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HSINCHU SCIENCE PARK

TAIWAN

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STRATEGY OF INDUSTRIAL COMPETITIVENESS

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INTRODUCTION

The Silicon Valley. The dream of every country around the world: to have a world-leading cluster in a rapid-growing industry. It appears to be such an appealing asset that the Taiwanese government decided, in the early 80s, to compete with the US Silicon Valley on electronic goods by establishing a science park on the little, but strategic, island of Taiwan.

In the 80s, Taiwanese products, mostly household appliances and light industry goods, were already world-known, but more for their cheap price and their low quality than for their innovative aspect (Porter & van der Linde 2004). Since 1965, the Taiwanese government had established industrial parks, so called export processing zones, but the attractiveness of these areas for foreign investors was declining and the Taiwanese economic growth was slowing down due to its base in low labour costs. So why did the Taiwanese dare to compete against the US technologically-leading Silicon Valley and how did they succeed in this challenge?

Today, Taiwan is one of the world's leading technology nations, much because of the Hsinchu Science Park. This cluster is among the world leaders in technology research, development and production within the areas of integrated circuits, PC/Peripherals, telecommunications, optoelectronics, precision machinery and biotechnology. The cluster is especially important in semiconductor manufacturing, as the home of the two largest companies, Taiwan Semiconductor Manufacturing Company and United Microelectronics Company. Also other large and important companies such as Philips, Realtek, Microtek and Logitech are present. In addition, the cluster comprises a plethora of other, small and large, companies, totalling at 392 in 2007. The cluster is also important as an education and knowledge centre, as the universities are among the best internationally and attract both local and foreign talent.

The Science Park stands for approximately 10 % of the Taiwanese economy, and employs more than 115'000 workers, almost 1 % of the working population of Taiwan and a quarter of the population of Hsinchu City. Its importance is hardly overstated.

The Hsinchu cluster is a strange and interesting entity. It did not emerge because of fierce local competition, high local demand or the presence of a large local firm. Rather, it was deliberately attempted by the Taiwanese government to create a cluster, and in doing so, they could almost be said to have "followed the textbook". This is one of the reasons why it is such an informative case.

After briefly presenting key points of the Hsinchu Science Park, we will present its context, emergence, development and extent and try to understand what makes one of Forbes Magazine's journalists conclude in 1998 that with the Hsinchu Science Park, *"Taiwan reinvents Silicon Valley"*. Finally we will expose the challenges faced by this cluster in 2007 and the policy that is needed to remain a global cluster.

DEFINITION

We should first check if this science park can really be considered as a cluster. For that matter we will refer to Michael Porter's definition of a cluster: "*clusters are geographic concentrations of*

interconnected companies, specialized suppliers, service providers, firms in related industries and associated institutions […] in particular fields that compete but also cooperate" (Porter 1998:197-198)

The Hsinchu Science Park represents 392 companies concentrated on an area of 632 hectares, working in close relation with at least three major high-tech universities and innovation-promoting institutions. The companies are specialized in the particular field of semiconductors and more precisely in integrated circuits, PC peripherals, telecommunication, optoelectronics, precision machinery and biotechnology. We will also show that they compete fiercely but at the same time cooperate and have multiple relationships.

According to Porter's definition, the Hsinchu Science Park can really claim to be a cluster. Starting with this statement we will now try to understand how this cluster did emerge, focusing our attention on the purpose of the implementation of this cluster and on the dynamics that made it a success.

THE BIOGRAPHY OF A CLUSTER: THE POLITICAL WILL AS A SUPPORT TO INDUSTRIAL EFFECTIVENESS

On the Hsinchu Science Park website it is claimed that the *"science parks are established to introduce high-tech industries and attract talent to Taiwan, promote the upgrading of Taiwanese industries, balance regional development and drive national economic development"* (Hsinchu Science Park 2004). It seems then that the decision to establish these science parks and in particular the Hsinchu Science Park has been made on the national level. It is to "drive national economic development". But it also seems that the decision was made in response to three different dynamics: the fact that "made in Taiwan" often meant low quality in consumer minds, the perspective that this cheap production would no longer be a comparative advantage with the emergence of new competitors in the mid 80s, and the brain drain from Taiwanese scientists to the US.

Other than their labour force, Taiwan has no natural resources that can be used as a source of competitive advantage. They therefore needed to educate a highly educated, specialized and dedicated work force. In the early 80s, the Taiwanese government decided to locate infrastructure so as to host small firms and an experimental high school in the outskirts of Hsinchu City. And so, the Hsinchu Science Park is created.

TAIWAN NATIONAL ECONOMIC STRATEGY

Taiwan had one major challenge when deciding to go for the high-tech industry. It was "how to move from a condition of little know-how, inadequate institutions, and an under-supply of trained scientists and engineers to that of a high-tech based economy." (Eriksson 2005) They needed a strategy, and it was based on four main points, taken from Eriksson:

- Building human resources
- Acquiring technology from the more advanced countries.
- Creating science and technology capacities
- Converting research results into commercial products

The Taiwanese government started exploring ways of solving these issues. First, educating the workforce had been a national priority since the sixties. All levels of education were the focus of strict reforms, increasing the number of engineering and science majors dramatically. The government encouraged going abroad for graduate schooling in the 60s and 70s. In the eighties people started coming back, seeing the opportunities before them in the growing technology sector. Having learned research, development and business strategies they fulfilled the government's aim. They brought the expertise abroad back home.

