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The Dilemma and Optimization of Science Parks related to Vocational Colleges

-- Analysis Based on Research Results from 36 Science and Technology Parks of Chinese Vocational Colleges

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Abstract

As a platform for the incubation of technology-based firms and the commercialization of innovations, science parks play an important role in regional technological innovation. The Science and Technology Park (STP) related to Vocational College, a relatively unique type of all kinds of science parks, is currently in its early stages of development and is growing freely with little restriction. This article conducts a survey of existing STP of Chinese Vocational College (STPCVC) from five aspects: developers, main functions and industry focus, management mechanisms, major achievements, and the legal contexts. It is found that the dilemma of STPCVC share similarities with the issues faced by the Hsinchu Science Park in Taiwan in its early days. Therefore, by analyzing the model of Hsinchu Science Park, this article proposes strategies to optimize the development of STPCVC from the 4 aspects: clarify the main functions and industry focus, introduce external innovation resources, shift the leading role to government and encourage active participation of enterprises.

Keywords

Science and Technology Park, Chinese Vocational College.

1. Introduction

The concept of Science and Technology Park (STP) originated from the establishment of Stanford Research Park in the 1950s. Since the 1980s, many STPs have also emerged in European and Asian.Academics have conducted in-depth research on STPs related to universities, and have achieved a rich research results. Currently, most of the research focuses on university science parks in developed countries, with less attention to STPs in developing countries. Among all types of park, STP related to Vocational College is a relatively special type and a unique phenomenon in China. The development of STP of Chinese Vocational College (STPCVC) is promising, with 36 STPCVCs emerging across the country. Until now, there is few research conducted on this type of STP. This study explored the development of STPCVCs using quantitative empirical methods, and the main research questions are as follows: What is the role of STPs? What is the current status of STPCVCs? What are the problems faced by STPCVCs and how to solve these problems for better development in the future? This paper will theoretically enrich the relevant research on STPs and provide a reference for the future development of university science parks.

2. The Definition of STPs.

Although there are many similar concepts of STPs, there is no unified definition. Academics generally believe that the characteristics of STPs include: (1) connecting with academic

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institutions such as universities; (2) supporting the start-up and serving as an incubator of technology-based enterprises; (3) promoting the transfer of technology and business knowledge; (4) most of STPs are property-based initiatives [1].

The main functions of STPs include incubating technology-based firms and commercializing sci-tech achievements. The development of STPs can be main drivers in promoting the regional innovation capabilities and improving local industrial systems [2]. The STP is a rather broad concept, which includes university science park. A university science park is typically characterised by (1) linking schools and firms to help universities transform research achievements into viable commercial products, and promote technology spill-over effects. (2) Providing a geographical environment adjacent to universities (as knowledge centers) to enterprises, enabling the establishment of various formal and informal relationships between academia and industry. Such relationships encourage the transfer of knowledge and the interaction between employees, which promotes R&D activities in both sides. (3) Significant reputational benefits from being located in the park. Many start-up technology companies decide to settle in the park because of the"prestige and overall image of the site", it is recognized that being located in the park brings the firms the endorsement of the knowledge center.

3. The Classification of STPs.

According to the main functions of the park, STPs can be further divided into four categories: research parks, technology parks, innovation parks, and industrial parks. Tenants in research parks engage in both basic and applied research, while those in technology parks mainly focus on applied research. Innovation parks primarily house start-ups and incubators, while industrial parks are mainly involved in production-orientated activities rather than R&D activities [3].

