1. INTRODUCTION

Taiwan has a notable history of developing high-technology industries. Since the mid-1970s, industrial technology research institutions and science parks, for example, ITRI in 1973, and Hsinchu Science-Based Industrial Park in 1980, have been established. It is also widely known that prior to the promotion of a technology-intensive industry, Taiwan had already earned a reputation of rapid economic growth as one of the “four Asian tigers,” being on a par with Hong Kong, South Korea, and Singapore in the 1970s; this pre-hi-tech development period was characterized by a rapid increase in the amount of small and medium-sized enterprises (SMEs), which was in contrast to the case of South Korea where large companies dominated the economy. It is generally accepted that in Taiwan there is a very strong tradition of entrepreneurial spirit, or at least, the spirit of “better be the head of a cock than the tail of a cow” (寧為雞首，勿為牛後). This kind of mentality has been regarded as advantageous for developing small firms that do not need much capital or intensive technology input. These two strands of forces have enabled Taiwan to have an economy of prosperous SMEs and a burgeoning high-technology industry. In the 1980s and 1990s, Taiwan’s economy appeared to be enjoying “the best of both worlds”—for the large number of SMEs provided society with a variety of jobs and thus a foundation for equity, and the high-technology industry recorded higher profits than the other existing industries. Yet, this was only the beginning of a long, and still on-going, pro-

The Promotion of Startups in Tainan Technopolis

Shiann-Far Kung, Yung-Chih Yen

1. Professor, Department of Urban Planning, National Cheng Kung University, Taiwan
2. Assistant Research Fellow, National Land Research Center, National Cheng Kung University, Taiwan

Abstract

Taiwan’s economy has been characterized by the strong existence and continuous creation of small and medium-sized enterprises. This phenomenon is commonly regarded to be the result of a culturally embedded strong entrepreneurial spirit. In the process of developing a high-technology industry in southern Taiwan, linking a newly established science park with existing local industries was one of the major challenges. This article reviewed the development history of Tainan Technopolis. Following a concise review of Southern Taiwan Science Park’s struggle against becoming an assembly of spillover establishments from Hsinchu Science Park, the authors focused on the efforts of incubating startups. Although only an initial study, the authors demonstrated the roles of National Cheng Kung University and Southern Taiwan Science Park Administration in introducing a two-track incubation system based on collaboration between the two institutions and startups.

Keywords

Startup; Small and medium-sized enterprises; Academic-industry collaboration; National Cheng Kung University; Southern Taiwan Science Park.
cess of industrial restructuring.

Regarding the SMEs established before the rise of the high-technology industry, some of them had evolved and developed into large enterprises; however, regardless of size, they became classified in general as “traditional” or “sundown” industries. These traditional industries gradually found themselves fighting on two fronts: on the one front with overseas countries, especially less-industrialized and lower-income countries, and on the other front with the more attractive higher paying jobs that were available in the high-technology industry. For the majority of traditional enterprises, this eventually led to either the exodus of operations to newly industrializing countries or to the end of their business; however, a small proportion of them chose to upgrade and change in order to be more competitive. These firms are more relevant to the discussion in this article.

The idea of building research parks to restructure Taiwan’s economy was envisaged and publicly expressed in the late 1960s by the Ministry of Economic Affairs, and then implemented in two key steps—the reorganization of research institutes to form the Industrial Technology Research Institute (ITRI) in 1973, and the establishment of Hsinchu Science Park (HSP) in 1980. The ability to develop high-technology industries in Taiwan had frequently been doubted before the mid-1980s; however, with some successes in niche markets, represented by UMC and Microtek, and the successful launch of TSMC in the mid-1980s, high-technology industries and the development of science parks came to be recognized as contributive to prosperity.

From the very beginning, HSP provided both laboratory-type small building units and larger sites for tenants. The former—the so-called “standard business unit”—was prepared for startups and small-scale high-tech firms, and the latter for larger scale firms; hence, the potential for new ventures and mass production were both realized. Yet, with the influx of capital towards fast-growing companies, and, obviously, the number of jobs and the amount of revenue being more eye-catching indicators in judging success, showcasing models for “success” soon shifted towards “size” in the late 1980s. This model for success had some important impacts. First, Morris
Chang and ERSI had already established a concept that the contemporarily fast developing semiconductor industry could be divided into two sub-industries, i.e., design and foundry; this model was first established in HSP, and it is still influential worldwide today. While the IC foundries required a large manufacturing space, hence suitable for location in HSP, the small-scale and often market-oriented IC design industries were more flexible regarding location, actually being more ideal for location in the capital city Taipei. Second, with more reports emphasizing glamorous scale figures, less attention was paid to new startups, and most of the HSP-related startups were, in fact, spin-offs from existing big companies (Kung, 1995). Thus, the spirit of and opportunities for startups seemed to be less encouraged in HSP. Third, HSP soon ran out of available land for further expansion demanded by the big foundries, and, as a result, the central government had to find a new site to accommodate the second science park in Taiwan.