By maintaining close connections with Silicon Valley as well as the Asian technology sector, and focusing on types of semiconductors the other Asian NICs weren't focusing their efforts on, the first PC-manufacturers in Taiwan quickly established a policy of original equipment manufacturing (OEM), letting foreign clients design the products themselves and then using Taiwanese firms such as Acer and Mitac to manufacture the products (Saxenian 2001), thereby creating the opportunity for the state of the art technology to come to Taiwan at a low cost.

When the Industrial Technology Research Institute (ITRI) and the Electronic Research Service Organisation (ERSO) was established in 1973-74 by the Taiwanese state, it was to strengthen Taiwan's own research and development. Their focus was upon both long term research and short term R&D ventures with private companies. Later the government also added research institutes at the four national universities doing research on "applied mechanics, material science, information technology and aviation and aerospace technology."

A major player in the commercialization of research is the Hsinchu Science Park. The government- planned cluster was based on the teachings of Silicon Valley. Easy entry for small and medium size manufacturing firms; easy access to venture capital; public funds and resources for public-private joint research and automation of production; and the focus on higher education for the work force were all part of a strategy of letting firms specialize and be quick to go from design to production. The new firm ideas of original design manufacturing (ODM) and later design cell strategies led to Taiwan having the most flexible manufacturing system in the technology world.

Taiwan succeeded in creating a policy which the people and private enterprises could back, while at the same time creating much needed economic growth to a country so devastated by economic recessions not many years before.

It seems the government has been successful in not only getting involved in the right projects at the right time, but also been able to pull away when they are no longer required. They have not been afraid of losing their expertise abroad, but trusted that their policies of bringing the know-how home would work.

The economic strategy, although quite different from the laissez fair policies of other countries, have not become overly planned as in so many economies in the former east block.

THE CONTEXT: TAIWAN

Taiwan is a small country off the south-eastern coast of China, a country it has somewhat of a strained relationship with, due to Chinese reluctance to see Taiwan as a legitimate entity (See Appendix A). Despite this external as well as some internal political turmoil, Taiwan has developed into a democratic and capitalistic country (CIA Fact book: Taiwan).

ECONOMIC PERFORMANCE

Taiwanese economic performance has been remarkably good for several decades. The country has gone from being poor to become very rich, and is today recognised as one of the "Asian Tigers". Economic growth has been high for decades, and is now at a lower, but still comparatively high rate at about 4, 5 % annually. GDP per capita was 29,000 $ in 2006, ranking Taiwan at 36th place internationally (CIA Fact book: Taiwan).

As for competitiveness, the results are even better. It was ranked at 8th place in the Global Competitiveness Report 2005-2006, and though it fell to 13th place last year, this must be seen as a remarkable achievement (Global Competitiveness Report 2006).

Taiwanese productivity, and productivity growth, is also among the best in the world. The industrial production growth rate was 6, 5 % in 2006. From 2004- 2005, the output per hour

were increasing by 7, 1 % (US Bureau of Labor Statistics 2005). This is much due to a high and rising rate of innovation (Porter 2001). In number of patents filed annually, Taiwan is at 10th place internationally (FT.com).

CLUSTERS

The Hsinchu cluster is without comparison the most important one to the Taiwanese economy, but it does also inhibit significant clusters in plastics and textiles (Porter 2001).

BUSINESS ENVIRONMENT

Taiwan has a sound macroeconomic policy, obtaining positive growth in all years since 1970 except 2001. It has low inflation, at 1 % annually (CIA Fact book: Taiwan). It has quite good protection of property rights and a functioning legal system (Porter 2001).

In recent years the Taiwanese government has privatised banks and industry, and the economy must now be said to be free- market driven.

Although democratic, Taiwan ranks lower in comparisons on political issues than in economic ones, but it must be emphasised that this pose little treat to businesses (Porter 2001).

Taiwan was at 21st place in the Economist Intelligence Unit's Quality of Life Index in 2005, between Austria and Greece. Overall, Taiwan must be said to provide a good environment both for businesses and population.

THE DIAMOND

There are five main industries in the Hsinchu technology cluster: Integrated circuits, computers and peripherals, telecommunications, precision machinery and biotechnology (Hsinchu Science Park 2004).

The **Integrated circuits** field was the original field of the semiconductor industry of which the Taiwanese set out to grab a share. In 2004 this was still the biggest part of the Hsinchu cluster with about 66 thousand employees spread in 164 companies. The industry in Hsinchu has gone from producing mainly PC-components to components for other products. These include consumer electronics and communication equipment, both of which are major manufacturing industries in Asia. The industry in Taiwan has moved towards more sophisticated System-on-chip design, moving up the value chain from their start in low-cost manufacturing.

