# Transcript of the Lectures and Speeches
# at
# The Honda Foundation International Symposium 2005, Hanoi
# Linking Innovation and Entrepreneurship
# for Developing Countries

**February 28, 2005: Melia Hanoi Hotel, Hanoi, Vietnam**


**Organized and Hosted by:**

**HONDA FOUNDATION (HOF)**

**with:**

**National Institute for Science and Technology Policy and Strategy Studies (NISTPASS),**

**Ministry of Science and Technology, Vietnam**

**Supported by:**

**Embassy of Japan in Vietnam**

**Honda Vietnam Co., Ltd.**

On February 28, 2005, the Honda Foundation (HOF), in collaboration with the National Institute for Science and Technology Policy and Strategy Studies (NISTPASS) of the Ministry of Science and Technology of Vietnam, held an international symposium titled "Linking Innovation and Entrepreneurship for Developing Countries" at Melia Hanoi Hotel in Hanoi. Focusing on the HOF-advocated *Eco-Technology* concept, the participants discussed how the fast-growing Vietnamese economy could remain prosperous while moving on to a more environmentally-benign direction. The symposium was supported by Embassy of Japan in Vietnam and Honda Vietnam, a Honda's local enterprise which produces motorcycles in Vietnam.

More than 20 researchers from Japan, Vietnam, and Thailand delivered speeches and exchanged views and ideas about how the Vietnamese economy can depart from the past catch-up growth model harnessed by the transfer of foreign technologies and investments. The discussants emphasized the importance of sci-tech based innovations, and such policies that facilitate them, for Vietnam's sustainable growth in a more creative, environmentally-sound fashion. In addition, Honda R&D engineers from Japan demonstrated a prototype of the fuel-cell and hybrid motorcycles to showcase the forefront of Honda's development in earth-friendly technologies. The symposium was covered on the national TV stations and commercial newspapers and drew wide attention.

What follows is a transcript of the remarks and talks of the discussants at the Honda Foundation International Symposium 2005, Hanoi.

**The Honda Foundation International Symposium, 2005, Hanoi**

# Linking Innovation and Entrepreneurship

## for Developing Countries

**February 28, 2005: Meliá Hanoi Hotel, Hanoi, Vietnam**

**Co-organizer:**

**National Institute for Science and Technology Policy and Strategy Studies (NISTPASS)**

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## [Program]

**8:30 Registration and Welcoming coffee**

**9:00 Opening: Vice Minister Le Dinh Tien (MOST)**

**Opening Session A: Keynote Address**

**[1] Ambassador Hiroto Ishida (Ex-Vice Minister STA, President Kanazawa Gakuin Univ.)**

**[2] Dr. Le Dang Doanh (CIEM/MPI)**

**Opening Session B: Special Presentation**

**Dr. Patarapong Intarakumnerd (NSTDA, Thailand)**

**10:05 Session 1: Innovation, Learning and Entrepreneurship**

**Chair: Prof. Nguyen Quang Thai (DSI/MPI) & Prof. Hiroyuki Odagiri (Hitotsubashi Univ.)**

**[1-1] Japan's Innovation Systems (Prof. Hiroyuki Odagiri, Hitotsubashi Univ.)**

**[1-2] Technology Transfer: the Role of MNCs in Vietnam (Mr. Nguyen Vo Hung, NISTPASS)**

**[1-3] Role of Firms in Industrial Innovation (Mr. Takashi Sawai, NTT Advance Technology)**

**[1-4] Link-up program between Firms - Research Institutes - State and Experiences from HCMC (Dr. Dao Van Luong, Department of Science and Technology, HCMC)**

**Discussions and Q&A**

**11:45 Lunch (Hosted by HOF)**

**13:10 <u>Session 2: Strategy and Policy</u>**

**Chair: Dr. Nguyen Manh Quan (Ministry of Industry) & Prof. Akira Goto (Tokyo University)**

**[2-1] Dynamics of the National Innovation System - A Case of the Thai Automobile Industry**

**(Dr. Nobuya Haraguchi, UNIDO)**

**[2-2] Institutional Building for Vietnam's Innovation System**

**(Dr.Tran Ngoc Ca, NISTPASS)**

**[2-3] China's Innovation Systems Reform and the Development Strategy**

**(Prof. Atsushi Sunami, GRIPS)**

**[2-4] Policy Lessons for Vietnam: Engineering capacity building for sustainable development, poverty alleviation and international integration**

**(Dr. Nguyen Truong Tien, Hanoi Construction Company, Ministry of Construction)**

**Discussions and Q&A**

**14:55 Coffee Break**

**15:10 <u>Session 3: Innovation, Eco-technology and Sustainable Development</u>**

**Chair: Dr. Nguyen Danh Son (NISTPASS) & Prof. Kunio Nakajima (GRIPS)**

**[3-1] ECO-TECNOLOGY --- Human Environment Conscious Science & Technology**

**(Prof. Hirohisa Uchida, Tokai University)**

**[3-2] Entrepreneurship and Development of Eco-Technology**

**(Prof. Bui Van Ga, Danang University)**

**[3-3] Case: Future of Motorcycle -- Introduction of a future study of Honda R&D research division**

**(Mr. Yoshiyuki Horii, Honda R&D, Japan)**

**[3-4] Case: Clean production in Xuan Hoa company**

**(Mr. Doan Van Bang, Deputy director, Xuan Hoa enterprise), with support from Dr. Tran Van Nhan, CPC, Hanoi Technology University**

**Discussions and Q&A**

**16:50 Closing Speech for The Symposium: Dr. Tran Ngoc Ca (NISTPASS)**

**17:10 <u>Exhibition; Fuel Cell & Hybrid Motorcycles</u> (Experimental)**

**(Honda Vietnam and Honda R&D Japan)**

**18:00 Pause: The End of Symposium for the General Audience**

Le Dhin Tien Vice Minister MOST Opening message

"His Excellency Ambassador of Japan,

Mr. Hiroto Ishida, President of Kanazawa Gakuin University, head of Japanese delegation,

Mr. Hiromori Kawasima-President of Honda Fundation,

Professor Chu Tuan Nhan, President of the National Council of Technology & Science Policy,

Ladies and Gentlemen,

On behalf of the Ministry of Science and Technology I sincerely appreciate the initiatives of the Honda Fundation, as well as the Institute of Strategy and Technology – Science Policy, the Ministry of Science and Technology for co-organizing this forum on the connection between technology innovation, entrepreneurship, lessons for developing nations and welcome domestic and foreign delegates attending to this conference.

Ladies and Gentlemen,

In the process of "Đoi Môi" 20 years, Vietnam have gained a number of significant and important achievements in all aspects. Thanks to "Đoi Môi", Vietnam overcame socio- economic crises, the economy grow rapidly and the technical equipments improved, the standard of living was continually enhanced, politico-society was stable and international relations were strengthened.

The GDP is doubled for 10 years from 1991- 2000 with an average annual growth rate of 7.5%; and for the last 3 years from 2001- 2004, the average growth rate has remained high at 7.1%. However, Vietnam is still considered as an undeveloped nation with a per capita income of 500 dollars per year. The speed of economic growth is relatively high but its quality is not assured such as low effectiveness in investment, in quality productivity and small added value for products and services, still low competitiveness in economic aspects as compared to other nations in the region and the world.

One of the main reasons for this situation is that the technology level in the production competence of Vietnamese enterprises has remained backward. In many economies, innovation speed and technology modernization are not efficient. Most of Vietnamese entreprises are at small and medium size. As a result, the ability to invest in technology innovation is quite restrained, experience in business is inadequate. Research and Development organizations in Vietnam are also in bad situation of investment ability. They are not able to keep up with and adapt to the changing economic environment which has transformed from a centralized planning system to an open market mechanism.

The linkages between entreprises and Research & Development organizations to carry out technology innovation are still limited, so it creates big challenges for all of them in the globalization, integration and international competition in Vietnam. On one hand, the impacts of globalization and international integration, through factors of innovative systems, provide opportunities for Vietnam to develop more quickly, to acquire progress in science and in technology as well as in society at the world level, to reinforce learning, to transfer and cooperate technology. On the other hand, this process will create a big challenge for every unit involved in this process, especially for organizations, individuals and enterprises in underdeveloped- countries like Vietnam.

The Vietnamese Party and Government place high priority on policies for industrialization, modernization and technological and scientific development. Our government views the development of education and training in science and technology as our most important objectives in national development policy, especially recently, the Vietnamese government has officially promulgated a strategy of technological and scientific development up to the year 2010 with "Renovation project of technological and scientific management mechanism". The Ministry of Science and Technology sets up important measures and policies to strengthen technological market development, complete laws of intellectual property and transfer of technology to promote trade initiative and technological innovation for improving competitiveness of products and services in the context of international and regional integration. This next coming 5 years, from 2006- 2010 is the critical implementation phase for the strategies of socio- economic development in Vietnam. Particularly,the aim of the 2001-2010 strategy is to keep out Vietnam a developing nation and create the premises for an industrialized nation by 2020. The Ministry of Science and Technology, therefore, appreciates the topics in this workshop and acknowledge help from scientists, managers, and foreign and domestic businessmen for ensuring the success of this forum. It is really an useful forum for us to share experiences, exchange ideas, discuss and make recommendations to related offices and organizations. This will help Vietnam gain valuable experience in the process of economic and techno-scientific integration.

On behalf of the Ministry of Science and Technology, I would like to express our thanks for the efficient support and closed cooperation of the Honda Fund and the Japanese Ambassador in organizing this forum. I hope that Vietnam and Japan continue to develop close ties and that our forum will be a success. Thank you.

## Hiroto Ishida's Speech

Hello, everyone. I'm Hiroto Ishida. It is my pleasure being here in Hanoi, a beautiful city surrounded by rivers and woods. And it is my great honor to deliver a keynote address to this gathering, the International Symposium in Hanoi 2005, in front of Mr. Le Dhin Tien, Vice Minister of the Ministry of Science, Technology and Environment (MOSTE).

With its focus on "innovation, entrepreneurship and economic development," this symposium is co-hosted by NISTPASS and the Honda Foundation. I believe it would serve as a catalyst for a tighter relationship and the bright future of Vietnam, Japan, and the rest of the Asian countries. Before starting my address, I sincerely thank all the participants, especially Dr. Patarapong from Thailand's NSTDA.

The Honda Foundation was established by Mr. Soichiro Honda, one of the most famous business entrepreneurs of Japan. In accordance with the spirit of the late, it has advocated a technological concept called "eco-technology," encouraging technologies that help create a more "humane" civilization. The foundation has hosted a number of symposiums in various countries as an opportunity for researchers and experts in the world to freely exchange their insights and experiences. Each of these occasions has drawn public attention and produced greater responses as the actual importance of eco-technology increases.

At the beginning of the 21st century, creating sci-tech based innovations is the key policy concern around the world. Some arguments even predict no nation can survive without improving national life with the full use of the sci-tech based innovations. We once argued modern technology may rob us of job, but that was a lie. Quite contrarily, technological advance creates new jobs while reducing toil from us. Today we know stable employment is an outcome of diligence to provide better products and services that customers want. Look at today's robust economy in Vietnam. Her economy picks up because Vietnamese people works so hard, although her prosperity is only half done. We strongly hope Vietnam will keep up the good work and move further into greater economic growth.

I served as a Japanese ambassador to Czech Republic in Europe from 1999 to 2003. In that age, the European Union accelerated its expansion: A union of 15 became that of 25 as a result of the liberalization momentum after the fall of Berlin Wall in 1989. Former Eastern European countries, now called Central Europe, started adopting technologies from the free world in pursuit of economic expansion. Czech was no exception. In such a turbulent age, I was often, however, inclined to think about my country and Asia. European countries have long history, but Asia has even longer history with a larger population. How can we Asians lead the rest of the world with our technological innovations and improve people's life? — This was a common concern among Asian ambassadors and business managers who then worked in Europe.

Asia is diverse, but we have a lot of things in common. For instance, we East Asians have a tradition of living close to each other intimately in rich natural environment. Yesterday, I visited the preservation site in historically important Don Ram village. I was very moved as I saw how people thank nature and respect ancestors because such a tradition is very intimate to me.

In Hanoi, I saw an aquatic puppet play in which all characters — men, dragons, frogs, fish, and buffalos — were active on the water. I felt it must be an expression of the Vietnamese people who live on the water like Mother Mekong and Mother Huong. I didn't understand what was going on behind the dynamic movements of the puppets. When the puppeteers appeared in front of the audience after the play ended, I could only guess how the puppets were manipulated. I still don't think everything is clear.

The Japanese culture also has the puppet theater. In *bunraku*, one of the registered world's cultural heritages, each puppet is manipulated by three puppeteers and they are present on the stage, beside the doll in black robes and head coverings. The audience can always see how they manipulate the doll. Especially, *omo-zukai*, or head puppeteer, wears no head covering. Sometimes all three puppeteers wear colorful robes. So *bunraku* theater requires puppeteers to perform not only their puppet but also themselves. The audience can enjoy the performance of "supposedly nonexistent" players as well as that of the puppets — I personally think this is the spice of the *bunraku* art.

As just described in the two examples, Asian cultures have likes and differences, and the future of this region depends on how we can take full advantage of this diversity and similarity.

In terms of national innovation, the top priority is to cultivate able human resources, a fundamental basis of all activities in modern nations. But when you use the term human resource, it should be always reminded it somehow implies our perception of human as means for some other end. Our end always lies in human himself — all national endeavors must pursue the society where every human can manifest his/her full humanity to lead a “humane” life.

I have a profound respect for endeavors of the Vietnamese to keep improving your educational and training systems as an engine of social and economic development in your long history, especially since 1993. As a result, you have made considerable achievements in many respects: Improved school enrollment, diversified vocational training, strong foreign language education, promoted special-talent fostering, and an increasing number of private schools. All these achievements make Vietnamese livelihood more stable, and stable livelihood is a basis for better material and spiritual life. This is where HOF’s concept of eco-technology aspires for.

Recently Vietnam and Japan have strengthened cooperation in various areas associated with people’s security, comfort, and health with the strong leadership of Embassy of Japan in Hanoi. One good example is a fuel-cell scooter which Honda Vietnam will demonstrate later. The fuel-cell motorcycle is a product of one of today’s most advanced technologies, and I believe it is very important for both nations to make full use of such environmentally-benign technologies for more secure, comfortable livelihood of the people.

In many other areas, Japanese embassies strive to improve collaborative relationships among Japan, Vietnam and the East Asian countries in general. For instance, we help researchers build a unified form of technologies to conserve and improve the earth's environment, and a cooperative prevention system to address disasters like the Sumatra Earthquake and the bird flu.

Intellectual activity is the most important activities of human being. To acquire new knowledge, we need not only intellectual cooperation among nations, but also physical investments for large-scale advanced equipment and technology. But new knowledge is just a starting block. More importantly, we need to closely watch sci-tech trends and cooperate to create innovation, to put knowledge into use, especially when the world shortens the span between the frontier of knowledge and the industry.

I expect Vietnamese people to step toward a new innovation based on your diligence and the cooperation with the international community, especially Japan. We will maximize our assistance. This is my passion for Vietnam and the end mark of my keynote address. Thank you.

**The Honda Foundation International Symposium, 2005, Hanoi**

**Linking Innovation and Entrepreneurship**
**for Developing Countries**

**February 28, 2005: Melia Hotel, Hanoi, Vietnam**

## Keynote Address

## Technology innovation, Entrepreneurship and Link-up Implementations in Vietnam

Le Dang Doanh

Vice Minister of Sciences and Technologies, Mr. Le Dinh Tien,
Ambassador Hiroto Ishida, President of Kanazawa Gakuin University
Distinguished guests,
Ladies and Gentlemen

First of all, I would like to thank NISTPASS and Honda Foundation for their initiative to organize this important international symposium and for my opportunity to give a speech at this gathering. The main theme of the symposium, **"Linking Innovation and Entrepreneurship for Developing Countries",** is a very useful topic for Vietnam and is an area Japan can set a good example of innovation and entrepreneurship for developing countries to learn useful experiences and lessons.

This symposium being organized in the Spring of 2005 is a meaningful coincidence in the history of the bilateral relationship between Vietnam and Japan. A hundred years ago, in 1905 Vietnamese patriots including our famous Phan Boi Chau who started the Eastward Going Movement, sending Vietnamese youths to Japan to learn a development model and seek helps and assistance in our fight for independence. Thus, we, Vietnamese, recognized the leadership of Japan in Asia 100 years ago and looked toward Japan. I believed that both Vietnamese and Japanese nations will celebrate the 100$^{th}$ Anniversary of the Eastward Going Movement in the spirit of cooperation, friendship and good prospective Vietnamese-Japanese relationship. I hope that this symposium being organized 100 years after the Eastward Going Movement will contribute to the promotion of Japanese investment into Vietnam, encourage Vietnamese entrepreneurs to innovate their technologies, which are the realistic measures to have close economic, science and technology linkages in the spirit of mutual benefits.

Vietnam has a long history of culture and heroic national defense for independence and sovereignty to develop with its own characteristics and with its own choices. This is also a dynamic and continuous innovation process, absorbing positive achievements of the human civilization and adopting creatively for Vietnam's particular conditions. The world has known Vietnam for its creative contributions in military, culture, traditional medicine, and agriculture during its thousand-long years of history. In the past, the State and villages, pagoda and the State, together with Confucianism, Buddhism were important institution. Vietnamese entrepreneurs during the national history made important contribution to the expansion of international trade with other countries including Japan, due to limited understanding, their contribution were not duly acknowledged by the society and written about.

At the present, when the whole human being is moving toward a new stage of development, which is called new economy or knowledge economy, when development and growth which are urgent and imperative needs for deeper integration into the world economy depend on science, technology and innovation, the symposium "**Linking Innovation and Entrepreneurship**" is highly topical.

In the past centuries, churches, pagodas, Confucianism, Taoism, the State, King, and the village communities formed the important national institutions. In the context of the 21st century, firms, research institutes, and universities are more and more important institutions. They have even become the major institution for economic development, competitiveness enhancement not only at the present but also in the future. That firms, universities and research institutes are the driving forces for economic and sci-tech innovation, the major institutions for innovation in business, production in a close relationship with the state and society. It is obvious that firms are the important linkage for introducing technologies in our life, affecting consumers and the whole society.

Hereafter, I would like to address the transition in Vietnam, development of entrepreneurship and technological innovation and to make several recommendations for future development.

## I. Roles of firms in the innovation and development process in Vietnam

Started from 20 years ago, Vietnam has been continuing its active transformation process:

- Transition from a centrally planning economy in which state owned enterprises were encouraged and private business were prohibited economic model to a socialist-oriented market economy which is step by step integrating into the regional and global economy.
- Transition from a small, agriculture and noncompetitive economy to an industrialized, modern, specialized economy, and step by step moving toward a large scale, high productivity and competitive economy.
- Move forward to a high knowledge, technological and scientific economy, in which well trained, qualified, able and creative persons play a key role.

These processes integrate, interacted and enable each other in the transition to a market economy in which socialist orientation is the key.

Vietnam has attained considerable economic, education, scientific and technological achievements. The most important change is to realize the right to pursue one's own business according to laws and regulations in the context of market mechanism, integration, cooperation and competition, in which each individual has the right to decide on the field of business, investment and education, instead of business prohibition and restriction as before.

At the moment, Vietnam has 160,000 registered firms, 2.2 million household businesses, 6 million rural farms, in which about 250,000 firms are licensed to import and export. Entrepreneurship has been lightened up and contributed into high growth rate, poverty reduction to a half, job and income creation and export improvement. From a food importer, Vietnam has become an important exporter of rice and many other agricultural produces like coffee, cashew nut and tea with much biological innovation in botanical and animal variety, irrigation. The fishery industry has made great achievement in aquaculture farming. Together with technological innovation, electronics, garment, wooden furniture exports have rapidly increased.

Newly born industries have appeared such as ship building and motorbike assembling. Vietnam has quickly absorbed and owned new technology in tunnel construction, bridge construction, and high-rise building etc.

The government has constructed and developed the infrastructure, improved investment and business environment for doing business. The government also has assistant program in information technology, e-government, administrative innovation, technological innovation for small and medium enterprises, and in agriculture extension. Vietnamese government plays a key role in boosting technological innovation, creating economic leverage to promote entrepreneurship. Enterprises Law in 1999, effective 1 January 2000 has significantly improved the development in the private sector and thus, boosted technological innovation.

The National Assembly has approved Competition Law dated 9 November 2004, effective 1 July 2005 with a hope to create a fair business environment, control state monopoly and reduce costs for firms.

The market driven economy's institutions like banks and creditors, technological markets and fairs have assisted firms in modernizing their technology.

Information technology plays an ever-increasing important role in business operation and science research. Information technology is a foundation for achieving biotechnological technology improvement, modern management and governance. Most firms have taken the use of emails in communicating domestically and internationally, world wide webs in introducing firms. Customers world wide are now able to order a traditional long dress or a suit online from Vietnamese talent tailors at proper price, for instance.

Vietnamese firms have taken greater attention to register their trade mark, their intellectual properties and obey the Law on this issue.

During the whole process, Japanese firms have played an active role in technology transfer, human resource training, developing cooperation relationship, and step by step forming clusters of satellite firms to supply parts and components. The 60% localization of the Honda motorbike is an encouraging example. Many Japanese importers have consulted and helped Vietnamese firms in meeting the quality requirement, style, sanitary standard, and food safety by transferring technology, advising the required standard. Thus, more and more Vietnamese products could be exported to Japanese market and to third countries like handicraft, agriculture, forestry and marine products.

Vietnamese firms can be categorized into three main types:

- Firms that have strong financial resources and are of suitable size, professionally managed and well ordered, operate in competitive import – export business environment. There is only a small number of such firms.
- Firms that are state monopoly, large sized, operate in non-competitive business environment thus their business behavior are very different from other firms. Technological transformation is mainly for maximizing abnormal monopolistic profit but not for improving competitiveness and satisfying customers' need.
- The third type includes state owned and private enterprises of small sizes, of whose management is ethnocentric oriented, concentrate on domestic market. These firms need support and co-operation from large firms, credit institutions and government institutions in modernizing technology. Household business is also belonging to this category.

Vietnamese agriculture is small sized, fragmented, economically inefficient to technologically self-innovate. Thus, support from government, banks, scientists and firms are urgently needed. Recently, there has been positive experience in joining governmental investment and universities and institutes 'technological innovation in applying scientific improvement, new animal and botanical varieties into agriculture, forestry, and fishery. Evidence shows that farmers have great potential in learning new technology to improve competitiveness.

There have been models in industry, in which there are direct connections between science and production, production orders science research, and scientific results applied directly in production. In both agriculture and industry, scientists 'income goes together with business effectiveness and their research is tested in reality.

It can be asserted that technological innovation and entrepreneurship are ever connected and promoted. It is easily noticed that firms operate in competitive business environment or engage in export have recognized the importance of technological innovation and be able to do so in this regard in comparison with state monopoly or small firms who only operate in domestic market. It can be seen easily the difference between exporting firms like Viet Tien, Thai Tuan and domestic firms operate in monopolistic areas. Managers who are highly educated, have knowledge of foreign languages, and are still very young are the ones who push up the technological innovation process. Software technology is an area that requires the involved firms to compete severely, to update their knowledge and have a well trained and able managerial force.

## II. Opportunities, challenges and recommendations

While acknowledging achievements in technological innovation, promoting entrepreneurship and university-institute linkages obtained during the past it must be admitted honestly that Vietnam is just at the very first stage of the process and facing many opportunities as well as challenges.

Vietnamese indicators on technological competitiveness, technological innovation ratio, technological level of product and services are very poor and slowly improved. Legal framework on technology transfer which includes regulations on technology importation, tax, and technology evaluation procedures need to be further developed to create favorable environment for businesses.

The key factor in bolstering technology innovation is to create a stable and secured business environment for firms to safely invest. Vietnamese firms are still incompetent in market research, marketing, customer management needed to apply suitable business technology. Due to the weakness in market research, quite a few firms are vague in modernizing technology, in choosing an appropriate technology suitable for market and customers' requirement.

Vietnam should also further develop financial and credit institutions which include venture capital for scientific research, new technological application investment. There must also be a linkage between universities, research institutes, firms, and farmers based on governmental preference, support and investment. The management reform in universities and research institutes must be encouraged, realistically organized to bring out persuasive effectiveness to firms and farmers.

The linkages between science and production, between universities, research institutes and firms must be carried out more closely, publicly and effectively. This must be done in the on-going business reform as well as scientific and technological reform. Firms must be put in domestically as well as internationally competitive environment and monopolistic firms must be supervised closely by impartial criterion. Only via this method has active entrepreneurship been encouraged. The technological system must be operated via a close linkage between business, technology and reality.

Throughout this process, learning experience and absorbing modern technology has a determinant role. Evidence has shown that, investment and technology transfer from Japan has significantly contributed in technological innovation in NICs (Newly Industrialized Countries) in South East Asian. More recently, Japanese investment and cooperation has greatly changed Chinese coastal provinces' agriculture, helped these provinces to produce agricultural products of high quality which meet the Japanese's standard. These are useful experience and lessons for Vietnam.

I hope this symposium will promote Vietnam's cooperation with Japan as well as other countries in the region, help Vietnam improve its competitiveness in its international economic integration. I believe that, together with the support and goodwill from the two governments, and the two nations' friendship, this symposium will contribute to the promotion of investment and technology transfer from Japanese firms into Vietnam.

May I wish you good health and our symposium great successes! I hope you all have a nice time in Viet Nam.
Thank you.

**The Honda Foundation International Symposium, 2005, Hanoi**

**Innovation, Entrepreneurship and Link-up Implementations for Developing Countries**

**February 28, 2005: Melia Hanoi Hotel, Hanoi, Vietnam**

# Special Presentation: Innovation, Entrepreneurship and Link-up Implementations for Developing Countries: Thailand's Experiences

**By**

**Dr. Patarapong Intarakumnerd**

**Project Leader of Thailand's National Innovation System Study**

**Science, Technology and Innovation Policy Research Department**

**National Science and Technology Development Agency (NSTDA)**

Vice Minister Le Dhin Tien,
Ambassador Hiroto Ishida,
Dr. Le Dang Doanh,
Dr. Tran Ngoc Ca of NISTASS,
Prof. Odagiri, Prof. Goto, Prof. Nakajima, Prof. Sunami,
Mr. Toshio Ban, Managing Director of Honda Foundation
Distinguished speakers and participants, Ladies and Gentleman

It is my great delight and honour to be invited by the prestigious Honda Foundation and NISTPASS to share my view at the conference. It is very trendy to talk about innovation and entrepreneurship, which have become buzzwords. However, what is much more significant in the context of developing countries is how innovation and entrepreneurship can be really implemented to eradicate poverty, increase quality of life of people, and enhance international competitiveness of a country. This conference is therefore very timely organised to address these critical development-related issues.

The outline of my presentation will be as follows. First, I will place entrepreneurship in the context of national innovation system. Then I will discuss about entrepreneurship in Thailand, which is very much relying on overseas Chinese business practices. I will move on by introducing all of you with major changes in Thai government policy for promoting innovation and entrepreneurship. Finally, two cases implementing cases will be used as examples. One is about how to leverage entrepreneurship and knowledge from outside and use them to strengthen the country's indigenous capability. Another is about how to nurture entrepreneurship and innovative capability, based on local wisdom and knowledge, at the grass-root level.

## Entrepreneurship in National Innovation System

In a nutshell, innovations are novelties of (potential) economic value. Innovations may be introduced to a market as products either in the form of goods or services. Alternatively, they may be used within the firm/organization as processes and organizational changes to increase productivity and product quality. It is widely accepted that in the era of globalisation and technological sophistication, no one can innovate alone. Innovations are very much influenced by many actors and embedded in national context which those actors operate or the so-called National Innovation System (NIS). NIS is the interactive system of existing actors, private and public firms (either large or small), universities and government agencies, financial intermediaries, private industrial associations and so on, aiming at the production, diffusion and use of knowledge within national borders. Interaction among these units may be technical, commercial, legal, social and financial as much as the goal of the interaction may be development, protection, financing or regulation of knowledge. Institutional context like law and legal frameworks, trust (among actors), attitude to failure affect behaviours all actors in the NIS. Entrepreneurship is also very important part of institutional context.