If we compare STPs according to the "developers", we can classify them as government-led parks, market-led parks (firm-led parks), and university-led parks.(1) Market-led parks. Under a well-established market economy system, such parks would have enterprises as the main drivers of R&D activities. For example, the Cambridge Science Park in the UK is one of the typical market-led parks. The park is managed by professional managers. Companies in the park operate according to the laws of the market and are not subject to government intervention [4].Universities and on-park companies are closely linked in academic research and commercial application. For example, the University of Cambridge maintains contact with 50% of the surrounding technology companies [5] and cooperates extensively with the industry in research activities, establishing research institutes, laboratories jointly. Companies are established to handle the transformation of sci-tech achievements in the university, and such achievements are used to raise funds for subsequent research activities. (2) University-led parks. The Stanford Research Park in the United States is developed and led by Stanford University, a research-intensive university with strong academic capabilities. It has made prominent development in electronic information and related industries by leveraging government, enterprise, and its own advantageous resources. Industries act as technology buyers, providing research funds and practical bases, while the government set relevant regulations and policies to strengthen protection of intellectual property rights and support enterprises of small and medium-size. (3) Government-led parks, such as the Tsukuba Science City in Japan and the Hsinchu Science Park in Taiwan. The government not only vigorously promotes innovation activities and provides comprehensive financial supports but also directly participates in the process of development and management of science parks. The differences between the Tsukuba Science City and the Hsinchu Science Park lie in their development models [6]. The Tsukuba Science City in Japan is mainly oriented towards basic scientific research, using a self-driven development model which starts from research activities, goes

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through the stages of technology, production, and ends with marketing. While the Hsinchu Science Park adopts a reverse development model of introduction-type. Enterprises in the park export high-tech manufacturing products and follow an" introduction-digestion-export" route, introducing foreign technology, talent, and capital for product manufacturing while absorbing and mastering advanced foreign technology.

4. Current Situation and Problems in The Development of STPCVCs

4.1. Developers of STPCVCs

Chinese Vocational Colleges (CVCs), also referred to as Polytechnic colleges, belongs to tertiary education level. Compared with general education, CVCs focus on job-specific training to students who are typically bound for one of the skilled trades. STPs of CVCs in this article referred to those parks built by CVCs or those that have cooperative relationships with CVCs. After examining the existing parks nationwide, a total of 36 parks meet the standard and became the subject of this article. The developer of the park is the main investor of the park. In the case of joint investment by multiple entities, the investor with more than 50% of the shares in the park management company is deemed to play a leading role. According to the different developers of STPCVCs, they can be divided into three types including college-led parks which are developed by single Vocational Colleges, joint parks which are developed by multiple entities of government, colleges, and enterprises, and government-led parks which are developed by local government. Of the three types, more than half are college-led parks, joint parks account for 31%, and government-led parks account for the smallest proportion at 11.1%. When it comes to joint parks, the situation becomes kind of complex. There are mainly three models of joint parks: joint parks developed by government and college (63%), joint parks developed by college and enterprise (27%), joint parks developed by government and enterprise (9%). Firstly, it is obvious that building a partnership between the government and college is a more common practice. Secondly, while taking a deep look into each developer of the joint park, it is recognized that the colleges, governments, and firms have different levels of involvement. As for the involvement of schools, vocational colleges are the principal participants while only 8 universities, accounting for 22% take part in the construction process. As for government, it is found that the government participates in the development of one-third of the parks, indicating that the government also plays an important role in the park's initiation. However, the participation of enterprises accounted for only 11%, indicating a lack of enterprises in terms of park development.

4.2. Main functions and industry focus

In accordance with Article 5 to Article 9 of *Administrative Measures for National University Science Park*, the goal of Chinese university science parks is to integrate innovative resources, transform sci-tech achievements, incubate sci-tech entrepreneurship, cultivate innovative talents, and promote an open and collaborative development. Following this official guide, almost all the STPCVCs describe the functions of parks as "incubating innovative enterprises, transforming sci-tech achievements, and cultivating innovative and entrepreneurial talents." As for industry focus, 64% of STPCVCs has industry focus and 36% of STPCVCs do not have a clear industry focus. In terms of specific industry focus, it is mainly about two industrial clusters: one is about intelligent equipment manufacturing, including industries related to robotics, artificial intelligence, smart manufacturing, etc. The other is about digital economy, including software and information-related business. In terms of the number of industry focus, nearly half of the STPCVCs have more than three key industries, and the relevance between those key industries is relatively low.

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4.3. Management mechanism

Whether to adopt a modern corporate system, that is, whether a company has been established to manage the affairs related to the science park, is an important indicator of the marketization level of the STPs. The research shows that 56% of STPCVCs are directly managed by colleges, and all those parks follow the management system which public-sector organizations implemented in colleges and universities, while 44% of STPCVCs are managed by companies and operate in a more market-oriented way. In the case of government participation, the local government often sets up a park management committee for macro guidance, and the company is responsible for the specific management of park affairs and the daily operation of the park. The board of directors of the company is composed of personnel appointed by shareholders from governments, colleges, and enterprises.

