STEPWISE STRATEGIES FOR TAIWAN'S SEMICONDUCTOR INDUSTRY AS CORE TECHNOLOGY

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ABSTRACT

Even thoughTaiwan is small, she has become the industry's leading in the field of semiconductor. The result can be seen, Taiwan occupies a position in the semiconductor industrydevelopment. The semiconductor manufacturing equipment export markets is number one in the world in 2016 and contributed the Taiwan export amount to 41.4% in 2015. To determine a core technology requires a decision-making process considering existing resources potential and competent to other countries that have been and will develop theircore technologies. To find out how Taiwan government prepares their process, this article discusses the stepwise strategies adopted by Taiwan's government to define the core technology and prepare the policies to support that realization. A variety of data, including government policies, industrial technology research institute programs, research universities, industry and economic news, and relevant literature are surveyed. Four stepwise strategies are developed as follows. Firstly, fast-follower approach makes a critical decision determining semiconductor industry. Secondly, establish industrial technology research institute (ITRI). Thirdly, initiate development Hsinchusciences park (HSP), and finally linkage between universities and industry to integrate academic-industrial resources. The study suggests that stepwise strategies to develop and maintain core technology in competitive semiconductor technology challenge to create innovation step by step.

Keywords: Semiconductor Industry, Core Technology, Stepwise Strategies, ITRI.

1. INTRODUCTION

Competitiveness of a nationrelies upon the ability of its industry to innovate and improvement, to compete and survive in an era of global competition. Companies gain advantage against the world's best competitors because of pressure and challenge. Demands and dispute make firms expand enhancement against the world's best(Porter, 1990). According to the World Economic Forum (2015), there are 12 pillars that affect the global competitive index, among others: Institutions, infrastructure, macroeconomic environment, higher education and training, technological readiness, , financial market development, business sophistication,good market efficiency, market size, labor market efficiency, and innovation.

A technological factor affecting the country becomes an important point in increasing competition index. In addition, the ability of a country to determine the core technology and also take a strategic step in determining policies and deciding that technology will have an impact on the competitiveness of nations. Having regard to the ability of internal resources and external conditions with attention to technology that has been and will be developed other nations. This will give an estimate in terms of policy making the right technology in a country. Superior technology and core technology will provide an overview of each country in a position to determine the direction that technology will take.

Taiwan as small island country has the potential of such natural resources and human resources. The ability to determine the excellent and core technology is ushering Taiwan became one of the world's largest semiconductor exporter. There are three questions, 1) How do Taiwan's strategic steps in determine its superior technology and core technology?, 2) How can Taiwan survive with an increasingly competitive environment?, and the last 3) How to face the challenges in the future.

2. IDENTIFYNG CORE TECHNOLOGY

To identify the core technology to be applied in a country needs to consider aspects such as the condition of the existing resources in the country. Furthermore, considering the market conditions, competition, and opportunities in a country. Several countries in the world to quickly be able to determine appropriate the

technologies in accordance with their capabilities. For example Japan define as core automotive and electronics technology, and South Korea select electronics as a base technology.

Some potential industry from Taiwan those have been developed and have become export commodities include electronics, flat panels, energy, agriculture, machinery, petrochemicals, metals, textiles, plastics, and chemicals. Based on the results of studies conducted by the Taiwanese government in 1970 to make critical decisions by adopting a fast-follower approach (Wang & Chiu, 2014). In 1973, the government established Industrial Technology Research Institute (ITRI) has been committed to serving industries stay sustainable and competitive.

SEMICONDUCTOR INDUSTRY DEVELOPMENT

According to Greve (2012) "Semiconductors are materials that have an electrical conductivity intermediate between the electrical conductivity of good conductor (such as aluminum and copper) and good insulators (some glasses and plastics). Semiconductor technology refers to sequence of process steps used to fabricate semiconductor devices" (p. 2).

By the end of 2014 (Table 1), Taiwan semiconductor industry involved of 16 fabrication companies, 245 IC fabless design houses, 7 substrate suppliers, 37 packaging and testing houses, 11 wafer suppliers, 14 lead frames company and 3 mask makers.