The word 'entrepreneur' came from the term 'entrepredre' in French since the Middle Age. Literally translation is a 'between-taker' or a 'go between'. One of the most important pioneer of innovation studies, Joseph Schumpeter, saw the entrepreneur as the 'bearer of the mechanism of change', i.e., a key factor in introducing innovations by performing one or combinations of these tasks: a) introducing of a new good, b)introducing of a new method of production, c)opening of a new market, d) acquiring a new source of raw materials or half-manufactured goods and e) carrying out a new organisation of any industry.

## Entrepreneurship in Thailand

With the exception of Indonesia, the Thai economy is rather unique in South-East Asia because no class of indigenous big business entrepreneurs exits. Even smaller businesses in Bangkok, especially in retailing, are mostly owned and operated by Sino-Thais. The dominance of family-owned enterprises established by immigrant Chinese entrepreneurs in Thailand has long been rooted into the Thai business norms and cultures. Therefore, historically and culturally, entrepreneurship in Thailand is not much different from Chinese-dominated countries like Taiwan.

In terms of trust, Chinese-owned businesses tend to be built as family-affiliated corporations that allow ownership- and kinship-led rather than skill-based management. This "family-ownership-control-type business", characterised by low stock ownership diffusion and more family-related CEOs has led to business and joint investment co-operation among different companies within the same family affiliates *but only few* co-operations among various enterprises of different families. Although many Chinese-run firms have grown into big conglomerates covering many business areas, the founding family still keeps the ultimate rein. After, firms under the same family umbrella overlap and compete, leading to intra-family conflicts. In sum, co-operation is less likely in inter-family businesses, and in the intra-family enterprises, co-operation often draws family complexity and contention.

An effect of the Chinese-Thai entrepreneurship on the failure acceptance attitude can be translated into two contrasting views. While the first view sees Sino-Thai influence as a threat towards innovation, owing to their low acceptance of failure and a lack of merit-based management, the second view the Chinese-Thai business culture as a positive condition, that tolerates risky ventures, needed for long-term planning and investment.

First of all, due to the fact that Chinese-run enterprises expand their businesses for the main purpose of their "total fortune of the family", they advance into areas such as finance and real estates. This evidence shows their risk-averse characteristics in doing businesses. The up-front profit from trading and property business is far more attractive than the expensive technology-intensive manufacturing that will only earn longer-term gains. As a result, technological deepening or long-term sustainability is not much of a concern. Political capability in terms of gaining access to lucrative oligopolistic sectors seems more important than technological capability in this case.

The structural and political context also affects behaviour of Sino-Thai firms. Most of the domestic expansion and diversification rationale comes from the fact that Sino-Thai firms take advantages of government's industrial promotion and other tax incentives while diversifying into foreign venture for scale and scope purposes, given the limited domestic market and intensive local competition. Therefore, liberalisation and high industrial growth of the 1980s, together with many outside favourable conditions unrelated to the fundamental capability of the Thai industries, allured the Thai conglomerates into new diversification technologically unrelated to their original businesses. In order to do that, the underlying capability these firms accumulated is capability to establish and maintain political connections with government authorities, rather than technological and innovation capabilities.

The second view, however, sees the Chinese-Thai entrepreneurship positively. The fact that "Sino-Thai families traditionally were reluctant to relinquish ownership and management of their companies…" allow them to create long-term vision for their very own family businesses. While some list their assets in the stock market, many still prefer to raise capital conservatively through loans and offshore bond issued at a chance to benefit from different international interest rates. The continuous vision from fathers to children protects them from the short-term concerns of the stock prices or threat of acquisition. Deep-rooted corporate culture and tacit learning of the family members create a qualified decision base for risky projects. Therefore, they are capable of creating risky ventures on the expectation of future success without being distracted by their stockholders.

Entrepreneurship in Thailand experiences interesting changes. The attitude and behavioral changes towards entrepreneurship in Thailand come from exposure to modernism, innovative culture and new technologies of the West, which have infiltrated through the overseas education among their predecessors of the newer generation. This factor is where the two contrasting views towards the Sino-Thai business culture finally merge. The combination of the fast decision traits and the long-term plan assets will create a condition that allows the Thai business to grow both horizontally and vertically. It will likely create a business structure, though remaining of the family-run type, that becomes increasingly innovative and adaptive to the changing environment. The attitude that favours kinship rather than managerial skills has also started to change. Professionalism of management grows despite the tight family control allowing a better prospect for competency building and technology development.

The innovation surveys show higher acceptance to failure attitude from 10.5 percent in the year 2000 to 19.5 percent in 2002. As high as 63.5% of surveyed firms in 2002 considered *establishing long term strategic partnership with other firms* rather important or important. There was also a positive change in other attitude indicators such as openness of customers to innovation. This indicates a better innovative environment in Thailand.

## Changes in government policy in promoting Innovation &Entrepreneurship

Up to the present government of Prime Minister Thaksin Shinawatra (starting January 2001), scope of S&T policy in Thailand was rather narrow. It covered only four conventional functions, namely, research and development, human resource development, technology transfer, and S&T infrastructure development. This narrow scope of S&T was very much based on the perception that private firms were "users" of S&T knowledge mainly produced by government agencies and universities. There was no articulate national innovation policy. Though the word "innovation" was mentioned in several national plans, it was not whole-heartedly incorporated into the scope of S&T policies. In addition, unlike Japan, Korea, and Taiwan, S&T elements were not part of broader economic policies namely, industrial policy, investment policy and trade policy and, to the lesser extent, education policies..

Industrial policy of Thailand has not paid enough attention to the development of indigenous technological capability as an integral factor in the process of industrialisation. Investment policy, especially the promotion of foreign direct investment (FDI), aims primarily at generating inward capital flow and employment. Unlike Singapore where FDI is specifically used to upgrade local technological capability, there is no explicit and pro-active link between promoting FDI and upgrading of local technological capability in Thailand. Trade policy, the most important instrument in Thailand being tariff, has not been used strategically to promote technological learning like in NIEs. Instead, trade policy was very much influenced by macro economic policy, for instance, to reduce domestic demand for imports at the time of balance of payment deficit. The Ministry of Finance, the dominant agency which controlled the policy, had little knowledge or experience of industry and industrial restructuring.

Moreover, industrial policy in Thailand has been limited to the so-called 'functional' intervention such as promoting infrastructure building, general education, and export push in general. There have been virtually no selective policy measures, such as special credit allocation and special tariff protection, targeting particular industries or clusters. The exception was the local content requirement in automobile industry, which was rather successful in raising local contents of passenger vehicles to 54% in 1986. Interestingly, with the exception of automotive industry, there has been no reciprocal performance-based criteria (such as export and local value added and technological upgrading targets) set for providing state incentives like in Korea or Japan. Investment promotion privileges, for example, are given away once approved. The intention to attract foreign direct investment and promote export overshadowed the need to develop local initiatives and indigenous technological capabilities. As a result, linkages between multinational corporations and local firms were also weak. Unlike Taiwan, the governmental protection and promotion, without strengthening absorptive capabilities of Thai suppliers, left a profound impact on the weak technology and suppliers' network of industries.

The major change in policy came recently under the present Thaksin government. Media and academics in Thailand and the Southeast Asia labeled this government distinctive policy as "Thaksinomics" (Thaksin's Economics). Dual track policy is the main thrust of Thaksinomics. The government is trying to enhance international competitiveness of the nation by strengthening 'external' side of the Thai economy, namely, export, foreign direct investment and tourism. At the same time, it is attempting to increase capabilities of domestic and grass-root economies by implementing projects like Village Fund (one million Baht to increase local capabilities of each village), a three-year debt moratorium on farmers' debt, One Tambon[1] One Product Project (supporting each Tambon to have product champion), and People Bank (giving loans to underprivileged people with no requirement of collateral).

This government, unlike its predecessors which pay most attention to macro-economic stability, focus more on enhancing meso- and micro-level foundations for international competitiveness. The high priority of 'competitiveness' issue on the government's agenda is illustrated by the establishment of National Competitiveness Committee chaired by the Prime Minister. It was the first time that Thai government has serious "selective" policies addressing specific sectors and clusters. The government declares five strategic clusters which Thailand should pursue: automotive, food, tourism, fashion, and software. Clear visions have been given to these five clusters. Kitchen of the World (food cluster), Detroit of Asia (automotive cluster), Asia Tropical Fashion, World Graphic Design and Animation Centre (software cluster), and Asia Tourism Capital. Building innovative capabilities of the nation is highly regard as very important factor increasing and sustaining Thailand's international competitiveness. "Innovative nation with wisdom and learning base" is one of seven Thailand's Dreams projected by this government. To make this dream come true, several strategies have been devised. These include continuous investment in R&D and technology, well environment for attracting and stimulating innovation, high accessibility to knowledge and information across the nation, fluent English as a second language, possessing strong learning basis such as passion for reading, better accessibility to cheap but good books, thinking school with innovation movement.

[1] Tambon is a unit of local government administration. One Tambon comprises several villages.

The new ten-year Science and Technology Strategic Plan (2004-2013) places the concept of national innovation system and industrial cluster at its heart. The scope of the plan is much broader than the aforementioned four functional areas. Measures to stimulate innovations and to strengthen national innovation system and industrial clusters are explicitly highlighted. Equally important, the Board of Investment (BOI) has substantially changed its policy by paying more attention to issues underlying long-term competitiveness of the country, namely, development of indigenous technological capability and human resources. Special investment package promoting "Skill, Technology and Innovation or STI" has been initiated. Firms can enjoy one or two years extra tax incentives if they perform the following activities in the first three years: spending on R&D or designing at least 1-2 percent of their sales, employing scientists or engineers with at least bachelors degree at least 5% of their workforce, spending on training of their employees at least one percent of their total payroll, and spending at least one percent of total payroll on training personnel of their local suppliers.

To carry out these changes, the government has introduced the private sector's management style to improve efficiency and effectiveness of bureaucratic system. Chief Executive Officer (CEO) style is now being implemented both at central and local government levels in order to integrate related government policies under clear leadership. Together, the Performance-Based Management (PBM) which clearly illustrates contractual relationship and delegation of authority in the bureaucratic lines of governance has been put in place.

Cluster concept is also used as a main industrial policy of Thaksin Government for national, regional and local levels. At the national level, it is used to strengthen advanced industries both in service and manufacturing sectors like automotive, textile and garment, software and tourism in order to make them to be coherent and innovative 'industrial clusters'. At the regional level, Thailand is now divided to 19 geographical areas. Each area has to plan and implement its own cluster strategy focusing on a few strategic products or services. It will be supervised by CEO governors located in the area. For the local level, the cluster concept is applied to increase the capacity of grass-root economy in the name of 'community-based clusters', especially to help the 'One-Tambon-One Product' succeed.

## Link-up Implementations

Here I will elaborate on how changes in the aforementioned policies have been implemented in practice by using two case studies. One is about how a research and technology organisation (RTO) played a bridging role to leverage entrepreneurship and innovative capability of transnational corporations to stimulate them to perform more technologically advance activities within the country and diffuse its knowledge to local companies. Another is about the development of entrepreneurship and innovative capability at the grass-root level based on local knowledge and wisdom.

## Hard Disk Drive to Chili Paste: TNCs led-Innovation and Entrepreneurship?

The hard disk drive is an electronic product playing a significant role in Thailand's electronics exports. Thailand is ranked as the most important global base for hard disk drive manufacturing. Thailand stands 2nd in the world rank of hard disk exporters next to Singapore with manufacturing segment of 17 percent of world production in 2003. The HDD sector in Thailand employs more than 50,000 people having an asset of at least 52,000 million Baht which is generating an export worth of 210,000 million Baht. This has become possible due to the Thai manufacturing bases of the hard disk giants like Fujitsu, IBM/Hitachi, Western Digital and Seagate.

Thailand-based operations generally import high technology components from abroad into the country as raw materials and exports the products to markets worldwide. The level of local content is estimated to be quite low, approximately 30-40 percent of total production cost, due to the lack of suppliers, low quality domestic components and the complicated processes of buying between domestic factories. Since the majority of HDD suppliers receive tax incentives from the Board of Investment (BOI) similar to the HDD assemblers, they are also eligible for raw material import tariff exemption for export products. If the manufactured components are not exported as declared to the BOI, the suppliers must submit papers declaring the value of indirect exports which may be considered as domestic sales for payment of the raw material import duties. Therefore, it is frequently easier for suppliers to directly export to neighboring countries like Malaysia and Singapore, leaving the assemblers to re-import it as raw materials for use in Thailand.

The industry heavily relies on technology transfer from their foreign affiliates. The foreign affiliates usually provide raw materials, machinery technology and markets. In addition, the TNCs 'headquarters play a major role in formulating marketing and production strategies.

National Science and Technology Development Agency (NSTDA) is the biggest research and technology organization in Thailand with 1,800 employees. It undertakes a broad-based, systematic approach towards enchanting the entire science and technology system of Thailand in support of national economic and social development. Four specialised centers-Genetic Engineering and Biotechnology (BIOTEC), Metal and Materials Technology (MTEC), Electronics and Computer Technology (NECTEC), and Nanotechnology Center- come under the NSTDA umbrella. These three centres have been established in the 1980s in line with the global trend at the time and perceived local needs for strong research capability in these areas. Though it is not an official policy, NSTDA, therefore, has strong path dependency of focusing on R&D with a smaller interest in supporting advancement of technological capability development of private firms through several financial and technical supporting schemes such as technical consultancy services, IP services, training services, quality control services.

It tries to play a role of knowledge broker or a bridging institute in the hard disk drive cluster. First, in collaboration with Asian Institute of Technology (AIT) and Asia Policy Research (a consulting company), they conducted studied on the hard disk drive cluster by mapping all key players, and evaluate roles, technological capabilities and linkages of key players of the industry.

From the study, there are five major private-sector players of the cluster:

1. HGA/HAS/HDD Assembly
2. Motors
3. Suspensions

4. Base plates
5. Flex assembly.

In addition, there are a few other value-added activities carried out by various players such as Gem City Engineering (automation engineering services) and Thai International (calibration). Apart from private-sector players, there are key government agencies important to the industry, namely, BOI, government research institutes like NSTDA, universities conducting research related to and in cooperation with the industry like Asian Institute of Technology (AIT), Chulalongkorn University, Suranaree University and Khon Kaen University, and training institutes providing courses in automation like Thai German Institute.

The firm-level interview survey of the HDD industry generated some mixed indications with regard to the technology activities of foreign invested firms in Thailand. Building on detailed interviews with 10 major companies in the HDD sector – all clearly foreign owned with the exception of one firm listed on the Thai stock market, the research exercise measured the technological capabilities in five broad areas and at three different levels: basic, intermediate and advanced.

The basic findings were that:

- The firms exhibited strong capabilities in investment, process development and industrial engineering areas, all areas that are required to support their manufacturing operations in Thailand;
- The firms showed much weaker capabilities in product engineering and innovation, with some indications that American firms had gone much further in building these capabilities in their Thai operations than non-American firms; and
- The firms show very weak capabilities in linkage development but showed a strong interest in developing stronger linkages if the support infrastructure is in place, and indicated that it would call for concerted efforts from both industry and the government to build an environment that is conducive to linkage development.

Most companies are linked to a certain degree into the vertical supply chain of the Thai HDD cluster and share related information with regard to specific product related issues, especially for new products. But it was found that a few firms cooperate closely with either Thai based suppliers or customers in broader product process or human resource development related activities that is marked by weak innovation related links amongst them. Moreover, fewer companies maintain links with universities, R&D institutions and service providers or with the competitors in their field.

From the study, seven projects aiming to technologically upgrade the hard disk drive cluster have been specified:

1. Training Program for Automation Engineers and Technicians
2. Revitalize the Certificate of Competence in Storage Technology (at AIT)
3. Establish a precision engineering part of the proposed Thailand Tool & Die Institute
4. Collaborative R&D Project in Automation
5. Establish a Disk Storage Institute
6. Develop a New Investment Package for the HDD Industry
7. HDD Technology Roadmapping

To implement these seven project effectively, NSTDA helped to set up a cluster management organisation headed by a HDD cluster manager, an adjunct professor at AIT who is also a technopreneur owning IC design company. He used to work for the industry, understand the industry's needs. He is highly accepted by the industry. This organization will act as a coordinator between all main actors, and push forward these projects. The work of HDD Cluster Manager is under the supervision of a steering committee chaired by a director of NSTDA's centre and composed of industry people, university professors in the field and representatives from concern government agencies.

At present, NSTDA is playing a role of an organizer and facilitator in the HDD technology roadmapping project (the 7$^{th}$ project) aiming at producing shared vision and technology roadmap of the cluster for the next ten years. Next step, NSTDA will partially finance and work with TNCs in the collaborative R&D project on automation (the 4th project) It will assist in establishing TNCS-Thai firms linkages such as helping to identify key Thai suppliers' engineers and technicians to be trained in the 1st project.

**Grilled-Fish Chilli Paste Cluster: Innovation and Entrepreneurship at the Grass Root?**

As mentioned above, at the local or community level, the government initiated "One Tambon, One Product" by encouraging each Tambon to select its product champion based on their comparative advantage. A 'product' can be anything such as handicraft, herbal medicine, foodstuff, manufacturing items, and tourism. 'Cluster concept' is applied at the community level to support these products and the government called them community-based clusters. Here we will examine a community-based cluster in the making. This cluster grew rather successfully before the government cluster policy initiative. The study was done jointly between the Office of Rajabhat Institutes and National Science and Technology Development Agency in 2002.

*History of the Community*

Wat Tuptimdang Community is located at Tambon Klong Song, Klong Luang District, Pathumtani province. This community is an old community dated back to the reign of King Rama V or more than 100 years ago. The community was named after a Temple, Wat Tuptimdang Dharmadaram, which was highly respected and used for religious ceremony by local people. At present, there are 1,031 inhabitants living in 171 households. Most inhabitants are farmers with their own land. Their economic status is fair and quite sufficient. Most of them are Buddhists and had only primary and/or secondary level of education. Relatives live together closely and rely on each other. These rural people live simply and close to nature.

*Local Wisdom*

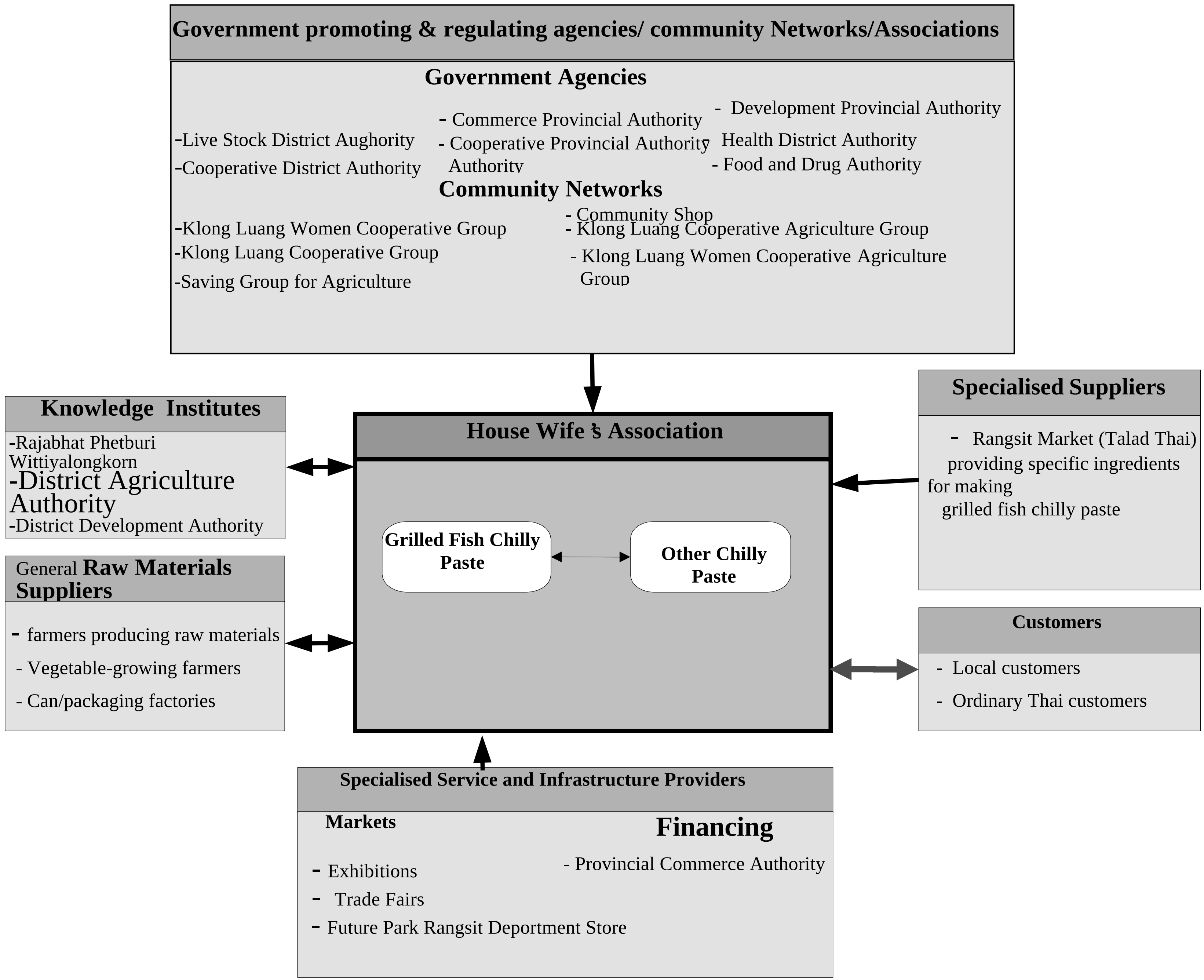
The Taptimdang Community has been rather stable. Ways of life have been maintained. The community has wisdom in the areas of agriculture (e.g. farming, breeding, mixed animal and plant farming), handicraft, food and food processing.

These areas of knowledge are mostly tacit as it is embodied in certain individuals of the community. The most striking local wisdom of this community is, of course, knowledge in making grilled fish chili paste. Fish has been very abundant and can be consumed all year round. Fish is cooked, processed and preserved in many forms. Chilly paste is an every-day food of people in the central region. Grilled fish has been used as important ingredient in a certain types of chilly paste and is considered as local wisdom passed on from one generation to another.

*Mapping of grilled fish chilli paste*

The cluster of the grilled fish chilli paste is mapped here. The driving force of the cluster is of course the House Wife Association. They are others important actors, namely, customers, general raw material suppliers, suppliers of specific ingredients, knowledge institutes at the local and provincial levels, specialised services and infrastructure providers, government supporting and regulatory agencies (both at local and provincial levels), community networks and associations  institutes (see the following figure).

# Cluster Map of the Production of Chili Paste with Grilled Fish



*Policy lessons from the case of chilli paste cluster*

The chilli paste cluster is a community-based cluster that relies heavily on the local knowledge in making chilli paste. As mentioned before, the local knowledge is highly tacit i.e., mostly embedded in people and relationship between people. They are four challenges for this type of knowledge.

1. Codification. Local community knowledge, to a large extent, is passed on from one generation to another orally. Attempts to codify and store them in media (e.g. written document) are quite limited. As a result, there is high risk that knowledge would be disappear as time go by.
2. Verification. The results of the local knowledge sometimes are not consistent i.e. they do not always yield the same and assured quality. They are problems of being able to repeat the same process provided by the local wisdom. In this case, the paste's taste could vary in terms of sweetness, hotness, dryness and the like.
3. Diffusion. As the knowledge is very much tacit and localised. In several cases, it is quite difficult to transfer the knowledge to wider public.
4. Upgrading. It is challenging to upgrade products of local wisdom such as to make it have longer shelf life, to make it more attractive for upper markets, and to be able to export to other countries.

While studying NSTDA and ORIC were addressing these four challenges. They attempts to codify ingredients and the detailed process of making the chilli paste. They verified this process by using laboratory testing to make sure that the quality and taste of chilli paste would be consistent and high standard. They publish manuals of making chilli paste which were distributed widely. As for upgrading, they provided technical assistance to the association by introducing can technology. The rationale is that if the chilli paste is in the canned packaging, it would last longer and more attractive for upper market. However, this is not so successful since consumers are still like to buy chilli paste in a small plastic pack, since they can see the colour and texture of the paste.

## Conclusion

Entrepreneurship is an indispensable institutional context of national innovation system. Rather than perceiving entrepreneurs as born and pre-given only, the government should encourage entrepreneurship and innovation by facilitating entrepreneurship development process and creating conducive environment. For developing countries relying on FDI, government should leverage knowledge and entrepreneurship of TNCs and link them to local firms while grooming local knowledge & entrepreneurship especially at the grass-root level where majority of population live.

Research and Technology Organisations, having organisational flexibility, accumulated knowledge and human resources, should be able to act as bridging intermediaries between transnational corporations and local firms. On the other hand, community-networking organisations, having local knowledge and trust of local people, can play important roles in diffusing knowledge and encouraging innovation and entrepreneurship at the grass-root level. Government should support and strengthen capabilities of these organizations to perform such roles.

# Harnessing the Potential of Science and Technology: The Changing Innovation System of Japan

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This chapter discusses the national innovation system of Japan. It begins with a historical and quantitative overview of Japan's innovation system in Section 1. In Section 2, we focus on the two components of the innovation system, industrial R&D and government policies, and in Section 3, we discuss government research institutes and universities. In Section 4, after examining how the environment surrounding Japan's national innovation system has recently changed, we discuss the peculiar features of emerging science-based industries (SBI), such as biotechnology and IT industries. In Section 5, we discuss recent government policies to promote such science-based industries. The main emphasis will be on university-industry collaborations, intellectual property policy, and the promotion of startups. In Section 6, we conclude our discussion by emphasizing the importance of the issue of R&D boundary of the firm and asking whether the conditions for SBI-friendly environment can coexist with the traditional Japanese system.

## 1. Innovation in Japan: A Historical and Quantitative Overview

Let us begin with a historical overview of Japan's national innovation system. Japan began its industrialization efforts right after the Meiji Restoration of 1867 when the Emperor, with the backing of young *samurai* from the western part of Japan, reclaimed the power from Tokugawa *Shogun*. The government soon raised 'Rich Nation, Strong Army' as its slogan, and started efforts to catch up with the more advanced Western countries (i.e., the USA and Europe) economically and technologically. They hired a number of knowledgeable people from the West, often at a surprisingly high salary (even higher than that of the Prime Minister in some cases), imported equipment, built infrastructure (e.g., transportation and communications network), and introduced social and legal frameworks (e.g., the company law and the patent law). Particularly noted is the investment they made to establish an education system, both at the compulsory elementary level and at higher levels. As a result, by the beginning of the 20th century, illiteracy was virtually absent. An engineering school, which later became the Engineering Department of the University of Tokyo, was established in 1873, just six years after the Restoration, with entirely foreign (mostly British) faculty, and started to supply educated engineers, a number of which later founded new companies, including Toshiba and NEC, and, later as a graduate of the University of Tokyo, Hitachi, Toyota, and Nissan. In fact, in our opinion, it is more the entrepreneurship of these people than government policies that was the driving force of Japan's industrialization. However, describing the details of this process of Japan's industrialization and technological development is not the purpose of the present chapter: see Odagiri and Goto (1996) for more.

When World War II ended, Japan was lagging behind the US and European countries, partly because of the war-time isolation from the scientific and technological knowledge developed in these countries (e.g., petrochemicals and penicillin), and partly because of Japan's heavy bias at the time to war-related industries, such as aircrafts and shipbuilding. Still, the country had inherited industrial and technological bases, both tangible and intangible, from the pre-war period, with more than sixty percent of the plants and equipment surviving the war, and a large number of workers with experience. With these bases, the country resumed its efforts to catch up with the West.

Figure 1 gives the trend of four innovation-related indicators during the post-war half century. Japan actively imported technologies from abroad, particularly during the 1950s and 1960s. Thus, on a real yen basis, technology import (i.e., the payment to technologies licensed from abroad) increased from 34 billion yen in 1952 to 5,119 billion yen in 1971 at an annual growth rate of 15.3 percent. During most of this period, the government regulated technology importation and the firms had to apply to the government to get an allocation of foreign exchanges with which to pay royalties to the licensors: were it not for this regulation, the amount of technology import might have been larger.