4.4. Operational effectiveness and performance evaluation

Currently, a total of 24 STPCVCs have been included in the official STP system, including 5 national-level parks, 17 provincial-level parks, and 2 municipal-level parks. Performance evaluations have been conducted on 12 parks by Chinese Ministry of Science and Technology and the provincial sci-tech authorities. The performance grade of the national-level park is divided into four grades: excellent, good, qualified and poor. Among all the national participants, 2 received a good evaluation,1 was rated as qualified, and 2 were rated as poor. Among the provincial-level parks, 57% were rated as class A, 29 % were rated as class B, and only 1 was rated as class C.

Since only one third of STPCVCs are included in the official evaluation system, it cannot reflect the whole picture. Therefore, the author conducted a survey on the performance of STPCVCs, collecting information from a total of 21 parks (related figures of the other 15 parks are not available), as shown in Table 1. In terms of the nature of the indicators, although the number of types of output indicators are more than those of input indicators, the frequency of input indicators is 1.5 times that of output indicators. Due to the lack of a unified standard, the types of indicators provided by each park vary greatly, making it difficult to make a quantitative analysis. In terms of the number of indicators, the most frequently used one is the "number of settled enterprises", which all 21 parks use to reflect the operational effectiveness, with an average of 211 settled enterprises per park. However, only 2 parks mentioned the number of incubated enterprises, indicating that the parks' ability to make output needs to be improved.

Table 1. Evaluation on the performance of STPCVCs

Indicators	Nature of indicators	Frequency of indicators
Number of settled enterprises	input indicators	21
Number of R&D institutions	input indicators	6
Number of service institutions	input indicators	3
Employment	output indicators	4
Annual income	output indicators	5
Number of intellectual property rights	output indicators	4
Number of innovation and entrepreneurship projects	output indicators	2
Number of industry-college-research cooperation projects	output indicators	3
Number of incubated enterprises	output indicators	2

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4.5. Related laws, regulations and policies

Regulations for STPs can be divided into specific regulations and related regulations. The former refers to regulations issued for specific purpose of supporting the development of parks and on-park firms. The latter refers to any related regulations made by local governments to encourage technological innovation. Special regulations often include a basket of measurements in areas such as finance, business support, intellectual property rights, land, talent, etc., with greater strength, such regulations are more conducive to the rapid growth of parks than related regulations. The research shows that 20% of STPCVCs enjoy special related regulations, mainly including (1) Financial policies: tax incentives, special funds, secured loans for start-ups; (2) Business support policies, including a. Enterprise incubation policies, which providing one-stop registration and related services for firms who seek to settle in the park, as well as personnel and financial agency services to newly settled enterprises. b. Enterprise development policies. Different preferential policies have been introduced for enterprises of different sizes. In addition to that, there are supporting measures which encourage enterprises to implement technological upgrading. c. "One matter, one discussion" policy for leading enterprises. For projects or enterprises that can bring significant social and economic benefits to the park, preferential treatment is provided according to the" one matter, one discussion" principle. By applying this principle, high-quality enterprises can negotiate with the local government to enjoy more personalized treatments. Therefore, the attraction of the park to leading enterprises and high-quality enterprises is further enhanced. (3) Policies related to Intellectual property (IP). Some policies provide greater emphasis on IP protection, such as priority application for technological achievements, increasing the proportion of researcher's income from the commercialization of research achievements, and special rewards for the commercialization results. The park's IP service platform provides comprehensive services such as IP agency, IP protection, planning, and consulting, further reducing the costs for enterprises in terms of IP managment. (4) Land use policy which always provide a rent reduction for units entering the park. (5) Talent policy which is designed to attract college students nearby to conduct entrepreneurial and innovative activities in the park, and to introduce high-level talents into the park. Based on the discussion above, the specific regulations to promote the development of STPs are rich in variety and intensity, which effectively enhance the attractiveness of parks to external investment. However, in practice, due to the large differences in local government practices, the popularity and coverage rate of special policies are relatively low, and most of the parks do not enjoy such customized measurements.