Computers and peripherals and **telecommunications** are two fields in which there has been an enormous development. Hsinchu companies like ACCTON, ELAN, Realtek and ACER have been responsible for both key components like WLAN-chips and processors and consumer products like the Skype Wi-Fi phone and laptop computers.

Precision machinery is a growing field. In Hsinchu the precision machinery sector had a growth of 60% from 2003 to 2004, giving revenue of $277 million.

Biotechnology is the way of the future in Hsinchu. With an increasing demand for high-tech medical equipment, several companies have seen the opportunity of capitalizing on already present expertise within the previously mentioned fields. The government has yet again been helpful addressing the R&D issues by initializing cooperation between state hospitals and research institutions and private businesses.

Michael Porter (1998) outlines four determinants of national competitive advantage in his "Diamond Model of National Advantage." We will show how these apply to the Taiwan and the Hsinchu Science Park in the following. See also Appendix B and C.

FIRM STRATEGY, STRUCTURE AND RIVALRY

Unlike most clusters, the Hsinchu cluster was established by the government to create a strong business environment in the technology sector. (van der Linde 2003)

The key word in the Taiwanese model of business is specialization. By specializing in a manner previously unseen in the Asian countries, the Hsinchu-based companies have managed to create a decentralized industrial system which "enhances speed and responsiveness because it reduces barriers to entry, encourages experimentation, and allows for greater focus and flexibility" (Saxenian 2001).

In addition there is a highly visible product line in the cluster. Every year there is the Innovative product awards for innovative R&D, in which some of the winners are components easily integrated into other firms' product lines, while others are complete appliances in them selves. As an example of products earning this award, in 2004 two of the awarded products were Realtek's triple mode WLAN-chipset and AU Optronics' 46" HDTV (Hsinchu Science Park), both of which use technology from other manufacturers situated in Hsinchu (See Appendix E).

The firms have more a single shared employee stock than separate employees. Of the 115,000 employees in the Hsinchu Science Park alone, several have worked in more than one company, and it is not uncommon for company leaders to have been researchers in the local universities, members of the different councils set down by the Taiwanese local and central governments or had leading positions abroad.

There is heavy international competition in the industries the science park consists of. Most prominently, Japanese and South Korean firms are hard rivals. Much of the competition is based on innovation. Competition within the cluster is less prominent, with firms acting more as complements to each other than as competitors (Saxenian 2001).

FACTOR CONDITIONS

The factor conditions in Taiwan are excellent for the Hsinchu science cluster. The main production factor in the semiconductor industry is entrepreneurship and human capital. Through the decentralized system of production there is a flow of human capital not only between firms, but also between this and other clusters. The low age of workers, in average 32 years, adds to this mobility.

In addition to the regular cluster effects of closely linked workers and spillover effects, the Hsinchu cluster has had the advantage of having the two main Taiwanese tech-schools in the immediate vicinity, creating a bond between education and business. In addition, the alumni of these universities have been a main factor in setting up training for the companies situated in the area. The National Tsing Hua University and the National Ciao Tung University are cooperating with companies to train specialized people particularly in engineering. The classes offered by the two universities are in direct match with the needs of local firms. As a counterpart companies of the Hsinchu Science Park are offering many on-the-job trainings and internships to the students of these two universities. As a consequence the skilled population working in the Hsinchu Science Park is rising constantly to reach the impressive number of 115,447 employees at the end of 2004. But even more impressive is the average educational background of employees working for Hsinchu Science Park companies. Indeed 67% of Hsinchu Science Park workers have a college degree or more (See Appendix D)(Hsinchu Science Park 2004).

The exodus of Taiwan's best brains has also been dammed up by the establishment of the Hsinchu Science Park. In fact over 4500 people with foreign university degrees have returned to Taiwan to work in a company located in the Hsinchu Science Park. These returnees have been a great source of upgrading and innovation, both technological and managerial, for the firms of the park. They have also contributed to the creation and the establishment of many Taiwanese companies in the Hsinchu Science Park, which can claim in 2004 to have about 335 Taiwanese companies and only 50 foreign companies in the park.

Venture capital, being a major condition for succeeding in the semiconductor field, is not a problem in Taiwan. The Taiwanese government tried to imitate their successful American counterparts in Silicon Valley by initializing a Taiwanese venture capital industry in the early eighties (Saxenian 2001). Capital is readily available, although financial market sophistication is lagging somewhat. Adding to these favourable conditions, taxes are low and infrastructure quite good, keeping costs down (Porter 2001). In combination with a stable macroeconomic regime, as mentioned above, the capital markets must be said to be attractive.

DEMAND CONDITIONS

Unlike most clusters, there was initially not really a local demand for the products manufactured in Hsinchu. The demand was international. By being a decentralized industry situated in a relatively small area, the companies managed to feed the external demand by combining in different variations of partnerships. One company may take a part originally meant for one use and utilize it in something completely different to feed a demand overseas.

Taiwan's main export destinations are China, the US, EU and Japan, as well as their other neighbours. It thus has a close proximity to some trade partners, and it has good infrastructure to serve the ones further away by sea or by air.

