

The dynamic evolution of an industrial innovation ecosystem: a case study of Around-Tongji Knowledge Economy Circle (Shanghai)

The dynamic evolution

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Abstract

Purpose – The purpose of this paper is to analyse the development and evolution of industrial innovation ecosystems of Around-Tongji Knowledge Economy Circle from the three levels mentioned above, focusing on knowledge-producing populations, core populations and service-supporting populations, and to further develop this research framework by combining with the latest developments.

Design/methodology/approach – Based on the five-helix theory and economic census statistical data, this paper adopts geographic information system technology and examines the characteristics of the industrial innovation ecosystem and the synergistic evolution process in Around-Tongji knowledge economy circle.

Findings – The knowledge product populations lead the development of industries in Around-Tongji Knowledge Economy Circle. It contributes political capital output for the government. It innovates community cooperation and governance mode, and it improves the natural ecological environment. In the face of the changes and challenges in the development environment, the future development must be recognised from the height of the iterative development of the interaction mode between university knowledge production and economic and social development.

Originality/value – Based on the five-helix theory and economic census statistical data, this paper examines the characteristics of the industrial innovation ecosystem and the synergistic evolution process in Around-Tongji Knowledge Economy Circle. It further expands the research framework used to develop a synergistic evolution model, which reveals the interactive and synergistic relationship among the populations and the evolution characteristics of the entire industrial innovation ecosystem. This paper also provides useful perspectives for the study of the industrial innovation ecosystem.

Keywords Around-Tongji Knowledge Economy Circle, Dynamic evolution, Network symbiosis, Industrial innovation ecosystem, Development path

Paper type Research paper



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1. Introduction

Around-Tongji Knowledge Economy Circle is located in the area surrounding Tongji University Siping Road Campus in Yangpu District, Shanghai. It is one of the four functional areas of Yangpu District. The core area is about 2.6 square kilometres, and the expansion area is approximately 10 square kilometres, including the “industry radiation points” (Figure 1).

In the 1990s, China’s urbanisation process led to rapid growth, which brought big opportunities for the urban planning and construction design industry. In the vicinity of Tongji University, relying on the overflow of Tongji’s advantageous disciplines and the huge demand for social development, related industries have rapidly developed. In May 2007, the Yangpu District government and Tongji University jointly issued the *Outline of the Plan of Around-Tongji Knowledge Economy Circle*, announcing the official launch of construction. In April 2009, Around-Tongji Knowledge Economy Circle was awarded the