To summarize, STPCVCs have gains some achievements, but in the big picture, they are still in a preliminary stage and need timely reflection and summarization to achieve a better development. The main problems currently faced by STPCVCs are as follows. Firstly, the guiding role of the government is not obvious. As for specific regulations, there are only few government provides such support. Moreover, the official evaluation system is not perfect. After the park being recognized by local government, subsequent evaluations are not well implemented at the provincial and municipal level. Half of the parks at the provincial level have not received official evaluations, and the municipal sci-tech authorities have not organized any evaluations. Secondly, enterprises are not so enthusiastic about taking part in the development of parks. During the construction phase, STPCVCs are mainly promoted by colleges and local government, with low participation from enterprises. Half of the parks are self-built and self-managed by colleges, applying the administrative management system of public-sector organizations rather than a market-oriented system. The third issue is a lack of distinctiveness. The functions of the most parks are relatively general, without a clear industry focus. One-third of the STPCVCs do not have key industries, and among those with key industries, the dispersion of industrial fields is also a major problem, the low relevancy between industries it difficult to

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form industrial clusters. The fourth and final point is the relatively weak innovation capability of the parks. The output effectiveness of parks needs to be improved. The hierarchy of the universities and colleges within the park is rather flat, and the willingness of universities to collaborate with vocational colleges in building science parks is not strong, which also limits the innovation level of parks.

5. Characteristics of the Hsinchu Science Park model in Taiwan.

In the 1980s, in the case of resource shortages, weak sci-tech foundation, and insufficient funds, in order to promote the transformation and upgrade local traditional industries, Taiwan authorities began planning to establish the Hsinchu Science Park. In recent years, the park's output value has exceeded NT$1 trillion, with over 600 companies registered in the park and over 160,000 employees working there. It is recognized as one of the most successful science park in Asia. Currently, STPCVCs are facing similar challenges encountered by Hsinchu Science Park at its beginning stage. Therefore, drawing some experience from the Hsinchu Science Park may help address the practical problems faced by STPCVCs.

5.1. Government playing a Leading Role

In the development of the Hsinchu Science Park, The government's role has threefold, including the developer, the service provider and the administrative manager. As the developer, the authority is responsible for the planning and construction of the park and provides a large amount of public resources such as land and infrastructure. As for financial support, the government not only establishes venture capital funds, provides low-interest loans and research grants, but also coordinates official, private, and multinational capital to invest in the park [7]. As the service provider, the government define itself as "the fair and just market guide and the maintainer of market order [8] ", without competing for profits with the on-park firms. (1) A complete set of service agencies are established within the park to provide convenient one-stop services, which means all the procedures set for firms can be completed within the park. (2) the government has issued 132 regulations, such as *The Act for Establishment and Administration of Science Parks*, covering six major areas: research and training, investment services, labor safety and environmental protection, industrial and commercial services, water, electricity and transportation, leasing and construction management. It has also established a digital database based on the above classification, and all relevant regulations is available online. Moreover, after the above-mentioned regulations are enacted, they will be amended according to the actual situation. For example, *The Act for Establishment and Administration of Science Parks* has undergone 8 revisions after its promulgation. The most recent amendment was made due to the change in technological research and the industrial adjustment on June 6,2018.(3)To encourage researchers to start businesses, the park allows researchers to use patents or patented technologies as share investments at a higher proportion than usual, with a maximum value of 25% of the total investment [9]. (4)To attract investment from social capital and maximize the effectiveness of fiscal funds, the government primarily allocates fund of industry-academia-research to universities and research institutes, thereby attracting the R&D funds from enterprises. For example, the regulations of the industry-academia collaboration research program specify that the research institute serves as the executing unit to manage the funds, and enterprises must contribute more than 25% [10]. As a manager, the park adopts a administrative management system, with the National Science and Technology Council (NSTC) directly responsible as the highest administrative authority and the administrative bureau responsible for specific plans and daily business management of the park. Furthermore, the government is also responsible for making development plans for the Hsinchu Science Park, such as the early *Ten-Year Development Plan for Science Parks (1994)* and

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the annual governance plans released since 2006, which play an important role in deciding where the park is going.

