The ITRI Experience: Innovative Engine of Taiwan's High Tech Industry

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1.Foreword

In recent years, Taiwan's flourishing electronics industry has become the role model for countries pursing similar paths. The focus of attention has been the so-called 'corridor of technology' between Taipei and the Science-based Industrial Park in Hsinchu. The high-tech electronics industry within this corridor is the driving force of the general electronics industry on the island- both in terms of annual output and management. Much has been written about reasons behind the phenomenal success of Taiwan's electronics industry, and a lot of literature analyzes the phenomenon from various angles- funding, know-how, human capital, government policy, to name a few. In fact, the largest government-funded research institution in Taiwan- the Industrial Technology Research Institute (ITRI)- has played a crucial role in the formation of high-tech electronics industry on the island and this article will examine the industry's development from an ITRI's perspective.

Several economists have written about ways government can support research activities in the private sector. One is through subsidy for research and development (R&D); another is through joint venture between industry and research body (usually funded by government). The rationale behind government's subsidy for research and development is that, where market malfunctions or capital market suffers from underdevelopment, the level of capital firms designate for R&D is lower than normal average. It is a natural outcome from the firms' perspective considering the relatively limited resources enjoyed by each. It should come as little surprise that firms tend to opt for R&D project of more commercial value, ones more likely to create profit, or those with higher potential for success (Lach, 2000). This tendency is also due to the public-good nature of R&D investments and the high degree of uncertainty in the development process (Arrow, 1962). In other words, it is difficult for firms investing in R&D to be in full control of the profits derived from their investment. Even if patents are successfully obtained after a new technology has been developed, competitors can enjoy the fruit simply by investing around the new technology. Moreover, R&D activities are by nature highly unpredictable, their commercial value and effects on business remain uncertain even after a project is successfully concluded. This is the main reason R&D activities are usually treated as expense and not capital expenditure. Looking at the overall picture, the

accumulated result is a lower level of investment in R&D than there should be in a society as a whole. Through subsidies, government channels firms into research activities of fundamental value that bring great social benefits. One of the social benefits is the technology overflow to other firms, namely upgrades in production process and reduction in overall manufacturing costs. Another benefit is the consequent high quality of goods for consumers. When the reward to society is potentially greater than that to a firm, government has every reason to subsidize R&D projects (Arrow, 1962). It should be pointed out that despite good intentions of the government, it is possible that not all government subsidies earmarked for R&D actually go into the designated projects, it is possible that some might even end up in the pockets of researchers and developers themselves (Goolsbee, 1998).

In regards to the joint venture between industry and research body, it is largely done through privately formed consortium between corporations or through a government-founded or -coordinated research body. Generally speaking, corporations form consortium with each other for certain mutual benefit. Through coordination, several firms pool together available resources in production, research, and development for technological cooperation (Poyago-Theotoky, 1995; Hagedoorn and Narula, 1998) and share the costs in joint R&D activities (Poyago-Theotoky, 1995). Another reason firms come together for certain R&D activities are the high risks involved. A consortium distributes the risks among participants, lowering the risk for any particular individual. In Irwin and Klenow's study (1996) for semi-conductor manufacturers in the United States, it was found that firms aimed to lower overlapping in R&D expenditure, thereby increasing efficiency. In this case, government subsidy reduces R&D expenditure, bringing in a substitution effect.

Branstetter and Sakakibara's study (1998), examining the Japanese government's subsidy to the R&D consortium in the private sector, found different results. Unlike the case of SEMATECH, it was found that Japanese firms enter a consortium in search of R&D projects complementary to the ones they have on hand. Government subsidy in this case actually increases firms' willingness to spend on R&D activities because through complementary projects, firms acquire know-how from one another. As regards the government-established or -coordinated research body, in addition to have the benefits already mentioned, has the additional advantage of greatly lowering the uncertainty involved. In return, government exerts a more direct influence on the private sector through publicly-funded research body or designated technology projects (Grovlen and Aarvak, 1997; Hendry, et al., 2000; Bozeman and Wittermer, 2001).

In recent years, the focus has been on the electronics industry in Taiwan, where most of the major manufactures are located in the corridor between Taipei and the Science-based Industrial Park in Hsinchu. In the past, literature that examines reasons behind the phenomenal success of the industry mostly cites the import of high-tech employees and extensive support from the academia as the main causes. This paper looks at the issue from the perspective of a government-funded research body. In particular, it accounts the formation of high-tech industry in Taiwan by examining the interaction and technological cooperation between high-tech manufacturers and the Industrial Technology Research Institute (ITRI) since its foundation 30 years ago.

2. Taiwan's High-Tech Industry and the Foundation of the Industrial Technology Research Institute

2.1 High-Tech Industry Development Policy in Taiwan

The government has played an important role in the history of industrial development in Taiwan. In the early era, the government directed the development of industries through its trade policy. The early era is broadly divided into the following four periods:

1. Light Industry Period (1945-1969)

After the Civil War in China and relocation to Taiwan, the government's priority was to stimulate production and assist in economic recovery. From 1945 to 1958, the first import substitution policy was implemented. It was hoped that by imposing restriction on imports[1], domestic industry would enjoy more room for growth. Under this circumstance, price of imported goods was inflated and, sensing diminished competition, local manufacturers were consequently more willing to produce and invest.