<Figure 1 around here>

Domestic R&D expenditures increased even more rapidly, at an annual rate of 16.9 percent during the same period. As a consequence, its ratio to GDP increased from 0.62 percent in 1956 to 1.85 percent in 1971: see Figure 2. Technology importation is not a simple process. Imported technology may be immature or unsuitable to local natural and social conditions. Quite often, fierce domestic competition propelled Japanese firms to import new technologies at a still commercially untested stage. Thus, they had to expend heavily on R&D to develop the technologies further in order to make them applicable to manufacturing processes and to make them commercially viable.

<Figure 2 around here>

Gradually, however, the weight of R&D shifted from improvement of imported technologies to own inventions. This shift resulted in an increase in patenting activity as shown in Figure 1. From 1971 to 1987, the number of patent applications by the Japanese to Japan Patent Office (JPO) increased at an annual rate of 9 percent[1]. Technology export also started rising, not only because of increasing inventions by Japanese firms but also because of increased licensing to Japanese subsidiaries abroad, which started to increase during the 1980s.

Thus, as shown in Figure 2, the ratio of technology exports to technology imports improved. According to the statistics by the Bank of Japan (BOJ), exports caught up with the imports only recently. However, according to the statistics by Soumusho (Ministry of Internal Affairs and Telecommunications) which, unlike the BOJ data, includes receipts from the provision of knowhow in relation with plant exports and excludes transactions related to trademarks[2], the export/import ratio exceeded unity in 1993 and since then increased rapidly. In 2002, the export was 2.6 times larger than the import. The ratio is particularly high in the automobile industry, reaching 75.0 in 2002, followed by iron and steel (4.8), chemicals (5.9), and pharmaceuticals (3.4). It also exceeded unity (at 1.05) in the electric, electronic, and communications equipment industry, suggesting that Japan is now at the forefront of global high-tech competition.

This high ratio in the automobile industry owes to active globalization of Japanese carmakers. According to the Soumusho data, 86.7 percent of technology export in the industry is made between parents and subsidiaries, whereas the same percentage is 49.2 in the manufacturing industries excluding the automobile industry. For technology importation, the percentage is 13.4 in the entire manufacturing industries, suggesting that the majority of technology importations are arm's-length transactions between independent firms. Still, it is 71.8 in chemicals (including pharmaceuticals), probably because many chemical and pharmaceutical foreign multinationals have their

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[1] As will be discussed later in Section 4, JPO started to accept multi-claim patent applications in 1988; therefore, the number of patent applications after 1988 is not strictly comparable to that of the earlier period.

[2] For more detail on the difference between the two statistics, see Yoshimi (1993).

subsidiaries in Japan.

An international comparison of innovation activities is shown in Table 1. In terms of R&D/GNP ratio, Japan is ahead of other large countries[3], even though the amount of expenditure is less than half of that in the US. In terms of the number of scientists per population, Japan is highest but, if converted to a full-time equivalent basis, Japan and the US may be at a comparable level (see the note to Table 1). As a consequence of these efforts, Japan's R&D performance also improved. Since differences in patent laws make an international comparison of patenting activity difficult, we show in the table the share of US patents registered by the nationals of each country. Besides the US that naturally occupies the majority, Japan's share is 20 percent, easily exceeding Germany, France, and the UK combined.

<Table 1 around here>

Another fact to be noted is the active involvement of industries in Japan. The proportion of R&D expended by industries is around 70 percent in every country (except France) in both 1991 and 2001. The proportion funded by industries is also near 70 percent in 2001 in Japan and the US but lower in European countries. Compared to ten years earlier, a marked difference is that, while Japan slightly decreased the proportion, other countries increased it. Thus, in 1991 and earlier, Japan was the only country in which the industry funded more than it expended, implying that the industry in Japan hardly received any funds from the government, whereas American and European industries received a sizable amount of R&D funds from the government. Since then, the US and Europe decreased the proportion of government funds owing, most importantly, to decreased defense-related R&D expenditures. By contrast, during the same period, Japan increased its government R&D funds proportionally. We will later return to discuss this increased government R&D spending in recent years.

In sum, Japan's national innovation system during the postwar half century is characterized by a rapid rise in the innovation activity, as characterized by R&D expenditures and technology importation, and the larger role of industries in R&D

[3] Among the OECD countries, only Sweden and Finland are ahead of Japan.

investment in comparison to the US and Europe. In the latter regard, however, an international convergence seems to have occurred during the past decade.

Before concluding this section, let me mention another feature of the Japanese industrial R&D system -- a larger role played by big firms. According to the Soumusho data, firms with 10,000 employees or more accounted for 68.8 percent of total industrial R&D in 1999 in Japan. In the US in the same year, the comparable percentage was 55.0 (the NSF data). According to the study by Kneller (2004) on patent applications in genomics, proteomics and related applications filled between 1991 and 1999, large firms (with roughly 500 employees or more) accounted for 72 percent in Japan and Europe but 50 percent in the US. By contrast, the proportion of startups and small and medium enterprises accounted for nearly 40 percent in the US but only 12 percent in Japan and 6 percent in Europe. Therefore, both in terms of R&D input and output, large firms play a larger role in Japan (and perhaps Europe) than in the US. Put differently, Japan lags significantly behind the US as regards the activities of startup companies. It is for this reason that, as will be discussed later in Section 5, the promotion of startups is considered to be one of the urgent issues in Japan.

## 2. Industrial R&D and Government Policies

A national innovation system, of course, cannot be described by the R&D statistics alone. Behind it are the business, industrial, and policy conditions that support and regulate the activities of the players.

During the high-growth era of 1950s and 1960s, the main engine behind active technology importation and R&D was a fierce market competition, combined with the prospect of a high return if the firm wins this competition. With rising income, the markets were expanding. Many new firms entered the markets with innovative products and processes, including not only such now world-famous cases as Honda and Sony but also less known cases, such as Tsuzuki, a textile company. Other firms entered new markets as a means of diversification, such as Suzuki, originally a producer of spinners and weaving machines, who entered into the production of motorcycles and then automobiles, and Toray, which diversified from rayon to nylon and then to various fine chemicals. There are also many cases in which smaller fringe firms challenged market leaders with innovative products and innovative plant layouts and new processes[4].

Therefore, competition was fierce and, if firms failed to innovate, they went down. If, on the other hand, firms succeeded in inventing new technologies or in introducing and commercializing imported technologies, the returns were often very high. Such returns were reinforced by the protection policy of the government. Because both import and inward foreign direct investment (FDI) were restricted until the gradual liberalization that occurred during the 1960s and 1970s, domestic firms could serve the market with little fear from the competition of foreign multinationals. Foreign firms could exploit their technological superiority neither by exporting the products to Japan nor by investing in Japan to manufacture locally; hence, they opted to license technologies to Japanese firms. With capital liberalization completed in 1973, many foreign firms became more stringent in licensing. Sometimes, they refused licensing and favored direct investment. Sometimes, they demanded technologies from Japanese firms to cross-license.

Even during this protection period, however, Japanese firms knew that capital and trade liberalization was soon to occur. Hence, they anticipated that inevitable entry of multinationals would threaten their survival. This fear was particularly acute in such industries as automobiles and electrical equipment because, from the pre-war experience, Japanese firms knew that foreign multinationals, such as General Motors (GM) and General Electric (GE), were far ahead of them technologically and financially. In fact, GM and Ford combined had the dominating market share in Japan of seventy to eighty percent around 1930. Similarly, in the electrical equipment industry, all the major manufacturers (except Hitachi) relied on American or European firms to learn technologies and management methods from, in return for these firms' capital participation. Therefore, these firms were keenly aware of the technological lag they had against the multinationals. Besides, these multinationals had an overwhelming financial power: GM, for instance, was 26 times larger in sales than Toyota in 1965. That is, even though, in the short run, the restriction of FDI helped Japanese firms to market their products in domestic markets, in the long run, they felt the threat of forthcoming FDI as real.

Such threat had Japanese firms invest heavily to catch up with the Western firms.

[4] For these and other cases, see Odagiri and Goto (1996).

A rapid rise in R&D expenditures and technology importation, shown earlier in Figure 1, testifies to this effort by the firms.

Several government policies, such as tax concessions, subsidies, and low-interest loans, also helped the firms. We only mention a few: for more on these policies up to the mid 1980s, see Goto and Wakasugi (1988). Tax credit for R&D expenditures, started in 1966, has been most widely used by the industry. With this scheme, the firm could deduct a certain proportion of increment in their R&D expenditure from the corporate income tax. During the 1980s, for instance, they could deduct 20 percent of the difference between current R&D expenditure and the largest R&D expenditure in the past, provided the former exceeds the latter, and the maximum amount they could deduct was 10 percent of corporate tax. The total amount of tax deduction with this and other R&D-promoting tax policies was estimated to be 38 billion yen in 1980, which was just 1.2 percent of industry R&D expenditures.

However small the amount is, the scheme helps the firm if it is increasing R&D expenditure every year. Yet, during the deflationary period since 1990, the increase in nominal R&D expenditure was small and, in fact, as shown in Figure 1, the expenditure decreased in 1993 and 1994; as a consequence, many firms could not take advantages of the scheme. To promote R&D under this situation, the government started a new scheme in 2003, in which the firm can deduct 10 to 12 percent of its entire R&D expenditure, subject to the 20 percent limit against corporate tax.

The government also supported industrial R&D with several subsidy programs. The amount, however, is relatively small. As shown in Table 1 earlier, the Japanese industries have been funding most of their R&D expenditures themselves. The industry R&D expenditure funded by the government was 162 billion yen in Japan in 2001, a mere 1.4 percent of total R&D expended by the industries, much smaller than 9.3 percent, a comparable figure in the US in the same year. The percentage has been basically stable in Japan whereas it substantially decreased in the US during the 1990s. In 1989 for instance, the percentages in Japan and the US were 1.2 percent and 34.3 percent, respectively[5].

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[5] Science and Technology Agency (until 2000), Ministry of Education, Culture, Sports, Science and Technology (since 2001), *White Paper on Science and Technology*, various years.

Such government funds were allocated to industries through several programs by several ministries, including the Ministry of International Trade and Industry (MITI), Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of Health and Welfare (MHW), Ministry of Posts and Telecommunications (MPT), and Science and Technology Agency (SAT)[6]. MITI was mostly responsible for the policies related to the manufacturing sector and financially supported a number of R&D projects through such programs as 'Large Scale Industrial Technology R&D Program' and 'Basic Technologies for Future Industries Program'. Usually, research associations (RAs) or, more commonly in later years, independent corporations were set up, with the funds of the participating firms. These RAs received subsidies from MITI and the research was carried out at their laboratories staffed mostly by people seconded from the member firms. In a few well-known cases, such as VLSI (very large-scale integrated circuits) and FGCS (fifth generation computer systems) projects, central laboratories were set up and the researchers from all member firms worked together. In most of other cases, the member firms let some space of their laboratories to the RA as its branch laboratories. In these cases, the RA researchers worked at the branch laboratories within their own firms; hence, it was sometimes dubious if real collaborations took place among the researchers of different firms[7].

## 3. Universities and Government Research Institutes

In addition to these funds distributed to industries, the government also expended on R&D at universities and government research institutes (GRIs, founded by the national or local governments). In 2001, 47 percent of government R&D budget went to universities and 42 percent to GRIs. GRIs had about 31 thousand researchers. In terms of the scientific field of these researchers, agriculture had the largest share at 37 percent. Besides agricultural institutes, there were also national laboratories oriented towards applied science and engineering with industrial application in mind, most notably, the Agency for Industry Science and Technology (AIST), which actually was a collection of laboratories, such as Electrotechnical Laboratory (ETL) that was well-

[6] Due to government reorganization, they were reorganized and renamed in 2001.
[7] For more on research associations, see Goto (1997). For a case study of FGCS, see Odagiri et al. (1997).

known for its research on computers and semiconductors. In 1997, for instance, AIST had the budget of 162 billion yen, almost entirely supported by the government. In 2001, it was reorganized as a semi-independent corporation with a new name, National Institute of Advanced Industrial Science and Technology (abbreviated again as AIST). Although it is still supported by the government, the proportion of funds accepted from industries has been increasing. AIST has also gone through internal reorganization and, for instance, no longer is there a laboratory called ETL.

Universities, needless to say, are a big performer of R&D and the major one on basic research. In 2001, universities accounted for 19.6 percent of national R&D expenditure, of which 62.3 percent was expended in the field of physical, engineering, agricultural, and medical sciences. Of the latter, the percentages among basic research, applied research, and development were, respectively, 53.5, 37.5, and 9.0. Not surprisingly, the percentages show a heavy bias towards basic research in comparison to those of the entire national R&D expenditure, which were, respectively, 14.6, 23.4, and 62.0.

Of course, universities are important not only for its research but also in the supply of scientists and engineers. As Panel A of Table 2 shows, the number of graduates from undergraduate courses increased by more than three times since 1965. The increase is even more impressive for those from masters' or doctoral programs. Panel B shows that, even though the majority of undergraduate students are in humanities and social sciences, science, engineering, and health dominate among graduate students. These statistics thus suggest that Japan has been making efforts to upgrade the quality of scientists and engineers in natural and health sciences.

<Table 2 around here>

An important characteristic of the Japanese university system is the coexistence of public universities (i.e., national universities and municipal universities) and private universities. Private universities overwhelm national and municipal universities in terms of the number of establishments and the number of undergraduate students as shown in Panel C of the table. However, in graduate education, national universities are the dominant contributors. Furthermore, most of the prestigious universities, in terms of both the quality of faculty and the difficulty of students' being admitted, are national, such as Tokyo, Kyoto, Osaka, and Tohoku among comprehensive universities, Tokyo Institute of Technology among engineering-oriented universities, and Hitotsubashi among social-science-oriented universities. Certainly, there are a few prestigious private universities, like Waseda and Keio. Still, the majority of such prestigious universities are national. As a result, competition to get into national universities, particularly prestigious ones, has been fierce, often dubbed 'examination hell.' Also, even though no specific data is available, it is commonly believed that there is a bias in the allocation of competitive research grants in favor of a few famous national universities, including those listed above.

The fact that major research-oriented universities were national had an important consequence on Japan's national innovation system for, at least, two reasons. First, reorganization of a national university, such as starting a new department, required not only the approval from the Ministry of Education (which is required for private universities as well) but also financial backing of the Ministry of Finance. As a result, university reorganization in response to emerging scientific fields tended to lag. Second, all the faculty members of national universities were government employees and hence subject to the civil servant code, which made the collaboration with the private sector difficult. For instance, it was prohibited for a faculty member to assume the directorship of companies, or to teach at the university on a part-time basis with the rest of time spent in companies. As the need for university-industry collaboration came to be recognized in the 1990s, these regulations were gradually lifted and, with the shift of formerly national universities to a semi-independent status in 2004, the changes are expected to accelerate. We will return to this topic in Section 5.

## 4. Changing Environment and the Emergence of Science-Based Industries

The environment surrounding the innovation system of Japan has been changing dramatically in the last couple of decades for industrial, macroeconomic, international, and technological reasons.

At the industrial level, changes in the business system have to be noted. The ownership structure of Japanese firms used to be characterized by the presence of stable shareholders, such as banks and friendly companies, with many of such shareholdings made as cross-holdings. However, with the financial crisis caused by non-performing loans among other reasons, banks started to reduce their shareholding of industrial firms.

From 1988 to 2002, banks (excluding trust banks) reduced their share ownership of public companies from 15.7 percent to 7.7 percent while the percentage of trust funds, pension funds, and foreigners together increased from 8.4 to 27.5.[8] Presumably, these shareholders are more sensitive to the firms' profitability. Industrial firms also started to reduce the shareholding of friendly firms, partly because of their own financial needs and partly because capital gains from shareholdings are now difficult to anticipate. Hostile M&As, which were rare in the past except for those aiming at greenmailing, took place[9]. Bankruptcy has become more common and so has *de facto* dismissal of workers even if it was disguised as (supposedly voluntary) early retirement with increased severance pay. These changes are affecting the behavior of Japanese firms and workers, if gradually, and may reduce the advantages of the Japanese business system. For instance, the famed long-run growth orientation in management has become more difficult to pursue under the strain of lower profitability, causing, for instance, many firms to shut down their basic research laboratories. And, together with the aging of workforce and the overseas shift of production, the accumulation and maintenance of skills at the shopfloor level have become (and expected to become) more difficult, raising concern on the loss of capability needed for continuous improvement (*kaizen*) and the introduction of innovation at the plant level[10].

Also worried by many is the declining rate of new company establishment. The rate of entry (the number of new enterprises as a percentage of the initial number of enterprises) dropped from 5.9 percent of 1975-1978 to 3.1 percent in 1999-2001, lower than the rate of exit during the same period, 4.5 percent[11]. Of course, the loss of market demand owing to the business stagnation of the 1990s has been a cause for this decline. Yet, the entry rate actually started to drop in the early 1980s when the

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[8] The average of 2661 firms listed in five Stock Exchanges in Japan. Source: Tokyo Stock Exchange, "Kabushiki Bunpu Jokyo Chousa" (http://www.tse.or.jp/data/examination/distribute.html)

[9] See Kester (1991) for cases of greenmailing up to the 1980s in Japan. In contrast to these cases, many (if not all) of the hostile takeover attempts since the 1990s aimed at real control of the target firms.

[10] For such advantages, see Odagiri (1992) or Odagiri and Goto (1996).

[11] Source: Small and Medium Enterprise Agency, *White Paper on Small and Medium Enterprises in Japan*, 2003.
(http://www.chusho.meti.go.jp/hakusyo/h15/download/2003haku_eng.pdf)

business condition was still favorable, suggesting that there may be other reasons for this low entry rate.

The so-called post-bubble depression since 1990 also affected existing firms. With many firms suffering from losses, the R&D expenditure was decreased in 1993 for the first time in the post-war history (see Figure 1). Many firms also started to relocate their production to low-wage developing countries, most commonly ASEAN countries and China. The rate of overseas production increased from 3.0 percent in 1985 to 17.1 percent in 2002. Among the firms who have any overseas subsidiary at all, the proportion in 2002 reached 41 percent[12]. Certainly, such overseas shift of mostly labor-intensive production activities must have contributed to the Japanese manufacturing firms in maintaining their competitiveness. However, the shrinking domestic production bases made the feedback from production to R&D more difficult, raised the cost of making prototypes and test plants, and hampered the smooth transfer from R&D to commercial production.

Many firms have also set up overseas laboratories in order to develop products suitable for local markets or plants, and to be located near research-intensive regions to source knowledge[13]. Still, their overseas R&D expenditure is estimated to be just 4.1 percent of domestic R&D[14]. That is, Japanese firms tend to concentrate their R&D activity in the home country.

This emphasis on innovation at home coincided with three important changes in worldwide technological race. The first is Japan's completion of catch-up. As discussed earlier, during the high-growth era of the 1950s and 1960s, Japan was eager to catch up with the more advanced western economies, by actively importing technologies and making efforts to assimilate and improve these technologies. However, by the 1980s, Japan has more or less caught up with the West. That Japan's R&D/GDP ratio outweighed that of the US for the first time in 1987 and has been higher since then is a clear indication of this catch-up. In consequence, American and European firms became more and more reluctant to license technologies to Japanese

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[12] Ministry of Economy, Trade and Industry, *Basic Survey of Overseas Business Activities* (http://www.meti.go.jp/english/statistics/data/h2c4tope.html).
[13] For the overseas R&D activities of Japanese firms for the purpose of sourcing of knowledge, see Iwasa and Odagiri (2004).
[14] See footnote 12 above.

firms who, they had observed, grew to be their formidable competitors in product markets. Often, the western firms started to require technologies to cross-license rather than just monetary payments in return for the technologies.

Second, in response to this Japan's catch-up with the US, the US shifted its public policy to a pro-industrial one in the 1980s. Mowery and Rosenberg (1993, p. 58) asserts that "the contrast between the position of the newly elected Reagan Administration in 1981, denying any role for the federal government in the development and commercialization of new civilian technologies, and the Reagan Administration of 1987-1988, is dramatic," raising as an example the launching of two military-funded research programs in civilian technology development. The US also strengthened patent protection "in three major ways: extending patent protection to new subject matter; giving greater power to patent holders in infringement lawsuits; and lengthening the term of patents" (Gallini, 2002, p. 133). During the 1980s, patents were extended, for instance, to genetically engineered bacteria, software, and business methods. Also, the creation of a court specialized in patent infringement cases, namely, the Court of Appeals for the Federal Circuit (CAFC), increased significantly the cases of patent-holders' success in legal disputes (Gallini, 2002).

The impact of this change shook Japanese firms through, for instance, the lawsuit brought by Corning Glass Works (a US firm) against Sumitomo Electric (a Japanese firm) on the latter's infringement of Corning's patent on optical fiber, which concluded six years later with the decision of CAFC to order Sumitomo Electric to pay 25 million dollars damage to Corning. This incident gave a strong lesson to Japanese firms on the need to respect others' IPRs and also to protect their own inventions with IPRs.

Third, the linkage of industrial innovation with science intensified. Of course, scientific achievements fostered inventions in early years too, from the application of chemical research in developing new dyes in the late 19th Century (Murmann, 2003) to the invention of computers and transistors. Yet, the last couple of decades have witnessed a dramatic increase in the use of scientific discoveries in industrial R&D. Narin and his group (e.g., Narin et al., 1997) have proposed to measure this linkage of industrial R&D to science by the number of citations to scientific papers per US patent. In the US, patent applicants are required to list any prior papers and patents that are related to the technologies to be patented. It can be assumed that, if the application cites many scientific papers, then the invention benefited greatly from scientific discoveries. Thus, the per-patent number of citations to scientific papers is used as an index of 'science linkage'.

This index rose from 0.31 in 1985 to 2.15 in 2002, a seven-fold increase in less than twenty years, indicating a rapid increase in science linkage[15]. In addition, two facts are noteworthy. The first is that the index is higher among the patents applied by Americans (3.23 in 2002) than those by Japanese (0.49 in the same year). This difference may be overstated because American inventors are more likely to cite papers by American authors in American journals, and they will be careful so as not to miss citing related papers in fear of being complained by the authors. Japanese inventors may have benefited from Japanese papers but they are probably less careful in citing them than American inventors, because Japanese authors are less likely to notice the lack of citation and so will be the USPTO (US Patent and Trademark Office) examiners. Still, the large difference between the two countries seems to suggest that Japan is in fact behind the US in terms of science linkages of industrial R&D[16].

Secondly, by patent code classification, several fields have particularly high indices of science linkage. Biology/microbiology has the highest score at 24.32, followed by organic chemistry (15.83) and medicine/veterinary medicine (8.24), suggesting that biotechnology-related patenting is most intensely linked to science.

To sum, the changing environment suggests that the industrial composition of the Japanese economy is shifting and has to shift towards *science-based industries* (SBI), such as biotechnology, in which the development is pursued by means of innovations based on sciences. Innovations, we say, are *based* on sciences in two senses. First, scientific research outcome would be applied and developed for industrialization. Second, sciences would be used to solve the bottlenecks that may arise in the course of R&D and production. Also, any discovery during R&D or production would be fed back to scientific research. Therefore, the flow of information is not uni-directional from science to development/commercialization as the so-called 'linear model' of innovation implies. Information also flows from development or production to science. This bi-directional and 'chain-linked' interaction between scientific activities and

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[15] NISTEP (2004). The original data is from CHI Research.

[16] That Japan is also behind the UK (2.29 in 2003), France (1.28), and Germany (0.87) indicates that being non-American does not alone explain Japan's lower scientific linkage.

industrial innovation is an important characteristic of SBI. [17]

We should also note that SBI is by no means a discontinuous jump from more traditional engineering-based or manufacturing-based industries. In fact, many science-based industries are also engineering-based. The information and electronics industries probably give the best examples. The development of a next-generation mobile communication system requires both scientific knowledge and engineering knowhow, and so is the development of next-generation semiconductors. In biotechnology, the development of DNA chips, for instance, also requires the engineering knowledge in hydrodynamics. Still, we focus on SBI because the deepened connection with science, we believe, is the most prominent characteristic of innovation in the 21st century.

The increasing importance of SBI, in turn, has affected the national innovation system gravely and called for important policy changes. We will discuss some of these in the next section.

## 5. Policies to Promote Science-Based Industries

In 2001, based on the recommendation of the Council of Science and Technology Policy, the Japanese Government has determined the 'Science and Technology Basic Plan,' in which four areas were given strategic priorities. They are life sciences, information and telecommunication, environmental sciences, and nanotechnology and materials. It is hoped that the promotion of these sciences will foster the development of industrial technologies, such as biotechnology, IT, and nanotechnology-based materials, thereby stimulating the development of related industries. These industries, therefore, we may regard to be the representative SBIs.

Following the Basic Plan, the government increased its R&D expenditure to these four fields by 14.1 percent during 2001-2004, while its total R&D expenditure increased by 4.5 percent only[18]. The four fields together accounted for 22.7 percent of total government R&D budget. A drawback of the Japanese government R&D budget

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[17] See Kline and Rosenberg (1986) for the comparison between the linear model and the chain-linked model.

[18] The figures include only the beginning-of-year budgets. In FY 2001, additional budgets were allocated in the latter half of the financial year. At the time of this writing, it is unknown if similar additional budgets will be allocated during FY 2004.

system, however, is that the funding is made through several different ministries. In addition, the inter-ministry proportion of funding tends to be fixed and the coordination between the ministries is limited. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has the largest share, as it handles the 'Grants-in-Aid for Scientific Research', the largest research funds competitively supplied to academic researchers, similarly to NSF grants (and a large part of NIH grants) in the US. MEXT's share in the R&D budget is 63 percent in 2004, surprisingly stable from 63.8 percent of 2001. Ministry of Economy, Trade and Industry (METI) follows with 17.2 percent. In addition, in the case of biotechnology for instance, Ministry of Health, Labour and Welfare (MHLW) provides funds related to medical research while Ministry of Agriculture, Forestry and Fisheries (MAFF) provides funds related to the application of biotechnology to agriculture and fishery[19]. Certain coordination among these ministries started just a few years ago but is hardly sufficient. For instance, these ministries may start similar projects independently of others. Also, they often provide research funds to particular (usually, famous) researchers without being aware that these researchers are also receiving funds through other government projects. In this regard, Japan, I trust, can learn from the system in the US in which National Institutes of Health (NIH) handles most of life-science R&D funds and is not just a fund-allocating organization but also conducts R&D within itself having a large staff with knowledge and experience on life sciences.

As discussed above, the majority of government R&D funds go to academic research through 'Grants-in-Aid' and other programs. Some funds go to government research institutes (GRIs) discussed earlier and some also go to industrial firms, usually through research associations or other joint R&D organizations formed by firms (which may include small firms and/or foreign-owned firms), GRIs, and universities.

Besides increased government R&D funding, several important initiatives have been taken in the last several years with the aim of transforming the national innovation system towards one that is more conducive to science-based industries. Here, we

[19] MEXT was created by the integration of the Ministry of Education and SAT, MHLW by the integration of the Ministry of Labour and MHW, and METI was renamed from MITI after absorbing some divisions of MPT and SAT. Other, larger parts of MPT were absorbed by Soumusho (whose English name is now the Ministry of Internal Affairs and Communications). See footnote 6 above.

focus on three: university-industry collaborations, strengthening intellectual property rights (IPR), and the promotion of new startups[20].

***University-Industry Collaborations***

As discussed above, SBI is characterized by strong science linkage. Because a major part of scientific research is done by universities, a closer collaboration between universities and industries is called for. Of course, as the measurement of science linkage implies, the most common flow of information from academic research to industrial innovation occurs through publication of papers. Yet, there are also occasions in which universities are expected to contribute to industrial innovation in other, diverse ways. Recall that the flow of science to innovation is not uni-directional. Often industrial R&D teams would face technological difficulties and, in order to solve them, they would seek the advice of academic scientists and/or propose to start joint research with such scientists.

Also, technology may be transferred from universities to industries by means of licensing of university patents. Rarely, however, the development of a commercially viable product out of patented invention is straightforward. The licensed patent may not cover all the necessary technology and knowhow; thus, it may be smoothly transferred only when the university inventor is actively involved. Also, as the term 'absorptive capacity' implies, a sufficient capability is needed on the licensee's side and, even with such capability, unexpected bottlenecks may arise in the course of development. An advice by university inventors or other academics may help the industry to acquire a necessary capacity or to solve the bottlenecks.

