and the Establishment of a Global Innovation Service Network

Since its establishment, TusPark has given top priority to its internationalization strategy and has therefore begun to develop strategic plans to enhance its international visibility and influence. It established the Tsinghua Overseas Students Pioneer Park in 2002 and becameengaged with the International Association of Science Parks and Areas of Innovation (IASP) in 2004. Four years later, IASP's China Office, the only overseas branch of the Association, settled in TusPark. In 2021, Herbert Chen, Deputy Director of the TusPark Development Center, was elected the Chairman of IASP. Moreover, TusPark has also built an international technology transfer platform by introducing foreign technologies, has actively introduced international capital, and has attracted Global 500 companies to establish R&D institutions within its grounds, all in a bid to construct an international innovation network.

6. The formation of a Model of "Corporate Operation under the Guidance of the University"

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Two construction models emerged in the process of developing Chinese university science parks: the "one university, one park" model and the "several universities, one park" model (Cao 2010). In the former model, a university science park is built mainly by one university with comprehensive strength, such as TusPark or the Peking University Science Park. In the latter model, a university science park is built jointly by several universities according to their advantages and characteristics, such as the National University Science Park of Henan Province, which was built jointly by the Zhengzhou High-tech Zone, Zhengzhou University, Henan University of Technology, Henan Agricultural University, and Zhengzhou University of Light Industry.

The construction of TusPark adopts the "one university, one park" model. It is run by TusHoldings in cooperation with Tsinghua University. In terms of organizational structure, Tsinghua University is the largest shareholder on a par with TusHoldings, playing a significant role in guiding the construction and development of TusPark. The "university-enterprise joint operation" model is conducive to the practice of giving full play to the university's rich scientific research achievements and the enterprise's strong market experience, as well as efficiently linking the supply and demand of scientific and technological achievements to promote their transformation and industrialization. This model meets the needs to cultivate innovative and entrepreneurial talents and to transform the scientific and technological achievements of the university. It also provides an impetus for integrating the university's scientific research achievements with local economic development, and promotes regional economic growth, achieving a win-win effect.

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IV. Approaches for Encouraging Future Development

Throughout its 26 years of development, TusPark has turned itself into a world-class university science park. In the context of the accelerating global scientific and technological revolutions and industrial transformation, as well as China's move to speed up the growth of its reputation as an innovative country, TusPark will play a more important role. It will seek further development under the guidance of a three-dimensional triple helix model comprised of the strategic lines of "Park, Industry and Funding", "Technology, Industry and Finance", and "Government, Enterprise and University".

Based on years of scientific and technological service practices and its goals of meeting the basic requirements of innovation and promoting industrial development, TusPark put forward a three-dimensional triple helix model, marking an important upgrade and development of the former triple helix of "government-industry-university" interactions for innovation (Etzkowitz 2016). This model comprises three spirals, involving the subjects, elements and carriers of innovation. These spirals are independent from one another, but they interact with each other dynamically, forming an important driving force for promoting technological innovation, the transformation of technological achievements and industrial upgrading.

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FIGURE 1. The multi-dimensional triple helix model of TusHoldings

1. The Triple Helix of Innovation Carriers - "Park, Industry and Funding"

In the dimension of innovation carriers, a triple helix of "park, industry and funding" has been formed, with science parks acting as carriers and funding bodies as links to promote the development of industrial clusters and build local innovative and entrepreneurial ecological environments with the characteristics of TusPark.

In a nutshell, the science park develops itself by investing in and incubating high-tech enterprises and strategic emerging industries. It becomes a shareholder of leading companies through investment, establishes a vertical incubation system, and solves the financing issue for investment and incubation by establishing a large number of funding and financial service platforms.

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From the perspective of the three entities contained in this triple helix, the investment supported by a comprehensive science park and its network is of great value to emerging technological industries. The cluster-type innovative network services of TusHoldings distributed across various regions can be shared to create an organizational form of mutual support and verification between projects and investments, greatly improving the success rate of these investments, which, in return, bring about further industrial agglomerations and development in the park and make it more attractive, thus forming a virtuous circle. The organic combination of the park, industry and funding makes it possible to form a lush forest capable of self-growth and self-renewal and full of vitality, becoming the most active hot spot for innovation and entrepreneurship in various areas and an important engine for local economic development.

2. The Triple Helix of Innovation Elements - "Technology, Industry and Finance"

In the triple helix of innovation elements, finance links the sources of technology and market demands to promote the transformation of scientific and technological achievements, as well as driving industrial upgrading and the development of emerging industries.

TusHoldings is fairly active in developing strategic emerging industries. It has invested in more than 500 technology companies; held shares in more than 10 large, listed companies; owned dozens of Chinese or world leading technologies; and focused on the development of environmental protections, new energy sources, comprehensive health plans, the digital economy and new materials. Its purpose is to promote the rapid transformation of scientific and technological achievements and industrial upgrading through the triple helix of technology, industry and finance.

TusHoldings sees no industry boundaries, though the industries involved must take technological innovation as the core of their competitiveness. TusHoldings' goal is to master

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core technologies through integration and fully upgrade an industry by virtue of finance. It not only participates in the creation of a cluster-type innovation system as an important component of generating resources, but also makes full use of the resources and advantages contained in the system. TusPark relies on its 300+ technology-related base incubators, 10,000 small and medium-sized technology companies, multi-level investment funds, assistance from dozens of large-scale technology enterprise networks, and the strong talent of its organizations and teams. Under the impetus of financial forces, TusPark is committed to accelerating the marketization of major national scientific and technological achievements, as well as speeding up the development of the R&D economy, assisting in the formation of high-tech industrial clusters and upgrading regional innovation capabilities in a well-rounded way.