Table 1: Taiwan Semiconductor Industry

No	Company	Amount
1	Fabrication	16
2	IC fabless design houses	245
3	Substrate suppliers	7
4	Packaging and testing houses	37
5	Wafer suppliers	11
6	Lead frames	14
7	Mask makers	3
	Total	333

Source: Taiwan Semiconductor Industry Association (TSIA) 2015

Based on data from Workman (2016) explained the order of commodity exports by Taiwan can be seen in the figure 1 below.Other chemical goods: $3.6 billion (1.3%), iron or steel products: $7.2 billion (2.6%), iron and steel: $8 billion (2.8%), organic chemicals: $8.6 billion (3.1%), vehicles: $10.2 billion (3.6%), oil: $11.6

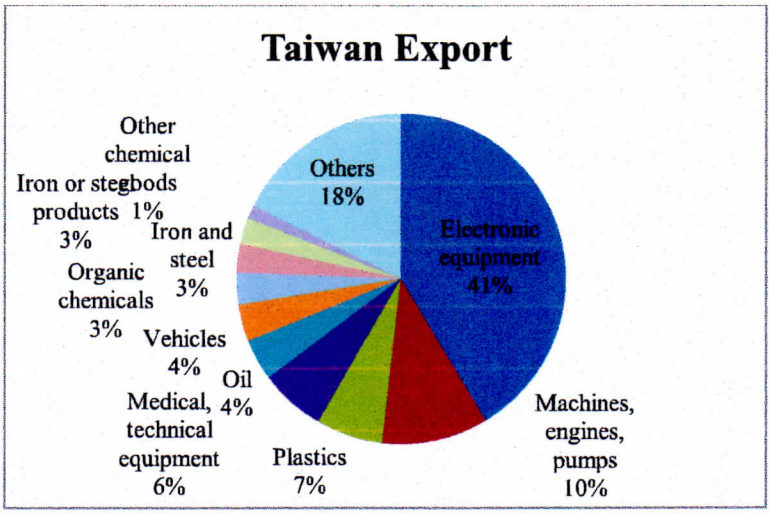

Figure 1. Taiwan Export
Source: Worksman (2016)

billion (4.1%), medical, technical equipment: $17.8 billion (6.4%),Plastics: $18.5 billion (6.6%), machines, engines, pumps: $29 billion (10.4%), and electronic equipment: US$116 billion (41.4% of total exports).

According to International Trade Administration (ITA) (2015) positioning Taiwan rank the seventh in a top semiconductor export market to 2016 and the first rank in top semiconductor manufacturing equipment export markets can be seen in Table 2.

Table 2: Top Semiconductor and Manufacturing Equipment Export Market to 2016

Semiconductor Export Markets	Rank	Semiconductor Manufacturing Equipment Export Markets
China	1	**Taiwan**
Japan	2	South Korea
Germany	3	China
South Korea	4	Japan
Singapore	5	Singapore
Mexico	6	Germany
Taiwan	7	Netherlands
Malaysia	8	Ireland
Brazil	9	Israel
Thailand	10	Malaysia

Source: ITA (2015)

4. STEPWISE STRATEGIES

In developing the semiconductor industry as a core technology, Taiwan government through the four steps strategic shown in Figure 2 namely, 1) fast-follower approach to making a critical decision determining semiconductor industry 2) in 1973 establish industrial technology research institute (ITRI), 3) in 1980 establish Hsinchu Science Park (HSP), and 4) develop semiconductor research with collaboration universities and industries.