There are also cases in which university-industry (UI) collaborations are called for at a pre-invention stage. That is, industries often find it advantageous to commission research to universities or conduct joint research with them. Joint research is an attractive option because supposedly complementary capabilities of university scientists (who are good at, say, theorizing) and industry engineers (who are good at, say, experimenting and building prototypes) can be combined.

To promote SBI, therefore, there must be an environment in which active UI collaboration, in the form of patent licensing, consultation, commissioned research, or

[20] Much of the following discussion overlaps with the second half of Odagiri (2004).

joint research, is feasible and encouraged. Accordingly, Japan is now shifting its gear towards this direction.

It is not that UI collaboration was absent in Japan. In fact, universities did play an important role in Japan's industrial and technological development since the mid-19th century (Odagiri, 1999). However, particularly after World War II, a uniform and rigid regulation began to be applied to the conduct of university faculties, making UI collaborations cumbersome. Such regulation was strictly enforced because, as discussed earlier, most of the major universities in Japan were national universities and their professors were civil servants. As a result, even though UI collaborations were by no means absent, many collaborations were made on an informal basis, for instance, based on personal relationships between professors and company researchers (including, often, the professors' former students).

In the past few years, however, there has been a drastic shift towards deregulation and encouragement of UI collaborations. Professors can now join boards of directors of private companies. Besides, to promote joint research with industries, several policies have been adopted. First, red tapes regarding the acceptance of company research funds and of company researchers to university laboratories were relaxed. Second, many universities have built special facilities for UI joint research. Third, universities can now offer their space to startups at a low rent, if these startups were established for the purpose of commercializing technologies of the university's origin. Fourth, many universities have founded technology licensing offices (TLOs), which help faculties in applying for patents and licensing them, and help companies in finding suitable university patents to be licensed and suitable faculties to start joint research with. Fifth, patent fees have been reduced for applications by university researchers or TLOs. Sixth, special tax concessions are now given to company R&D expenditures used for UI collaborations.

Furthermore, with the 'National University Corporation Law', every national university in Japan was incorporated into a semi-independent corporation in 2004. Although the majority of its budget continues to be supported by the government, universities can now keep their income and, naturally, have more incentive to increase its revenue not only by offering more up-to-date courses but also by attracting industry funds for UI collaborations and promoting the patenting and licensing of university inventions. In addition, the reform is expected to facilitate UI collaborations by, for instance, allowing the university to offer a flexible employment arrangement.

With these reforms, UI collaborations have been rapidly increasing[21]. The number of UI joint research by national universities increased from 1139 in 1990 to 4029 in 2000 and 6767 in 2002. The number of startups based on university-invented technologies increased from 11 in 1995 to 135 in 2002 and, as a result, the number of such companies in operation at this moment is estimated to be more than 600, which is much fewer than in the US[22]; still, the increase is impressive. 36 TLOs have been set up and several cases of licensing have been already reported, even if they are still few and the TLOs are suffering from loss. Also, as of September 2003, 280 cases were reported in which the professors of national universities were acting as directors or auditors of companies.

This rise in UI collaborations and, in more general, the changing expected role of universities has been significantly transforming the national innovation system of Japan.

***Intellectual Property Reform***

Intellectual property rights (IPR), such as patents and copyrights, have strategic importance in SBI. This is primarily because huge R&D expenditures are required in SBI and IPR is considered to be the most effective means of appropriating the returns to R&D investment. Thus, the pro-patent policy of strengthening IPR may appear to be the right policy proposal for promoting SBI.

Yet, stronger IPR may actually hurt technological progress because it restricts the usage and diffusion of invented technologies (Merges and Nelson, 1990). Particularly, an increase in 'research tool patents', such as patents on DNA chips and transgenic mice, can hinder technological progress as the need to clear permission with the owners of these patents can make R&D more costly and time-consuming. If each patent-holder acts aggressively, then, many R&D projects might become economically infeasible, hindering technological progress as a result. Therefore, the positive incentive effect

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[21] The following statistics are available at the MEXT website (http://www.mext.go.jp/), although few of them are in English.

[22] In the US, 450 startups were formed in 2002 and the accumulated number during 1980-2002 was 4,320 of which 2,741 were still in operation. Source: The Association of University Technology Management, *AUTM Licensing Survey: FY2002*. (http://www.autm.net/index_n4.html)

and the negative usage-restriction effect have to be balanced in any design of an IPR system.

In this tradeoff between "diffusion and exclusion", the Japanese patent system used to be more inclined to diffusion relatively to the American system (Ordover, 1991). This inclination was a rational one because, during the catch-up period, Japan probably gained more from the usage of patented knowledge than from raising the incentive to inventors. However, with the end of catch-up, it became an urgent need to encourage inventions. Besides, the TRIPs agreements and the US-Japan agreements during the 1990s also fostered the Japanese government to align its patent system with a more protection-oriented international standard. Consequently, patent application with multiple claims started to be accepted in 1988 and its pre-grant opposition system was changed to a post-grant opposition system in 1994. The scope of patentable inventions was gradually expanded during the 1990s, particularly as regards software, business models, and biological inventions. In addition, the restriction on the possibility of compulsory licensing, and the introduction of the doctrine of equivalents had the effects of strengthening patent rights (Nagaoka, 2004).

In 2002, Japan enacted the ‘Basic Law on Intellectual Property’. With this law the government established the ‘Intellectual Property Policy Headquarters’ within the Cabinet, for the purpose of "providing stipulations on the development of a promotion program on the creation, protection and exploitation of intellectual property." Particular emphasis was placed on wider utilization of patented technologies and a stronger enforcement of patent rights.

The effectiveness of patent protection depends on the enforceability of patents. Patent litigation is a notoriously costly and time-consuming process in Japan, mainly because there is no court specialized in patent-related litigations and, hence, there is no judge (and only a few lawyers) with technological knowledge. To remedy this situation, a discussion is currently going on to establish a special court within Tokyo High Court to deal with patent litigation. Also, with the adoption of the concept of opportunity costs, the amount of damages the court determines increased, even if it is still much lower than in the US.

To supply more personnel with knowledge on patent law and patent management to industries as well as the courts and the government, the government encouraged universities to establish necessary courses and Japan Patent Office (JPO) has been making efforts to hold public lectures on related issues. Since small and medium enterprises (SMEs) in particular suffer from the lack of necessary personnel, the government has been also establishing a scheme to introduce to SMEs those people having retired from big companies after years of experience in patent management.

Another policy emphasis has been on the production and utilization of patents by universities and national institutes. Thus, an important policy change was made in 1999 with a law dubbed the 'Japanese Bayh-Dole Act' after the 1980 Bayh-Dole Act of the US. With this law, researchers who made inventions out of the R&D projects commissioned and funded by the government can now claim the ownership of the inventions. This new policy aimed to give more incentive for researchers to patent and also to promote commercial application of the patents by the researchers themselves or by licensing. As discussed already, patent fees were reduced for academic inventions and TLOs have been set up in many universities.

Consequently, although the rise in university patenting and licensing may not be spectacular yet, a gradual change has been occurring and, together with the incorporation of national universities as discussed earlier, a big impact on Japan's national innovation system is anticipated in coming years.

***Promotion of Startups***

Several policy measures have been taken to promote startups. Policies regarding university-based startups have been already discussed. In more general, under the 'Law for Facilitating the Creation of New Business' (dubbed the Japanese SBIR program after the US Small Business Innovation Research program) of 1999, the government started to provide subsidies and debt guarantees to support the investment by SMEs (existing SMEs, new startups, or individuals) to start new businesses and to develop and commercialize new technologies. In addition, the government started in 2002 to give tax advantages to individuals investing in startup companies (called the Angel Tax System), and reduced the minimum amount of capital required to found a stock company from 10 million yen to a mere 1 yen, provided the company is established to start a new business, on the condition that the capital should be increased to a minimum of 10 million yen within five years of the establishment. Startup firms were also allowed to use stock options as a compensation scheme to its directors and employees, in view of the fact that these firms often face cash-flow shortages as they have to expend for R&D and other investment in the early stage when their revenue remains still low.

With these and other policies to promote startups, the number of high-tech startups has been actually increasing. For instance, the per-annum number of newly established biotech startups increased from less than 20 in the latter half of 1990s to more than 40 after 2000. As a result, the number of existing biotech startup companies increased from 60 in 1998 to 387 in 2003[23].

Financing of these startups has been made easier. Three stock markets, such as JASDAQ and MOTHERS, were opened or reorganized to make it easier for startups to trade their shares. The number of new initial public offerings (IPOs) has accordingly increased: in 2003, for instance, about 100 firms made IPOs in these markets. Many venture capitals have been also established, even though many of them still lack sufficient capabilities to evaluate potential startups, advise them on managerial and technological matters, and recruit talents for them that many US venture capitalists have.

## 6. Conclusion: The Changing Innovation System?

To sum, Japan has been making conscious efforts to transform its innovation system towards one that is more suitable for growing science-based industries. The government has not only increased budgets for SBI-related research but also made efforts to adapt the legal and policy framework to an increasing need for UI collaborations, effective use of IPR, and startups. Industries have been also adapting themselves in order to survive under the changing environment, for instance, by shifting unsophisticated manufacturing to overseas, eliminating unprofitable and declining businesses, improving the IPR management, and making efforts to incorporate scientific advance to own R&D. In this connection, the issue of R&D boundary of the firm has become imperative, for it is now not only inefficient but also impractical for firms to perform all R&D-related works in-house. Through R&D alliances, licensing, outsourcing, and such, they have to incorporate and utilize outside capabilities to achieve innovations efficiently and swiftly.

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[23] Source: Japan Biotechnology Association, *2003-Nen Baio-Bencha Toukei Houkokusho* (http://www.jba.or.jp/bv/bv-tokei2003.pdf, in Japanese).

I trust that this increasing importance of inter-organizational collaboration applies to any industry today. Still, it probably applies best in SBI, such as biotechnology and pharmaceuticals. The number of research alliances (including those with firms and universities, in Japan or elsewhere) by the ten largest pharmaceutical firms in Japan increased three-fold between 1989 and 1999 (Odagiri, 2003). They include technology acquisitions (i.e., licensing-in) and joint or commissioned R&D. As a partner of these alliances, new biotech firms (NBFs), particularly those in the US, were as popular as established firms. This tendency of increasing R&D alliances with many of them being those with NBFs is found among all major pharmaceutical firms across the world (see, for instance, Henderson, Orsenigo, and Pisano, 1999).

According to the survey by the National Institute of Science and Technology Policy (NISTEP), the most important reasons for R&D alliances were the "utilization of the partner's technological knowledge and capabilities (rather non-patented ones)", "speed", "utilization of capital equipment", and "cost reduction" that can be gained through alliances, indicating that utilizing outside assets (tangible or intangible) and capabilities and combining them with internal ones are critical for efficient company R&D now (Odagiri, Koga, and Nakamura, 2002).

Firms also actively outsource routine R&D-related services from specialists, such as, in the case of biotechnology and pharmaceuticals, animal tests, supply of specific samples, production of test products, software development, genome analyses, and clinical tests. The amount spent for outsourcing reached 25 percent of R&D expenditures among pharmaceutical firms, according to the NISTEP survey.

Such increasing utilization of outside capabilities has grave implications. From the managerial viewpoint, it implies that the issue of R&D boundary of the firm, that is, the decision of how much the firm should perform within the firm and how much to depend on the outside, has become a critical strategic decision[24]. From the national viewpoint, it implies that the availability of potential partners for alliances and outsourcing is a prerequisite for the development of SBI. Universities, government research institutes, and startups are all probable partners, as well as big firms. The above-mentioned

[24] Traditionally, the issue of the boundary of the firm has been discussed widely in relation to the make-or-buy decisions for parts and materials. For instance, the close and long-term relationship with suppliers has been considered to be the strength of the Japanese automobile producers (Odagiri, 1992).

promotion of UI collaborations and startups is imperative for this purpose also. Furthermore, potential partners have to be broadly distributed across industries. SBIs have a wide applicability: in the case of biotechnology, bio-related informatics and services, as well as the provision of laboratory equipment, bio-electronics, and samples and reagents, constitute an important part of biotech industries. Many firms in these fields are active outsourcees whether they are large or small and established or new. The presence of such firms is a prerequisite for an SBI-oriented innovation system.

Japan has been thus transforming its innovation system. Still, a deep question remains: can the new system coexist with the existing business and industrial system of Japan, or does the latter system also have to change to make it more adequate for the new innovation system? For a long time, the financial system of Japan, characterized by close bank-firm relationship and the presence of stable shareholders, was considered to be complementary to the labor system characterized by long-term worker-employer attachment. And this system was considered to be conducive, for instance, to the accumulation of firm-specific human skills and the close intra-firm (and intra-group) information sharing, which made cumulative technological innovation easier (Odagiri, 1992). The current competitiveness of Japan in such industries as automobiles, digital cameras, and plasma displays is closely related to this system. Such advantage has been actually exploited even in science-based fields; for instance, a big brewer applied its accumulated technologies on fermentation to the production process of biotech drugs.

Still, to promote new industries and new startups, the economy needs to foster reallocation of talented people through external markets (as opposed to internal labor markets) and the supply of more venturous funds (for which banks lack comparative advantages). For instance, according to our structured interviews with 65 Japanese biotech startups, the firms raised 'the difficulty in recruiting technological staff', 'difficulty in financing', and 'difficulty in recruiting non-technological staff (e.g., finance, accounting, and legal)' as significant barriers in founding their firms (Odagiri and Nakamura, 2002). That is, the recruitment of technological and non-technological staff is a big hurdle for Japanese startups, together with (if not more than) financing.

A major cause for this hurdle is the lower mobility of workers in Japan[25]. It is true

[25] Another cause is the relatively small number of bachelors and Ph.D.s in biological

that Japan's labor system has been gradually moving towards a more mobile one and yet, at least at this moment, the mobility is lower if compared to other countries, particularly the US. This tendency is most evident in big firms and these big firms tend to have talented people both because they can recruit better workers and because their workers tend to receive more in-company training and wider experience. This situation makes it difficult for startups to recruit good scientists and engineers as well as management staff including those in accounting, finance, legal affairs, intellectual property management, and administration, as shown in the above-mentioned result of our survey to Japanese biotech startups[26].

Do we, then, have to move towards, say, a Silicon Valley-type system, characterized by high mobility of both companies and workers, and risk money supplied by venture capitals? This author does not have a firm answer. Probably and hopefully, it is a feasible option to incorporate more mobility to the Japanese system and yet maintain the merits of the Japanese system in a large part of the economy. For instance, many established firms now hold redundant middle-aged workers and their reallocation outside the boundary of the firms must be beneficial to both existing firms and newly emerging firms. Also, during the first decade of the 21st century, the postwar baby boomers will reach sixty years-old, the retirement age at many big Japanese firms, and, after retiring from these firms, some of them may opt to establish their own startups or to work for other startups, not minding the lower and unstable pay. Thus, after a transitory period, we may well have a system in which the merits of both Silicon-Valley type system and the so-called Japanese system somehow coexist. Exactly what such a system will be like is a question that we will keep asking.

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sciences in Japan. Although a strict comparison is difficult because of different definitions of academic fields between the two countries, the US probably has more than four-times more Ph.D.s per population than Japan.

[26] We should hasten to add, however, that a change, if a gradual one, has been actually taking place towards more mobile labor markets and more recruitment of talented people by startups from established companies. For instance, the first university-spinoff biotech company to have made an IPO, called Anges MG, first had a CEO who had had an experience of leading a startup in Silicon Valley in the US but was succeeded by a person who had quit one of the biggest chemical companies in Japan.

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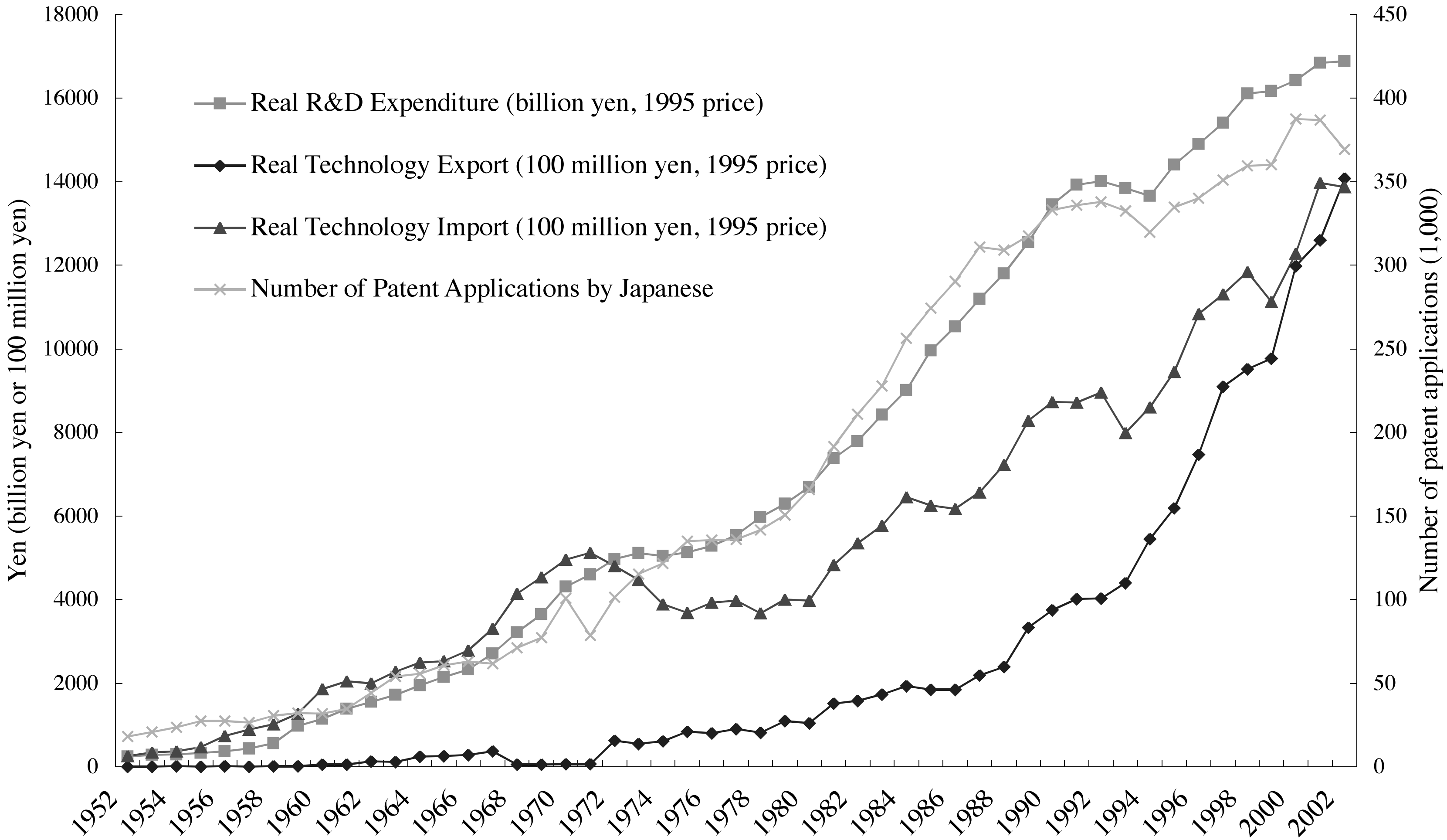
**Figure 1. Trend in Innovation Activity in Japan, 1952-2002**




Source:
RD expenditure: Soumusho (deflated with GDP deflator for 1952-1980 and RD deflator for 1981-2002)
Technology export and import: Bank of Japan (deflated as above)
Patent applications: Japan Patent Office.

**Figure 2. Trends in R&D/GDP, Technology Export/Import, and Patenting**

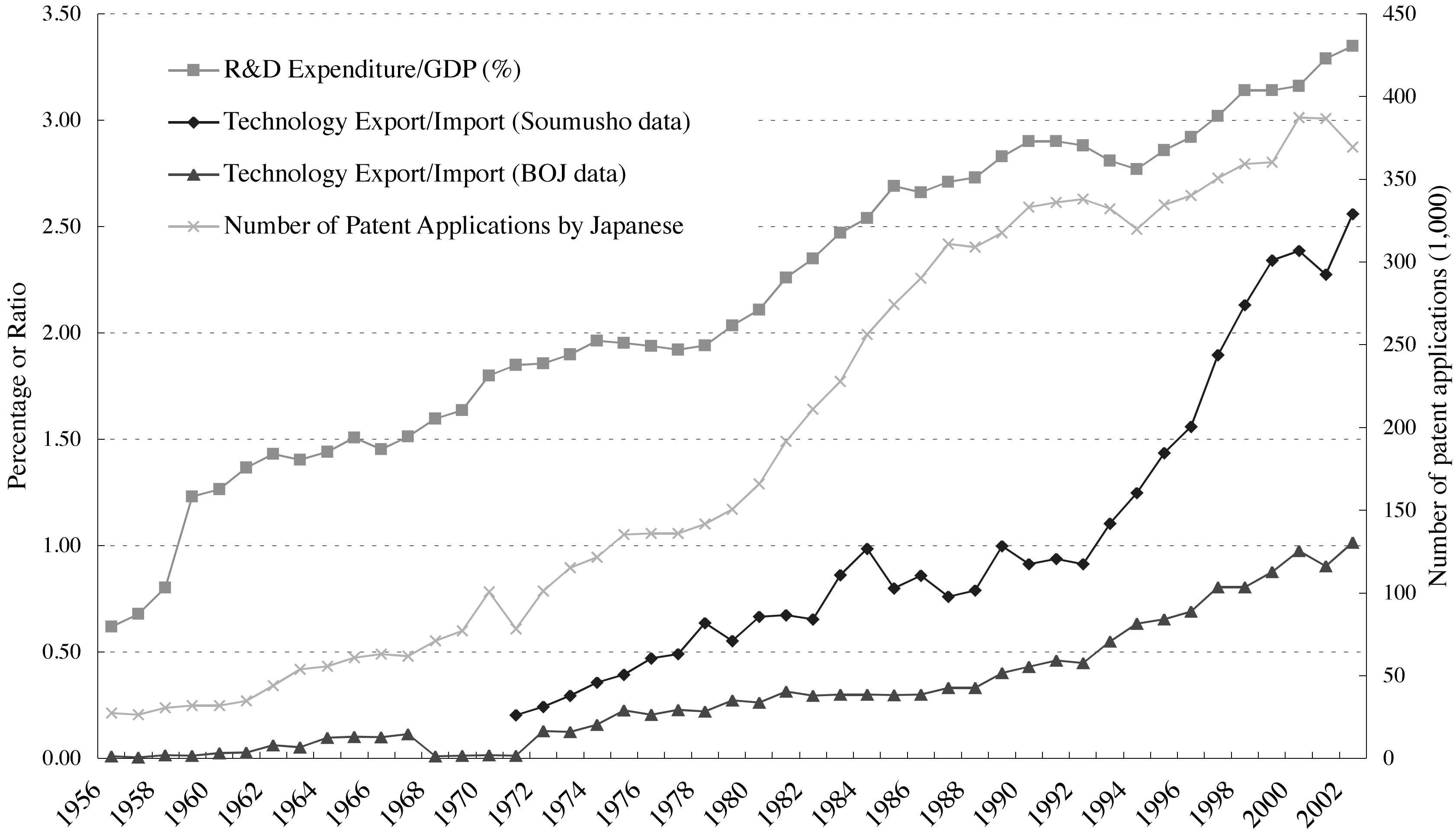


**Table 1. International Comparison of Innovation Activities: 1991 (upper row) and 2001 (lower row)**

| | Japan | USA | EU | Germany | France | UK | China | Korea |
|---|---|---|---|---|---|---|---|---|
| R&D expenditure (billion yen)* | 13,772 | 31,066 | 22,159 | 6,856 | 4,834 | 3,597 | 2,525 | 1,335 |
| | 16,528 | 42,201 | 27,907 | 8,212 | 5,258 | 4,399 | 8,961 | 3,324 |
| R&D exp./GDP (%) | 2.92 | 2.68 | 1.90 | 2.53 | 2.37 | 2.02 | 0.74 | 1.92 |
| | 3.29 | 2.79 | 1.93 | 2.53 | 2.18 | 1.89 | 1.09 | 2.92 |
| Proportion of R&D exp. funded by industries (%)** | 72.7 | 57.4 | | 61.9 | 42.5 | 49.6 | | |
| | 68.9 | 68.5 | | 66.5 | 52.5[a] | 46.2 | | 72.4[a] |
| Proportion of R&D exp. funded by government (%)** | 18.2 | 38.7 | | 35.7 | 48.8 | 35.0 | | |
| | 21.0 | 26.7 | | 31.0 | 38.7[a] | 30.2 | | 23.9[a] |
| Proportion of R&D exp. expended by industries (%) | 70.7 | 72.7 | | 69.5 | 61.5 | 67.1 | | |
| | 69.3 | 74.5 | | 71.0 | 62.4 | 67.4 | | 74.0[a] |
| Proportion of basic R&D exp. in total R&D exp. (%) | 13.3 | 16.9 | | 20.9 | 20.3 | | | |
| | 14.6 | 20.9 | | | 23.6[a] | | | 12.6[a] |
| No. of scientists*** | 582,815 | 981,659 | 746,543 | 241,869 | 129,780 | 128,000 | 471,400 | |
| | 728,215 | 1,261,227[b] | 971,497[a] | 259,597 | 172,070[a] | 157,662[c] | 742,700 | 136,337 |
| No. of scientists per 10000 population | 47.0 | 38.7 | 20.3 | 30.2 | 22.2 | 22.1 | 4.1 | |
| | 57.2 | 45.2[b] | 25.7[a] | 31.5 | 28.4[a] | 26.6[c] | 5.8 | 28.8 |
| Share of US patents (%) | 21.8 | 53.0 | | 7.9 | 3.1 | 2.9 | 0.4 | 0.1 |
| | 20.0 | 52.6 | | 6.8 | 2.4 | 2.4 | 2.1 | 0.1 |
| Technology export / technology import**** | 0.94 | 4.42 | | 0.79 | 0.71 | 1.01 | | |
| | 2.27 | 2.36 | | 0.67 | 1.19 | 2.22 | | |

* Current value, converted with OECD ppp. The figure for China, 1991 is underestimated. The figures include expenditures for humanities and social sciences except for

** R&D expenditures are also funded by universities, non-profit institutions, and foreigners; hence, these two do not add up to 100%.

*** Headcounts (HC) for Japan. FTE (full time equivalent) value is estimated to be about 77% of HC in 2002.

**** Soumusho data for Japan.

a 2000, b 1999, c 1998

## Table 2. Number of University Students

| | Undergraduate | | Master | | Doctor | |
|---|---|---|---|---|---|---|
| Panel A: Total number of students finising the course: tı | | *Index* | | *Index* | | *Index* |
| 1965 | 162,349 | 100 | 4,790 | 100 | 2,061 | 100 |
| 1970 | 240,921 | 148 | 9,415 | 197 | 3,152 | 153 |
| 1975 | 313,072 | 193 | 13,505 | 282 | 2,882 | 140 |
| 1980 | 378,666 | 233 | 15,258 | 319 | 3,614 | 175 |
| 1985 | 373,302 | 230 | 19,315 | 403 | 4,358 | 211 |
| 1990 | 400,103 | 246 | 25,804 | 539 | 5,812 | 282 |
| 1995 | 493,277 | 304 | 41,681 | 870 | 8,019 | 389 |
| 2000 | 538,683 | 332 | 56,038 | 1,170 | 12,375 | 600 |
| 2003 | 544,894 | 336 | 67,412 | 1,407 | 14,512 | 704 |
| Panel B: By type of universities (2003) | | % | | % | | % |
| National (14.%)* | 102,639 | 18.8% | 39,211 | 58.2% | 10,284 | 70.9% |
| Municipal (10.8%)* | 21,309 | 3.9% | 3,280 | 4.9% | 782 | 5.4% |
| Private (74.9%)* | 420,946 | 77.3% | 24,921 | 37.0% | 3,446 | 23.7% |
| Panel C: By fields (2003) | | % | | % | | % |
| Humanities | 93,744 | 17.2% | 4,836 | 7.2% | 1,383 | 9.5% |
| Social science | 215,205 | 39.5% | 9,830 | 14.6% | 1,162 | 8.0% |
| Science | 19,549 | 3.6% | 5,722 | 8.5% | 1,500 | 10.3% |
| Engineering | 101,401 | 18.6% | 28,498 | 42.3% | 3,212 | 22.1% |
| Agriculture | 15,933 | 2.9% | 3,471 | 5.1% | 1,093 | 7.5% |
| Health | 30,479 | 5.6% | 3,733 | 5.5% | 4,561 | 31.4% |
| Mercantile marine | 198 | 0.0% | 12 | 0.0% | – | 0.0% |
| Home economics | 10,822 | 2.0% | 444 | 0.7% | 50 | 0.3% |
| Education (incl. teacher training) | 31,767 | 5.8% | 5,036 | 7.5% | 362 | 2.5% |
| Arts | 15,222 | 2.8% | 1,431 | 2.1% | 96 | 0.7% |
| Others | 10,574 | 1.9% | 4,399 | 6.5% | 1,093 | 7.5% |

Notes: All the figures exclude those of junior colleges (*tanki daigaku* ).