5.2. An appropriate development mode

The development model of STPs includes development paths and development strategy. The development paths is "what to rely on to achieve development", which mainly includes three types: local advantage-oriented type (mainly relying on local resources to promote development), external advantage-oriented type (mainly relying on the introduction of external resources to promote development) and comprehensive development type(combining local resources and external resources to promote development). With Taiwan's rather weak technological foundation, it is difficult to engage in independent R&D activities at beginning. Therefore, the Hsinchu Science Park chose to import foreign technological resources and adopted a path of "introduction-digestion-export" to transform advanced external technology into local technology. Such movements have driven the transformation of traditional industries into high-tech industries, greatly promoting the development of Taiwan's high-tech industry and the upgrading of its industrial structure.

Development strategy is "what industries to rely on to achieve development". the The dominant industries in the Hsinchu Science Park are distinct, high-tech and modular, which consisted of six major high-tech industrial clusters, including integrated circuits, computers, communications, optoelectronics, precision machinery, and biotechnology industries. With a clear division of labor among on-park firms, a strong correlation between firms, and a complete industrial chain, a modular industrial cluster led by the core firm is thus formed [11]. The core firm is responsible for setting standards for products, and other suppliers work as independent modules (components) under the coordination of the core firm. Finally, the core firm will integrate all parts made by other suppliers into final products, making products that best meet buyer's need in the least time. Currently, Hsinchu has moved beyond the phase of technology transfer and focuses on contract manufacturing. The park has developed its own technological capabilities, and it has entered a technological breakthrough period of cultivating its own brand and focusing on product innovation.

5.3. Academic and research institutions at multi-level

The Hsinchu Science Park has formed a three-tiered pyramid structure of academic and research institutions, providing strong intellectual support for industrial development of the park. The first level is companies aligned with overseas research resources. Companies in the park maintain close relationship with universities and research institutions in the United States, and top high-tech companies have research laboratories or design companies in Silicon Valley [12]. The second level is the utilization of local R&D resources. The surrounding area of the park has abundant research resources, with National Tsing Hua University mainly conducting basic theoretical research, National Chiao Tung University mainly focusing on engineering technology research, and the Industrial Technology Research Institute mainly engaging in industrial research and development. Among the above-mentioned institutions, The Industrial Technology Research Institute, as a comprehensive platform for research and development of public industrial technology, combines the three functions of industrial scientific research and development, technology and knowledge services, and technological derivative value-added activities. It has greatly promoted scientific research, technological progress, and commercial development in the park. The third level is the cultivation of practical talents. In order to educate talents for manufacturers in the park, strengthen graduates' professional skills, and bridge the gap between learning and practice, the park encourages surrounding vocational colleges to offer module courses in line with the industry needs. Moreover, through enterprise internships, graduates will become technical and skilled workers who can directly engage in production for manufacturers in the park [13].

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5.4. On-park firms attaching great importance to R&D activities

Through industry-university cooperation, on-park firms can obtain cutting-edge technology and research findings from academic and research institutions. Enterprises in the park and counterpart academic and research institutions jointly build R&D centers in a benefit-sharing and risk-sharing way. The R&D expenses of TSMC (Taiwan Semiconductor Manufacturing Company) have been increasing year by year, reaching US$4.465 billion in 2021, accounting for 7.9% of annual operating income (In the same year, the total R&D investment of the top 500 enterprises in mainland China accounted for only 1.77% of their total operating income). At the same time, there is frequent personnel exchange between the two parties. The relationship between on-park firms and academic and research institutions has changed from sponsorship to partnership. Employees from on-park firms can communicate with teachers and students from universities at any time, and within the park, over 70% of the entrepreneurs and employees in the high-tech companies are alumni of National Chiao Tung University [14].

6. Advice for the Future Development of STPCVCs

6.1. Clarifying the main functions and industry focus

Firstly, STPCVCs should clarify the main functions, choosing some from applied research, technical services, transformation of technological achievements, enterprise incubation, and industrial production as the main functions. Secondly, it is important to emphasize key industries. At present, the industries cultivated by STPCVCs are relatively dispersed, making it difficult to form a joint force. The science park should select the main industries of the park based on local pillar industries and characteristic industries, and the advantageous disciplines of the surrounding schools should also be taken into consideration. The science park should also pay more attention to introducing resources of leading enterprises in the industry, and form an industrial cluster with a clear division of labor and a complete industrial chain, which may actively promote the growth of on-park firms on a large-scale.