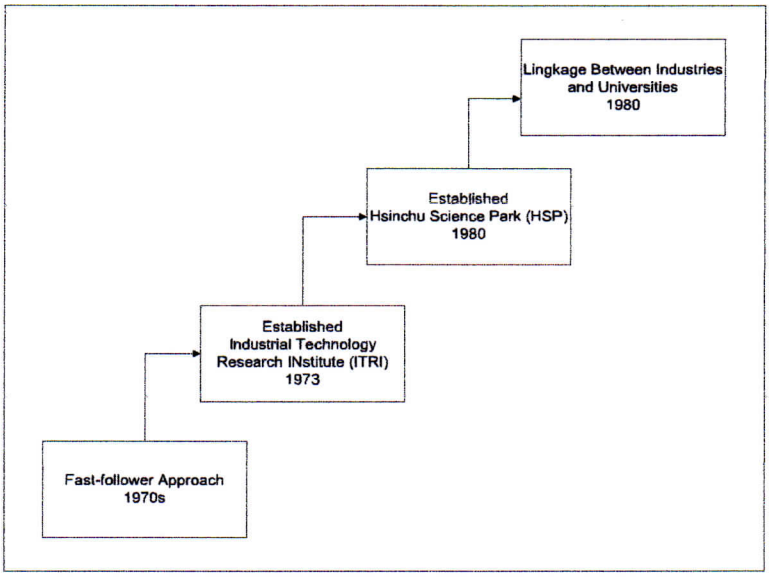

Figure 2. Stepwise Strategies of Taiwan to develop Semiconductor Technology

4.1. Fast-Follower Approach

According Wunker (2012) firms or countries searching for approaches to support development by catching new markets, there is a squeezing need to ponder in case it's sensible to be alate follower, fast follower orearly mover.Every of these alternatives requirea different competitive strategy. A more astute methodology is to watch how early mover preferred standpoint may bond initiative in specific markets, after consider what methodologies and industry environmentsaccept fast followers or late followers in different settings to triumph.

Firstly early mover approach,if the suitability of an early mover position is controlled by the components, an organization meeting these criteria ought to drain its points of interest for all they are worth. Secondly fast-follower approach, followers require the control to keep and after that to move rapidly before an industry's aggressive request gets to be an unavoidable. In any case, there is a basic admonition: Many organizations think that its difficult to be a fast follower; when they get the chance to showcase fundamentally, they will be past the point of no return. Due to variables, for example, decision-making timeframes, product-improvementsequences and the distance of the sales procedure, an organization's consequent passage into a rapidly moving business sector might be so deferred as to be superfluous (Wunker, 2012).

Taiwan government has acted a critical role in the development of Taiwan Semiconductor Industry (TSI). In the 1970s, as a result of little size of nationalcompanies and their falling behind externalcompanies in technology and innovation, the government created a strategically basic choice to begin TSI by adopting fast-follower approach. It implies the government would endeavor to secure technological abilities from foreign sources and give essential assets to begin domestic pioneer research (Wang & Chiu, 2014).

With a suitable fast follower approach to begin the industry, trailed by the fruitful improvement of a positive industrial nature and creative plans of action, and reinforced by a hard-working and knowledgeable workforce fit for reacting to change with prodigious organizational and operational adaptability, Taiwan semiconductor industry has prospered to end up a top player in the worldwide semiconductor market. This achievement has additionally added to the accomplishment of other innovative commercial ventures in the country (Wang & Chiu, 2014).

4.2. Industrial Technology Research Institute (ITRI)

So as to empower the national industrial segment to put resources into research and development deeds, the real type of government specialized help to industry is to contract non-profit research organizations to perform non specific innovative improvement and after that to exchange their research outcomes to the national industrial segment (Hsu & Chiang, 2000).

The government established ITRI has been dedicated to helping industries stay competitive and sustainable. Since 1973, this institution is a nonprofit R&D organization aiming to innovate a improve future, engaging in applied research and technical services. ITRI has played a vital role in Taiwan's economic growth as it shifted from a labor-intensive industry to a value-added, innovation-driven one.

As a national research institute, ITRI attempts connected research with the mission of quickening industrial technology improvement in Taiwan to advance industrial development and social prosperity. Generally, ITRI publishes research results to the industrial segment in time with the end goal of keeping up the intensity of national industries in the worldwide business sector. Mainly, It gives facilities and assignments the technology improvement to small and medium entrepreneurial firms (Hung & Chu, 2006).