* Percentages in terms of the number of universities.

Source: Ministry of Education, Culture, Sports, Science and Technology.

# Impacts of FDI on Technological Innovation and Learning: the Case of Motorbike Industry in Vietnam

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With the Law on Foreign Direct Investment (FDI) issused in 1987, FDI has become a tremendous phenomenon in Vietnam. By the year 2003, the total number of licensed FDI projects reached 5441 with US$45,7 billions of resistered investment capital and US$22,3 billions of legal capital. In real term, by the end of 2002, there were 2308 FDI enterprises in which 1561 were whole owned by foreign investors. By the same time, these enterprises directly employed about 691,088 jobs, accounted for 14.83% of total workforce of enterprises. The value of their fixed assets and long term investment reached 170,579 billions VND, about 30.9% of value of all enterprises (Statistical Yearbook 2003).

FDI in Vietnam is expected not only as a source of capital but also and even more importantly as a source of technology and management knowledge, a means for improving the competence of the local workforce and a catalyst for the development of local industries and the whole economy. Various policy measures have been designed to provide incentives for FDI[1] with the hope to realize the above expectation. However, *to which extend FDI has fulfiled the expectation is a controvesal issue* among policy makers and research community.

Based on a random sampling survey of 169 FDI enterprises in Vietnam, Nguyen et. al. (2004) found that foreign investors in Vietnam, especially recent entrants, are often small focused firms with little international business experience. Foreign investors in Vietnam report managerial capabilities and machinery as their most important resources, ahead of both technology and networking assets. This pattern suggests a traditional pattern of competition, as few references are made to intangible assets such as technology and marketing assets. The survey also reveals that the training expenditures appear weakly related to the R&D intensity of the parent. The highest training expenditures (over 15%) are incurred by parent firms with R&D expenditures of more than 4% of sales. On the other hand, of firms with less than 4% R&D expenditures, more than half spend less than 0.5% on training. Hence there appears to be some support for the notion that attracting R&D intensive firms generates more knowledge transfers.

[1] Law on Foreign Investment in Vietnam instruments and stipulates explicitly several incentives for technology transfer in FDI establishments. According to previous regulations, the maximum royalty level was stipulated at 5% of net sale price or 8% of total investment capital in the event the valued technologies form contributed capitals. Currently, this rate is allowed up to 8% of the net sale price or up to 30% of the after-tax profit. Where the contributed capitals are made of the technologies value, payment price for the technology transfer can account up to 10% of total investment capital.

Regarding the impacts of FDI on local industries, Nguyen et al (2004) shows that there are positive spillovers of FDI which is reflected in positive changes in the assessment of the local industry at the time of entry and at the time of the survey. Although the improvement in the local industry is fairly consistent across sectors, and for different aspects of the local industry, large margins of change emerge only for the trade and tourism industry, followed by machinery and equipment. In the primary sector, the local industry is by some criteria even declining.

The above review reveals some aspects of spill-over impacts of FDI. In this paper, motorbike industry will be examined since the industry has became a flagship of consumer branches in Vietnam considering both, the market dimension and the rapid expansion within recent years. The industry is also significant case for studying the variety of entities involved. By the end of 2002, there were 7 FDI establisments, 51 local assemblers and about 107 part-makers operating in motorbike industry with total capacity of about 1.5 million motorbike per year. Findings in motorbike industry will not only benefit the policy making works related to the industry, but also provide insights into policy arrangement on FDI, local enterprises and S&T institutions.

### Motorbike Industry with bold impacts of foreign players

Motorcycle has become an important transportation means in the whole of Vietnam since the country's unification in 1975. Right after the unification, used motorbikes (most of them were Japanese) were traded from the South to the North, making it a new way of personal transportation in the North of Vietnam. In the years followed (1975 - 1987), a significant amount of East European motorbikes had entried Vietnam via Vietnamese who worked overseas under a labour export deal between Vietnam and former socialist countries. Under another labour export arrangement at that time, Vietnamese academic staff was sent off to serve in education sector of some African countries. Earning foreign currencies, many sent home their saving in kind of new Japanese and/or French bikes. These new bikes were the symbol of prosperity in Vietnam over that period and that attitude to new motorbikes is still strong today.

Period from 1988 to 1992 is characterised by dominance of Japanese bikes. This was caused partly by change in policy and partly by availability of new sources of supply. For this period, every person travelling overseas was granted duty free for 2 imported bikes. Given the huge gap between world price and domestic price, the product became profitable bring-back for overseas travellers. However, what different from previous years is that new sources of supplies had emerged. Firstly, significant quantities of second-hand bikes were accumulated in Japan and their trading prices were very attractive. Secondly, many international flights that link Vietnam to the world were re-routed via Bangkok. Given Honda's affiliates that become important motorbike producers there, the place was ideal for motorbike trading. The legendary Honda 'Dream II were used to be carried from Thailand as traveller's luggage, even as the "handbags" in extreme cases. Due to trade barriers and short of supply, motorbike's prices were set relatively high and only middle-income families could afford to have a bike. Very few could have more than one bike for the whole family at that time.

By 1992, motorbike had already become an important transportation means as accumulated number of registered bikes reached 2,846,000 (see Table 1). However, regardless of a large mechanics sector, which included many large SOEs, making motorbike's spare parts had remained the business of small production units (mainly in kind of mechanics collectives). Motorbike industry did not exist at that time, the production of spare parts based on out-of-date machinary, and quality of products were low in general.

Period from 1992 up to now observes the development of motorbike industry in Vietnam with some incredible jumps (Table 1). The first FDI Law in 1987 and its subsequent amendments have made way for entries of foreign motorbike makers into Vietnam (Table 2). First products of these FDI enterprises were introduced in 1994 and developed quickly in terms of models and quantities in the years later. Considered as an import-substitute industry, high tariffs have been applied to imported bikes, creating favourable conditions for these FDI enterprises to explore local market (at the cost of consumers).

Table 1: Growth of registered motorbikes in Vietnam

| Year | Cumulative units registered | Units registered in the year | Industry growth (%) |
|---|---|---|---|
| 1990 | 2,770,000 | 36,400 | - |
| 1991 | 2,806,000 | 36,000 | -1.1% |
| 1992 | 2,846,000 | 40,000 | 11.1% |
| 1993 | 2,901,000 | 55,000 | 37.5% |
| 1994(1) | 3,275,000 | 374,000 | 580.0% |
| 1995 | 3,678,000 | 403,000 | 7.8% |
| 1996 | 4,209,000 | 531,000 | 31.8% |
| 1997 | 4,827,000 | 618,000 | 16.4% |
| 1998 | 5,219,000 | 392,000 | -36.6% |
| 1999 | 5,585,000 | 366,000 | -6.6% |
| 2000 | 7,452,524 | 1,867,524 | 410.3% |
| 2001(2) | 9,422,524 | 1,970,000 | 5.5% |

Souce: MoI

Notes: (1) The first FDI in motorcycle is the 100% foreign owned project of Ching Fong Group, a Taiwanese conglomerate. It received the investment license in 1992, and started production in late 1993.
(2) Motorbikes originated from China accounts for approximately 86.5%.

By 1999, market share of FDI assemblers was about 51.5%, while domestic assemblers accounted for only 24.5%. The picture was turned up side down after that, with the share of FDI firms fall to 15.3% and 12.5% for 2000 and 2001 while domestic assemblers which mainly based on Chinese models and parts gained market share of 73.4% and 78% in 2000 and 2001 (see Table 2). Since 2000, the domination of FDI motorbike enterprises has been challenged by cheap Chinese bikes entering Vietnam via operation of dozen of local assemblers. The introduction of cheap Chinese bikes has created a boom in motorbike consumption in 2000 and 2001. This illustrates high demand elasticity to price of the product. The number of motorbikes registered in 2000 is almost equal the accumulated number of registered units in the four consecutive previous years (or a growth of 400% in a single turning year). Development in 2000 and 2001 out-performed all industrial growth predictions, which predicted a growth of 500,000 units per year. People started to talk about it as fruit of 'local content' policy. As a result of it local producers had competed well with foreign affiliates and motorbike is now affordable for low-income households. However, inconsistent policy and its problematic implementation has encouraged rent-seeking practices. Objectives of building a competitive motorbike industry driven by 'local content' policy are not achieved as expected.

Table 2: Foreign bike assemblers in Vietnam

| Firms | Licensed Date | Registered Cap. (USD) | Legal capital | Foreign shares(%) | Investors |
|---|---|---|---|---|---|
| VMEP | 25/3/1992 | 120.000.000 | 42.000.000 | 100 | Taiwanese |
| Suzuki | 21/4/1995 | 34.175.000 | 11.700.000 | 70 | Japanese |
| GMN | 31/10/1995 | 39.000.000 | 15.000.000 | 70 | Thai&Lao |
| Honda | 22/3/1996 | 104.003.000 | 31.200.000 | 70 | Japanese |
| Yamaha | 24/1/1998 | 80.268.000 | 24.250.000 | 70 | Japanese |
| Lifan | 02/6/2000 | 4.670.000 | 1.570.000 | 70 | Chinese |
| Vina - Siam | 20/11/2001 | 12.000.000 | 3.600.000 | 40 | Thai |
| Total | | 394.413.000 | 129.320.000 | | |

Souce: MPI & MoI

Table 3a: Quantity of bike sold by different producers (unit: unit of motorbike)

| | 1999 | % | 2000 | % | 2001 | % | 2002[1] | % |
|---|---|---|---|---|---|---|---|---|
| Honda | 96,000 | 26.2 | 162,049 | 8.7 | 169,931 | 8.6 | 398,551 | 26.6 |
| Suzuki | 30,000 | 8.2 | 23,999 | 1.3 | 28,038 | 1.4 | 42,991 | 2.9 |
| SYM | 30,202 | 8.3 | 43,948 | 2.4 | 83,592 | 4.2 | 233,289 | 15.6 |
| GMN | 30000 | 8.2 | 45963 | 2.5 | 25,436 | 1.3 | 25,015 | 1.7 |
| Yamaha | 2346 | 0.6 | 9,216 | 0.5 | 23,379 | 1.2 | 68,068 | 4.5 |
| Lifan | - | | - | | - | | 2,000 | 0.1 |
| Local firms[2] | 89,778 | 24.5 | 1,370,000 | 73.4 | 1,536,600 | 78.0 | 650,000 | 43.3 |
| Un-accounted[3] | 87,674 | 24.0 | 212,349 | 11.4 | 186,532 | 5.2 | 80,086 | 5.3 |
| Total[4] | 366,000 | 100.0 | 1,867,524 | 100.0 | 1,970,000 | 100.0 | 1,500,000 | 100.0 |

Note: (1) in 2002, motorbike production is governed by quota. The number for total 2002 are quota allocated.
(2) local firms assembles bikes mainly based on Chinese components.
(3) Included importation of complete bikes.

(4) Number for 1999-2001 are number of new motorbike registered with police; a proxi for number of bike sold.

Table 3b: Market share of FDI bike assemblers

| | 1999 | % | 2000 | % | 2001 | % | 2002[1] | % |
|---|---|---|---|---|---|---|---|---|
| FDI assemblers | 188,548 | 51.5 | 285,175 | 15.3 | 246,868 | 16.8 | 769,914 | 51.3 |
| Local assemblers | 89,778 | 24.5 | 1,370,000 | 73.4 | 1,536,600 | 78.0 | 650,000 | 43.3 |
| Un-accounted | 87,674 | 24.0 | 212,349 | 11.4 | 186,532 | 5.2 | 80,086 | 5.3 |
| Total | 366,000 | 100.0 | 1,867,524 | 100.0 | 1,970,000 | 100.0 | 1,500,000 | 100.0 |

Souce: MPI & MoI

Concern of rent-seeking activities as well as quality of so called Chinese bikes created a lot of debate about the policy and its efficience. After months of investigation, the government decided to restrict the industry by applying import quota on parts for each assemblers depending on variuos criteria, such as their performance in previous years, investment level for making complicated components, local contents etc. After two years of booming, the domestic assemblers with their Chinese bikes are now lost their market position, falling to account for only 43.5% of market in 2002 and even lower share in 2003 and 2004.

## Local content policy: Rent-seeking vs. Technology learning

### *Evolution of the policy*

Lacking effiecient public transportation system in main cities, motorbikes have become the dominant means for private transportation in urban Vietnam. Given the potential commercial benefit of motorbike business, the government has paid great attentions on policy measures to regulate the trading and making of motorbikes. There has been many shifts of policy over the last decade.

Before 1997, bike trading via importation were mainly controlled by quota which at the time was managed by Ministry of Trade (MoT). The MoT allocated quota to some trading companies which we assume to have a close relationship with MoT, to import bikes. At that time, many bikes were traded under the umbrellar of the exchange program between Lao and Vietnam in which Vietnam provides Lao "garlic" in exchanges for motorbikes (mainly imported to Lao via Thailand). The program won a nick name of "garlic for bikes" and in this period there were about 100 CKD assemblers in all over the country.

In 1997, the "garlic for bikes" program ended, and so the control of MoT by quota in bike trading. Instead, high import duty was applied for the bikes and their parts, which on the one hand, help to increase tax income, on the other hand, was believed to attract foreign and domestic investments needed for the development of the industry. Various import tax rates were applied due to the fragmentary level of assembling activities. Some types of CKD and IKD assembling were defined and certified by Ministry of Science, Technology and

Environment (MOSTE and now MOST). Given this classification and certification, MoT managed the bike trading activities. In this period, there were about 20 IKD assemblers and the market were dominanted by Japanese bikes.

With the ambition to develop a full-scale auto-motor industry in Vietnam, by 2000, the authorities, mainly the Ministry of Industry (MoI), has proposed a "local contents policy" which tax imported bike parts in arcordance with proportion of local contents in assembled bikes. The threshold of local contents for applying privileged import duty was proposed at 40%, then the more the local contents, the less the duty. By that time, most of the FDI assemblers claimed to meet the 40% threshold and be ready for new policy, while most of the domestic assemblers with their Chinese bikes were strungling with 10 to 20% local contents. The policy was then delayed for a year, become effective only from 2001.

Right after coming into effect in 2001, the local contents policy has shown many complications and become a hot topic for debate, not only between the authorities and bike assemblers, but also among government bodies. It was criticised that the methods used to calculate local contents are not appropriate and given the lack of effective monitoring system the policy created room for rent-seeking activities. Several calculation methods and proving requirements were tried within 2001, lot of investigation were done, all of these created a chaos in bike industry. Failure of the transportation infrastructure to cope with motorbike boom made things go from bad to worse. Enterprises blamed the government for inconsistance, the government bodies blamed each other, government office was busy to fight for solution. At the end, the debate was ended by the abandance of "local contents policy" and the government introduced a new mechanisms to regulate the industry by production quota and other demand side measures such as restriction of bike registration.

***Attracting FDI and spill-over impacts: positive side of the policy***

It is obvious that, the protection of domestic motorbike industry by means of tariff and non-tariff measures has attracted international bike makers to invest in Vietnam. Their activities in Vietnam and the local content requirements also attracted affiliated international parts makers who supply them various kinds of parts globally. By 2001, there were only 7 FDI bike assemblers, however the number of FDI projects in motorbike indutry reached the number of 84 (Table 4). Patterns in Table 4 also indicates that assemblers from one country usually bring with them parts suppliers from the same country. Figure 1 also indicates the impacts of local content policies with the boom of foreign investment in parts making. Figure 2 shows that Japanese and Taiwanese are the major investors in term of the registered capital.

Table 4: FDI in Motorbike Industry

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| China | | | | | | | 1 | | | 7 | 8 |
| Japan | | | | 2 | 5 | 5 | 2 | | 1 | | 15 |
| Korea | | 1 | | 1 | | | | 1 | 1 | 1 | 5 |
| Taiwan | 2 | 1 | 12 | 2 | 1 | | 4 | 5 | 8 | 10 | 45 |
| Thailand | | | | 1 | 1 | | | 1 | | 2 | 5 |
| Other | 1 | | | | 1 | 2 | | | | 2 | 6 |
| Total | 3 | 2 | 12 | 6 | 8 | 7 | 7 | 7 | 10 | 22 | 84 |

Souce: MPI database of FDI projects.

Figure 1: Number of FDI projects in Motorbike Industry

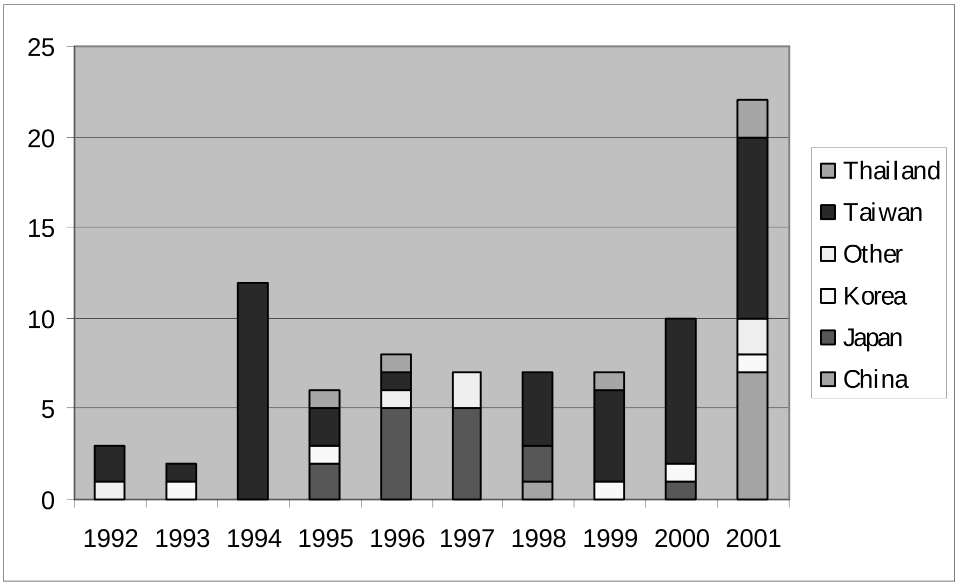
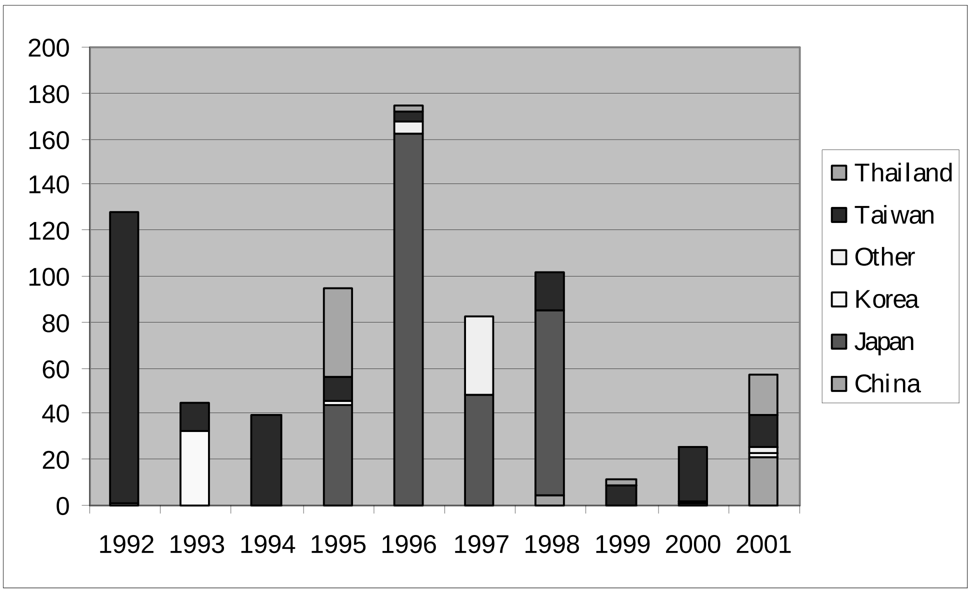



Figure 2: Registered Capital of FDI projects in Motorbike Industry



With regard to the development of networks of suppliers, the case of Honda Vietnam and VMEP are typical examples. In order to meet local contents requirement, Honda Vietnam (HVN) has developed a network of about 20 suppliers in Vietnam in which 13 are Japanese invested firms, a Thailand invested firm, and 6 domestic firms. Honda itself has entered into two joint-ventures with other local partners to produce motorbike's parts. The entry of VMEP, a Taiwanese bike maker in Vietnam in early 1990s also creates similar impacts. Since its entry, there have been dozen of Taiwanese parts makers who set up their operations in Vietnam.

The process of seeking local domestic suppliers of MNCs has an important impact on awareness of local firms. By negotiating with MNCs, they learned more about quality requirements and management. Those who fail to be included in the production chain could learned a lesson of why they had fail and so what they have to improve. Those who are included have greate oppertunty to upgrade in the process of santisfying MNC's requirements. In many cases these local firms also got technical supports from MNCs especially with regard to quality management.

Training within MNCs have important impacts on human resource development for the industry. In the case of HVN, before starting production, the company has built up a core staff which comprises of engineers and technicians who then sent to Japan and Thailand for training. Six months course was also provided for production-line managers and three months course was for managers at lower level. In total, 100 people have got this type of training. Once the production commenced, HVN keeps sending its supervisors on a regular basis to overseas and provide guidance to production activities. Besides oversee training, on-the-job training has been applied since the start of operation in form of short training courses provided by Japanese lecturers. This type of training aims at specific or problematic issues realised in the operation of the new venture.

Training activities in other MNCs such as VMEP, Yamaha etc. have many similar characteristics of HVN although there are some different in scale and time depending on strategy of each MNCs. However, since manufacturing is the main concern of MNC's operation in Vietnam, training efforts are mainly in production skills, operation management, and quality management. There is little training to develop design and R&D capability, although there have been some progress in recent years.

The entry of MNCs in motorbike industry also changes the competition in local market. High price set by MNCs has created opportunities for low price motorbikes to enter the market. As reported earlier, the emerge of so called 'Chinese motorbikes' with prices range from half to a third of that of Honda's standard ones is an example. In respond to the challenge of 'Chinese bikes', HVN launched its new model 'Wave Alpha', which is priced at about 20% higher than that of 'Chinese ones'. Soon after its launch, the new model has gained a significant share in the low-end market, creating a kind of dynamics in this industry.

***Rent - seeking activities: a negative side of the policy***

Besides positive effects discussed in the above section, local contents policy also has negative impacts on the development of the industry. The lack of an effective and efficient tax system, plus smuglling and weak monitoring system have created much room for rent-seeking activities. As described earlier, the threshold of local contents for applying privileged import duty was 40%, while in 2000 almost all wholly Vietnamese assemblers were reported to have only 20% local contents, at most, in their Chinese bikes. In 2001, when the policy come into effect, all of these assemblers claimed that they were successful to raise the local contents in their Chinese bikes to meet the threshold level of 40%, an "amazing efforts" if this was real. However, later investigation shows that firms have used many tricks to increase the local contents artifficially.

It should be noted that, majority of domestic bike assemblers have background of trading firms. They were bike trading first, then when the trade barrier was raised, they switch to assembling activities using simplest technology without any major investment for production of parts and components. The 40% local contents requirement is a strong force which would lead the assemblers to cooperate with local parts suppliers or to invest in making them. However, given the weak position of parts making sector at that time and huge capital required for investment in parts making activities, the firms had found a quicker way to santisfy the requirement.

Figures 3 illustrates how some domestic assemblers have managed to increase their "local contents". Given wide spread of smuglling activities at Vietnam - China boarder, bike parts had been smuggled to Vietnam. Once in Vietnam, these smuggled parts were registered as locally made. Investigation shows that there are about 400 firms which were registered as local parts makers, but in fact, were trading firms without any significant investment for production. Many of them were especially set up for this "local contents" purpose. As a result, the "local contents policy" which supposed to develop the motorbike industry had turned out to be a land for rent-seeking activities.

As discussed in previous section, production network based on country of origin has helped to develop the industry quickly, however it also raise barriers for domestic part makers to enter the market. Figures 3 indicates a situation in which majority of local firms are not linked with operations of MNCs in the industry. Rent-seeking practices have prevented local firms to take opportunity of local content requirements to upgrade their technological capability.

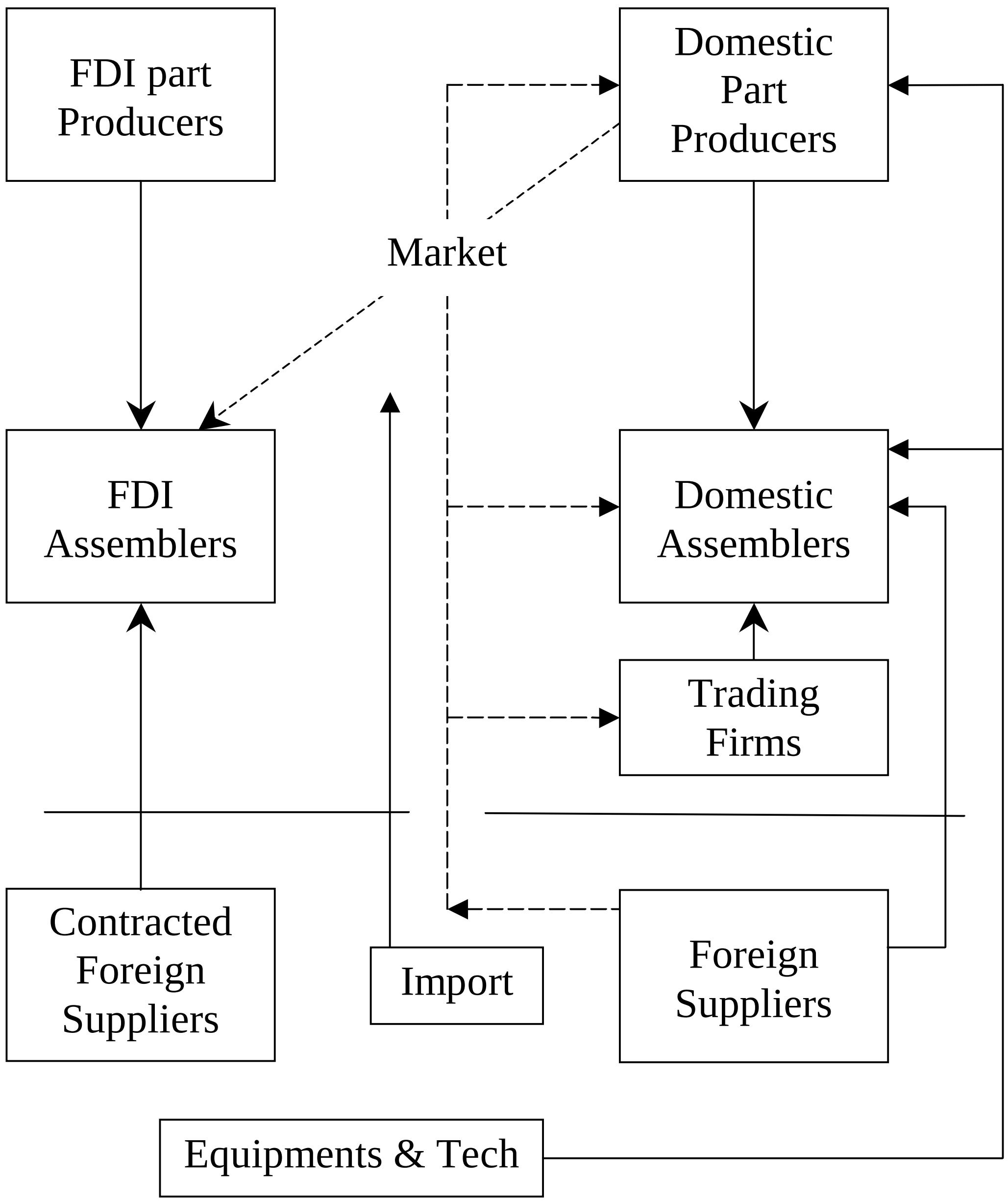



Figure 3: Production Network

## Learning behaviour of local firms

Although strategies of MNCs and rent-seeking activities have limited learning efforts of local firms, it is also the technological capability of local firms and the lack of an effective supporting system that did not allow them to play a more active role in the industry. Understand learning behaviour of local firms and their interactions with other players will help policy makers to come up with more effective supporting measures.