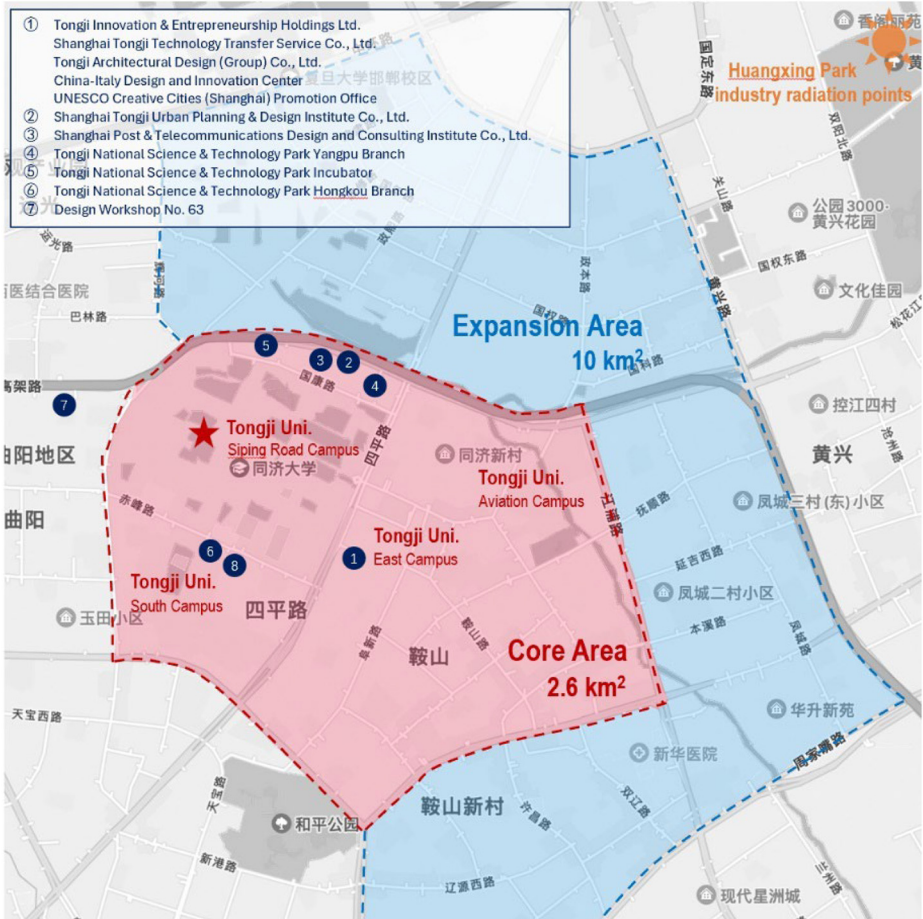


Figure 1. Spatial geographic area of Around-Tongji Knowledge Economy Circle

Source: Figure by authors

title of “Torch Plan R&D and Design Service Characteristic Industrial Base” by the Ministry of Science and Technology, becoming the first national industrial base focusing on modern service industries. In February 2010, Shanghai was awarded the United Nations “Creative City of Design”, and the UNESCO Creative Cities (Shanghai) Promotion Office was located in Tongji. In 2011, a national design and innovation service platform between the governments of China and Italy, namely, the China–Italy Design Innovation Center, also settled in Around-Tongji Knowledge Economy Circle. After nearly 20 years of development, Around-Tongji Knowledge Economy Circle reached a total economic output of 56.375bn yuan in 2021, and it has formed a knowledge-based service industry cluster with architectural design, planning and design, engineering design, etc., with the number of high-tech enterprises accounting for nearly 40% of the total in Yangpu District. By 2025, Around-Tongji Knowledge Economy Circle will strive to build a world-class “big idea” industrial highland and a national-level innovation and entrepreneurship agglomeration area. The economic goal is to achieve 100bn yuan in output value. Against the background of China’s promotion of innovation-driven development strategy and the expansion of strategic emerging industries, Around-Tongji Knowledge Economy Circle should better serve regional development and S&T innovation and realise the expectations of national leaders to “become a benchmark for people’s cities and a new highland for the integrated development of schools and places” (People’s Government of Yangpu District, Shanghai, 2022). This paper tracks and analyses the evolution of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle, describes its development experience and explains its optimisation strategy for high-quality development in the new era.

2. Literature review

2.1 Innovation ecosystem

The concept of the innovation ecosystem originated from ecology in the natural sciences. Looking at the competition between modern enterprises from an ecological point of view, the business ecosystem is an economic association composed of organisations and individuals that influence each other and is a living organism of the business world (Moore, 1996). The innovation ecosystem is a collaborative integration mechanism that integrates the innovations of the various companies in the system into a coordinated, customer-oriented solution (Adner, 2006). Compared with the innovation system, the innovation ecosystem emphasises the dynamic connection between the innovation subjects within the system, as well as the self-organising evolution and competition symbiosis between the innovation subjects and the external environment (Wu *et al.*, 2022). The composition of the innovation ecosystem largely revolves around core enterprises, suppliers, cooperative enterprises and users and includes peripheral circles such as governments, universities, research institutions, related enterprises and service institutions (Xie and Wang, 2020). From a functional point of view, an innovation ecosystem can also be divided into producers, consumers, decomposer populations and innovative service support communities (Gao and Mao, 2019). Most current research on innovation ecosystems focuses on the characteristics of value co-creation (Yuan *et al.*, 2022; Sun *et al.*, 2023), evolution and symbiosis (Luo *et al.*, 2022; Zhang and Ren, 2022; Zhang *et al.*, 2022) and construction strategies (Li *et al.*, 2022; Wang *et al.*, 2023).

2.2 Around-Tongji Knowledge Economy Circle

Many researchers have carried out studies on Around-Tongji Knowledge Economy Circle. Chen Qiang continuously tracked the design industry from the perspective of the industrial innovation ecosystem and diagnosed the industry’s development status and bottlenecks in

different periods (Chen, 2009; Chen and Wang, 2010; Chen *et al.*, 2017). Most other researchers have focused on the relationship between different subjects within Around-Tongji Knowledge Economy Circle (Chen and Zhang, 2009; Luo *et al.*, 2014), the government’s instigation behaviour (Yuan and Zhao, 2011; Chen and Zhao, 2013) or industrial development ideas (Ma *et al.*, 2010; Wang, 2013; Zhang, 2013).