Moving forward, the organization will keep serving as a pioneer for industries by establishment its abilities of multidisciplinary advancement and collaboration with global accomplices everywhere throughout the world. Services delivered of ITRI to the industry in Taiwan, including: industrial consultancy services, new ventures, education, and training service, testing and certification, open lab/incubator, technology transfer, and R&D collaboration (ITRI, 2016).

4.3. Hsinchu Science Park (HSP)

Developed in December 1980, the Hsinchu Science Park (HSP) with a specific end goal to pull hi-tech entrepreneurs and encourage their progressive in Taiwan. It is entirely government oriented, for instance, by competently supported one stop service;the improvement of accessible area with infrastructure facilities; national and global network; automated customs service and on-job coaching. Through its proceeded with endeavors, the pursuing industries have been effectively created: Integrated Circuits (IC), Computers and Peripherals (C&P), Telecommunications (Telecom), Biotechnology (Biotech), and Precision Machinery (PM). Its performance additionally exhibits its honor in appropriate as benchmarking model of first hi-tech industry improvement in Taiwan furthermore its exceptionally good reputation in the world (Lee & Yang, 2000).

HSP give effect to accelerate the development process of semiconductor industry. If we look at Figure 2 shows the increase in the number of firms from year to year increased significantly. Firms that join at the beginning totaling 17units, along with the growth and increasing activities in the field of electronics by 2015 company in HSP amounted to 478 units.

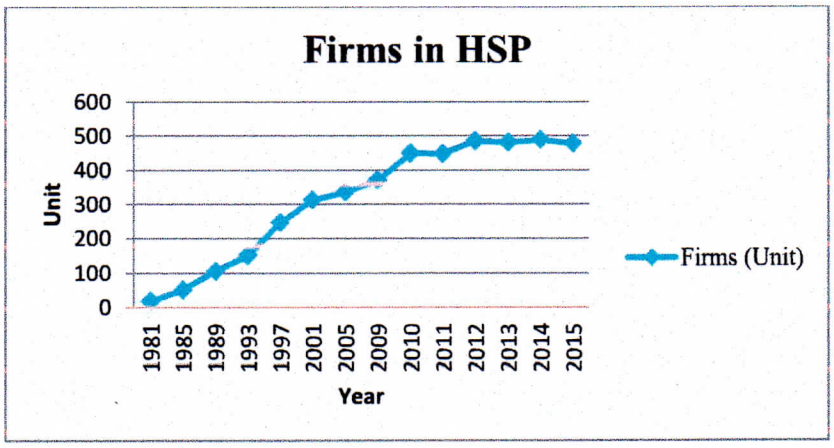

Figure 3. Firms in HSP

Source: http://www.sipa.gov.tw/english

Further aspects of the total sales in HSP, based on the figure 3 below shows the fluctuations in sales at the beginning of the establishment precisely in 1985 still amounted to US$ 3.27(hundred million).The next year to increase rapidly through 2007 reached US$ 357.79(hundred million).When the economic crisis in 2008, sales decreased until 2009. Then rose again in 2010 and then fluctuated until 2015 to reach US$ 343.70 (hundred million).

Lee and Yang (2000) identified contribution achieved and main impact and by HSP are that it: 1) effectively introduces the related hi-tech human resources for economic and technology improvement, also successfully founded the initial science park model in Taiwan, 2) through the cross licensing and strategic alliance

cooperative operations could encouraged R&D innovative investment, 3) upgraded the national core competence, 4) encouraged the hi-tech quality of life society for public progress development, 5) for the next local hi-tech industry expansiondesign by provided a worthy real references model, 6) best fit adaptation by demonstrated permanent dynamic flexibility.