However, even though this substitution policy successfully induced many manufacturers to production and investment, the relative small size of individual manufacturer translated into limited effects on the general economy. Moreover, the protectionist policy aimed to shield infant industry from competition then had the obvious effect of prolonging the lifespan of uncompetitive manufacturers, lowering the overall production efficiency. The major beneficiary of the first wave of protectionist policy was the textile industry, but due to the small size of the domestic market, this import substitution policy very soon reached its limit.[2] Therefore from 1958 on, the government in Taiwan implemented an export expansion policy instead. Textile and plastic goods, along with other light industry products, replaced rice, sugar, and other agricultural products to become the majority of exports. Trade surplus brought in foreign reserve for Taiwan. On the other hand, import substitution and protectionist policy for infant industry survived, and the problem of inefficiency persisted, creating a sharp contrast to the effective export sector.

2. Heavy Industry Period (1969-1980)

Following the export expansion policy of the previous period, domestic manufacturers started to assemble machine parts made overseas and export the finished products abroad. The machinery needed in the production process was mostly imported at this stage. From 1969, the government in Taiwan began implementing the second wave of the import substitution policy and with it, the fifth Four-Year economic development plan. The main goal was to help domestic manufacturers make the material needed for production downstream themselves and to build the machinery required for production. Lowering dependence on imports step-by-step, the ultimate aim was to achieve total technological independence. Petrol-chemical, mechanical, ship-building, and steel industries were the main foci of attention. Parallel can be drawn between the import substitution policy in this period and that before. However, while the restriction on import was aimed at consumer goods, in this period, the limitation was on production material and machinery.

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[1] In the first import substitution period, domestic manufacturers can apply for import restriction if the price of their products is within 15% of imported products.

[2] The textile industry experienced price drop in 1958 as a result of overproduction.

In this period, other external economic and political factors also played a role in the industrial development in Taiwan. The Oil Crises in 1973 and 1978 and Taiwan's withdrawal from the United Nations, coupled with the rapid rising of neighboring economies, strengthened the administration's resolve for further industrial development. In addition to the restriction on imports and exports, the government put in place a regulation to encourage investment in 1960. Selected industries were exempted from taxation for a certain period –mostly in the export sector and the domestic infant industry- lending a helping hand to the struggling industries in the early period.

3. Technology-Intensive Period (1980-1995)

With the momentum and experience accumulated in raw material and machinery production, the economy was primed for certain strategic technology-intensive industries. The focus began to shift to information, electronics, automobile, mechanical and electric engineering. The Science-based Industrial Park was established in Hsinchu in 1980, where these capital- and technology-intensive industries pushed Taiwan's economy into a period of rapid growth.

Additionally, the government began to allow foreign firms to invest in Taiwan. The benefits of foreign investment include obviously the introduction of capital and expansion in size of industry. Moreover, the production know-how that follows foreign investment has a positive spillover effect on local industries. The government implemented a special regulation in 1990 aiming to upgrade the industries by encouraging investment in R&D, automated assembly line, and pollution prevention measures. It was hoped that this new regulation would gradually replace the one put in place in 1960. In 1991, the Six-year National Construction Plan began in earnest. Telecommunication, information, consumer electronics, precision machinery and automation, high-performance material, semiconductor, pharmaceutical, aviation, medical and health, pollution prevention, were designated as focal points. To realize development in the above industries, the following technology was named as of particular relevance. They include optoelectronics, software, material application, industry automation, precision measurement, energy conservation, and biotechnology.

4. High-Tech Industry Period (1995-present)

With the benefit of experience accumulated so far, Taiwan's high-tech electronics industry began to take the front seat in the island's drive for development. The vital strengths of high-tech come from its high added value and the high threshold to new entrants. These features enable firms to quickly accumulate capital and re-invest in research and development. The high-tech electronics industry in Taiwan has concentrated in Hsinchu and the region to its north. The Science-based Industrial Park, located in Hsinchu itself, is key.

With the benefit of hindsight, one can conclude that the trade policy of the earlier era left an indelible mark on the shape of industries in different period. It is obvious that the high-tech electronics industry did not descend upon the island out of nowhere. From light, heavy, technology-intensive to high-tech industry, progress was achieved with plans and the accumulation of the required know-how. Government policy has played an indisputably vital role in facilitating development. Besides the industry policy that had a direct bearing on firms, significantly the government also put in place research institutes

that act as the go-between for itself and the private sector. What follows is an account of the role played by the Industrial Technology Research Institute (ITRI) so far.

2.2 The Rationale of ITRI

As seen from above, before the 1970s, agriculture and labor-intensive light industries were the core of Taiwan's economy. Between 1960 and 1970, the import substitution and export subsidy policy took effect and the trade surplus became the norm. With the rise of textile, plastic, and electronic goods industries, the government's main strategy was to accumulate as much foreign reserve as fast possible through mass production. With pressures coming from political crisis (Taiwan's withdrawal from the United Nations), economic backlash (the first Oil Crisis in 1973), and the rapid emergence of neighboring economies, the government was anxious to lend its force to industrial development and trigger an economic take-off. To realize this goal, the focus had to shift from labor-intensive consumer goods industry to technology-intensive manufacturing industry. Learning from successful models overseas, the government contributed the funds to combine existing technology research institutes,[3]and with the assistance of Taiwanese scholars abroad, founded the Industrial Technology Research Institute in 1973.