With 22 million inhabitants, there is a sufficiently large domestic market to provide advantages to Taiwanese businesses. The technology sector has an advantage in that the Taiwanese are quick to adapt to new technologies; here it ranks 8th in the world (Porter 2001).

RELATED AND SUPPORTING INDUSTRIES

Because of the incredible flexibility of the Taiwanese system, any industry using semiconductors is a related industry, from refrigerators to high-end network servers. This means that any manufacturing company in Asia and beyond can use the Taiwanese firms as suppliers of parts in addition to the consumer products produced by the Taiwanese themselves.

In addition to the above-mentioned venture capital industry, the knowledge industry with both universities and research institutions has been very active in the area. This is mainly through the Taiwanese government and their attempts of improving human capital through a number of ways. They encouraged engineers to spend time in the research labs available to ITRI, ERSO, or one of the other research institutions of Hsinchu to become familiar with research in the technology field.

STRATEGIC ISSUES / RECOMMENDATIONS

One clear statement has to be done: the future of the Hsinchu Science Park is not guaranteed and clouds are rising in the sky of Taiwan's high-tech sector. To convince one self of the possible problems ahead for the Hsinchu Science Park, we just have to take a look at its latest financial results. In an article published by the Taiwan Headlines on March 27, 2006, it is reported that "*the Hsinchu Science Park saw its revenues fall by 7 percent in 2005. This figure is in sharp contrast to the original target of a 6-percent growth set by the National Science Council, which administers Taiwan's science parks"* (Taiwan.com.au). In the light of this figure, it seems pretty obvious that the Hsinchu Science Park has to worry about its future and pay great attention to the strategic challenges it is facing today. In an attempt to help the Hsinchu Science Park remain a dynamic and leading cluster we will put forward some recommendations.

The decline in profits that we just mentioned is due to slumping prices for high-tech products in general. Indeed the market of PC peripherals is quite mature and some of leading Hsinchu Science Park companies specialized in PC peripherals are moving to the Mainland of China and specially to the Dongguan area in Guangdong province to take advantage of wages that are one-tenth of those in Taiwan (Saxenian 2001). Unfortunately for the Taiwanese economy this move does not only concern low-added value products but it also concerns video cards, notebook PCs

as well as IC design. So it really seems to us that the Hsinchu Science Park has to upgrade its production.

For that matter the Taiwanese government should make new investments into sectors that are today marginal in the Hsinchu Science Park production and that will be fast growing in the coming years. We claim that sectors such as optoelectronics, precision machinery and especially biotechnology should be developed to make sure that the Hsinchu Science Park will remain dynamic in the future (See Appendix F). We believe that the Taiwanese institutions should concentrate their efforts on fostering the development of an upgraded cluster specialized in medical devices and biotechnology. This upgrading makes good sense as some Hsinchu Science Park companies can capitalize on their current knowledge in semiconductors and precision machinery to produce medical devices. Some easy industrial bridges can be built.

Even though to deliberately crush the existing cluster would be simply dramatic for Taiwan, it seems that its middle term future is in danger. So the Taiwanese government should anticipate this trend and reconfigure some of its assets. Here are some of the strategic consequences this upgrading will have for the Hsinchu Science Park. These consequences represent strategic issues the Taiwanese will have to pay great attention to.

If the Hsinchu Science Park is being upgraded to be specialized in the sector of medical devices and biotechnology, it may suffer from a lack of competences in this particular field. So the challenge for the Hsinchu Science Park will be to attract new companies that are specialized in biomedical devices as it has been done in the 80s and 90s with foreign companies specialized in semiconductors. We believe the Taiwanese government can follow the path to upgrade as it did to develop the cluster: to attract knowledge from outside and then capitalize on it to become innovative. The Hsinchu Science Park ability to be appealing for foreign companies depends once again on its infrastructure/capital structure and on the relation the Taiwanese institutions have with companies and similar institutions in clusters specialized in medical devices and biotechnologies. The Hsinchu Science Park cooperated (and still cooperates) with the Silicon Valley to develop and it has to do the same for its upgrading: establishing privileged relationships with leading entities in the medical devices industry such as the US based Massachusetts Medical Device Industry Council.

As we put it before it is one thing to attract new competences that will match with the ambition of the Hsinchu Science Park to be a cluster in medical devices and biotechnologies but it is another to be able to capitalize on these competences. As a consequence the Hsinchu Science Park may have to reconfigure its knowledge value chain. Indeed it has been shown that the highly skilled labour force trained by local top-level universities has been one of the key success factors of the Hsinchu Science Park. So the Taiwanese government has to pay great attention to the fit between the competences that are needed by companies and what the labour force is trained for. We would recommend that the content of what is being taught in the Taiwanese universities have to be redesigned and adapted, for instance by creating trainings specialized in biotechnologies and medical devices industry.

Another recommendation would be to encourage the attraction of Small and Medium size Companies (SMCs) specialized in medical devices. These SMCs are known to be very flexible, to have great adaptation ability. As the sector of medical devices and biotechnologies will develop a lot in the coming years, no one can predict what will be profitable in 10 years. As a consequence experimentations will have to be conducted in this area. Based on the Japanese example, it is known that SMCs are more efficient in leading experimentations. As a conclusion, to have more chances not to miss the next evolution in biotechnologies, the Taiwanese government and institutions such as the ITRI or the ERSO should encourage the implantation of SMCs specialized in biotechnologies.