Tainan was selected as the location for the second science park after defeating fierce competition among several cities. One of the key reasons for choosing the fourth largest city in Taiwan, instead of the more populous and industrially larger cities Kaohsiung or Taichung, was because of the existence of two renowned major international research institutes in the city—National Cheng Kung University (NCKU) and the World Vegetable Center (WVC, known as the Asian Vegetable Research and Development Center before 2008). NCKU was the largest, and also considered the top, engineering school in Taiwan, and WVC was expected to play an important role in the development of new agricultural biotechnology industries. An additional research arm was installed—the ITRI Southern Region Campus in 2006. The second science park was originally called Tainan Science Park (TSP) and then renamed as the Southern Taiwan Science Park (STSP) after the inauguration of a new site in Kaohsiung. Thus, with the existence of TSP, KSP, and Tainan Technology Park, Tainan became the second core for high-technology industrial development. The authors refer to this as “Tainan Technopolis.” The main campus of NCKU and its hospital are located right in the center of the three high-tech parks (Figure 1), and NCKU has played a significant role in the promotion of new business formations in Tainan Technopolis.

Because the existence of STSP resulted mainly from the expansive demands of HSP IC foundry companies, there were concerns that STSP might become a satellite park of HSP. Kung et al. (2006) and Kung and Yen (2008) analyzed the early growth of STSP firms by industry and found that instead of HSP’s large semiconductor firms, it was actually TFT-LCD led optoelectronic industries that had become the leading sector in STSP. Kung et al. (2009) explored the role of STSPA in the formation of a medical device industrial cluster. Yen et al. (2009) described the telecommunications industrial cluster in STSP. Kung (2014) also summarized the development of the “green” industry and the green environment in STSP. It seems that a decade after its establishment, STSP has fully developed into a park with several high-technology clusters and a supportive ecosystem to sustain future industrial development (Kung, 2011). Yet, similar to the HSP experience, there has been too many statistics monitoring scale indicators; however, the role of startups and innovative spirits has never been totally forgotten by the National Science Council (NSC, now the Ministry of Science and Technology), science park administrators, and those who view startups as key to the vitality of an economy.

In general, globally there has been a growing trend of emphasizing the importance of entrepreneurship and creativity since the beginning of the millennium, evident from the popularity of publications, for example, by Richard Florida and Charles Landry. In Taiwan, some of the high-technology companies have now grown into sizable multinational enterprises. They have not been restricted by the increasing global competition and economic ups-and-downs. Taiwan did not suffer as badly as its neighboring countries in the 2008 financial crisis, yet its newly established TFT-LCD industry has suffered greatly from fierce competition with Korean competitors. NSC and STSPA have increased their interests in encouraging startups from a wider industrial perspective since the beginning of the 2010s. At the regional level, STSPA has collaborated with local universities, especially NCKU, to deal with many new activities promoting startups. For example, the authors were involved in an NSC assignment, together with STSPA in 2013, to review regulatory barriers and suggest measures to encourage startups.

2. FROM SPILLOVER TO STARTUP IN SOUTHERN TAIWAN SCIENCE PARK

2.1 From HSP Spillover to Local Spinoff

The earlier thought concerning the promotion of new enterprises in STSP was about preparing sites for new firms with the same industrial classification to be located together. TSP
was originally planned for the development of three target industries: microelectronics and precision machinery, semiconductors, and agricultural biotechnology. These were to be divided geographically into three specialized zones (National Science Council, 1996). A list of featured sub-industries for each target industrial cluster was prepared, and several promising products or technologies related to each of these industries were also highlighted. Thus, the underlying concept of STSP industrial planning was to form an “industrial cluster.” Kung and Yen (2008) and Yen and Kung (2008) found that none of the three largest local industries in 1986 or 1996 could be identified as having strong linkages with STSP target industries. Therefore, the new science park firms were mainly expected to be spillovers from HSP, and this was exactly the reason for establishing a second science park. There was strong demand for land, especially from the big semiconductor firms in HSP, and indeed much of the bigger land parcels were soon leased to them, making STSP more like a satellite park with HSP branch factories. This was not the healthy industrial development agenda that was ultimately expected by the locals.