Besides the merger of existing research institutes, the Electronics Research and Service Organization (ERSO) was founded in 1974, its mission was to develop the integrated circuit "Complementary Metal-oxide Semiconductor" (CMOS) technology. A partnership was established with the RCA from the United States in 1975. ITRI chose CMOS as the priority because it foresaw the future of the electronics industry in consumer goods, and CMOS has the strength of evolving with the technology in consumer goods production. Besides, there was no conflict of interest with RCA, whose focus was on semiconductor. As a partner, RCA not only supplied assistance concerning CMOS technology, it also provided training on its site for employees from ITRI. There is no doubt that the CMOS technological support from RCA laid the cornerstone for Taiwan's semiconductor industry. In certain aspects, the training of selected ITRI staff at RCA was the decisive moment in the semiconductor industry's 30-year history. Economists have discussed about technology transfer through reassigning rights, technological cooperation, or investment. These are direct transfer. On-site training, on the other hand, is less direct and subtle. Because of its geographic-specific and non-saleable quality, there is a lot one would miss unless within the vicinity. In other words, the most valuable outcome was the 'hidden' knowledge these ITRI trainees brought back. RCA's technology transfer later on was merely an official acknowledgement of the right to utilize that knowledge.

ITRI differ from other national research institutes in its 'factory.'[4] As soon as the trainees returned from RCA, a model factory for integrated circuit was established within ITRI in 1977. The purpose of the 'factory' was to stimulate production and promote R&D activities. The products from this 'factory' were freely distributed among domestic manufacturers. The operation of this 'factory' served as a practical confirmation for those who received training at RCA. The 'hidden' knowledge they gained by just being at RCA

[3]Union Industrial Research Laboratories, Mining Research & Service Organization, and Metal Industrial Research Institute.

[4] Called 'workshop' at first, later changed to 'factory' to reflect its commercial value.

was passed along to those who were not fortunate enough to be selected. Secondly, the model 'factory' allowed the RCA trainees to experiment from the actual production process, and pass along the newly discovered know-how to the private sector.

The literature published so far has pointed out that a government-funded research institute has the advantage of avoiding repetitive investment in similar R&D projects (Sakakibara, 1997), the public nature of government-funded institute facilitates technological spillovers (Nadiri, 1993; Sakakibara, 1997; Autant-Bernad, 2001). Both benefits are evident in the case ITRI. Additionally, the RCA trainees brought significant benefits to the economy with their newly acquired knowledge and more importantly, their ability to solve complex issues arising from production process. The model 'factory' multiplied its volume of production and quality of its products very soon surpassed that of RCA. RCA was compelled to withdraw from the Asian market after losing significant market share.

Most of the literature dealing with the high-tech community north of Hsinchu has centered on the impact of government policy, technology drive, and market forces. There is a consensus that ITRI was vital in the drive for advance in technology. The history of the high-tech community can be divided into three general periods. The first is pre-1990, when a large number of Taiwanese-born scholars returned to establish their own businesses and the origin of this high-tech community- ITRI's founding Electronics Research and Service Organization (ERSO) in 1974. Notable events include the model 'factory' mentioned above and the production of first IC in 1977. Several research units within the Institute were spun off as companies: United Microelectronics Corp. in 1980, Syntek Semiconductor Co. Ltd. in 1983, Taiwan Semiconductor Manufacturing Company Ltd in1987, Taiwan Mask Corporation (TMC) in 1988, and Vanguard International Semiconductor Corporation in 1994. The second period began around 1995 when local R&D and cooperation with foreign firms both flourished. ITRI's main role at this stage was technology transfer and training. With the industrial scientific and professionals in 1997, the passage of Scientific Technology Basic Act and Small and Medium Enterprise New Technology Development Plan in 1998, and the academia scientific and professionals and releasing of intellectual property rights in 2001, indigenous firms have accumulated enough R&D momentum. Therefore in the third period, the role of ITRI was less direction than encouragement and assistance.

The main factors behind the coming together of the high-tech community north of Hsinchu are technology, human capital, funds, and management. There are five different ways technology came about in this region. At the beginning the majority of the new technology was introduced by research bodies from abroad. Then the technology was brought in by the firms themselves or developed jointly by firms and research bodies. Sometimes research bodies transferred the technology to the private sector while other times the firms developed the technology wholly on their own. As far as introduction of technology is concerned, ITRI is the most important source of technology. However, through "Spin-off Company", "Incubator Center" and "Technology R&D Share" the private sector has gradually adopted ways of introducing new technology independent of ITRI, for example, directly through authorization from foreign companies, technology stocks, and returning scholars.

In regards to the human capital, the source of employees is largely 1) ITRI; 2) graduates of Tsing-Hua and Chiao-Tong universities; 3) returning scholars from abroad;

4) the professional training organized by the Science-based Industrial Park in Hsinchu. The private sector confirmed the ability of ITRI staff with the substantial salary they generally receive when transferring to posts in private sector. From its spin-off companies and contract work with firms, ITRI also contributes to the flow of talents.

In conclusion, ITRI plays a vital role in the phenomenal success in the Science-based Industrial Park and beyond. What follows is a detailed study of the interrelationship between research body and the private sector. Exhibit 1 explains the ITRI model for creating technological enterprises, including the spin-off companies and flow of talents that gave rise to the flourishing of information technology industry in Hsinchu.