The Taiwanese government has put a lot of efforts in developing new science parks in other areas of the island. These science parks are specialized in other, but related, high tech industries. The development of these science parks has been partly made to the prejudice of the Hsinchu

Science Park because by diversifying its investments the Taiwanese government has hindered the ability of the Hsinchu Science Park to adapt itself to its environment. We believe that the Taiwanese government should realize that the upgrading of the Hsinchu Science Park may cost less than investing in new science parks because of the capitalization on existing infrastructures and relationships and that the upgrading of the Hsinchu Science Park cluster can be a great source of profits in the coming decade.

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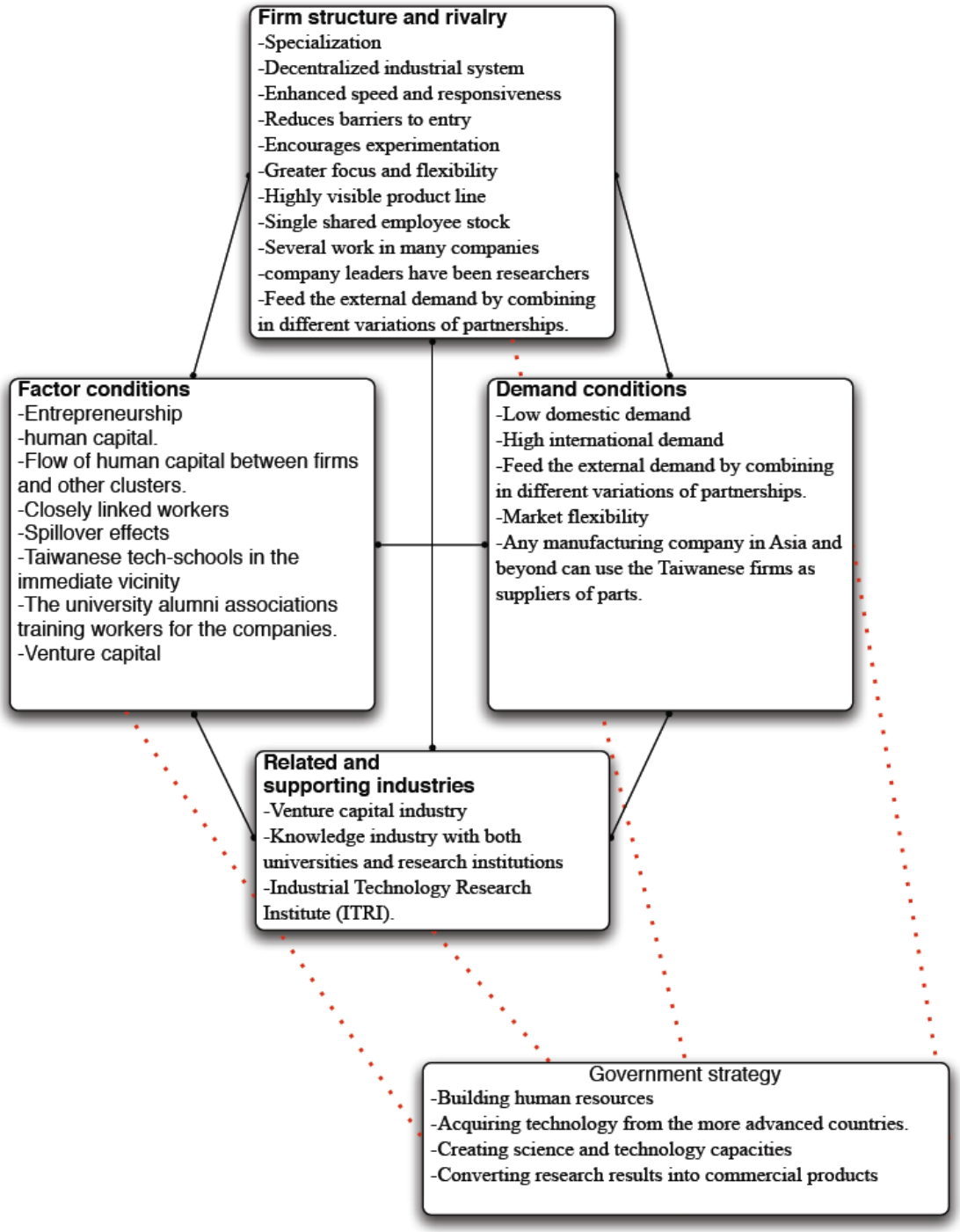
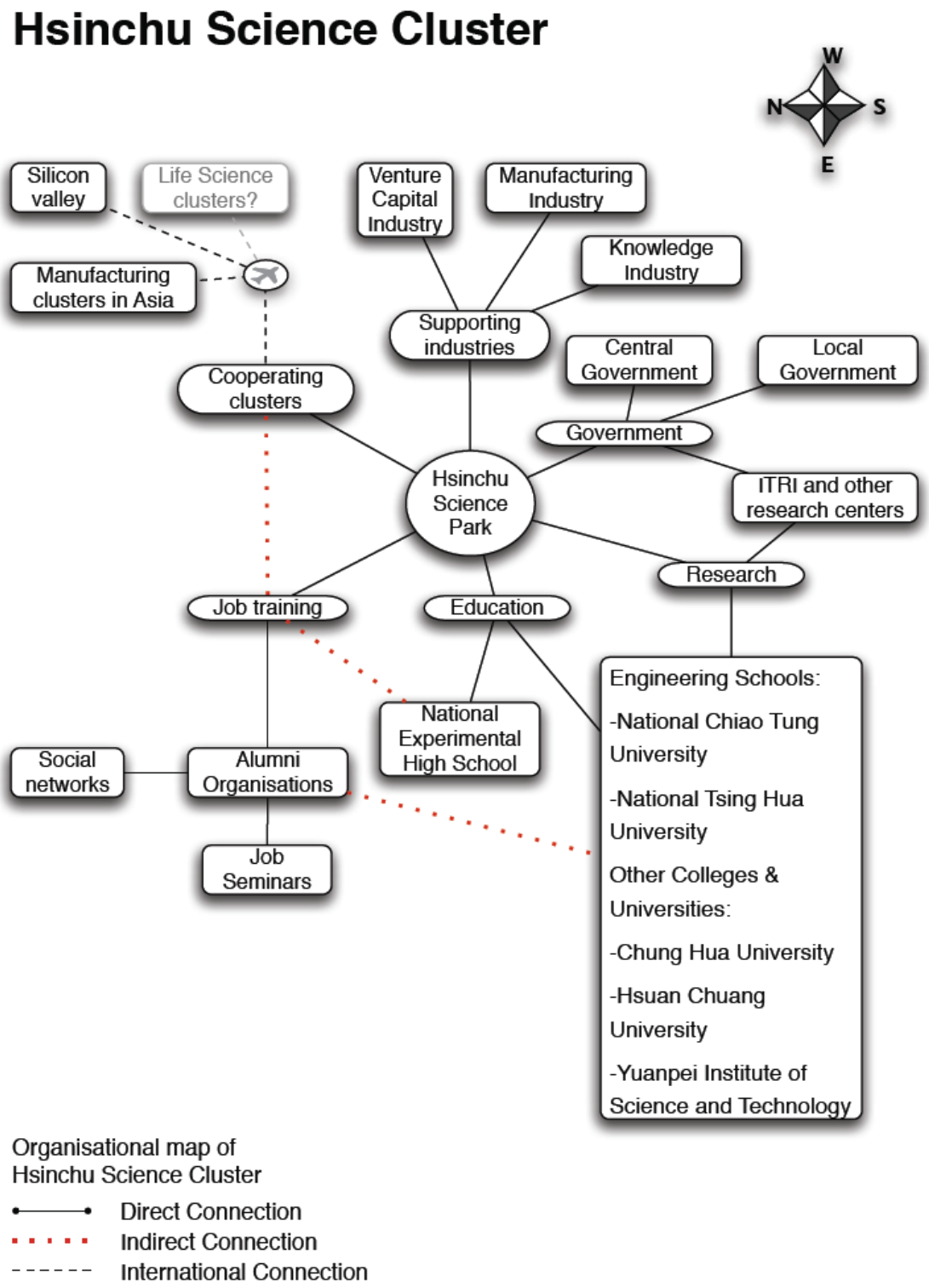
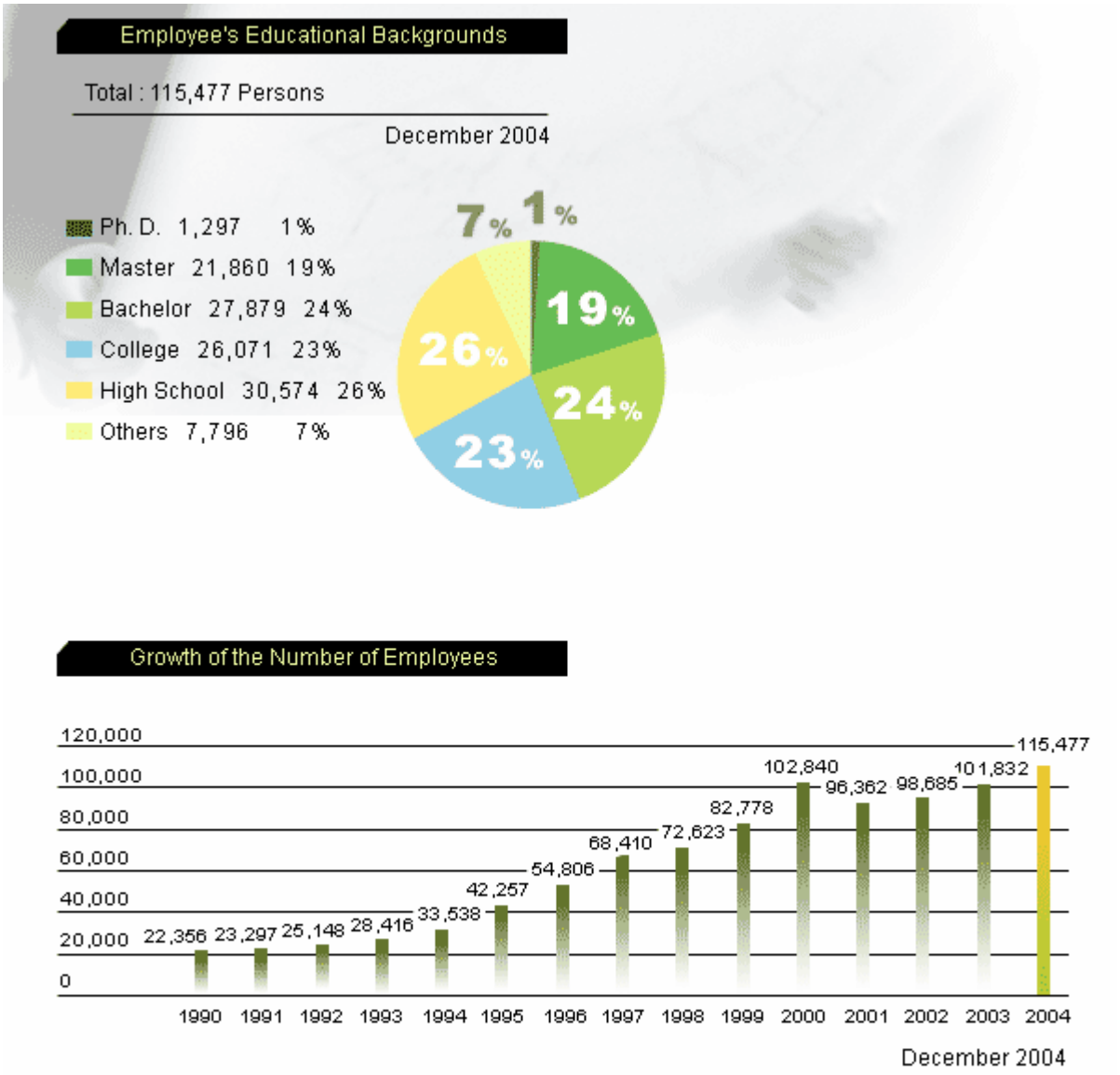
APPENDIX A: MAP