The research results of viewing Tongji industry from an innovation ecosystem perspective can provide solid theoretical and methodological support, but researchers have argued that in the current focus on the impact of universities on regional innovation from macro levels, the specific interactions between universities and other subjects and elements at the micro level have not yet been completely analysed and presented (Yuan *et al.*, 2022), which is critical for innovation ecosystems such as Around-Tongji Knowledge Economy Circle. The development of Around-Tongji Knowledge Economy Circle has resulted in general agreement on the strategy of the campus-park-community “tri-zone connection”; however, the vast majority of research was conducted in the Thirteenth Five-Year Plan period, and, after entering the Fourteenth Five-Year Plan period, research on Around-Tongji Knowledge Economy Circle, especially research specialising in Around-Tongji Knowledge Economy Circle’s industrial innovation ecosystems, has been rare, and monitoring of Around-Tongji Knowledge Economy Circle’s development data has stopped at the Third Economic Census (conducted in 2014). Meanwhile, against the background of profound changes in the development environment at home and abroad, the Around-Tongji Knowledge Economy Circle industrial innovation ecosystem is also in urgent need of identifying and sorting out new development problems and updating and adjusting its development path so as to better face development challenges and realise the economic goal of 100bn yuan in output value, which is the purpose of this study.

3. Analysis of the evolution of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle

3.1 Research framework

This paper uses the framework developed by Chen *et al.* (2017) to analyse the industrial innovation ecosystems of Around-Tongji Knowledge Economy Circle (Figure 2). The research framework is similar to that for a natural ecosystem and divides the industrial innovation ecosystem into two major parts: the industrial innovation community with biological components and the abiotic innovation environment. The framework is based on

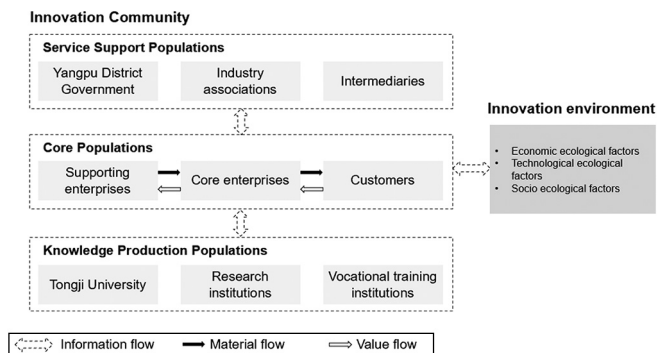


Figure 2.
Industrial innovation
ecosystem structure
of Around-Tongji
Knowledge Economy
Circle

Source: Chen *et al.* (2017)

a long-term examination of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle and has been adopted by many scholars when analysing the composition of industrial innovation ecosystems.

The goal of this paper is to analyse the development and evolution of the industrial innovation ecosystems of Around-Tongji Knowledge Economy Circle according to the three levels mentioned above, focusing on knowledge-producing populations, core populations and service-supporting populations, and to develop this research framework by combining it with the latest developments.

3.2 Knowledge production populations

With the changes in knowledge production modes, scholars have built a more complex university–industry–government–public–natural environment “five-helix” model to analyse the leading and synergistic roles of universities in innovation ecosystems, based on the “triple helix” and “quadruple helix” models used to address the issue of how universities can lead collaborative innovation in a region and influence the formation and evolution of innovation ecosystems (Carayannis and Campbell, 2018). In the three-helix model, the university pays more attention to the economic value of knowledge, focuses on the diversity of participating subjects and quality control and carries out innovation in applied disciplines. In the five-helix model, the university’s research, in addition to the above characteristics, also has the characteristics of non-linearity, uncertainty, complexity of innovation, as well as an ecological, transdisciplinary, systematic and inclusive nature. The university’s research is faced with the contradiction between economic development and ecological environmental protection, the difficulty of operational practice, etc. (Qie and Yu, 2021; Yuan *et al.*, 2022).

Examining the role of knowledge-producing populations centred on Tongji University in the evolution of the innovation ecosystem of Around-Tongji Knowledge Economy Circle through five-helix model allows the following observations.

Firstly, it leads the development of industries in Around-Tongji Knowledge Economy Circle. In addition to actively improving innovation source capacity and increasing the accumulation of intellectual capital, Tongji University provides entrepreneurial seeds and talents for Around-Tongji Knowledge Economy Circle. About 80% of the entrepreneurs are working students or graduates and faculty of Tongji University. Many students enter the mentor’s studio or company to participate in project research directly after study, which provides a large number of low-cost, high-quality human resources for enterprises in Around-Tongji Knowledge Economy Circle (Chen, 2009). Tongji University also provides rich knowledge overflow. A large number of enterprises have in-depth disciplinary interactions with Tongji University and maintain close contact with experts and scholars from Tongji, so enterprises can quickly access the latest industry trends and academic achievements and receive strong support from the experts and research facilities of Tongji University. Tongji Architectural Design (Group) Co., Ltd. has an annual economic output of nearly 1bn yuan and more than 1,000 employees. It has set up an internal engineering design platform with the participation of Tongji faculty, including a landscape design office and an urban design office. Tongji faculty are directly involved in the design and production practice, which realises the close connection and interaction with Tongji University and pushes the brand and technology of “Tongji Design” towards the world.