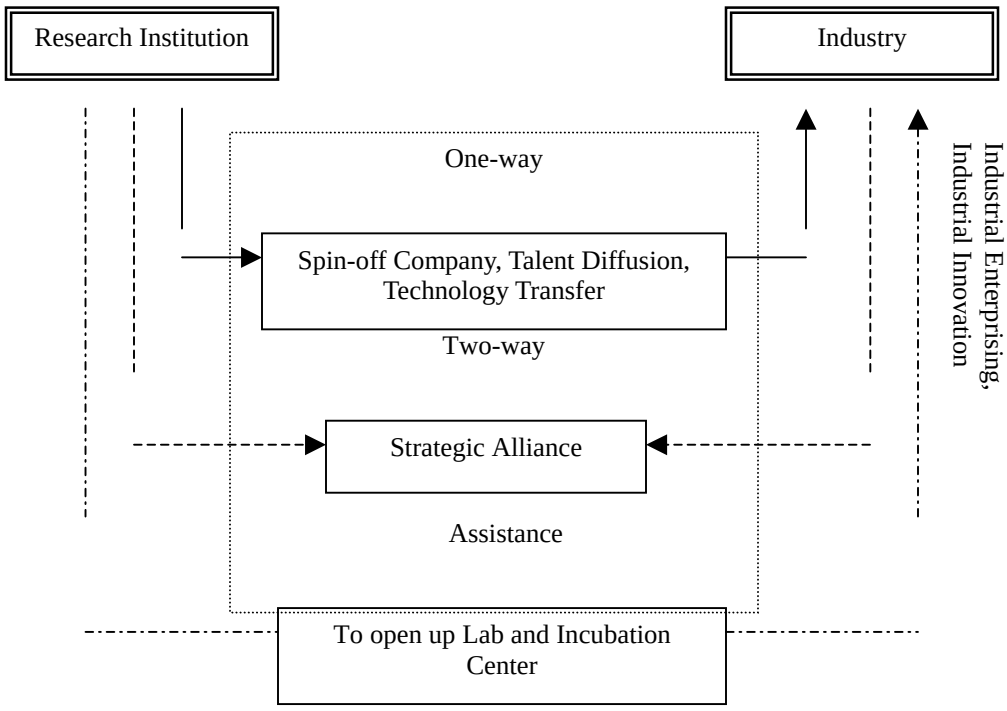

Figure 1. ITRI S & T Enterprising Mold Diagram

ITRI and the Development of the Electronics Industry in Taiwan

The government established the Electronics Research and Service Organization (ERSO) in 1974 to focus on semiconductor products research. In 1978, the IC factory at ITRI was completed and indigenous producers began to manufacture IC independently. In 1979, ITRI initiated studies on the informatics industry, its role as incubator of industries emerged. The 'incubator' stimulates investment when the technology is still at an early age, accelerating growth in industries. Moreover, the continuous R&D activities within the 'incubator' to incubate talents, and the spread of which facilitates further development in industry. The development of ITRI is described as follows:

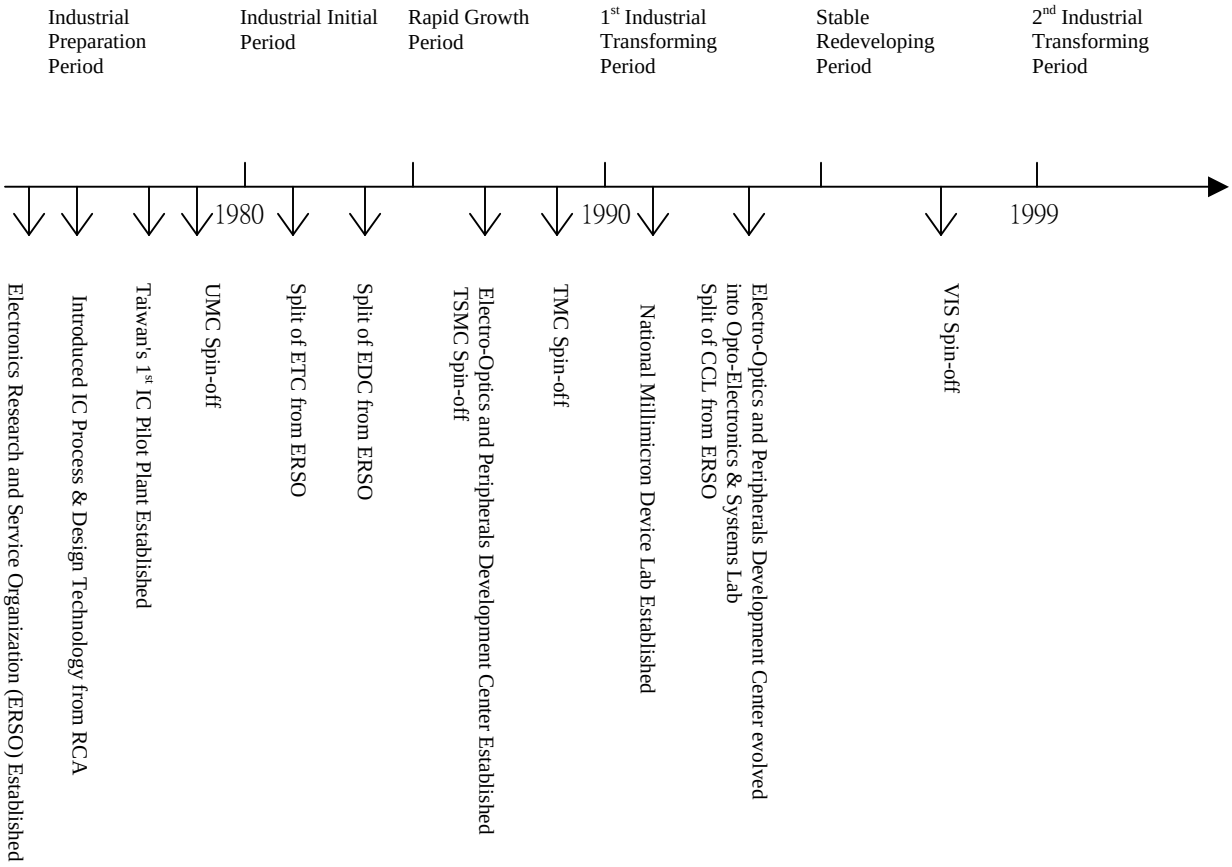

Figure 2. ITRI's Transition in Semiconductor Industry

Exhibit 2

1) Industrial preparation period (1960-1980)
2) Industrial initial period (1981-1983)
3) Rapid growth period (1984-1988)
4) 1st Industrial Transforming period (1989-1992)
5) Stable Redeveloping period (1993-1996)
6) 2nd Industrial Transforming period (post 1997)

In 1974, the government passed the Electronics Research and Service Organization (ERSO)'s development plan- Setting up the Integrated Circuit Model Factory (execution period 1975-1979). In April 1979, ITRI founded the Electronics Research and Service Organization (ERSO) to coordinate research on IC and manage IC production, ushering in an indigenous IC industry. In 1975, the Ministry of Economy commissioned the creation of IC Model Factory; the Electronics Research and Service Organization (ERSO) was responsible for its execution and transfer of IC manufacturing process to the private sector. In 1976, the Electronics Research and Service Organization (ERSO) introduced CMOS and NMOS IC design and manufacturing technology from RCA, United States. In July 1977, the Electronics Research and Service Organization (ERSO) signed contracts to introduce mask reproduction technology from IMR, United States. In October 1977, ITRI established the first 4-inch chip IC Model Factory in Taiwan and obtained the 7 μm CMOS manufacturing technology, laying the groundwork for Taiwan's semiconductor industry. In August 1978, ITRI formally began mask production. In 1979, ITRI successfully developed the first commercial IC chip, and started to take orders from domestic watchmakers, boosting the indigenous production of electronic watches.

In 1979 the Electronics Research and Service Organization (ERSO) was reorganized to become the Electronics Research and Service Organization. In July 1979, the organization began the second four-yearly IC project; the focus was on developing the capability to manufacture masks indigenously. From then on, the organization also actively transferred the technology it introduced from RCA to manufactures in the private sector. However, even with the technical support from ITRI, the capital required and the risks involved presented major obstacles, resulting in the general lack of confidence in the private sector in creating IC firms. The Ministry of Economy decided to lead by example, establishing an IC company then transfer the ownership to the private sector. United Microelectronics Corp was spun off from ITRI in May 1980 to become the first IC company in Taiwan.

In the development of the semiconductor industry, the government has been very directly involved in the process with its 'picking the winner' attitude. The government participated as an investor, searching for new technology and ideas with potential. It also plays the role as the director or cheerleader, exercising its power to restrain or direct industrial development. As the executor of the government's semiconductor policy, the Electronics Research and Service Organization played a key role in resource push, support the private sector in its R&D and manufacturing with government's financial resources and ITRI's know-how.

The growth of ITRI and industrial development are closely intertwined. From the formation government's policy on the semiconductor industry in 1975 to the spin-off of Vanguard International Semiconductor Corp., government's vision has always been carried through in its execution.

From the perspective of organizational interaction, ITRI enjoys a continuous relationship with the private sector in resource and information exchange. Through industry-research body cooperation, technology and talent flow, and frequent interaction with firms in the private sector, ITRI maintains its position as the premier technology application institute. For instance, in the Industrial Park in Hsinchu, many companies are spin-offs from ITRI, and about 50% of the manufacturers have some sort of partnership with ITRI- joint development, technology transfer or service. This is feature is unique among research institutions worldwide.

Looking from the industry production chain perspective, ITRI's role is more akin to the supporter of governmental policy. ITRI coordinates projects commissioned by the government, research for the technology needed by the private sector. The government's technology policy has two fronts- technology transfer after it is successfully developed and encouraging R&D in the private sector. Here ITRI is the bridge between government and the private sector. It is a bridge in the sense that it closes the gap between local and more advanced level of technology abroad. In another sense, it distributes technology to the private sector, inducing investment and stimulating growth in the industry.

ITRI measures its success by whether the technology it developed is transferred to the private sector- whether it travels 'out-of-door.' Through application of the technology by manufacturers in the private sector, ITRI exerts an indirect market impact.

1. Talent flow
2. Technology transfer

Technology transfer refers to the process when the creativity of one organization is adopted in another. It is a transfer of technology or knowledge. Some scholars describe the free flow of technology as technology diffusion. The transfer done with contracts is called technology transfer.