However, not before long, statistics reflected the rapid growth of a new sector—the TFT-LCD industry. Not more than ten years since its establishment, STSP became a world-class TFT-LCD industrial cluster, and the leading firm has been CMO (Kung and Yen, 2008). CMO was established in 1998 by Chimei Corporation, a leading chemical enterprise in the region. CMO could be regarded as a spinoff from Chimei, which identified the relationship between the promising TFT-LCD industry and the chemical materials it produced. It also aggressively pursued the establishment of a complete supply chain for TFT-LCD production by persuading its existing industrial partners in the region and even in Japan to build spinoffs and, with the assistance of the park’s administration, to co-locate in STSP. It even successfully lobbied the local government to build a new industrial park—the Tree Valley Park—in close proximity to STSP in order to accommodate TFT-LCD related downstream firms which were not qualified to enter STSP.

Based on the concept of building a complete industrial chain for further development, CMO invested in the R&D sector with a long-term perspective, for example, it granted a research lab to NCKU for the promotion of R&D in optoelectronic technologies. It is clear that the local industrial giant Chimei and its spinoff company CMO have together played a vital role in the formation of a new industrial cluster (Figure 2). CMO has also helped STSP to retain its own industrial strength, helping to prevent STSP from simply becoming a satellite park with spillover factories from HSP.

### 2.2 Startups from SMEs

Because of the rapid growth of large-scale semiconductors and TFT-LCD industrial firms, TSP lacked space for new development within a decade of its establishment. The KSP was established in 2003 as the second site under Southern Taiwan Science Park Administration (STSPA). As in the cases of TSP and HSP, there were notions of utilizing KSP as a spill-over site for the rapidly expanding TFT-LCD industry in TSP. However,
a political decision to build the third science park system in Taichung much earlier than expected resulted in a shift of new TFT-LCD investment towards the Central Taiwan Science Parks (CTSP). It was seen as a big loss of investment; yet, in hindsight, created time and space for KSP to reconsider its development path.

Kaohsiung has been the major steel and petrochemical industrial center in Taiwan since the 1970s. With a variety of materials and the convenience of the largest harbor in Taiwan, metal works and precision machinery SMEs have clustered in Kaohsiung and in the southern Taiwan region and played a significant role in the regional economy since the beginning of the millennium. Owing to the growing competition from China and ASEAN countries, the remaining SMEs had to find new ways of producing higher value-added and more sophisticated products. This required a lot of external information and technological support. STSPA and local industrial researchers decided to utilize lessons learned from the TFT-LCD cluster formation in TSP to attract existing local firms to invest in KSP and transform their existing industries.

A medical device (MD) industry was chosen because it offers opportunities to combine high technologies from different fields, including the metal, precision machinery, chemical, and plastic industry, among others, for which the region already had a strong reputation in the manufacturing sector (Kung et al., 2011). In order to produce high-level MD products, firms had to upgrade their existing technologies or develop new technologies, access market information, understand consumer needs, and even cultural sensitive issues related to medical treatment; there were no “flagship firms” in this sector in the region, and the activities mentioned above were not easy tasks for SMEs. Therefore, the realization of medical industry development in KSP had to be based upon a new model of linking local firms, research institutions, hospitals, and academic-industry collaborative research.

The linear R&D model depicts the birth of an industrial product in the market that starts with basic knowledge or ideas, proceeds with design and testing, prototype development, and manufacturing processes, and ends with marketing and selling to customers. The linear R&D model far from depicts the complexity of real-world production. However, it is easier to utilize the linear model to demonstrate the main gaps between the major production processes. In the case of the MD industry in the Kaohsiung area, it is represented in Figure 3. As can be seen, at least three large gaps can be identified.

**Gap 1**

To produce high-level MD products, upgrading technology or developing new technology is vital. Market research is also needed so that new ideas and competitive products can be created. These activities often take much time and require substantial investment.

Regarding supply, diverse technologies from HI, TI, and medical industries (MI) need to be combined. MI has high professional and closed-market characteristics; therefore, it is very different regarding the distribution and sharing of knowledge with other industries. Concerning demand, doctors, hospitals, and consumers are the main users of MD products. Furthermore, clinical information about patients is highly complex, difficult to codify, and prone to informal transmission (Gittell and Weiss, 2004).