Secondly, it contributes political capital output for the government. In addition to providing intellectual support for Yangpu District Government, Tongji University contributes to national and regional socio-economic development through think tanks such as the National Institute of Innovation and Development and Shanghai Industrial

Innovation Ecosystem Research Center. Tongji University also uses the advantages of applied disciplines and puts forward the value proposition of “writing one’s thesis on the motherland”, which creates great social value through the preparation of high-quality plans, solving major engineering technical problems, improving ecological quality, etc. For example, China’s support for the African Union Conference Center project designed by Tongji Architectural Design (Group) Co., Ltd. has strongly supported China’s “One Belt, One Road” initiative. The achievement of the “Key Technology of Shanghai Tower Project” won the Grand Prize of Shanghai Science and Technology Progress.

Thirdly, it innovates community cooperation and governance modes. In recent years, the integration between Tongji University and its community has become deeper, and the mode of cooperation has become more innovative. Tongji University has established a CPC Construction platform with Siping Subdistrict, breaking spatial limitations. Tongji University has entered the community through professions in architecture, landscape, design, etc., and it promotes the three micro-governance projects of “micro-improvement of buildings”, “micro-remodelling of space” and “micro-renewal of landscape” and creates brand-name projects such as “NICE2035” and “Hundred Grass Garden” to improve the community’s quality of life. Tongji University has also set up “Future Living Labs”, focusing on future technology and creativity in the community, reshaping the spatial functions of the community, creating application scenarios and transforming the old community into a “new garage” that nurtures innovation and is a leading area for future living.

Fourthly, it improves the natural ecological environment. In addition to continuously optimising the environment around Tongji through architecture, landscape, design and other professions, the environmental protection disciplines of Tongji University have made great contributions to major national environmental projects such as the governance of Yunnan Dianchi Pond and circum-Taihu Lake.

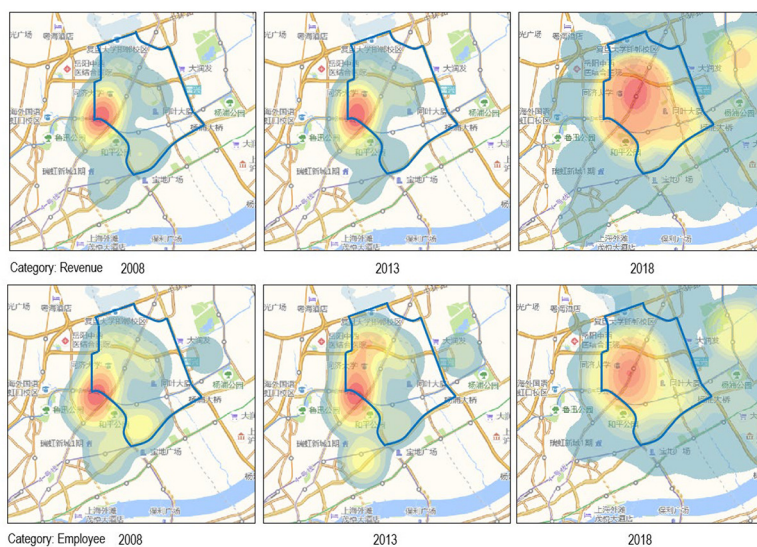
3.3 Core populations

Various core and supporting enterprises constitute the core population of the innovation ecosystem. In the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle, enterprises of different scales have complete populations and coexist harmoniously, especially in the design industry, which has formed a “tropical rainforest”-type ecosystem.

3.3.1 Dynamic evolution. This paper visualises the dynamic evolution of enterprises in the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle through the latest (fourth) China official economic census data, which was gathered in 2018, combined with the results of the previous two economic censuses. Based on the National Economic Industry Classification (GB/T 4754-2017) used in the fourth economic census, statistical results show that Around-Tongji Knowledge Economy Circle had a total of 45 industry broad categories in 2018, including housing construction industry (47) and civil engineering construction industry (48). There were 45 industry broad categories and 1,599 enterprises in Around-Tongji Knowledge Economy Circle in 2018, which absorbed 32,900 employees and created nearly 30.7bn yuan in enterprise revenue and 698 patent applications.

This paper adopts geographic information system technology through the address decomposition and geocoding of enterprise data from the past three economic censuses. Arcgis 10.7 software was used to draw heat maps of enterprise revenue and employees in the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle. From the heat maps of past years, we can visualise the characteristics of the evolution of industrial development in Around-Tongji Knowledge Economy Circle, as shown in [Figure 3](#).