### *Interactions for problem solving*

Generally, science and technology organizations are expected to be important sources which firms can rely on to tackle their technical problems. However, this is hardly true in reality. Evidence from NISTPASS' innovation survey conducted in 2002 shows that among domestic firms in mechanics sector, in which majority of them are motorbike parts makers, interactions with academic sources are not seen as the main sources for problem solving. In fact, interactions with business partners, especially foreign partners, are much more important for firms as channels for problem solving (Table 5).

**Table 5: Channels for problem solving, SMEs vs. non-SMEs**

| Channels | Technical | | Product Market | | Input Market | |
|---|---|---|---|---|---|---|
| | SMEs | non-SMEs | SMEs | non-SMEs | SMEs | non-SMEs |
| Formal cooperation with R&D institutes/universities | 2,21 | 2,23 | 1,48 | 1,58 | 1,58 | 1,45 |
| Cooperating with individual scientists | 2,00 | 2,08 | 1,62 | 1,50 | 1,55 | 1,75 |
| Cooperating with infor-tech centres | 2,00 | 1,77 | 1,97 | 1,42 | 1,63 | 1,36 |
| Cooperating with foreign partners | 2,33 | 2,67 | 2,20 | **3,08** | 2,34 | **3,00** |
| Cooperating with FDI partners | **2,75** | **3,31** | **2,80** | **3,42** | **2,79** | **2,75** |
| Cooperating with domestic partners | **2,94** | 2,57 | **3,15** | 2,85 | **3,06** | 2,33 |
| Self-reliance with reference to practices of other domestic firms | **3,47** | **2,83** | **3,30** | **3,08** | **3,03** | **3,00** |
| Self-reliance with reference to practices of oversees companies | 1,97 | 2,00 | 1,70 | 1,86 | 1,87 | 1,83 |
| Self-reliance with reference to technical documents | 2,23 | **2,83** | 1,97 | 2,58 | 1,90 | 2,75 |

Souce: Calculated from dataset of 2002 NISTPASS' innovation survey

Note: Scores are average value of a likert scale from 1 to 5 to evaluate the importance of each channel in solving problems faced by firms in their innovation activities. The higher the score, the more important the channel.

The ineffectiveness of S&T organizations in supporting local firms in motorbike industry should not be a suprise. Given the weak position of S&T sector, inefficient financial market and underdeveloped technical services in Vietnam, interactions with business partners would becomes dominant. It is quite common for local firms in developing countries to rely on foreign sources for capital goods and sometimes even key materials. This is partly due to the lack of reliable local suppliers, but in many cases, it is also the requirements of customers or financial dependence of local firms on their suppliers. This creates a situation in which local firms are lock-in with foreign technology and at the same time S&T organizations are lock-out of technical interactions. The situation can be illustrated as in Figure 4 below.

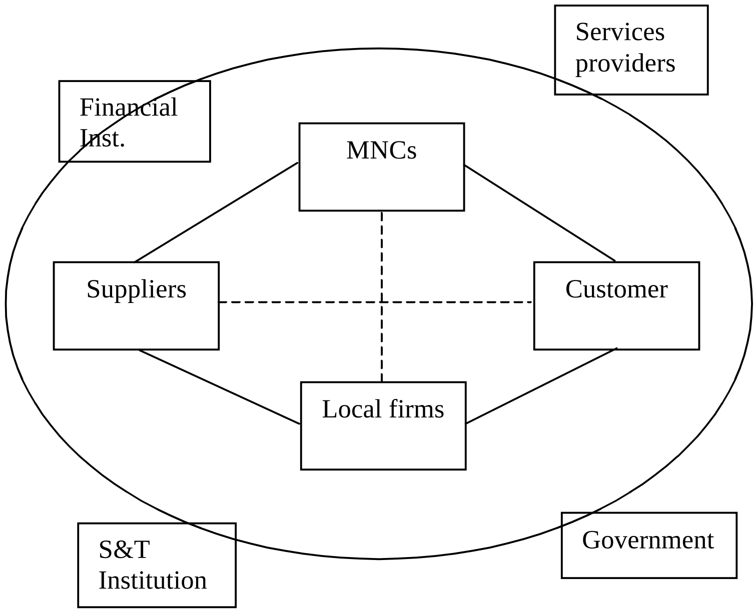



Figure 4: Interactions of local firms.

As mentioned earlier, suppliers and customers of local firms also have some interaction. For customers, especially foreign ones, they might request the producers to buy capital goods from reliable sources to guarantee quality. For suppliers, they might have to link up local firms with customers so that they can convince them to buy their capital goods. Suppliers and customers in Figure 4 can also be FDI firms in Vietnam. As such, the diamond in Figure 4 can represent the dominant production interactions of firms and the circle surounding the diamond indicates that financial institutions, S&T institutions, other services providers and government are locked out to different extend (the closer to the diamond, the more the interaction between these institutions and the elements of the diamond).

***Learning from foreign affiliates in Vietnam***

As disccused in previous section, foreign and FDI firms are expected as the important source for technology learning. Results from the innovation survey reveals that there are 71% of SMEs and 93% of non-SMEs in mechanics sector reporting to have relationship with foreign/FDI firms. Table 6 provides a general pictures of the type of foreign/FDI firms that domestic firms have had interactions. It is not surprise that *"main supplier of equipment"* and *"main customer"* are reported as the most important channels for learning. The data also indicates that proportion of non-SMEs that have relationship with foreign partners are higher than SMEs in all categories. This means that big firms tend to have a larger window for learning than small firms.

In terms of content of learning from foreign partner, in overall, *"quality control"* and *"processing procedure"* are the two most important areas of knowledge that local firms have learned from foreign/FDI partners (Table 7).

**Table 6: Type of FDI partner**

| Type of foreign or FDI partners | Mechanics | |
|---|---|---|
| | SME | non-SME |
| Foreign/FDI partner is the frequent supplier of materials | 40% | 62% |
| Foreign/FDI partner is the temporary supplier of materials | 48% | 54% |
| Foreign/FDI partner is the main supplier of equipment | 55% | 62% |
| Foreign/FDI partner is not the minor supplier of equipment | 26% | 54% |
| Foreign/FDI partner is the provider of technical service | 23% | 23% |
| Foreign/FDI partner is the main customer | 39% | 69% |

Souce: Ibid.

**Table 7: Type of knowledge learned from foreign/FDI partners**

| What the firms have learned | Mechanics | |
|---|---|---|
| | SME | non-SME |
| Marketing skils | 2.83 | 2.75 |
| Distribution network | 2.80 | 2.58 |
| Design and specification of the products | 3.38 | 3.31 |
| Quality control procedure | **3.42** | **3.69** |
| Operation management | 2.92 | 3.31 |
| Processing procedure/process technology | **3.25** | **3.46** |
| Source of materials/additives | 2.68 | 2.92 |
| Source of equipments | 3.17 | 3.25 |
| Training for workers | 2.75 | 3.08 |
| Training for engineers | 2.52 | 3.08 |

Souce: Ibid

***Technology Managment Practices***

Earlier, I have argued that low level of technological capability of local firms can limit them to play a more active role in the industry. This weakness is reflected partly in technology management practices of local firms. Table 8 shows that SMEs are less capable than non-SMEs in almost all iterms which reflect technology management practices of firms. Majority of big firms are aware of technology used in the sector in the same local areas (93%), and the proportions are quite high when the geographical areas are expended to "Vietnam" (79%), and some countries in the world (71%). The similar proportions in SMEs group are much lower, which are 71%, 69% và 49% arcordingly.

Table 8 also reveals that equipment management are much better done than knowledge management. Almost all big firms and two third of SMEs have log-book to keep track of main equipments, while only half of big firms and a quater of SMEs documented their skills, procedure and other technical information. Linkage with S&T organisations is quite weak with SMEs, while the linkage is stronger in non-SMEs group.

**Table 8: Technology management practices, SMEs vs. non-SMEs**

| Technology management's practices | Mechanics | |
|---|---|---|
| | SMEs | Non-SMEs |
| Aware of technology used in the sector in some coutries | 49% | 71% |
| Aware of technology used in the sector in Vietnam | 69% | 79% |
| Aware of technology used in the sector in province/city | 71% | 93% |
| Having log-book to monitor operation of main equipment | 66% | 86% |
| Skills, procedures, technical information are well documented | 29% | 57% |
| Organised examination to promote professional grade for workers in at least every two years. | 49% | 86% |
| Staff are exchanged quite often from one department to another | **40%** | 36% |
| Having frequent relationship with S&T organisations. | 26% | 57% |

Souce: Ibid.

It can be argued that many of the above practices are standardized and can be easily disseminated with appropriate training. Working on these simple things can improve a lot the technological capability of local firms and here we can see a potential for S&T institutions and interventions of government.

## Conclusion and policy orientations

This paper shows that FDI has significant impacts on development of motorbike industry. However, FDI opearations tend to concentrade on production activities, using proved technology to explore cheap labour advantage and/or market protected by high trade barriers. This mode of investment determines the type of investment and knowledge transfer from parent firms to their affiliates in Vietnam. Analysis in various sections of this paper indicates that machinary investment and production technology are the main type of resource transfer. Training is also concentrade on production management. There are few activities in terms of design or more sophisticated engineering work. Some MNCs are just starting to develop design capability and more advanced skills in their affiliates in Vietnam.

For local firms, results from the Innovation Survey indicate that linkage among business sources plays a much more important role than linkage with academic sources for problem solving. Within business community, foreign and/or FDI partners are indicated as the main channel for learning, not only for technical issues, but also for issues related to product market and inputs market. Big firms seem to have better practices of technology management than SMEs and they also have more chance to be part of production networks of foreign/FDI firms.

Studies in motorbike industry show that innovation requires many type of learning, some are industry specific and common among local firms. It would be a waste of efforts if each firms try to address these problems individually. However, cooperation between competitive firms are not easy and here the wise intervention of government and S&T institutions are needed. These are areas where the government should support for cooperation of firms and S&T institutions and should be the areas for fruitful formal international cooperation. In motorbike industry, this study has indentified following common areas:

- CAD/CAM skills, both basic techniques and floor experience. Training by foreign engineers are badly needed.
- CNC operations.
- Technology management training.
- Quality management training.
- Standard development.

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# Role of Firms in Industrial Innovation

The Honda Foundation
International Symposium,
2005,Hanoi

February 28, 2005

NTT Advanced Technology Corporation
Takashi SAWAI

## Contents

# An Innovation for a Company

- A technical innovation is indispensable in order that a company gains profits and exists continuously.
- Intellectual property is utilized in order to heighten the effect of the innovation.
- Creative talented persons and teamwork support the innovation.

# An Innovation and IP

- Strategic Linkage
  - Business Strategy
    - The pillar and view of a profit
  - R&D Strategy
    - The breakthrough for bringing a profit
  - Intellectual Property Strategy
    - Recovery of investment and reinvestment
- Meaning of Intellectual Property
  - The Card of Competition
    - Lawful exclusion of competitors
  - The Fountainhead of Profits
    - The return of investment
  - The Symbol of Trust
    - Satisfaction of customers
  - Risk Hedge
    - Freedom of business

# A Changing Focus

Patent (Protection of Technology)

＜Expansion for Protection＞

Intellectual Property (Protection of Intangibles)

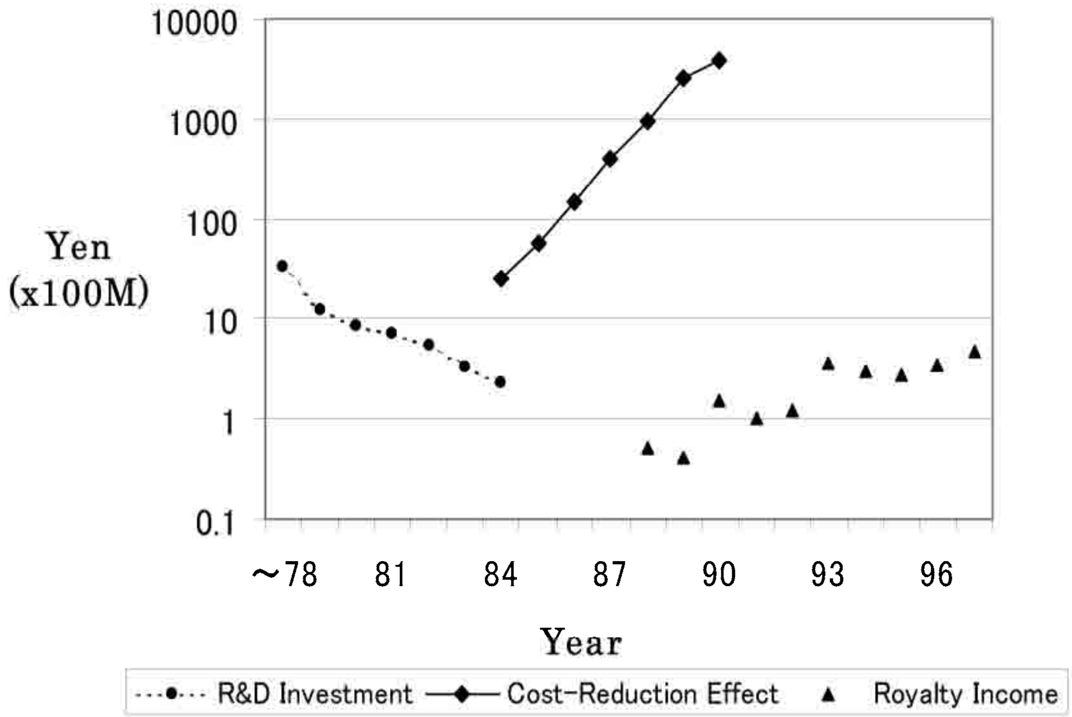
＜Emphasis of Return＞

Intellectual Asset (Conversion of Property-value)

# Case 1: Optical Fiber Cable

- Direct Effect
  - 100 times R&D Investment
  - 10 Years after the Basic Invention
  - Bigger Contribution than Indirect Effect
- Indirect Effect
  - License of Patents and/or Know-how
  - Long-run of Royalty Income
  - Almost Equivalent to the Amount of R&D Investment
- Social Effect
  - Creation of New Industry (Optical-communications)

## Investment and Effect of R&D for Optical Fiber Cable




# Case2: Planar Light-wave Circuit

- Sold-off Company
  - R&D Oriented Company (Establishment: 1987)
  - Capital: 1 billion yen
  - Sales: 4.5 billion yen (1998)
  - Profit: 1.6 billion yen (1998)
- Buyer
  - Establishment: 1983
  - Aggregate market value: 1000 billion yen
  - Sales: 12 billion yen
- Sale Conditions
  - The Amount of Sale
    - 160 billion yen+ 34 billion yen
  - A Stock Equivalent Exchange

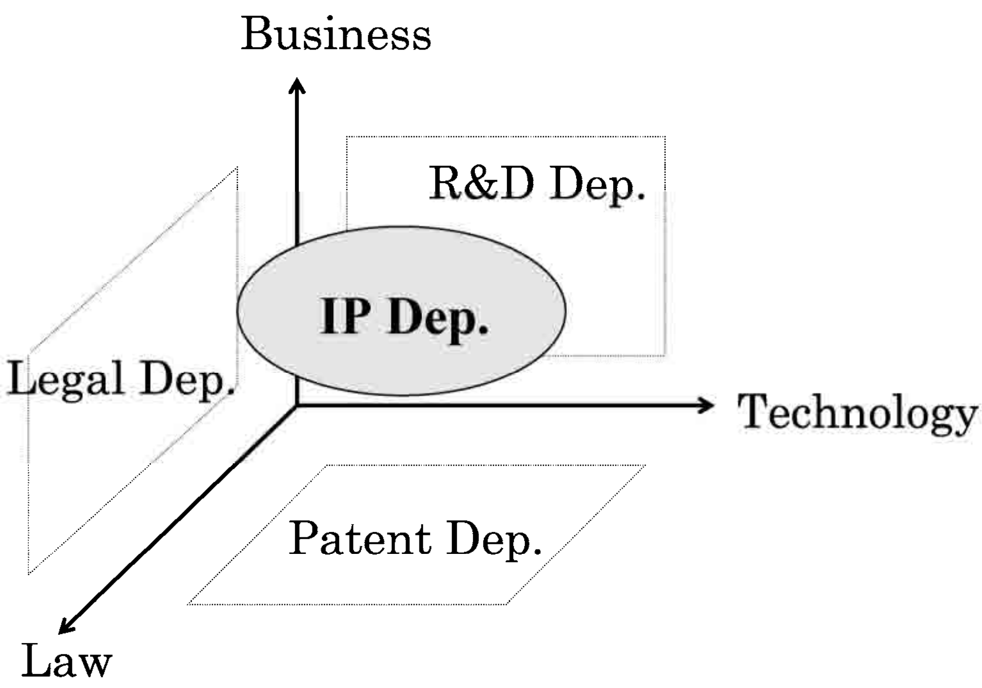
## Circulation of Investment

R&D Investment

- Recovery by the enterprise (Direct effect)
- Recovery by the license (Indirect effect)
- Recovery by enterprise sale (Property-effect)

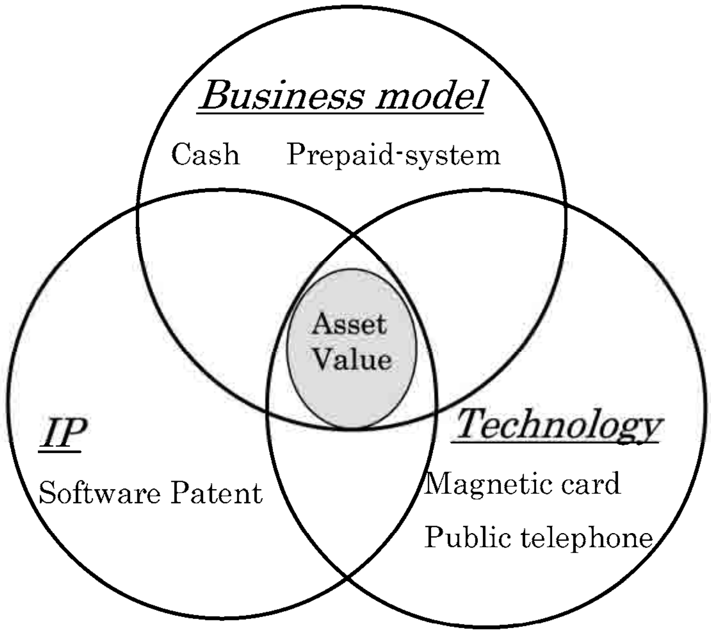
Reinvestment to R&D

## Basic Coordinates of IP Management

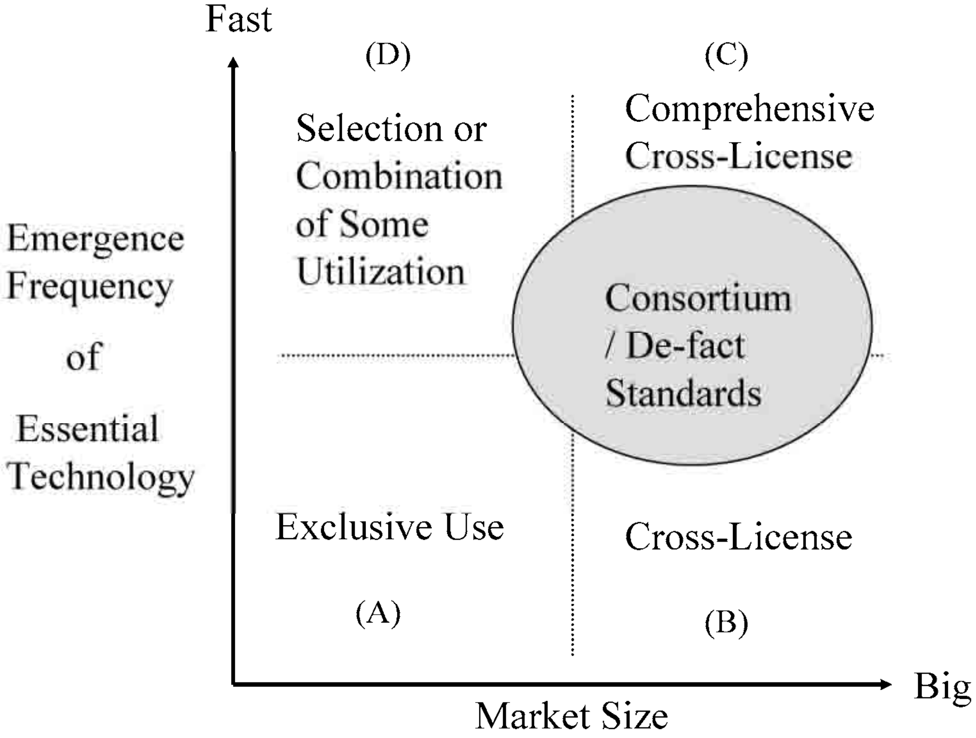


# Fusion of Creativity

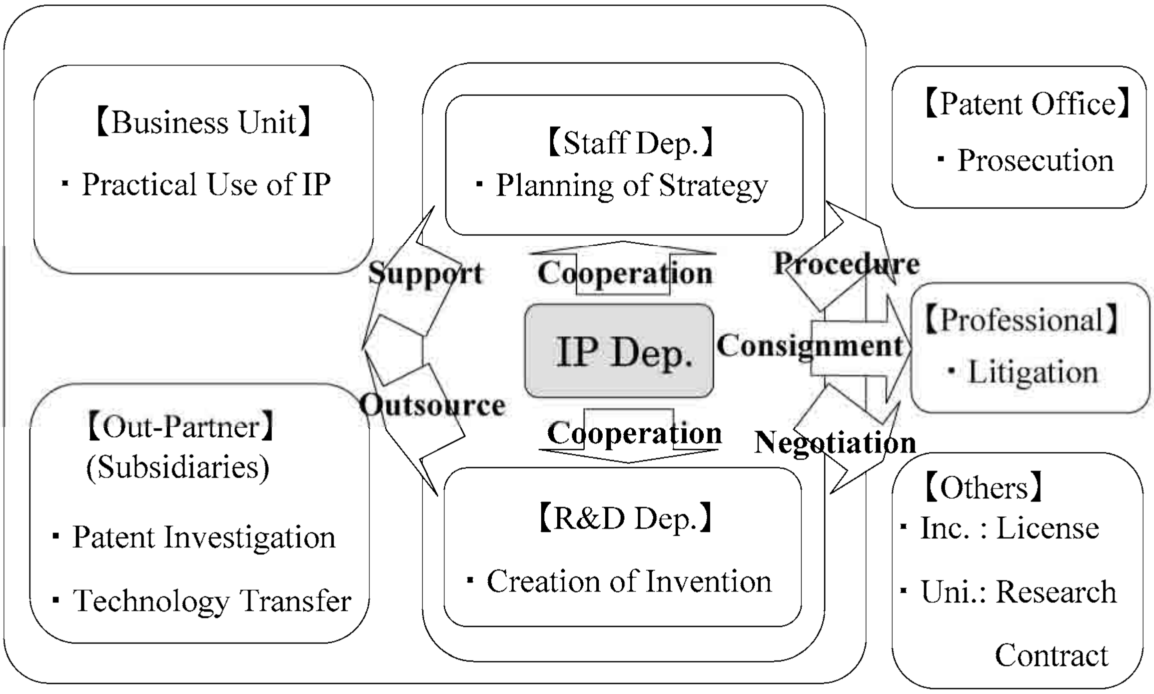
(ex. : Telephone Card System)




# Strategy of IP Utilization

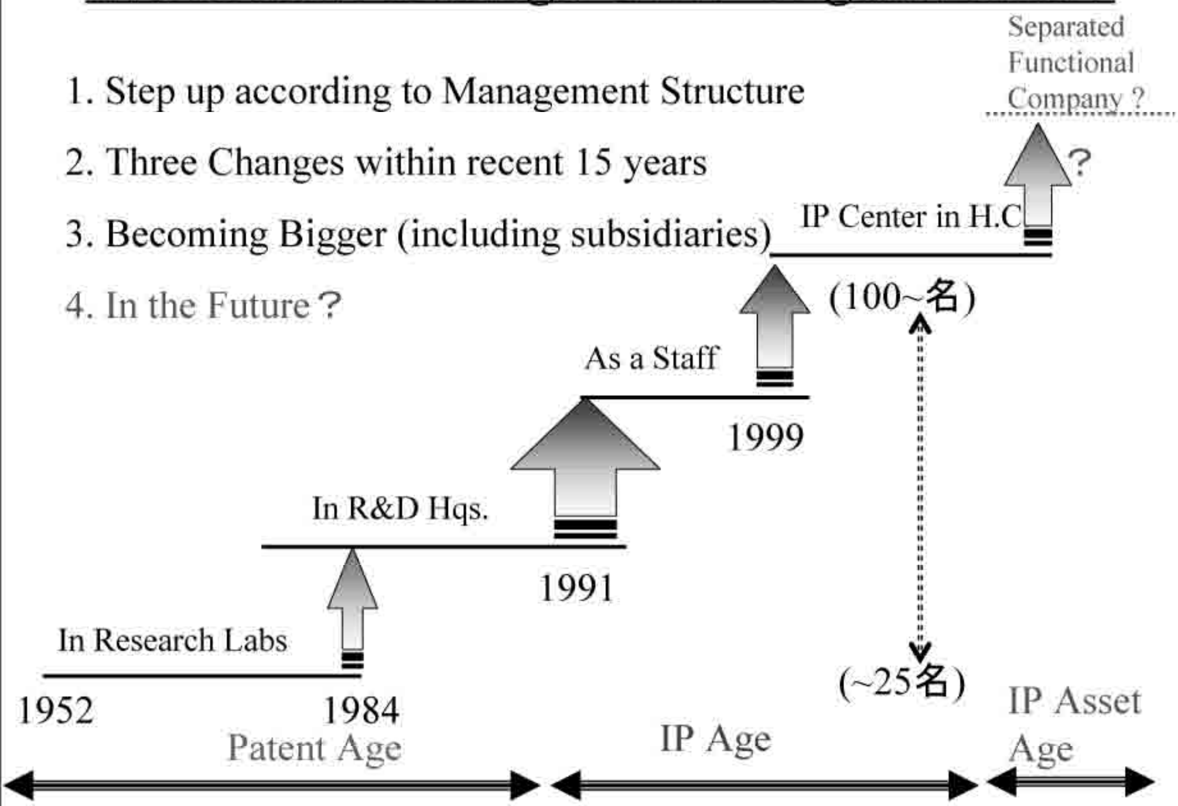


# The Interface of IP Dep.

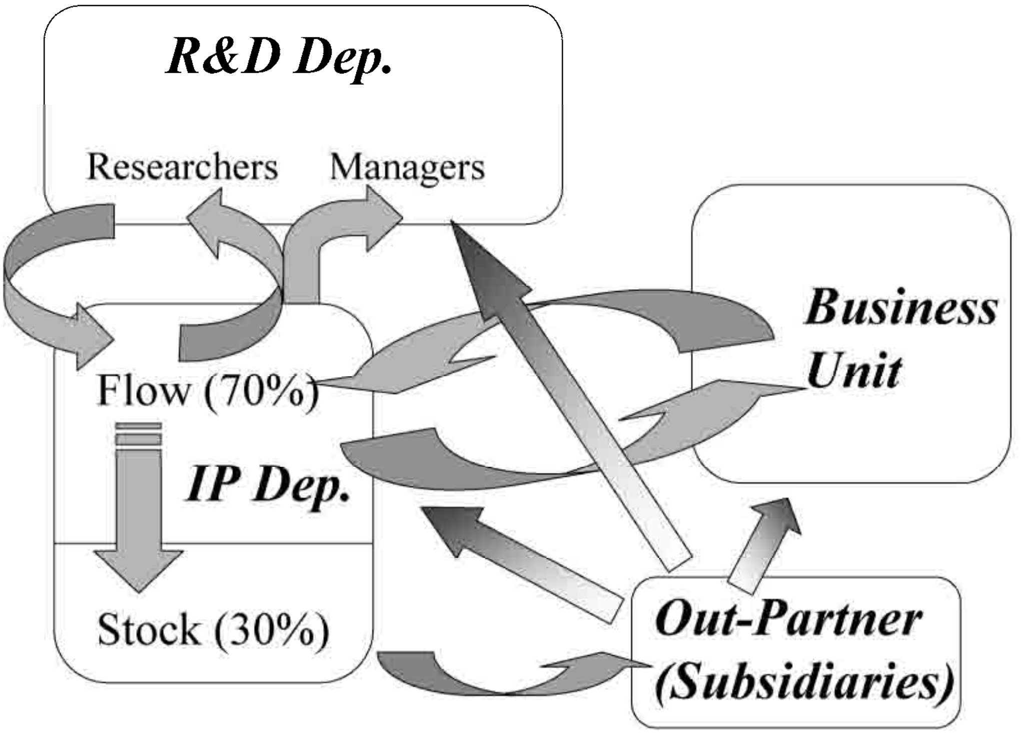



# Historical Change of IP Organization

1. Step up according to Management Structure
2. Three Changes within recent 15 years
3. Becoming Bigger (including subsidiaries)
4. In the Future？