ITRI is highly flexible in its partnership with the private sector. Various ways of cooperation ensures that firms find the right degree and kind of working relationship with ITRI. 1. Technology and information diffusion 2. Technical assistance 3. Technical consultation 4. Technical training 5. Technology introduction 6. Performs research on clients' request 7. Industry-Research joint venture 8. Technology transfer. The transfer of technology can be done through transferring of patent rights, joint venture, or creating spin-off companies.

A. Creating spin-off companies

There are three major considerations when ITRI spun off the existing companies: 1) to facilitate the development in the semiconductor industry 2) to increase competitiveness in the international market. At the time there was no firms in the private sector capable or receiving the transfer and applying the knowledge in new products. 3) it is possible that technology has difficulty in sustaining growth with change of staff at IRTI, a spin-off company ensures the continuous growth of the technology and timely service to the private sector.

B. Other forms of technology transfer

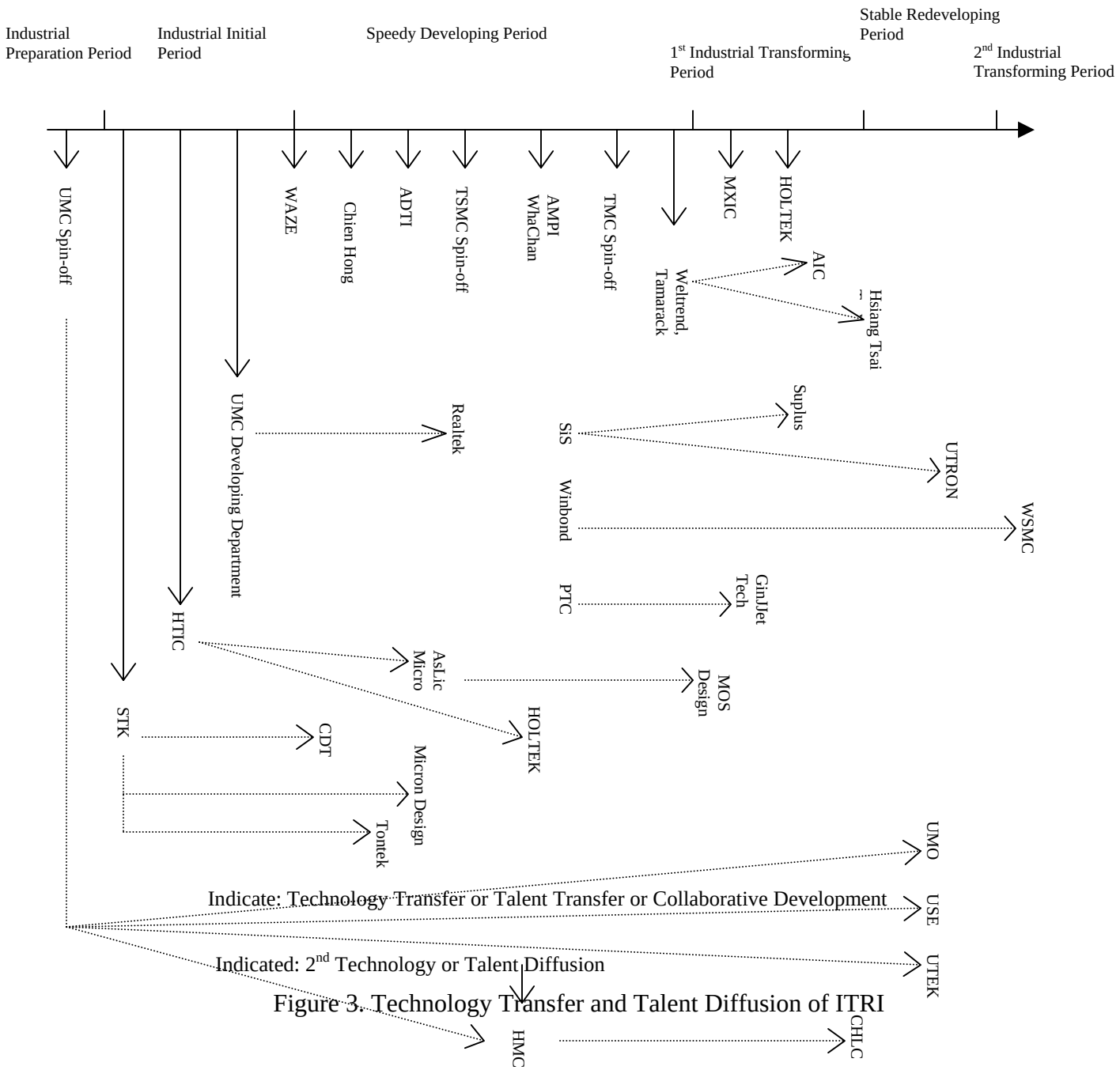

Figure 3. Technology Transfer and Talent Diffusion of ITRI

3. The Spin-off Company and Technical Knowledge's Direct Transmission

ITRI, apart from its dramatic strength during the process of establishment, the most talk with great relish story is that she "incubated" two well-known children in the world – they are the United Microelectronics Corporation, UMC and the Taiwan Semiconductor Manufacturing Company, TSMC. We here do not use the word "give birth" to describe the establishment process of these two companies, ITRI is using the concept of "incubation" under the support of the government to nurture the technical professions of semiconductor industry in the long-term basis; and, at that time, for carrying out the basic idea that to lift Taiwan's R&D capability and to upgrade the industry technology, ITRI begun to establish the spin-off company[5]. In other word, it is a result that has been "incubated" before produced, not a result that has been "produced" first and then "incubated". At that time, under the financial organizations provided the capital arranged by Taiwan Government, Mr. Robert Cao, the Vice Chairman of the Electronics Research and Service Organization (ERSO) of ITRI, found the United Microelectronics Corporation, UMC with his supporter staffs; and in the year of 1986 Mr. Morris Chang, the Chairman of ITRI at that time, brought a large number of technical professions and 6" wafer technology transferred from the Electronics Research and Service Organization (ERSO), had found the Taiwan Semiconductor Manufacturing Company, TSMC. Upon since, Taiwan started to dominate the semi-conductor industry gradually and to build the semi-conductor kingdom in the world.