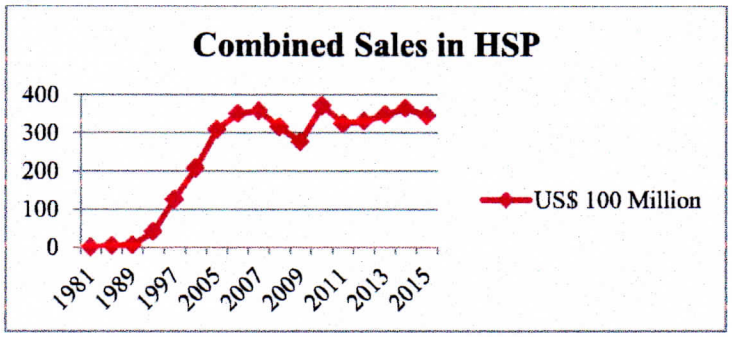

Figure 4: Combined Sales in HSP
Source: http://www.sipa.gov.tw/english (2016)

4.4. Linkage Between Universities and Industry Resources

In addition to supported by the research institute that has been founded at the beginning, also sustained of research on product development and innovation prospect. These two institutions that encourage Taiwan could persevere through the competition in the semiconductor technology. System for technology diffusion between industry and universities to combine academic assets and successfully direct R&D outcomes, a strategy of Taiwan government (MOEA) launched three disseminations into practice, one of them are Technology Transfer Centers (TTCs) and universities (Mathews & Hu, 2007).Industrial Technology Research Institute, National ChiaoTung University (NCTU),and National TsingHuaUniversity (NTHU), there are research and educational institutes nearby region of the HSP (Lee & Yang, 2000).

Table 3: Piloting Cooperation Project Between Industries and Academia at Science Parks, statistics, 2010-2014

Year	Cases (Units)	Amount (US$ 1 Million)	R&D Personnel from participating companies (Persons)	High-tech industrial Manpower training (Persons)
2010	33	4.431	538	197
2011	23	2.634	313	123
2012	21	2.546	265	106
2013	20	2.390	260	96
2014	18	2.186	245	79
Total	115	14.188	1,621	601

Source: HSP Annual Report (2014)

Based on HSP annual report (2014) description piloting cooperation project between industries and academia at science parks. During 2010-2014 total cases 115 units or average 23 units per year. The grants research project total US$ 14.188 Million or average US$ 2.837 Million per years. R&D personnel from participating companies amount 1,621 personnel or average 324 personnel per year. Furthermore, high-tech industrial manpower training amount 601 people or average 120 people per year shown in Table 3.

5. FUTURE TECHNOLOGICAL CHALLENGES

With experiences that have been there, Taiwan can contribute to the development and advancement of the global semiconductor industry technology to affect the development of the nation. On the other hand, whether there has been this experience will lead Taiwan to be able to survive in global competition and able to respond to the dynamic changes in the semiconductor industry.

ITRI role in conducting research and development is crucial challenges of technological change. At the beginning of its founded to focus on the semiconductor industry, along with the development then expanding the study in several fields of research. Publication ITRI spring Issue (2016) featuring some of the latest research results, among others: New development Internet of things (IoT), panel display industries, self-driving cars and drones, green industry application, LED Technology creates new value for agriculture, water technology, next -generation technology for desalination.

6. CONCLUSION

During five decades, Taiwan has able to survive and develop semiconductor technologies and industry. It is caused by government policy in determining the strategic steps and encourages innovation in following market needs. Four stepwise were carried out starting fast-follower approach to making a critical decision determining semiconductor industry, in 1973 establish industrial technology research institute (ITRI), in 1980 establish Hsinchu Science Park (HSP), and develop semiconductor research with collaboration universities and industries.

Challenges ahead, if Taiwan was able to survive with the competition getting tougher with countries that earlier develop industry or the emergence of new countries that try to develop this technology. In order to survive in the competitive semiconductor industry, Taiwan continues to innovate in the field of semiconductor technology.

In addition, developing other technologies to be an alternative to sustain the core technologies that have been run. Industry developed, among others: optoelectronics, computer and peripherals, telecommunication, precision machinery, and biotechnology. This will provide support in Taiwan's technology and industry in the future.

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