3. The Triple Helix of Innovators - "Government, Enterprise and University"

In this triple helix, the subjects of innovation are seen as the core means to promoting innovation. In this model, government, enterprise and universities work hand-in-hand to optimize the systems and mechanisms of their cooperation in order to improve the efficiency of innovation.

TusHoldings' implementation of this triple helix started with its cooperation with Tsinghua University and local governments. On this basis, each element was extended, forming a new spiral. The first is the government spiral. In addition to cooperating with a single local government, a large number of high-level government circles at home and abroad must also be established. The second is the enterprise spiral, involving not only TusHoldings but also the many enterprises under TusHoldings as a shareholder. The third is the university spiral, involving Tsinghua University and other academic collaborators, such as research institutes and other universities at home and abroad.

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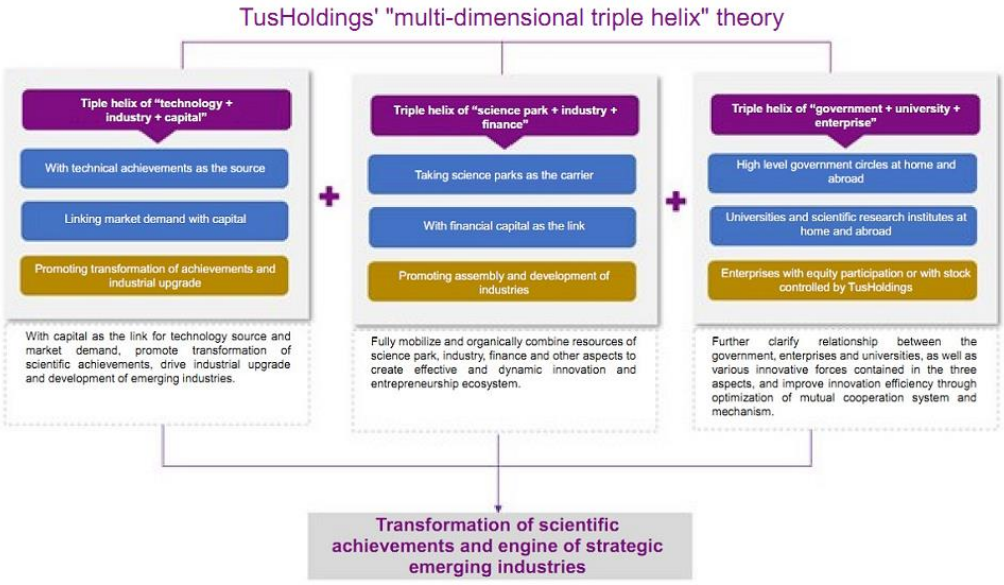
TusHoldings will continue to explore ways to optimize the innovation mechanism and further clarify the relationship between the three innovation subjects - government, enterprise and university- as well as the various innovative forces contained in the three helices and the dynamic combination of forces and interactions that exist between the forces, so as to create a more spontaneous and efficient model for innovation-driven development.

The initial functional positioning of TusPark was to become a base for the transformation of scientific and technological achievements, a base for the incubation of startups and a base for the cultivation of innovative talents. Today, TusHoldings' three-dimensional triple helix model still closely revolves around these three main functions. Its science parks in various regions also regard the transformation of scientific and technological achievements, the incubation of startups, and the cultivation of innovative talents as the most important goals and missions. Through its flexible utilization of the three-dimensional triple helix model, TusHoldings is determined to make great contributions to the upgrading of local industries, the development of regional economies and the construction of an innovative and entrepreneurial ecosystem.

FIGURE 2. The Theory of the Multi-dimensional Triple Helix helps TusHoldings become an engine of strategic emerging industries



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V. Conclusions

Over more than 20 years of development, TusPark has established a sound system of business incubation and innovation services. These are geared toward the continuous promotion of Tsinghua University's cultivation of innovative and entrepreneurial talents, the transformation of scientific and technological achievements and the expansion of industry-university-research cooperation. It has turned into a world-renowned science park with outstanding achievements in the cultivation of innovative talents, the transformation of scientific and technological achievements and the incubation of startups.

Although it is a pleasure and an honor to review and study the history of TusPark, there are some inevitable limitations in this research: 1) University science parks are a fairly new industry, hence the accumulated data lacks a structure of systematization that would allow for comparison and reference between data sources; 2) University science parks' missions, working tasks and management models are still developing rapidly and dramatically; 3) Although the name "university science park" is commonly used worldwide, the research produced by university science parks is strongly tied to their regions, as the social patterns, administration systems, and economic development standards differ greatly from region to region. It is thus currently unlikely that researchers may draw general conclusions of universal guiding significance, either by using traditional proven research methods or through straightforward comparisons of university science parks.

Today, the world is undergoing profound changes that have not been seen in a century, while China is working hard to promote high-quality development. In this context, TusPark has explored a creative three-dimensional triple helix model for development on the basis of the triple helix model for innovation, a model initiated in the United States. Based on the study and

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summary of its history, TusPark remains committed to the cultivation of innovative and entrepreneurial talents, the transformation of scientific and technological achievements, the incubation of startups and the cultivation of emerging industries, with the goals of making further contributions to Tsinghua University's cultivation of innovative and entrepreneurial talents, as well as increasing regional economic development.

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