As can be seen in [Figure 3](#), in the past decade or so, in terms of aggregation scale and coverage, industry has gained significant growth, and the core circle around the Siping Road



Source: China official economic censuses 2008, 2013, 2018; Figure courtesy of Chen *et al.* (2017); Figure by authors

Figure 3.
Heat map of business revenues and employees of enterprises in Around-Tongji Knowledge Economy Circle

Campus of Tongji University has gradually formed a highland for enterprise revenues and employment, allowing Around-Tongji Knowledge Economy Circle to gradually become an important driving force to support the economic transformation and development of Yangpu District. By 2018, the radiation area had expanded southward to Kongjiang Road in Yangpu District. The Huangxing Park Radiation Point has also formed an industrial agglomeration dominated by environmental protection enterprises.

3.3.2 Network symbiosis. Design service is the leading industry in Around-Tongji Knowledge Economy Circle. The number of enterprises in the design service industry accounted for about 21% of all enterprises in 2018 but absorbed about 50% of practitioners and contributed more than 50% of the revenue and approximately 70% of the patent applications. Examining the interior of the design service industry, the industry subcategories of engineering survey, engineering design, engineering management, engineering supervision, planning, design and management are exceptionally active. They intertwine to constitute the whole industry chain of the design industry. In the process of long-term development, the network symbiosis between design enterprises is diverse and close. Among enterprises in different design segments, business subcontracting and outsourcing cooperation are very frequent, which significantly improves the cohesion of the population, and different enterprises have also established formal and informal cooperation networks through information sharing, long-term cooperation and joint investment of resources. The connection with Tongji University is also very conducive to the formation and development of inter-firm trust and cooperation networks.

While accepting the knowledge overflow from Tongji University, the enterprises also feed academic research through project and financial support, feedback on the latest market demand, financial donations, etc., all of which help research teams condense the most cutting-edge scientific research topics and boost the construction of “Double First-Class” of Tongji University.

3.3.3 New species emerge. In addition to professional and technical services centred on the design industry, new species in the fields of blockchain and environmental protection have also emerged and developed rapidly. These new species are highly compatible with the disciplinary development direction of Tongji University's Siping Road Campus. Take the environmental protection industry as an example: thanks to the State Key Laboratory of Pollution Control and Resource Reuse, the State Engineering Research Center of Urban Pollution Control, and other scientific research platforms, Tongji National Science and Technology Park Hongkou Branch and the Huangxing Park Industrial Radiation Point have initiated an environmental protection enterprise agglomeration, which is active in the field of pollution control.

3.4 Service support populations

Service support populations include government, science and technology parks, communities and social intermediary service organisations. Although they do not directly produce knowledge, products and services, the support they provide is indispensable for the healthy development of industrial innovation ecosystems. The "tri-zone connection" path is the key successful experience sorted out from the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle.

3.4.1 Government. The Yangpu District Government of Shanghai is an important curatorial body for Around-Tongji Knowledge Economy Circle. Its role is reflected mainly in the following aspects.

Firstly, it has established a common value proposition with Tongji University. In July 2000, Yangpu District Government issued a special policy to promote the development of start-ups derived from Tongji University by providing tax incentives and exemptions, one-stop services for enterprise registration and the establishment of an enterprise incubator. The Shanghai government, Yangpu District Government and Tongji University have set up multi-level, regularised communication and coordination mechanisms, such as the Joint Meeting of Around-Tongji Knowledge Economy Circle, the Around-Tongji Knowledge Economy Circle Development Council and so on. Tongji University and Yangpu District Government signed a new comprehensive strategic cooperation agreement in September 2021 to further in-depth cooperation.

Secondly, actions are matched in corresponding to the common value proposition. In the process of the development of Around-Tongji Knowledge Economy Circle, Yangpu District Government has directly invested 8m yuan to enhance the image of Chifeng Road, introduce Shanghai Post and Telecommunication Design Institute and other foreign species and optimise the environment, thus increasing the industrial agglomeration of Around-Tongji Knowledge Economy Circle.

Thirdly, it is optimising the regional business environment. Yangpu District Government issued support policies in the field of engineering contracting and consulting which match the industrial characteristics of Around-Tongji Knowledge Economy Circle. Yangpu District Government also issued special policies in the fields of artificial intelligence, big data, blockchain and other areas and set up the "Enterprise Business Service Center" to encourage the growth of core populations.

3.4.2 Science and technology parks. Tongji National Science and Technology Park (hereinafter referred to as Tongji Science Park) plays an important role in the development of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle. Firstly, it has provided low-cost incubation spaces for start-ups by means of self-built and property-holding. Secondly, Tongji Science Park has established an innovation and entrepreneurship service system covering "innovation enlightenment", "business funding" and nine business incubation service platforms such as for investment and financing, project declaration and human

resources. It has provided professional innovation and entrepreneurship services for start-ups as well as students and faculty members of Tongji University. Thirdly, it promotes the integration of industry and education and accelerates the enterprise empowerment support system, talent cultivation system and enterprise empowerment support system. The latest strategic positioning of Tongji Science Park in the Fourteenth Five-Year Plan is a practice base for cultivating innovative talents, a demonstration platform for the integration and innovation of industry, academia and research and an important engine for high-quality development of the regional economy. It is trying to deepen the implementation of the Qifan Program, the Listed Enterprises Promotion Program and the Innovation Capability Enhancement Program to construct autonomous intelligence. It is attempting to realise this strategic positioning through implementation of the Qifan Plan, the Listed Enterprise Promotion Plan and the Innovation Capacity Enhancement Plan and through construction of Future Industry Science and Technology Park, the creation of a venture capital fund, etc.