APPENDIX B: DIAMOND




Hsinchu Science Cluster
W
N
S
E
Silicon valley
Life Science clusters?
Manufacturing clusters in Asia
Venture Capital Industry
Manufacturing Industry
Knowledge Industry
Supporting industries
Central Government
Local Government
Government
Cooperating clusters
Hsinchu Science Park
ITRI and other research centers
Research
Job training
Education
Engineering Schools:
-National Chiao Tung University
-National Tsing Hua University
Other Colleges & Universities:
-Chung Hua University
-Hsuan Chuang University
-Yuanpei Institute of Science and Technology
National Experimental High School
Social networks
Alumni Organisations
Job Seminars
Organisational map of Hsinchu Science Cluster
Direct Connection
Indirect Connection
International Connection


Employee's Educational Backgrounds
Total : 115,477 Persons
December 2004
Ph. D. 1,297 1%
Master 21,860 19%
Bachelor 27,879 24%
College 26,071 23%
High School 30,574 26%
Others 7,796 7%
7%
1%
19%
26%
24%
23%
Growth of the Number of Employees
120,000
100,000
80,000
60,000
40,000
20,000
0
22,356
23,297
25,148
28,416
33,538
42,257
54,806
68,410
72,623
82,778
102,840
96,362
98,685
101,832
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1996
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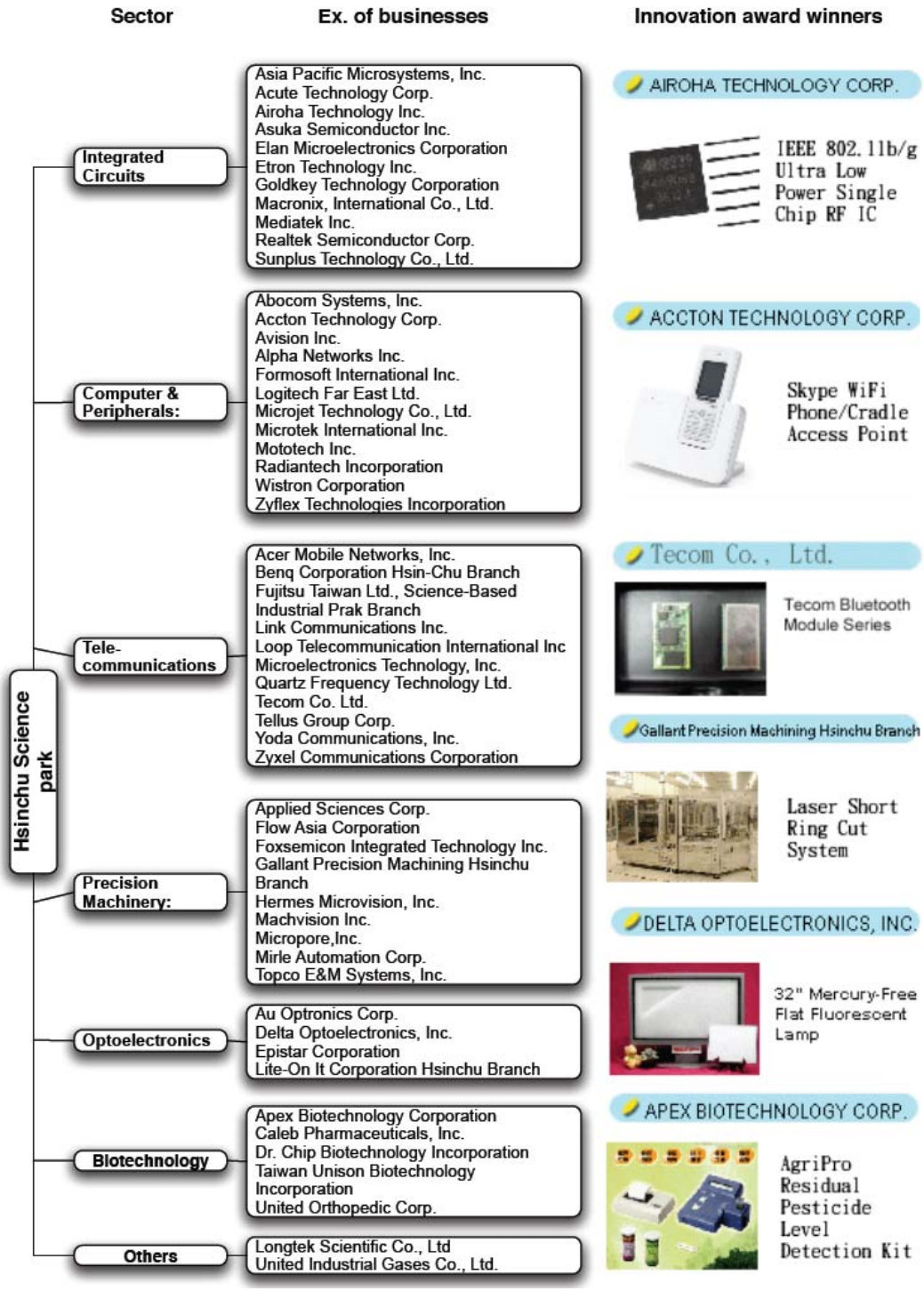
2004
December 2004


Sector
Ex. of businesses
Innovation award winners
Hsinchu Science park
Integrated Circuits
Asia Pacific Microsystems, Inc.
Acute Technology Corp.
Airoha Technology Inc.
Asuka Semiconductor Inc.
Elan Microelectronics Corporation
Etron Technology Inc.
Goldkey Technology Corporation
Macronix, International Co., Ltd.
Mediatek Inc.
Realtek Semiconductor Corp.