**Gap 2**

Safety and efficiency are important for medical products since they are used in human bodies. The US and the EU have set up many regulations and legal procedures to ensure proper inspection, verification, and management of the quality of biotechnology and medical products before they enter the market. Therefore, due to high product certification and
competition, it is difficult to predict whether a product can pass the examination or when a product can enter the market. This may result in high operation costs, low survival rates and high entry barriers for small and medium-sized firms in early stages of development.

**Gap 3**

Through industrialization processes, Taiwan has fought strenuously to gain market access to the world through its capacity in OEM/ODM production, such as electronics and IT products in the high-tech sector (Amsden and Chu, 2003). It
has also learned that marketing and branding are even harder than manufacturing. Yet, the MD industry in Taiwan is still in its emerging stage, not a major OEM/ODM manufacturer in the global market. With the much stricter regulations on MD products, and without a brand name that is familiar to hospitals or major consumers, the gap between manufacturing and selling could be very wide.

These three gaps are very difficult for a single SME to manage alone. Creating teams built on trust has been a major issue requiring a solution. STSPA has cooperated with public research institutes and constructed an innovation platform to solve the problems. It has encouraged traditional industry small and medium-sized firms to establish new firms tenanted in KSP and collaborate with universities.

3. STARTUPS FROM THE COOPERATION BETWEEN UNIVERSITIES AND SCIENCE PARKS

A “startup” is a technology firm whose ideas lie outside of the commercial world in a university or other academic setting. In contrast, a “spin-off” is an entrepreneurial venture initiated in a large corporation that is aimed at the market. The transition of technology from invention to innovation is accompanied by the migration of its inventors from academia to a new business. The process of transforming a basic science “invention” into a commercially viable “innovation” may be divided into 5 stages, as shown in Figure 4. The boxes at the top indicate milestones in the development of a science-based innovation.

The importance of institutional innovation has been less discussed; however, as mentioned by Etzkowitz (2012): “Institutions taking non-traditional roles are viewed as a major potential source of innovation in innovation.” The establishment of the pioneering research park ITRI and the science park HSP in Taiwan basically represent a new institutional arrangement; behind the curtain, academia, industry, and government (AIG) are reorganized and generate “a knowledge infrastructure in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces.” As shown in Figure 5, for the successful operation of HSP, the public research institute ITRI plays an important role in the three early stages. The universities and ITRI

Fig. 6. The case of Tainan Science Park
are funded by the government. First, start-up teams tenant in ITRI in order to get technology transfer and business validation. Then they become start-up firms in HSP. Because of ITRI and HSP, angel investors and venture capitals have been willing to invest in these start-up teams and start-up firms.

Different to the case of HSP, TSP has had to rely more on the resources from NCKU. The public research institutes—ITRI and MIRDC, among others—play an innovative management role in this process, as shown in Figure 6. Figure 6 also shows the structure of NCKU academia-industry collaboration (AIC) activities. In most of the other universities in Taiwan, the AIC activities are supervised by the office of R&D; however, in NCKU, the Research & Service Headquarters (RSH) is responsible for most of the AIC activities. NCKU started such operations with RSH in 1996. RSH is a self-funded unit, i.e., it does not receive a university budget. AIC activities contribute to its operational budget.

Currently, there are 75 self-funded research centers in NCKU under the supervision of RSH, and every center has to work with industries to support their own operations (Figure 7). Established in 2007 following a merger of the former Technology Transfer Center with the Incubation Center, the Technology Transfer and Business Incubation Center (TTBIC) is the key branch providing technology transfer and business incubation services under RSH.

In general, the collaboration between universities and industries follows the one to one model in that an industrial partner provides a research fund, and then a university organizes the brainpower and equipment necessary in order to solve a problem identified by the industry and advance the technology. A matching fund partnership approach was established in 2009 between Delta Electronic Co. and NCKU. In this type of matching fund project, both parties are required to raise research funds as well as provide the research manpower. The research topic was proposed by NCKU and accepted by at least one of the nine Delta R&D departments. During the whole research period, NCKU and Delta teams have to meet frequently, and Delta will provide additional industry resources for research teams to solve particular problems when necessary. This is very important for academic teams, especially during prototype development stages. In the past, manufacturers would often reject orders from academia due to limited numbers of prototypes; however, the commitment of Delta to prototype manufacturing solved this comm-
Fig. 8. NCKU AIC Performance

Fig. 9. Two-track incubation at NCKU-STSPA
monly encountered problem. After almost eight years of program execution, four patents were granted and two technologies were licensed. This special collaboration model indicates the potential of “makerspaces,” which have become popular in the last few years.