3.4.3 Intermediaries. Within Around-Tongji Knowledge Economy Circle, various intermediary service organisations are also very active. A representative one is the Around-Tongji Promotion Association, which was established with the support of Yangpu District Government and which carries out research on topics related to the development of Around-Tongji Knowledge Economy Circle, integrating social resources, building platforms, promoting cooperation, operating the brand, etc. The Yangpu Industry-University-Research Promotion Association, Environmental Protection Industry Alliance of Around-Tongji Knowledge Economy Circle and Tongji New Material Industry Alliance are also very active in their respective fields and have become important forces linking various innovation populations.

3.4.4 Community. The community has always been an important pole in the “tri-zone connection”, providing open and convenient living conditions for teachers and students of Tongji University and providing initial business places for spin-off enterprises (Liu Qiang, 2007). At present, under the common value proposition, the positioning and role of the community are also gradually changing. Firstly, in the governance model, Siping Community, Yangpu District Government and Tongji University are exploring a new community governance mode and the formation of integrated solutions in the fields of ageing and community safety management. Secondly, to boost technology transfer, the community is creating application scenarios for the latest digital intelligence technologies of Tongji University, and the community itself is becoming a composite space that combines the functions of life, research and development, socialising and so on.

3.5 Expansion of the model of the innovation ecosystem of Around-Tongji Knowledge Economy Circle

Based on the research findings above, this study expands the research framework used to develop a synergistic evolution model of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle, which reveals an interactive, synergistic relationship among the populations and the evolution characteristics of the entire industrial innovation ecosystem (Figure 4).

4. Paths and strategies for optimising the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle in the new era

4.1 Changes and challenges for the development of the industrial innovation ecosystems of Around-Tongji Knowledge Economy Circle

4.1.1 Changes in the internal and external development environment. From the viewpoint of the external environment, firstly, the fourth industrial revolution is bringing great changes to social and economic development, and all countries are endeavouring to accelerate the

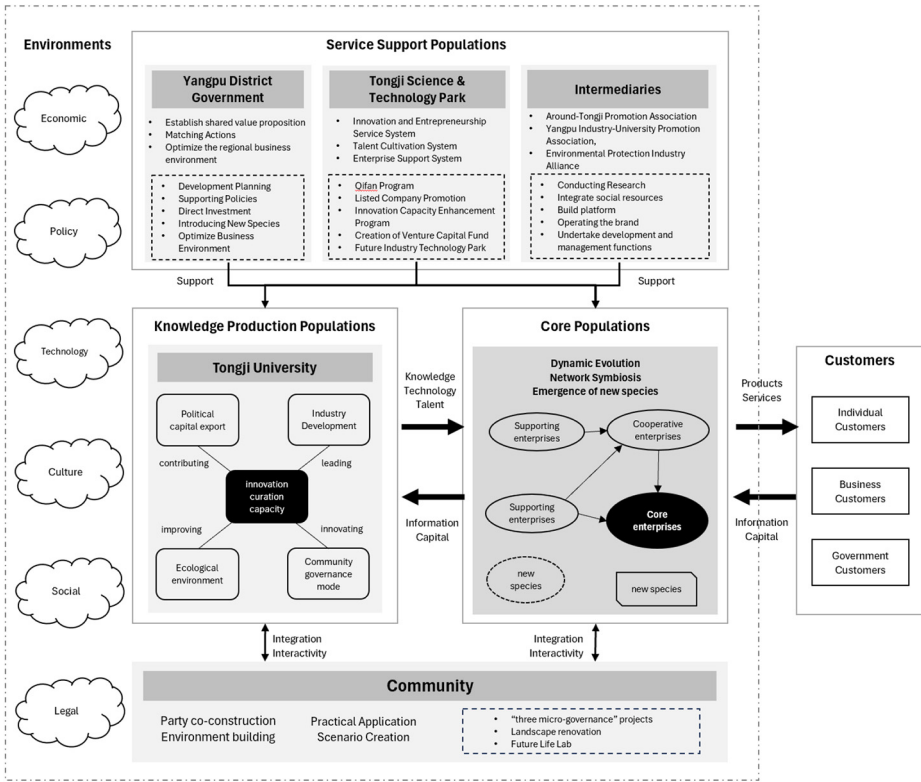


Figure 4. Synergistic evolution model of industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle

Source: Figure by authors

transformation of knowledge into productivity. Secondly, Around-Tongji Knowledge Economy Circle has become an important source for global and regional development. Major countries with developed science and technology have attached great importance to the construction of Around-university Knowledge Economy Circle to accelerate the transformation of knowledge into real productivity and have formed effective experiences. Thirdly, the establishment of a new talent cultivation model integrating industry and education has become the key to the continuous stimulation of the endogenous power of Around-university Knowledge Economy Circle.