Sunplus Technology Co., Ltd.
AIROHA TECHNOLOGY CORP.
IEEE 802.11b/g Ultra Low Power Single Chip RF IC
Computer & Peripherals:
Abocom Systems, Inc.
Accton Technology Corp.
Avision Inc.
Alpha Networks Inc.
Formosoft International Inc.
Logitech Far East Ltd.
Microjet Technology Co., Ltd.
Microtek International Inc.
Mototech Inc.
Radiantech Incorporation
Wistron Corporation
Zyflex Technologies Incorporation
ACCTON TECHNOLOGY CORP.
Skype WiFi Phone/Cradle Access Point
Tele-communications
Acer Mobile Networks, Inc.
Benq Corporation Hsin-Chu Branch
Fujitsu Taiwan Ltd., Science-Based Industrial Prak Branch
Link Communications Inc.
Loop Telecommunication International Inc
Microelectronics Technology, Inc.
Quartz Frequency Technology Ltd.
Tecom Co. Ltd.
Tellus Group Corp.
Yoda Communications, Inc.
Zyxel Communications Corporation
Tecom Co., Ltd.
Tecom Bluetooth Module Series
Precision Machinery:
Applied Sciences Corp.
Flow Asia Corporation
Foxsemicon Integrated Technology Inc.
Gallant Precision Machining Hsinchu Branch
Hermes Microvision, Inc.
Machvision Inc.
Micropore,Inc.
Mirle Automation Corp.
Topco E&M Systems, Inc.
Gallant Precision Machining Hsinchu Branch
Laser Short Ring Cut System
Optoelectronics
Au Optronics Corp.
Delta Optoelectronics, Inc.
Epistar Corporation
Lite-On It Corporation Hsinchu Branch
DELTA OPTOELECTRONICS, INC.
32" Mercury-Free Flat Fluorescent Lamp
Biotechnology
Apex Biotechnology Corporation
Caleb Pharmaceuticals, Inc.
Dr. Chip Biotechnology Incorporation
Taiwan Unison Biotechnology Incorporation
United Orthopedic Corp.
APEX BIOTECHNOLOGY CORP.
AgriPro Residual Pesticide Level Detection Kit
Others
Longtek Scientific Co., Ltd
United Industrial Gases Co., Ltd.