Other matching fund programs were also established with major research institutions and enterprises in the southern region, for example, MIRDC, ARTC, TSMC, China Steel and AIDC have all set up a partnership co-research program with NCKU. Overall, more than 10% of the whole research fund of NCKU came directly from industries (Figure 8). Since 2009, NCKU royalties in technology licensing has exceeded NTD 100 million, or approximately 3.3 million US dollars. In 2012, the protein IL20 was licensed to the Danish pharmaceutical company Novo Nordisk for an agreed licensing amount of NTD 400 million, which was a new record regarding technology transfer in Taiwan.

In general, there are two tracks for startup programs in NCKU (Figure 9). The first track is mostly for students. NCKU provides courses and training for students to learn about entrepreneurship in the hope that one day they can become entrepreneurs. The second track is aimed at transforming faculty research teams into startup teams by providing services for IP, marketing, finance, and even fundraising.

Following on-campus incubation, if necessary, NCKU can relocate a startup team to STSP. At STSP, NCKU and STSPA have co-established an accelerator where industrial resources are accessible more easily. Following establishment, start-up companies are most welcome to retain connections with the NCKU-STSPA incubation system and apply for the SBIR Project or even file an IPO together. Through the NCKU in-campus incubation process and the NCKU-STSPA collaborative incubation system, many startups have been founded during the last five years. According to preliminary information obtained from websites, the total number of startups has reached 124, as shown in Table 1. According to NCKU-STSPA’s classification system, 62 or half of the startups belong to the category of “innovative technology,” 35% belong to “biotechnology” and the remaining 15% belong to “cloud technology”. Concerning academic affiliation, 21 startups could not be identified in the publicized data among the 124 cases, NCKU associated teams account for almost 50%, and the remaining half are from other academic teams. Although not yet a complete and rigid statistical source, this information may provide a snapshot to understanding the startup phenomenon in the Tainan Technopolitan area and the roles of its major academic player NCKU and the major science park STSP.

### 4. SUMMARY

The science park builders and researchers in Taiwan have been continuously trying to ensure that prosperity is not re-

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Technology</th>
<th>University</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Biotech</td>
<td>Innov Tech</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2013</td>
<td>13</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>2014</td>
<td>28</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>2015</td>
<td>25</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>2016</td>
<td>7</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>2017</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>N/A</td>
<td>48</td>
<td>11</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>124</td>
<td>44</td>
<td>62</td>
</tr>
</tbody>
</table>

served within the park alone. In particular, based on the negative experience of HSP’s early stage development, much of the effort made in the construction and development of the STSP has been made giving consideration to local concerns; thus, the park, the city, and the major university NCKU have managed to co-create a successful collaboration since the introduction of TSP. This positive triple-helix in the region is the foundation of “Tainan Technopolis”.

Following the first stage success in building optoelectronics and green-related industries which are based on existing local industries, Tainan Technopolis has witnessed the rise of initiatives which focuses more on the incubation of high-technology startups. Based on a preliminary investigation of the NCKU-STSPA incubation system and its incubation results, more than one hundred startups have been established through the two-track multi-stage incubation mechanism. Based on the NCKU-STSPA incubation experience, two important points regarding startups have been identified. First, technology is important; however, knowledge of how to transform technology from invention to innovation (business model) is of greater importance. Second, professional support covering all aspects (IP, BM, BP, marketing, finance, regulation) is crucial in order for academic teams to become startups.

The authors noticed that more incubation programs have been established in the Tainan Technopolitan area over the last five years, most notably, makerspaces, and within NCKU, for example, the C-HUB Creative Center. There is a need for further investigation of these new initiatives to learn the multifacet incubation potentials for startups within Tainan Technopolis.

**REFERENCE**


Shiann-Far Kung, Yung-Chih Yen

Park”, 5th International Conference on Planning and Design (25-29 May 2009), Tainan, Taiwan.
Office for Innovation & Entrepreneurship National Chen Kung University. Available at: http://startup.ncku.edu.tw/entrepreneurs/ (accessed at May 2018)

Received March 26, 2018
Revised June 07, 2018
Accepted June 11, 2018