From the viewpoint of the internal environment, the industrial innovation ecosystems of Around-Tongji Knowledge Economy Circle have a relatively good foundation in terms of top-level design, business environment, innovation atmosphere and community lifestyle. When General Secretary Xi Jinping inspected Yangpu Riverside, he put forward the concept of “people’s city built by the people, people’s city for the people”, which provides an important guideline for the path of innovative governance. In the context of urban digitisation, the possibility of forming new business models and creating new markets is huge. China (Shanghai) Digital City Research Institute, National Experimental Base of Intelligent Social Governance and other functionalities led by Tongji University are participating in the process. They will provide a solid guarantee for Around-Tongji Knowledge Economy Circle to grasp the initiative in future development and lay out new

industrial track. Environmental protection technology will also embrace a broader market under the guidance of the strategic goal of “dual-carbon” and the green development requirements of industries.

4.1.2 Challenges for the new era. The first challenge is the lack of a competitive policy system. Around-Tongji Knowledge Economy Circle is not an administrative region; there is no authority to formulate exclusive policies in industrial investment, talent attraction and other aspects of policy. Compared to neighbouring regions and other industrial development zones, it does not have advantages in the transformation of scientific and technological achievements, science and technology parks, the development of innovative projects or investment, either. In addition, some policies issued by the Shanghai government cannot be applied to Tongji University as it is under the direct authority of the Ministry of Education.

The second is the lack of sufficient space. Around-Tongji Knowledge Economy Circle is located in a built-up area, the supply of new workspace is very limited and the upgrading/remodelling of old factories is also becoming increasingly difficult.

In addition, the growth rate of urbanisation, which has been almost one percentage point per year since the reform and opening up, is slowing. Real estate development is rapidly cooling. Large-scale, high-intensity infrastructure construction is gradually returning to a steady track. The leading industries, such as urban planning and architectural design, in Around-Tongji Knowledge Economy Circle are facing growing limitations. Relying on existing industries, it is extremely difficult to realise the output multiplication plan from 50bn to 100bn by 2025.

4.2 Optimization ideas of the industrial innovation ecosystem of Around-Tongji knowledge Economy Circle in the new era

In the face of the above changes and challenges in the development environment, the future development of Around-Tongji Knowledge Economy Circle must be recognised from the height of the iterative development of the interaction mode between university knowledge production and economic and social development.

Firstly, the knowledge production mode of Tongji University, as a knowledge overflow centre, should be upgraded. Tongji University (Siping Road Campus) should aim at the world’s scientific frontiers and national major strategic needs, explore the innovation of knowledge production and talent cultivation modes and seek breakthroughs in the synergy of basic disciplines and applied disciplines. It should also improve the overall level of urban disciplines (planning, construction, development and governance) and construct an “international urban knowledge production center and talent highland”.

Secondly, the interactive interface between the knowledge production of Tongji University and the needs of society must be renewed. Taking the knowledge overflow from the urban disciplines of Tongji University (Siping Road Campus) as the core and relying on Tongji Science Park, the Around-Tongji Promotion Association and other organisations, the interface for the interaction between knowledge production and the demand side should be continuously updated to accelerate knowledge diffusion and dissemination. At the same time, through efficient interaction with the demand side, the direction of knowledge production should be calibrated through external energy feedback.

Thirdly, ecology, which boosts knowledge into future industrial growth momentum, must be constructed. Around-Tongji Knowledge Economy Circle should focus on the construction of “hardware” (such as the workplace and functional platforms) and the creation of “software” (such as the business environment, policy guidance and service capacity, capital operation, systems and culture) so as to build an innovation ecosystem conducive to the development of innovation and entrepreneurship activities and the cultivation of future industries.

The optimisation path and strategy for the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle in the new era are thus formed (Figure 5).

4.3 Strategies for optimising the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle in the new era

Enhancing the innovation capacity of Tongji University. Through forward-looking support for several cutting-edge basic research fields and key technologies, continuously encourage frontier cross research to effectively enhance the innovation and technology development capabilities of Tongji University. Promote Tongji University’s technology transfer service capacity and further strengthen the cooperation with Around-Tongji Knowledge Economy Circle enterprises relying on Tongji University’s R&D and transformation functional platforms.