The original idea of founding the ITRI spin-off company is because that the product process of semi-conductor is changeable rapidly and the life circle is very short, in the condition of competing with other country that produces the semi-conductor, we have to continually invest and to expand its production scale over and over; however it will be contradictory to invest the production by using all resources as a non-profitable organization concept like ITRI founded by Taiwan Government. Besides, the electronics industry, at that time, was mainly still in the stage of assembling style, if we do not transfer the semi-conductor technology to the private company, a strange phenomenon of a great number of low production technical companies around a non-profitable organization with world-class technology but unable to process the mass production will be appeared. Further more, if a foreign company that also produces similar product land to establish a factory in Taiwan, all those professions who have been endeavor incubated by ITRI and Taiwan Government will be taken by this foreign company and may cause the shortage risk of technical professions for domestic company in Taiwan. Standing as a spin-off company's point of view, its advantage and disadvantage are that the source of production technology is worriless, but the failure ratio is high due to the small scale for this kind of company, respectively. This kind of company cannot take too much risk and may easily cause the collapse by a wrong decision-making or unexpected market change. The difference between a spin-off company incubated by ITRI in Taiwan and that of in

[5] ITRI, at the initial stage, apart from establishing the spin-off company, was considering transferring the technology through the way of technology rental and valuation for investing to private company in return; but it stops due to the limitation of government regulation.

other country's research organization is that the technical professions of a spin-off company incubated by ITRI, both in ITRI and the spin-off company, all well participated the operation and production skill in model factory; in other word, there is no much change to the technical professions before and after, only the working place is different, its production style and process design are almost same as the model factory, it is a kind of business transmission. For a spin-off company comes from other country's research organization, it is a kind of transfer from foundation research to business; a spin-off company, holding the primary technology as foundation at the initial stage, must be able to produce the commercialized product in the market to be accepted for competition. It means that a spin-off company incubated by ITRI only needs to face the risk in the market competitive environment, but for a spin-off company comes from other country's research organization has to face both risks of product technology commercialized and market competitive environment.

On the other hand, the benefit for a spin-off company are that a company after the spin-off process, when any problem occurs in terms of technology, can always ask for help and solution to the research organization in both formal or informal way. Moreover, the direct floating of professions means the tangible and intangible technology and knowledge are directly transferring, and the closed technical professions relationship and social network can be build through out the creation in technology and communication between a spin-off company and the research organization. This structure of network would speed up the communication in both technology and knowledge between people and group mutually.

4. Open Laboratory and Industry Research Cooperation Alliance

The spin-off company, as we mention above, can transfer directly a very competitive production technical knowledge in ITRI to the industry, it enables the traditional middle-small scale enterprise in the industry became a highly market competitive manufacture; therefore ITRI established open laboratories in 1996 for private manufacture to be enrolled in public. The purpose of this establishment is to provide a ideal R&D environment for both manufactory R&D professions and technology transformation unit, to obtain the necessary technology as well as knowledge in operation for manufactory R&D professions through the systemized, efficient and organized learning in daily management work, and to upgrade the value of the manufacture. In short, the establishment of the open laboratories is another vivid example for ITRI to demonstrate that how to transfer the tangible and intangible technology and knowledge from its professions to the private manufacture; apart from the spin-off company, it is also a most important channel linking with the private manufacture. These kinds of open laboratories establishment are applied to many advanced countries in Europe, American and Japan, in order to upgrade their manufactures' technology capability.

ITRI open laboratories are, through the mutual technology development model, mainly to transfer technology and knowledge to the private manufacture. In mutual technology development model part, it is not only can avoid the duplicate investment, promoting the

R&D efficiency and technology floating effect produced, but also, for the private manufacture participating the mutual technology development scheme, can enlarge the R&D expense itself and ahead of the related R&D scheme; this kind of technology spreading by means of the mutual R&D development enables the degree of competition in the product market getting serious and causes the efficiency promotion for whole market. Besides, due to the private manufacture enrolling the open laboratories can be treated same as units in ITRI to use all hardware infrastructure construction and great deal of technical professions as well as technical knowledge resources in ITRI, under this ideal R&D environment, it benefits the R&D scheme be shorten on one hand and the closed mutual relationship between private manufacture people and unit people can mend the R&D scheme direction together on the other hand, and at last the highly competitive business knowledge can be transferred successfully from ITRI. In the other word, on the certain degree, the open laboratories are like repeating the advantage of ITRI spin-off company; it enables the risk reduction from facing both risks of product technology commercialized and market competitive environment to only need to face the risk of market competitive environment for private manufacture, and this market competitive environment risk can further be reduced by gathering the team work of different private manufacture in same industry. The main operation process of the open laboratories includes Technology Collaboration and Incubator Center. Technology collaboration is mainly targeting the existed company and to develop the advanced technology by mutual cooperation. The incubator center is mainly targeting the middle-small enterprise hi-tech company and to develop the technical product by company itself.