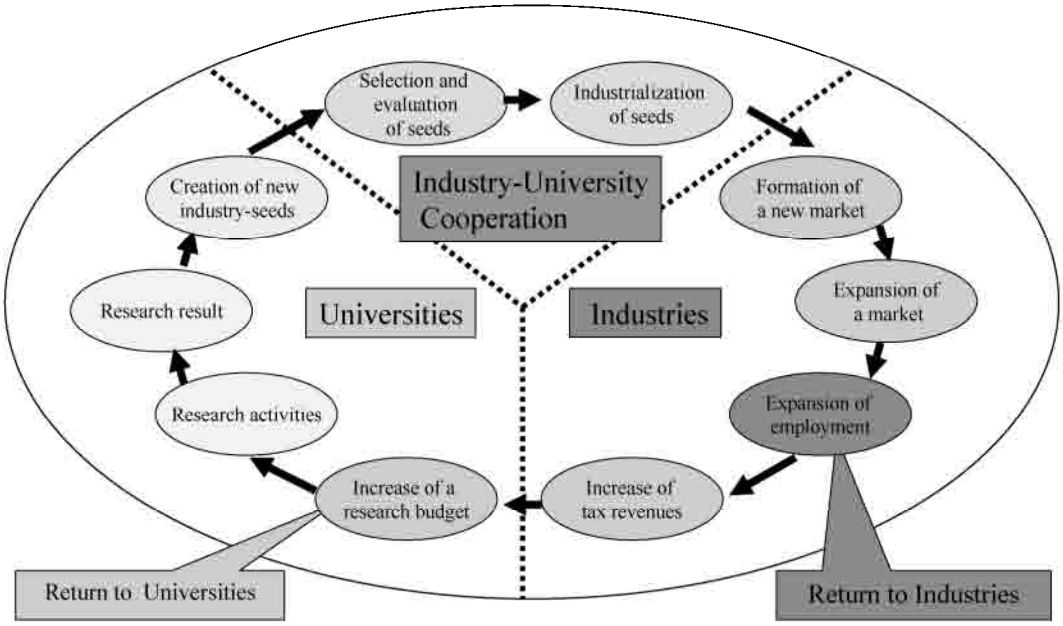


# Personnel Exchanging System




# The Target of Industry-University Cooperation :The Return of Continuous Win-Win

(The revitalization-of-the-economy cycle by industry-university cooperation)



## Difference & Fusion of Company-University

| | Company | University | The Point of Fusion |
|---|---|---|---|
| Purpose | Profit | Knowledge（？） | The spread of technology |
| Authority system | Established | Be fixing（？） | Respect of organization logic |
| Fund | From Market | From Tax （？） | Return to organization |
| Business | Direct | Indirect（？） | Target promise-type research |
| Job range | Clear | Ambiguous（？） | Joint-research as a job |
| Secrecy | Strictness | Indefiniteness（？） | Observance of a contract |

# The Key of a Success

--Talented persons & Teamwork--

- The Sharp Sense of Smell
  - A person who has his/her technical intuition
  - A person who has his/her own original view to the future technical prospect
- Amazed Persistence to Technology
  - A person who has adherence to his/her technology
  - A person who can explain the physical meaning about his/her technology clearly
- Abundance of the Way of Thinking
  - A person who can grasp weak points about his/her technology objectively
  - A person who can be drawing the whole image about the field in which his/her technology is applied
- Creative Talented Persons' Teamwork
  - Fusion of creativity in Business, Technology & IP
  - Communication among different cultures

# LINK-UP PROGRAM BETWEEN FIRMS – RESEARCH INSTITUTES – STATE FOR TECHNONOLY INNOVATION AND BUSINESS COMPETITIVENESS IN ECONOMIC INTEGRATION

Department of Science and Technology
Ho Chi Minh City

In the course of international integration, all nations have to participate in this process and face the competition of free trade. This is particularly true for a country of low economic, science and technology capabilities like Vietnam. Having decided to become a member of AFTA, APEC, a party to Vietnam-US bilateral trade Agreement and WTO in the future, we have to compete in a general framework. This is not only a formidable challenge but also a good opportunity to access new markets for Vietnamese enterprises during the course of integration.

At present there are about 6 million people in Ho Chi Minh City, with the average per capita income of USD 2000 per year. Our city is one of the biggest economic, cultural and scientific centers in the country. The economy of the city is structured around services and industries, characterized by finance, trade, tourism science and technology, education, post and telecommunication, software development, manufacturing, construction, electronics, food processing etc.

Recently, the science and technology activities in Ho Chi Minh City have seen significant progresses and played a leading role in many fields thanks to the coordination between agencies, authorities, research institutes and universities, to the efforts made by scientists and researchers and to the cooperation from enterprises.

In Ho Chi Minh City, there are many programs and projects to assist enterprises in their innovations with respect to equipment, technology, managerial capabilities, productivity improvement, and cost-reduction to improve competitiveness in the integration tendency. Most notable is the program called *"Enterprise assistance program* *to modernize with low cost, establish comprehensive competitiveness and export promotion"* (Implementing Directive No. 04/2000/CT-UB-KT dated 23 February 2000 by Ho Chi Minh City People's Committee).

This important program is directed by a Vice-president of the Ho Chi Minh City People's Committee, the Department for Science and Technology is the standing organization whose responsibility is to coordinate with other departments, agencies such as the Alliance of Science and Technology Associations in the city, research institutes, and to oversee the implementation in firms and businesses from all economic sectors in the city.

## PART I: NOTABLE RESULTS FROM THE LINK-UP PROGRAM TO ASSIST ENTERPRISES IN ECONOMIC INTEGRATION

The conference held to evaluate after 4 years of operation of the program has concluded that the Program 04 has met the needs of enterprises, boosted the roles of science and technology and the roles played by the state in assisting enterprises with training and updating knowledge of international economic integration, business management, building quality control system, establishing trade marks and intellectual property rights protection; designing and producing equipments and technologies with low cost to replace imported ones, organizing market place for equipment and technologies as a step to establish market for science and technology, providing information and assisting enterprises with trade promotion.

Results achieved from the Program 04 have had importance influence on the socio-economic development in Ho Chi Minh City. All socio-economic performance indicators have seen improvement, with the GDP grew by 9.5% in 2001 and 11.6% in 2004, the highest level since 1998.

Program 04 has resulted in practical impacts both extensively and intensively on enterprises in the innovation of equipment, technology, higher product quality, better managerial capabilities, and bigger export market, all of these have contributed to the industrial growth in the city (15-16%), the recognition of the roles played by science and technology in modernizing production processes. Indeed, the objective of the program was achieved, that is to create a comprehensive competitive advantage.

**Result 1: Establishing and developing "triangle link-up: Enterprises – State – Research Institute" model** in science and technology activities as follows:

1- **Program to design and manufacture advanced technological equipments with low cost to replace imported equipments:**

In Ho Chi Minh City, there are more than 40 universities and colleges, 60 research institutes and centers with 300,000 science-technology researchers, accounting for 25% to the total number of sci-tech staff in the country. These are the resources the enterprises can resort to when they need technology innovations to produce at low costs, improve their managerial capabilities and competitiveness.

By the triangle link-up Enterprises – State – Research Institute mechanism in which the Department of Science and Technology serves as a bridge between production and research organizations, projects and research topics can be selected to produce good which can compete with imported goods and meet the needs of the majority of firms and enterprises in each industry.

* After 4 years of implementation, we have achieved the following results

- Designed 37 types of equipments and technologies to replace imported equipments and technologies with the total investment of VND 24 billion. The costs of home made products are about 30-70% of imported ones.
- Transfer 250 equipments and save USD 18 million (over VND 270 billion) for firms and enterprises.
- Outputs of the programs have been exported to other countries such as Laos, Thailand, Australia, Cambodia, and Taiwan with the revenue of USD 1.5 million after 2 years of implementation.

**2. Mechanization of sugar cane industry**: 3 types of complex equipments: growing, serving and harvesting the sugar cane. They have been demonstrated and commissioned at Nuoc Trong plantation, Tay Ninh province. The technology was then transferred to Dong Nai and Phu Yen province: the productivity of sugar cane production doubled, with a cost reduction of about 30-40%.

**3. The implementation of investment project to build and equip for the Center for Designing New Equipment – Neptech** has been approved by the People's Committee (the City invest 29 VND billion in the first phase). The project also receives supports from Ministry of Science and Technology in terms of equipment. The center is the gathering place of science-technology people to research on technology improvement and pilot production of equipments which contribute to the modernization of key industries of the City.

The triangle link-up model has associated scientific research with business and production; demonstrated the capability to replace imported technologies and equipment with home-made substitutes; assisted enterprises to modernize with low costs; contributed to the modernization of several industries (pharmaceutical, construction materials, food processing, agricultural mechanization, etc), enhanced firms' competitiveness. However, there are several limitations and difficulties such as: slow progress in transferring equipments as compared with the actual need and potential; unclear profit-sharing mechanism which impedes the transferring progress; inadequate conditions to develop high technologies due to lack of research facilities.

**Result 2: Initial achievement in establishing market for science and technology by means of setting up market places for equipments and sci-tech consultancy**

Initial success in establishing market for science and technology by setting up 19 trade fairs for equipment, technology and softwares in Ho Chi Minh City, Hanoi, Danang, Dong Nai, Dac lac, Gia Lai, Can Tho ect. Through these trade fairs near

10000 contracts and memorandum for transferring equipments, technologies, production solutions, softwares were concluded with the estimated total value of nearly VND 1000 billion.

In 2004, in addition to organizing the market place for equipments and technologies, we also set up a market place for sci-tech consultancy services at Gia Lai province on an experimental basis focusing on 4 areas, i.e. forestry-agriculture, processing industry, IP, information technology. We also organized a large scale sci-tech consultancy market during the Week of Science-Technology and Higher Education, No.II in Ho Chi Minh City with the participation of 30 consulting firms, resulted in 95 business memorandums; 500 visits paid by customers to contact, discuss with consulting firms on the setting up of a market for sci-tech consultancy and business management consultancy. 5 contracts were concluded at the market with the total value of nearly VND 400 million.

- Business consultancy helps to assess the requirement and problems to be address in the process of innovation and modernization of businesses: production organization, application of information technology to collect information and improve management efficiency; improvement, innovation and modernization of equipment-technology, product diversification and quality improvement in connection with environmental protection and sustainable development; assistance in technology transfer allowing enterprises to access and develop new and modern technologies with high intelligence content.

- Organize 10 training courses on the evaluation of intangible, protection in technology transfer for 450 participants from sci-tech consulting firms with an aim to improve their professional capability in sci-tech consultancy.

In addition, an on-line market place has also been set up at the address htttp://db3.hochiminhcity.gov.vn/techmart, in which over 2000 equipment, technologies and softwares are put on sales, over 1000 buyers and nearly 1000 transactions were concluded.

The market for sci-tech consultancy and the market for equipment and technology have contributed to the development of market for science and technology, the commercialization of science and technology products, the promotion of the application of scientific and technological research results in production, and played an important part in turning science and technology into a driving force in national industrialization and modernization.

Ho Chi Minh City itself has transferred the technology to organize market places for equipments and technologies to other provinces and to the Ministry of Science and Technology. Through these activities, Ho Chi Minh City has strengthened its cooperative relationship with other provinces and cities (Hanoi, Dac lac, Da Nang, Dong Nai, Can Tho, etc) for the purpose of promoting science and technology potentials of economic regions and the whole country.

**Result 3: Providing training and assistance to enterprises during the course of international economic integration**

To assist firms and enterprises to improve their knowledge during the course of international economic integration, the program includes seminars, conferences, training courses to provide managers of enterprises with knowledge about AFTA and WTO.

**1-Training courses for 1000 directors and managers of enterprises**

The first stage from 1999-2003 was completed. Up to now, the program has organized 13 training courses (10 month each) for 800 participants of whom 657 has completed 11 courses with the success rate of over 80%. Over 95% of participants responded that they can apply the knowledge learnt after the training courses.

In the second stage, the program has been improved to meet the demand from enterprises. In addition to 10-month long courses, the program also provides short courses on such topics as human resource management, finance and accounting, etc.

**2. Training to enhance the competitiveness for integration:** training programs on trade promotion (Vietnam-US trade agreement, WTO), international quality standardization system, IP, trade mark have been organized.

During the last 3 years, Investment & Trade Promotion Center (ITPC) has organized over 100 training courses and seminars on enhancing the competitiveness in integration, export, trade promotion for enterprises in the City for over 6000 entrepreneurs.

The City also organizes training programs on international quality control systems (ISO 9000, ISO 140000, HACP, SA 8000, OHSAS 18000, GMP etc) for which unto now, over 130 courses have been organized with 3500 participants; trade mark registration and protection (10 courses on preparing application for trade mark registration for over 500 enterprises); energy savings (12 courses for over 400 participants from 200 enterprises in fishery, plastics , rubber, paper, food processing, services and tourism businesses); information technology (applying CMM on software development, E-commerce, web designs etc).

**3. Assisting enterprises in applying international quality control system, especially ISO 9000; trade mark registration; scientific solutions in energy savings:**

- *Assisting enterprises in applying advanced quality control system:* The city funds 10-15% of the cost in applying ISO 9000 (consultancy, training and certification fee); provides consultancy on the implementation of ISO 9000 at businesses; and provides consultants during the implementation of ISO 9000.

Up to now, the city has assisted more than 2000 enterprises in their application of international quality control system, of which 78 enterprises have been certified.

- *Registration and protection of trade marks*: Over 500 enterprises participated in the program to assist enterprises in designing, registration and protection of over 1000 trade marks. Free look-up for 373 trade marks saves VND 75 million for enterprises. The book "Registration Guidance for Enterprises" was completed. Consultancy was provided to over 1000 individuals and organizations on the IPR procedures and protection. 3

collective trade marks were also registered. The regulation on the use of "Saigon and Ben Thanh Market" symbol was also prepared. 2700 IPR cases were investigated.

- *Energy savings*: Information was provided to 10,000 enterprises. Auditing and consulting services were provided to over 100 enterprises on energy savings solutions, enabling them to save more then 10% of energy consumed.

**Result 4: Program to provide information to enterprises**

- Ho Chi Minh city has built a database on market information for such countries as UK, Germany, France, USA, Japan, Korea, China, Russia, South Africa, etc. Setting up investment web pages in foreign languages such as English, French, Japanese, and Chinese to provide foreign investors access to speedy and correct information.

- Establishing dialogue channel between enterprises and city's authorities at the following address: http://doithoaidn.hochiminhcity.gov.vn with the participation of 18 departments and agencies to provide answers to any questions raised by the businesses. The system is designed and operated 24/7. The system allows speedy and timely response to questions raised to meet the need of enterprises. With this system, leaders of the City People's Committee can oversee the processing of requests and questions from enterprises to State management agencies. The dialogue has met the demand for questions to be answered by enterprises. At present, over 200 enterprises participated in the system.

**Result 5: Program to develop key industrial products of Ho Chi Minh City**

The city encourages the participation by enterprises in the program to improve their competitiveness.

Requirements: high quality and reliable trade marks; low production costs; modern and useful designs; high production capabilities and good working environment; giving priority to domestic technologies and materials; big market potential; high economic efficiency for enterprises and significant contribution to the city GDP.

From 2003-2010, the city is aiming to develop 60-100 key products which can contribute 10-15% of the city GDP.

43 products from 35 enterprises have been chosen as key industrial products of the city including mechanics, electronics, plastic, rubber, wood processing, food processing, paper, leather shoes etc. Credit subsidy, marketing assistance, domestic and foreign market information, free consultancy of trade mark registration abroad, raising Vietnamese standards for each product according to international standards, and capital subsidy for technology innovation are provided to firms producing these products. The purpose is to improve the competitiveness of these products, to raise the economic efficiency for enterprises so that they can contribute significantly to the city's GDP.

Five-component assistance program for the city's key industrial products includes: registration of trade marks abroad and processing of claims on violation of IPR; assistance to develop and apply advanced quality control and technical process; assistance for consultancy; assistance for implementation of research projects to apply science and technology in production.

**PART II: ANALYSIS OF SUCCESS FACTORS AND LIMITATIONS**

1- Based on analyzing "opportunities and challenges", advantages and disadvantages, Ho Chi Minh City has made the right decisions and appropriate solutions to timely promote production, to raise the competitiveness of enterprises and speed up economic integration process.
2- With the coordination of departments and agencies, under the guidance by a stranding vice-president of the People's Committee, and with the active participation by Alliances of Science and Technology Associations, universities, research institutes and enterprises, Science and Technology Department as a standing organization has prepared plans to assign subordinate agencies to carry out specific duties and regularly checked the implementation progress so that timely instruction could be given.
3- With all three forces in the link-up triangle, domestic capabilities can be put into full play, be associated with production needs to boost up demand and at the same time to create a market for science and technology. The close connection between scientist among many research institutes and universities in many diverse fields

will create a formidable combination of forces capable of solving many big problems, inter-agency problems, and creating products of high scientific contents. As results, enterprises may be able to create their own products of high competitiveness which promote the development of some industries.

4- Under the direct and strict guidance from leaders of the city, the support from the Ministry of Science and Technology a team of whole-hearted staff has been gathered to follow-up these activities, from the beginning to the end. The program has also received the cooperation and support from public media.

**Limitation:**

1. The potential of the science and technology resources in the city has not been brought into full play. And science and technology has not become the driving forces of the industrialization and modernization of the city and the region.
2. Although the market for science and technology was set up, its scope and social roles are still limited
3. Although the science and technology management mechanism has been gradually improved, it has not been able to encourage the investment from all economic sectors for science and technology activities.
4. Most of enterprises have not understood and planned to invest in product innovation, in technology development, in the improvement of productivity and product quality, and trade mark development.

## PART III: ASSISTANCE PROGRAM FOR ENTERPRISES IN 2004-2005

### 1. Objectives of the program

- Continue to promote state management, establishing the connections between State agencies – enterprises – scientists with a view to promote industrialization and modernization of enterprises; developing the connection between sci-tech research with actual production needs by domestic resources.
- Assist enterprises to improve their competitiveness by providing them with necessary knowledge and implementing solutions and measures to raise productivity, quality and energy savings, clean production, and promoting exports.

- Develop markets for science and technology, for sci-tech consultancy, and for economic and business management.

**2. Content of the program: includes 3 groups of solution**

- Assisting enterprises in productivity and quality improvement and in clean production for sustainable development
- Developing markets for science and technology, for sci-tech consultancy and business management
- Assisting enterprises in international economic integration.

## Hiroyuki Odagiri's Summary (Session 1)

Let me start with saying I have learned a lot from the four lectures of this session including mine. Particularly the presentation of Mr. Luong of the Ho Chi Minh City government impressed me in that Vietnamese officials exercise quite a few policies in an active manner. Being a discussant myself, I don't have any room to comment on specific points made in each of the lectures. So please permit me only to deliver my general impression of the discussions so far.

My lecture focused on the past Japanese experience. Although I believe it is not wholly irrelevant at all, those days are quite different from the current situation surrounding Vietnam in many respects — geopolitical power balance, presence of foreign multinationals, increasing importance of IPR, and so on. Information technology has changed business landscape and the speed of commercialization and spread of new technologies. Yet there are a couple of very important lessons we should learn from the Japanese experience.

First, learning takes time. On one hand, you learn many things from foreign companies or you import foreign technologies; and, on the other, you learn science for your own R&D researches. In both cases, it takes a very long time to gather your crops. This is not only true when Mr. Hung talked about the motorbike industry that learned from foreign makers, but also true when Mr. Sawai discussed about the importance of technological innovation in a more forefront industry. So anyone who wants to prosper for long periods needs to consider learning as a cycle of R&D, implementation, and innovation. This kind of learning is no business for short-term gainers.

Secondly, to help such learning, policy makers must maintain consistency over time. If they often change their policies, no companies could afford investments that require long-term learning. Consistent policies are of basic importance.

In terms of learning in association with seeding an innovation in Vietnam, the Vietnamese firms who learn from FDI companies admit the value of learning as suggested in the survey answers in the first presentation. They recognize learning technology is learning everything around it such as quality control, management, and workers' morale. In terms of learning in the context of research activities, innovative, forefront technologies do not spring from nothing; rather they are outcome of gradual improvements.

This symposium is supported by the Honda Foundation, so let's take Mr. Soichiro Honda for example. It is a famous story that the first CEO of Honda still sweated and got his hands dirty in the factory amid his workers. This tells how Mr. Honda knew the importance of "on-the-spot" experiments, ingenuity and improvements and valued it.

All the above discussions converge with the importance of education; and especially crucial is which you put more weight on — precept or practice? In universities, students learn frontier theories in paper and do researches. This is only half done. They can learn more if they go to a laboratory for experiments or assemble a machine by themselves. Making such attitudes their custom habit is important. In this context, "get your hands dirty" carries a positive connotation.

We should train students in this manner at elementary and high-school levels to enhance their appetite for learning and working through practice. Youngsters become more interested in science and technology if they use their hands for experiments and see what actually happens. This constructs motivation in them beyond mere passive knowledge. In my opinion, we need to stress the importance of this type of practice in our education system today.

Unfortunately I don't have yet an opportunity to visit schools in Vietnam, thus my knowledge on the Vietnamese education is fairly limited. Please tolerate me if my suggestions are irrelevant, but I believe learning with the spirit of "get your hands dirty" has timely importance and implications for the orientation of sci-tech education. In fact, many Japanese thinkers worry the past overemphasis on theories, and lack of practice, in our science education. Their worries may be not a reality in Vietnam, but you better watch out. That's it for today: My general impression of the discussions rather than comments on specific details. Thank you.

Prof.Nguyen Quang Thai Co-Chair-1 DSP/MPI

We have completed 4 reports and the brief and interesting remarks by co-chairman from Japanese Fund. Thanks to all of these valuable contributions which cover from general experience on technology innovation to the specific experience from NTT Corporation. This provides us with precious lessons of the process of transformation into the most industrialized nation in the world so we could research and study. Through this, the very lesson we learn is that so we must often update and modify continually our policies. There is not only unique policy applied for all countries in each development period.

The speech about specific experiences in the fields of FDI( Foreign

Direct Investment) on Motorbike industry in Vietnam as well as experiences from delegates of HCM City are precious lessons about triangle linkages between Research Institutes, Universities, Enterprises and the intervention of the government. Motorbike industries with foreign investment create important conditions for innovative process in Vietnam. Especially, at the moment of high pressures of integration and competitiveness, the technology innovation needs be controlled and studied reasonably at the level of our development period. In coming years, integration has become very important to Vietnam, so that our policy needs be updated to keep up with new conditions which are large challenges. Precious lessons given by Thailand lecturer are very useful and encourage us to think about the relatively low development in Vietnam. We think that 4 presentations in this morning are helpful as well. Because of time limit, we have a working dinner and we will discuss more with some delegates. And if there are so many lecturers, discussion will be taken place during the lunch. We hope that our sustainable relationship is strengthened in order to find out appropriate innovation policy on technology and linkage in enterprises to serve development policy in each nation. Thank you Ladies and Gentlemen, Please take a rest and the morning forum is over.

# THE DYNAMICS OF THE NATIONAL SYSTEM OF INNOVATION - A CASE OF THE THAI AUTOMOBILE INDUSTRY -

This paper examines the technological development or underdevelopment of the Thai automobile industry from the perspective of the national system of innovation, as a result of a study based on questionnaire surveys (6 assemblers and 85 parts suppliers) and interviews in addition to statistical analysis and a literature review on the Thai automobile industry. For this end, it looks into the principal actors of the Thai automobile industry and above all investigates the interactions of the strategies of multinational corporations, the policies of the Thai government and the management structures of the Thai firm in order to shed light on how the path of the industry's technological development has been shaped.

At the beginning of the 21st century, when a country takes on the development of a scale intensive industry, such as automobile manufacturing, the chances of the country pursuing a relatively liberal development approach like Thailand seem much greater than the other end of continuum, state-led development, because of the past failure of government intervention, globalisation of the world economy, and by the default condition of the increasing difficulty of undertaking state-led industrialisation due to international pressure. In this sense, after due consideration of specific differences of domestic and international conditions of the time, the case of the Thai automobile industry may be able to provide important lessons for countries in this period of globalisation, where many of the governments are likely to have fewer measures available for industrial development than the counterparts until two or three decades ago.

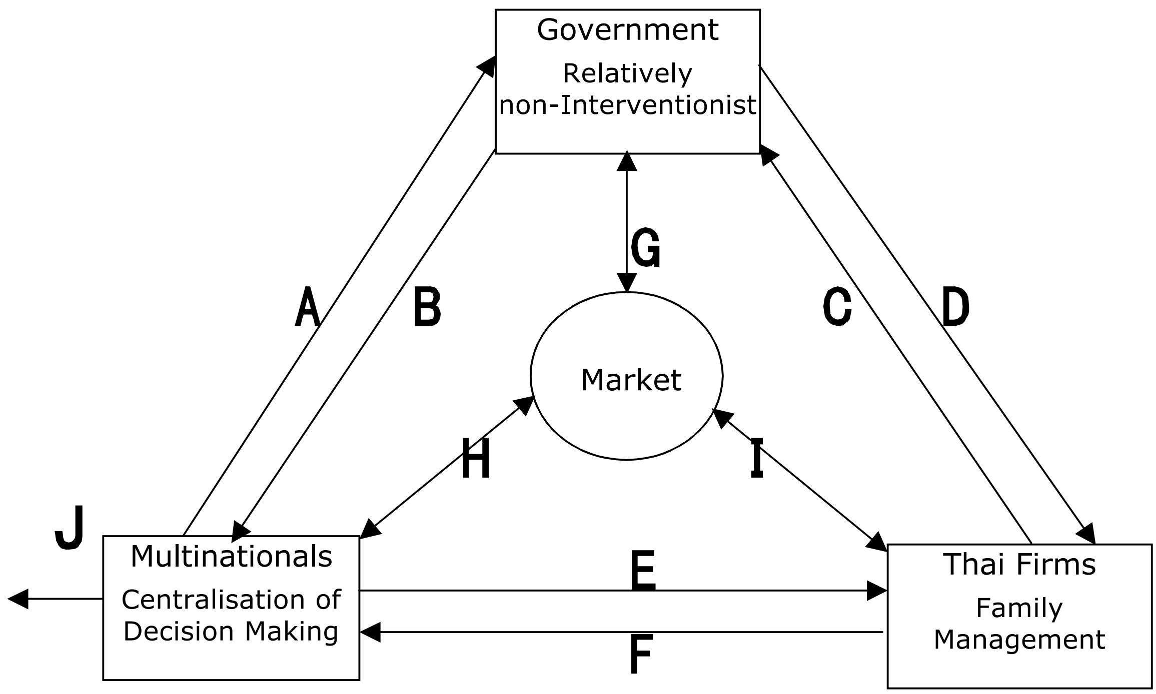
The Thai automobile industry grew in quantitative terms until 1996 with the relatively less interventionist approach of the Thai government and active participation of a large number of multinational corporations. However, the author's study found that quantitative expansion did not bring qualitative, technological improvement at the same pace. After 40 years of the industry's operation, the Thai automobile firms were still lagging behind in terms of Lall's definition of technological capabilities which include investment capabilities, production capabilities and linkage capabilities. The comparisons of production functions between Thai firms and foreign invested firms suggested the limited investment capabilities of the Thai firms which generally confined their operations in small-scale, labour intensive productions. As for production capabilities, the Thai firms have been slow in their improvement of productivity measured in both total factor productivity and physical productivity, and also slow progress in the development of adaptability was evident in questionnaire surveys. Finally, the limitation in the linkage capability and hence shallow industrial structure was noticed in the input-output analysis. In a recent study, on a net basis, local content rate including parts procured from other ASEAN countries was still around 24% (Takayasu and Mori, 2004).