Innovating the talent cultivation mode. Strengthen the construction of the Tongji innovation and entrepreneurship education system, realise the integration of the education, innovation and industrial chains, improve the quality of Tongji University talents in all aspects and realise the continuum of “idea–creation–innovation–entrepreneurship”.

Strengthening the modern design industry. Attract domestic and foreign leading enterprises and their branches in the modern design industry to establish business in Around-Tongji Knowledge Economy Circle. Promote the application of artificial intelligence, virtual reality, big data and other new technologies and promote the development of the digitalisation, networking, intelligence and ecology of modern design industry. Encourage the design enterprises to expand their business scopes in the direction of industrial design, fashion design, graphic design, animation design and display design, as well as creative design, eco-design, etc. Empower other industries and promote upgrading of the whole industry of Around-Tongji Knowledge Economy Circle through “Design+” and “Intelligence+”. Encourage design enterprises to set up representative offices and offices across the country and even around the world, and expand the brand effect of “Tongji Design” to create a welcoming domestic and international environment.

Accelerating the development of new strategic industries. Relying on platforms, such as the National Comprehensive Experimental Base of Intelligent Social Governance, China (Shanghai) Digital City Research Institute and Blockchain Research Institute of Tongji University, accelerates the development of intellectual economy represented by new

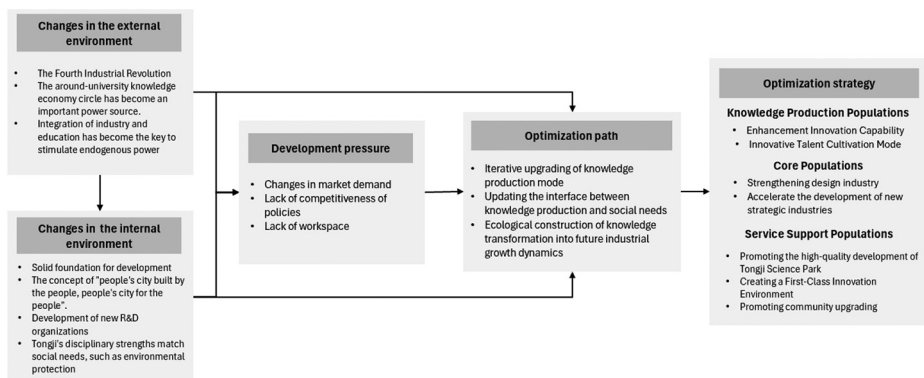


Figure 5. Optimisation path and strategy of the industrial innovation ecosystem of Around-Tongji Knowledge Economy Circle in the new era

Source: Figure by authors

technologies such as AI, big data, blockchain, cloud computing and network security. Relying on the R&D advantages of the State Key Laboratory of Pollution Control and Resource Reuse, the State Engineering Research Center of Urban Pollution Control and other platforms, expands and strengthens the green and low-carbon industries. Accelerate the development of industries related to the silver-hair economy.

Promoting the development of Tongji Science Park. Yangpu District Government, Tongji University and Tongji Science Park should work together to reach the goal of developing a National Demonstration University Science and Technology Park. They should also focus on providing more workspaces and attempt to improve the science and technology park incentive system.

Promoting community upgrades. Promote the in-depth integration of big data, AI and other technologies with community governance and improve the digital management of community neighbourhoods. Improve the public space, make it a creative and fashionable place and create a new Yangpu District cultural landmark in Around-Tongji Knowledge Economy Circle. Carry out “innovation, entrepreneurship, creativity” activities in the community and turn it into a model demonstration of a smart community and a smart urban area that can be replicated and promoted through deep integration of industry and the city.

5. Conclusion

Based on the five-helix theory and economic census statistical data, this paper has examined the characteristics of the industrial innovation ecosystem and the synergistic evolution process in Around-Tongji Knowledge Economy Circle. It has expanded the research framework used to develop a synergistic evolution model, revealing the interactive and synergistic relationship among the populations and the evolution characteristics of the entire industrial innovation ecosystem. Combined with analysis of the internal and external development environments, this study has proposed strategies for optimising the innovation ecosystem of Around-Tongji Knowledge Economy Circle in the new era and has outlined a specific path. Considering that the fourth economic census was carried out in 2018, the description of the latest state of Around-Tongji Knowledge Economy Circle in this paper may be imperfect, and the ever-changing internal and external development environments have presented many novel challenges, but this paper may provide useful perspectives for the study of an industrial innovation ecosystem. Research using new perspectives on the interaction between the production of knowledge and the demand of society, the rise of the new species of biomedicine and biomedical products, and the another Around-Tongji Knowledge Economy Circle “Jiading” can be conducted in the future.

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