In terms of the targeting candidate selection of the open laboratories it can be divided into 3 categories: Category 1 is the domestic manufacture, Category 2 is the strategic alliance manufacture that Ministry of Economic Affair signed the contract with foreign large-scale enterprise, and Category 3 is the other institutional research organization. The open laboratories are formally open for private manufacture to enroll in 1996: there are the technology transfer results since established as below:

Form:

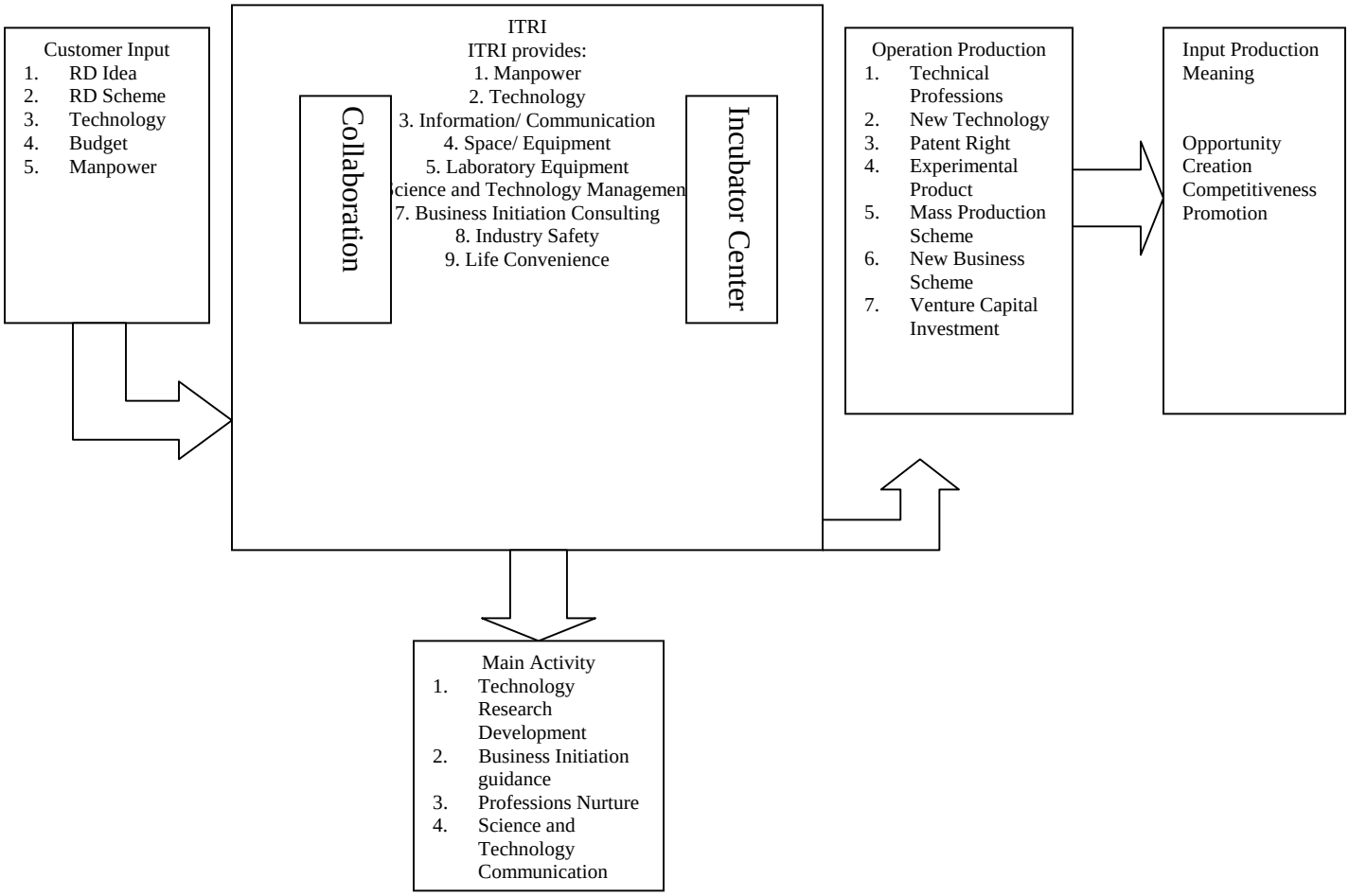

Figure 4. The Total Concept of ITRI's Open Laboratory

5. Conclusion

It can be seen roughly, from the earlier paragraph mentions, a common point that passing through this article – Technical Professions. No matter in term of hasten ITRI's birth, semi-conductor technology learning in U.S.A., model factory establishment after returned Taiwan, the spin-off company and open laboratory in the latter time, technical professions this term always be the very important key factor to be involved; more precisely, The technical knowledge tangibly as well as intangibly brought by the technical profession is the key to build today's semi-conductor kingdom in Taiwan, we can see these two kinds of technical knowledge floating in between in all developing process and it became a very inseparable knowledge spiral. The technical profession's efforts and continual improvement for promoting their own technical knowledge stage, it appears a very tight knowledge floating net and is the core motivation for excellently developing an industry.

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