6.2. Introducing external innovation resources

The three-level academic and research institutions in the Hsinchu Science Park have formed a chain of innovation achievement transformation from importing technology overseas to local transformation, and then to Industrial production. As the focus of research work in vocational colleges is applied research and technical services, rapports with research-oriented universities and high-level research institutions both domestically and overseas should be built. Through this partnership, the park is able to introduce scientific and technological resources, and at the same time use the college-related resources to serve the transformation of technological achievements, establishing a virtuous circle between the diffusion of external knowledge and the creation of knowledge within the park.

For example, pilot-scale production is often the first process tackled by companies seeking to commercialize a technology that has proven successful at the lab-scale. It is a scale-up trial production process carried out in order to form technical standards for large-scale production after the laboratory research and development. Pilot-scale production requires versatile professionals with theoretical knowledge and first-line product development experience, as well as corresponding site and equipment support. As vocational colleges have inherent advantages such as practical laboratories and "dual-qualified" teachers who have both theoretical knowledge and practical experience, they can actively seek cooperation with relevant academic and research institutions to establish pilot platforms within the park.

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6.3. Government playing the leading role

In the case where the advantages of the park itself are not prominent, external superior resources are essential elements for the development of the park. It is important to improve the attraction of the park by building a sound, transparent and responsible investment environment. For example, high-quality factories and office buildings, abundant talent and preferential policies are all indispensable factors contributing to sound investment environment. Such a good innovation ecosystem can only be built under the guidance of the government.

The government should incorporate the construction of science parks into the annual work plan and provide support such as funds and land resources to the park. During the operation of the park, the government should provide guidance and policy services. In general, the government should make more specific regulations to support the development of the park, and pay more attention to the update of related regulations. To be more specific, On the one hand, the government should focus on innovation-oriented administrative management. It can be achieved by setting up a management committee responsible for making decisions on major issue of the park, coordinating government major tasks, university R&D activities, and local industrial activities, formulating long-term development plans for the park, and setting annual work priorities. Then the development of the park should be tracked through official evaluations organized by the government. The evaluation results should be linked to the level of support, thereby enhancing the output capacity of the park. On the other hand, it should improve the business environment in the park. In terms of financial support, in addition to existing measures such as entrepreneurial guaranteed loans and tax incentives, the government should make full use of investment funds and special funds for scientific development to lead social capital flow to the on-park enterprises. In terms of laws and regulations, provincial and municipal governments should enact policies to promote the development of STPCVCs in a more targeted manner. Pilot projects for patent equity financing can be carried out, allowing colleges and on-park firms to invest in their intellectual property portfolios. At the same time, the government should focus on the efficiency of administrative management, simplify administrative procedures, provide one-stop services, and establish an online policy database so that all relevant policies can be easily accessed.

6.4. Encouraging active participation of enterprises

During the construction of the park, private capital should be encouraged to participate in the investment process, and efforts should be made to build market-led parks. After the park is put into operation, measurements should be taken to encourage enterprises to increase R&D expenses. Close collaboration between colleges and enterprises should be promoted, a hand-in-hand relationship should be built between the two parties in terms of technology research and development, college majors, assessment and evaluation, and gradually reaching an ideal state of benefit sharing and risk sharing. In addition to that, it is necessary to strengthen the personal link between colleges and enterprises, and deepen the link through entrepreneurship, personnel training, and student internships. In terms of park management, it is suggested to implement a third-party management model by establishing a park management company to integrate the strengths of different entities from the government, schools, and enterprises, thus avoiding direct intervention on park's day-to-day business by a specific entity.

7. Conclusions

Through the quantitative analysis of the development of STPCVCs, it can be observed that although STPCVCs are developing rapidly, the quality is relatively low. The limited support of the government and industries, the unclear function of the parks, and the low innovation all

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check the development on STPCVCs. In order to address the above issues, based on the experience of the Hsinchu Science Park, STPCVCs should clarify their industry focus, introduce innovative resources, and further leverage the role of the government and enterprises in driving their development.

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