The main objective of this paper is to examine how the path of the technological development of the Thai automobile industry has been shaped by the three main actors of the industry's national innovation system. To analyze their interactions and assess the effect of these interactions on the technological development of the Thai automobile industry, this paper focuses on the underlying forces and main characteristics of each actor based on the results of the author's questionnaire and literature surveys. In reality, there was no clear-cut single characteristic representing each actor; moreover, the effects of characteristics have changed over time. There has also been overlapping of strategies and policies in a single period. However, the importance of understanding their interactions at a conceptual level forces us to look at the cores of the characteristics and changes through a degree of abstraction.

The first section depicts the principal processes of their interaction. These processes have had a lasting influence on the technological state of the Thai automobile industry throughout the three development periods. After identifying the underlying forces behind technological underdevelopment, the second section introduces dynamism to the framework, looking at how the interactions have changed in the three different periods. Within the limit of their principal relations, we have seen changes in interaction, in each period producing different opportunities for and constraints on technological development. This dynamic nature in turn suggests that within limits more beneficial interactions are possible for a national system for technological development depending on the adoption of the right policy mix. Thus, the last section discusses some policy recommendations for the Thai automobile industry.

## THE INTERACTIONS OF PRINCIPAL CHARACTERISTICS

### Conceptual Framework




From early on, multinational automobile firms, especially from Japan, dominated the Thai automobile industry, and were generally able to operate on their own terms in the wide-open Thai market. This behaviour of the multinationals was based on or made possible by several relations shown in the above conceptual framework. First, represented by arrow A, multinational corporations possessed something very attractive to the Thai government, that is technology. Their skills and technological know-how gave multinational corporations a strong bargaining power over the government. The government did not necessarily give in to the demands of the multinationals all the time, but especially when multinationals were closely united, they were able to push their demands through.

Second, the limited interference of the Thai government to the activities of the multinationals, represented by arrow B, also helped multinational corporations to operate in relatively unrestrained environment. Essentially, the government wanted to develop the automobile industry, and, given the situation of local firms lacking the necessary technology, the government was generally supportive rather than hostile to foreign automobile firms coming into the Thai market. When local development needs came into conflict with the activities of multinational corporations, the government intervened in the industry. However, the effectiveness of the intervention was conditioned by state capability and the relationship between the government and Thai firms. Often bureaucratic in-fighting prevented effective intervention, whilst weak government-business relationships could not constitute a strong counterforce against multinational corporations. The growth of local parts firms during the import substitution period strengthened the ties between Thai firms and the government through a formal association. Yet, as indicated by arrow C, the association was not organisationally cohesive, accepting companies of different kinds into membership, ranging from majority foreign-owned firms to small Thai firms manufacturing only spare parts. Nor was the government so keen to foster the relationship, as was the case with the Korean and Japanese governments when they tried to develop their domestic automobile industries.

Finally, the existence of very few technologically capable Thai firms made multinationals conduct business with firms with their own group or with advanced foreign firms. Keeping the production chain in the hands of multinational corporations was also convenient for and strategically compatible with assemblers in Thailand. Their headquarters in home countries centralised decision making for its role in research and development and co-ordination with their group firms. Thus, it was much easier for an assembler to purchase parts from a foreign-affiliated firm with whom a business relation had already been established at the level of their headquarters, probably through joint participation in product development or at least regular meetings at a suppliers' association. In addition, when Japanese multinational corporations sought a supplier, they were interested in more than the quality and price of a product. They were more interested in the production system which reliably assured high quality and low cost of product. Since the system was developed in Japan and involves such aspects as employment practice, training, and management-labour relations, it takes time to transfer the system to a Thai company which engages in the industry via different institutions from those of the Japanese automobile industry. Consequently, Japanese automobile firms conducted business largely with foreign-affiliated firms and had very weak relations with Thai firms as shown by arrows E and F in the framework. Although Thai firms were able to expand their business opportunities as the government increased the local content requirement, wholly Thai-owned firms usually came to last in the list of potential parts suppliers because of their technological underdevelopment and the above behaviour of multinational corporations.

These three factors enabled multinational corporations to enter in droves into the Thai market and to operate based on their own strategies, as arrow H indicates. More than a dozen multinational corporations produced vehicles in the Thai market. Moreover, the small market size was further fragmented with numerous vehicle models and types. This customisation strategy of multinational corporations was designed to keep a higher profit margin in the Thai market, where customer tastes were highly differentiated and price elasticity of demand was low.

This same situation was simultaneously engendered by the Thai government. Opening up the Thai market with investment incentives helped to bring multinational corporations into Thailand. Once they were in the market and had started production, it was not easy for the government to reduce the number of manufacturers. All it could do was to forbid new entrants. In addition, the failure of the government to regulate the crowded sustained market conditions which limited the benefits of economies of scale. The government's minimal intervention in the market due to the lack of administrative capability and industrial know-how, as indicated by arrow G, coupled with the oligopolistic behaviour of multinational corporations and their long experience in the automobile industry, therefore, resulted in the fragmentation of the Thai auto market.

Turning to the government's effort to upgrade the skills of Thai firms and the general public at large, policy implementation was both qualitatively and quantitatively limited (arrow D). Other than the local content requirement, the government did not have so many tools to improve the technological state of Thai firms. When they did extend their assistance to the Thai firms, as seen in the example of the 'Vender Meet Customers' Program, it was hardly sufficient to change technological conditions in any significant way.

Similarly, governmental promotion was inadequate in advancing the country's education, and science and technology capacities. Low enrolment in secondary schools was alarming since secondary education was often considered a minimum qualification necessary for skill development at work. As for higher education, the expertise of graduates supplied by universities did not meet the demand of industries. Strong government policy initiatives were needed to ameliorate the situation. The shortage of engineers hobbled every stage of technological adoption, adaptation and innovation. Ultimately, government support in research and development was insufficient to meet the country's technological needs. Funding as well as co-operation with academia and the private sector were lacking.

Of course, the government was not omnipotent. There are practical limitations to what a government can do. This is especially so for the government of a developing country, often constrained in terms of financial, technical and managerial resources. What should be emphasised here, however, is that in the case of the Thai government, there seems to have been a predisposition to a lower level of intervention, which characterised the overall action of the government. Whether it was caused deliberately or not, that low-level intervention of the Thai government was likely to be rooted in given institutions.

So far discussion has centred mainly on multinational corporations, the Thai government, the market and their interactions, explaining how their actions, reactions, and inaction affected the development of the Thai automobile industry. Based on the discussion, this section concludes with an analysis of the causes of the technological underdevelopment of Thai firms, one of the central themes of this paper.

As shown in the framework, Thai firms had possibly three external supports for their technological development: technology transfer from multinational corporations (arrow E), government promotion (arrow D) and market forces (arrow I). As already explained, these are not independent one another. A degree of influence from one source is often determined by its relation with others, including Thai firms. Also the effectiveness of these external factors on the technological development of Thai firms depended on internal factors of the Thai firms themselves, such as the level of technological accumulation and management characteristics.

First, looking at the influence from multinational corporations, the discussion explained the marginal business relations between multinational corporations and Thai firms in comparison with the relations among multinational corporations themselves and their relations with their headquarters. The strategies of multinational corporations, the weak intervention of the Thai government and the lack of technological know-how and skills of Thai firms all contributed to this weak linkage between multinational corporations and Thai firms. Since the existence of business relations is a minimum condition necessary for technology transfer to take place, Thai firms were not able to benefit significantly from this source for technological development.

Second, support derived from government policy was equally insubstantial. The technological superiority of multinational corporations and their long experience in the automobile industry often made the strategies and demands of multinational corporations prevail in the Thai automobile industry, limiting the scope of government policy for the development of Thai firms. This influence from multinational corporations was certainly in addition to the government's own characteristic low-level intervention. State fragmentation and lack of know-how resulted in insufficient and ineffective policy intervention at both industry-specific and functional levels, and the relatively weak government-business relation did not help the situation.

Finally, market conditions were not conducive to the sound development of the Thai firms. The open-market policy of the government brought a large number of multinational corporations to the small Thai automobile market and, after their entrance, failed to reduce the number of vehicle models and types. Market fragmentation and model proliferation limited benefits of the economies of scale, which largely determines the kinds of products that can be produced in the market. From their incipient stage of development, thus, Thai firms had to face market conditions which, except in terms of volume, rather resembled those of a developed country: a segmented market with frequent model changes. Without being given an opportunity to accumulate the learning experience of one production, Thai firms were not able rapidly to run down the learning curve, which is necessary for gaining competitiveness and further acquisition of technological capability.

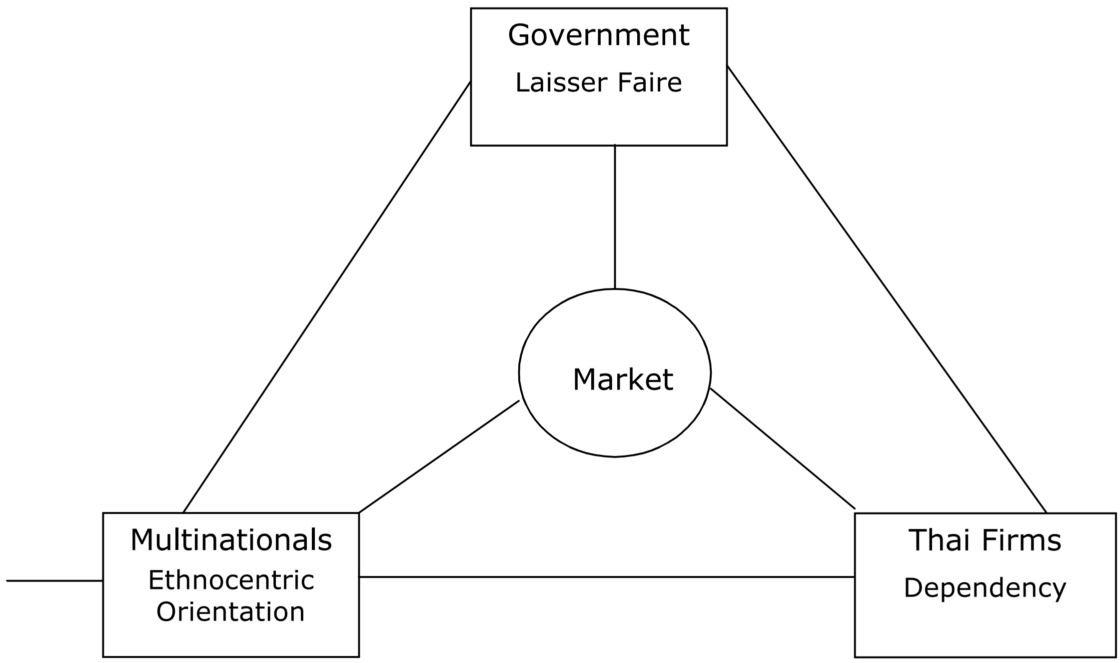
Accordingly, all the three external factors, the behaviour of multinational corporations, government policy and market conditions, were not helpful to the Thai firms. They were in an unfavourable environment for their technological development. However, it should be remembered here that the effects of these factors were determined through their interaction with the internal factors of the Thai firms. Their family management system seems to have slowed the progress of skill formation which probably further dimmed the prospect of business opportunities with multinational corporations. Also, they failed to make full use of the period of government protection through modernisation of management. Little improvement in the competitiveness of the Thai firms led the Thai government to lose confidence in the continuation of the import substitution policy, resulting in a gradual shift in the policy towards liberalisation.

Based on the principal characteristic of each actor, this section examined the causes of technological underdevelopment of Thai firms by looking at the interactions of the actors. Since principal characteristics and their basic relations among actors were slow to evolve, the underlying forces which shaped the development of the Thai automobile industry have had lasting effects on the technological development of Thai firms throughout the periods covered in this study. While the above analysis epitomises the condition of the Thai automobile industry in general, there was also dynamism in their interactions as the strategies, policies and the positions of the actors changed. The concurrence could be explained by the fact that each actor is a source of influence on other actors, and this again points to the importance of putting the actors together in an analysis of their interactions. To look at the dynamism of industrial development, the following section looks at the interactions of the actors in three distinctive periods.

## THE DYNAMICS OF THE INTERACTIONS

### From the beginning of the 1960s to the beginning of the 1970s

**Figure 1**




In this early period of the Thai automobile industry, the foremost priority of the Thai government was to attract foreign automobile manufactures into the Thai market and develop the industry. The lack of technological capability among Thai firms, and the government's distant attitude to local capital led to a development driven by the multinational corporations. Thus, there was little the government could do other than making sure that the market climate was conducive to foreign direct investment.

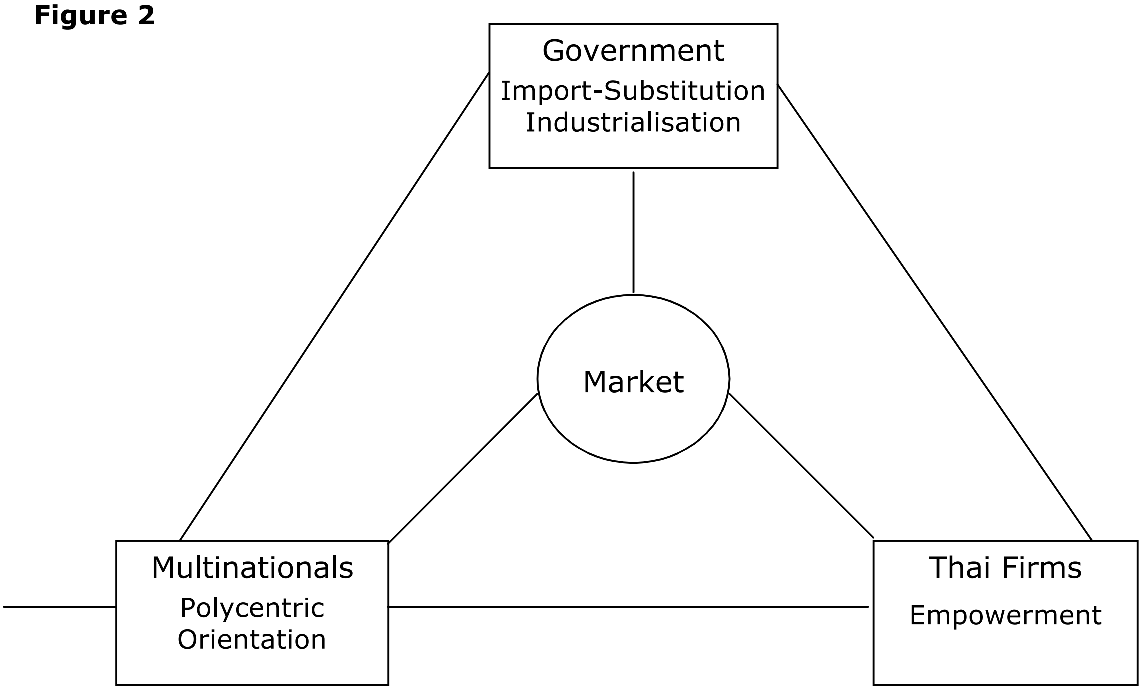
As a result, multinational corporations did not face much regulation and were largely free to operate according to their own strategies. In addition, Japanese automobile firms, the majority of the multinational corporations in Thailand, were inexperienced in foreign direct investment; their Thai subsidiaries were one of the first foreign subsidiaries they established. When a firm is novice in international business, it tends to prefer an ethnocentric orientation in which the management style of the headquarters is applied to the subsidiary. Hence, Thai government non-intervention was compatible with the international business strategies of the multinational corporations new to foreign subsidiary operation. Their strategic intention supported by the open investment climate resulted in minimum local production taking place. The multinational corporations preferred to import most of the parts from their own long-time group suppliers and were allowed to do so by the government's *laisser faire* policy.

At this stage of the Thai automobile industry, the number of Thai firms was small and their technological capability was very limited. Most of the Thai firms entering into this relatively new industry were not technologically oriented, as evidenced by their previous activities as importers and retailers of automobile products. They had neither technological capability nor ability to produce at low costs. Despite their lack of skills and technology, they were able to enter into automobile production through connections with multinational corporations from their previous businesses, by making use of their merchant talents. These connections were necessary to compensate for their technological deficiency and, if firms could also secure political connection, they were even in an even better position. In the authoritarian regime of the 1960s, when the government-business relationship was still governed by patron-client ties, having a political connection was an important competitive advantage for firms relatively new to the industry. Hence, the Thai firms were dependent on technological connections with multinational corporations and political connections with the government. They were in no position to influence, let alone alter, the strategies of multinational corporations and the policies of the government.

Unopposed, indeed facilitated, by the Thai government and local firms, as discussed above, multinational corporations were able to operate on their own terms. They maintained close relations with their headquarters in home countries and undertook only the final assembly process in Thailand using largely imported parts. Under these conditions there were not many opportunities for technology transfer from multinational corporations to Thai firms. Added to this, Thai firms themselves seemed to have been interested in investing more in connections than in technology. Finally, hordes of foreign investors in the Thai market as a result of the government's open-market policy sowed the seeds for model proliferation and hence limited economies of scale, a lasting legacy of this period.

**From the beginning of the 1970s to the middle of the 1980s**

**Figure 2**




Although tariffs were levied on imported auto parts from the beginning of the Thai automobile industry, their effect on the behaviour of the multinational corporations was minimal. As long as they were allowed to, they imported auto parts because they could not find them in Thailand. In this sense, a non-tariff measure introduced in this period changed the relations among actors in a significant way because it forced assemblers to purchase parts in Thailand.

The local content requirement, born in the context of a domestic cry for industrial deepening, was thus considered the beginning of the import-substitution industrialisation in terms of the effects on the structure of the Thai automobile industry. The government's localisation policy increased the number of Thai auto firms, leading them to join hands to assert their interests through a formal association. Empowered quantitatively and institutionally, Thai firms were no longer a passive group. Their demands were reflected in the measures of the localisation policy, which in turn further strengthened the position of the Thai firms.

The forced purchase of local parts and the steady increase in the amount to be purchased gave the multinational corporations no choice but to reorganise the way they produced automobiles in Thailand. It was no longer an option for them to assemble vehicles through the wholesale import of parts from foreign countries. Parts production had increasingly to be based in Thailand, and the locally produced parts had to be included in assembled vehicles. Facing this new reality, multinational corporations had two ways to cope with the situation.

First was to find or help establish, where unavailable, wholly Thai-owned firms and improve their skills and production processes so that they could become parts suppliers. Some of the foreign assemblers encouraged their former local parts importers and retailers to get into production, and provided necessary know-how to those new producers. Also, engineers from the assemblers visited their local suppliers and assisted in solving production problems. In addition to these individual supports, Japanese multinational corporations tried to transfer their production system *en masse* by establishing a suppliers' association, which functioned well in Japan as a catalyst for interactive learning among suppliers. In these processes of upgrading the skills of wholly Thai-owned firms, foreign parts suppliers, who had been associated with their multinational assemblers for a long time, were involved as advisers, technology licensors and leaders in suppliers' associations, to facilitate technology transfer.

The second measure taken by foreign assemblers for local procurement was to encourage foreign suppliers to start parts production in Thailand. The close relations of the assemblers' headquarters with their group suppliers enabled the headquarters to play a role in facilitating the direct investment of the parts suppliers into Thailand. These multinational parts suppliers were greatly valued by the foreign assemblers since they practiced the production system preferred by the assemblers, had expatriates ready to act on the technical requests of the assemblers, and often shared a long experience with the headquarters in home countries. These advantages of the multinational parts suppliers, in addition to their technological capability, made them very attractive and convenient to the assemblers. As a result, a limited number of foreign parts suppliers and the small auto market in Thailand led to a loosening of the group business practice prevalent in Japan. The parts makers supplied the products to many, and often all, assemblers beyond the bounds of a *keiretsu* group, in order to satisfy the needs of the assemblers who wanted to purchase from foreign suppliers as much as possible and the needs of the suppliers who wanted to have more customers in the small market.

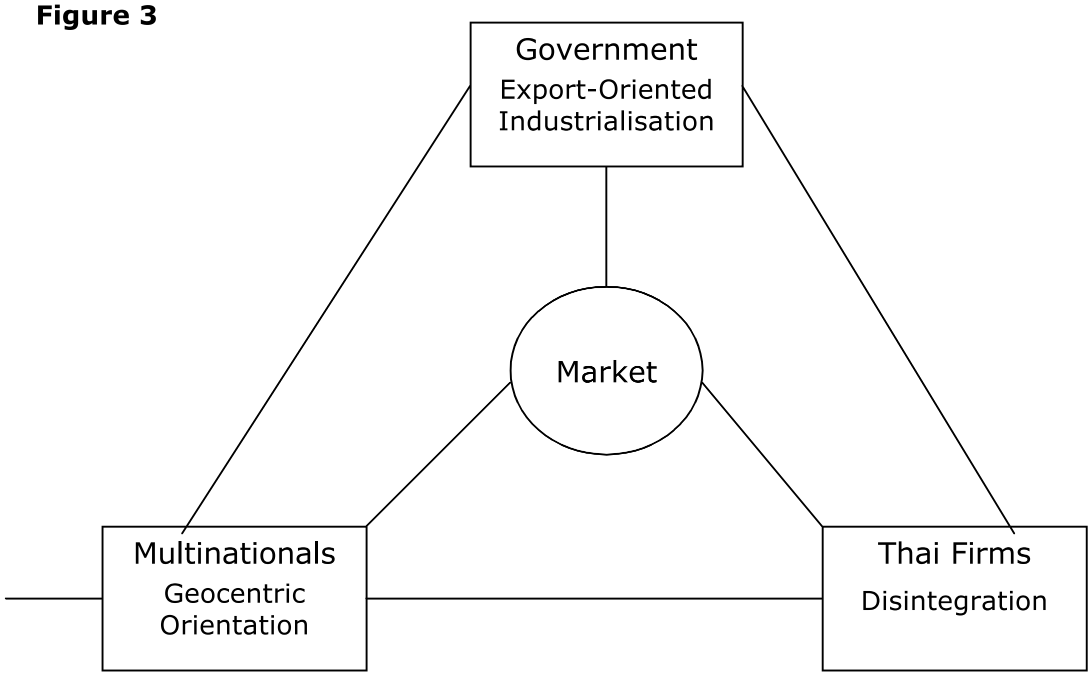
Of the two measures employed by assemblers to cope with parts localisation, the assemblers relied much more on foreign-affiliated firms because of closer ties through the headquarters and their superior technological capability. The localisation policy of the Thai government increased the number of wholly Thai-owned firms and helped technology transfer from foreign firms to Thai firms; however, the central energy of foreign firms was spent on expanding business with foreign-affiliated suppliers as the local content requirement increased. Thus, it appears the main effect of the localisation policy was to localise the operations of foreign suppliers from whom the parts used to be imported in the past.

The government policy forced multinational corporations to localise their production, but that process of localisation was also supported by a shift in their strategies. After accumulating experience in international operations, the multinational corporations became more comfortable in delegating some decision-making authority to their Thai subsidiaries. Especially, during this period, the Thai automobile industry was protected from foreign competition and entirely oriented to the domestic market. In this situation, the localisation of production accompanied by the delegation of appropriate authority was likely to enhance the efficiency of the Thai subsidiary as well as the group performance of the parent multinational as a whole. The localisation was, therefore, not entirely against the interest of the multinational assemblers as seen in their co-operation to the increase of local content rate up to a certain extent.

Summing up the local technological development of this period, the import-substitution policy failed to establish the wholly Thai-owned firm as a major business partner of the foreign assembler. Nonetheless, Thai firms who entered into businesses with foreign assemblers were usually successful and increased their sales rapidly along with market growth, since they did not have many competitors in Thailand and faced no threats from imports due to government protection. Sheltered from foreign competition and making handsome profits, wholly Thai-owned firms felt little competitive pressure during this import-substitution period and hence had no incentive to modernise family management for technological advancement. Added to limited technology transfer from foreign firms, little technological development from their own efforts slowed progress in competitiveness. In hindsight, these conditions failed to prepare Thai firms for the coming market liberalisation and an industrial shakeout caused by the Asian economic crisis.

**From the middle of the 1980s to the present**

**Figure 3**



The tide of the industry gradually turned in favour of export orientation, or at least regional co-ordination, from the mid-1980s, becoming more apparent still in the 1990s. In this period, the inflow of foreign direct investment continued and accelerated; however, the investment was not only for purely localisation purposes to meet the government regulation. The purpose and the kind of firms coming to Thailand varied, including smaller and lower tier parts producers.

These changes in foreign direct investment and the growth of the Thai automobile industry to become a regional production hub gave an incentive to the multinational assemblers to concentrate more pro-actively in production in Thailand with a view to exporting pick-up trucks to the world market. As the Thai automobile industry was increasingly integrated into the international division of labour, at least in the strategies of multinational corporations, they increasingly relocated pick-up production to Thailand and suggested to the Thai government the need for an institutional infrastructure for regional co-operation. The strategic shift of multinational corporations strengthened the role of the headquarters once again, but in comparison with ethnocentric orientation, the roles of headquarters and subsidiaries were more differentiated, where the headquarters exerted influence eclectically with an eye to improve co-ordination among subsidiaries and the efficiency of the group's global performance.

The changes in strategy and behaviour of multinational corporations proceeded in interaction with the shift in government policy from mere localisation to industrial deepening and to promoting international competitiveness through liberalisation. More than a decade of forced localisation had engendered an uncompetitive industrial structure, which allowed firms to be complacent inside the wall of government protection, and to enjoy a high profit margin at the expense of consumers. Technologically, the industry was stagnant and showing no sign of catching up with advanced countries. These conditions together with international pressure to liberalise the market gradually formed a broad consensus for market liberalisation. Initially, opening the Thai auto market proceeded whilst maintaining the basic measures of localisation, permitting the co-existence of both import-substitution and export-oriented industrialisation policies. Then, the Asian economic crisis tipped the scales toward full deregulation.

The strategic change of multinational corporations and policy shift of the government had considerable effects on the Thai firm. Due to continued market growth and existence of localisation measures, however, Thai firms were slow to realise the effects and failed to adapt to the changing industrial environment. Thus, when the crisis hit, the Thai firms were suddenly exposed almost to the full effects of deregulation. Facing the dwindling auto market, the government was no longer in a position to localise the industry, but instead needed to promote exports. Besides, abiding by an international treaty, it was deprived of the measures of localisation. Multinational corporations also had to make every conceivable effort to export products and find parts of exportable quality in Thailand or, if not available, through import. Thai firms, caught short in these sudden retreats from domestic orientation on the sides of both the government and the multinational corporation, was vulnerable without technological competitiveness and political clout. The association of Thai parts firms, already organisationally weakened, was not able to help ameliorate the situation through political channels.

The economic crisis sifted firms with international competitiveness from those who could survive only under heavy government protection. Most wholly Thai-owned firms belonged to the latter group and faced financial difficulties. The firms in the former category moved on to strengthen relations with multinational corporations. At the end of the 20$^{th}$ century, the Thai firm was no longer an integrated actor in the industry.

Through the three periods of the Thai automobile industry, the prime determinant of the Thai firm's success has changed from connections, to protection and finally to technological capability. Among these, technological capability is the only determinant, which makes the firm truly sustainable. Since the 1960s, the forty-year history has not been favourable for the development of this capability, as a result of the policies of the government, strategies of multinational corporations, the management characteristics of the Thai firm, and above all the way they interacted with each other.

## IMPLICATION FOR POLICY

As the above discussion suggests, after the crisis, market forces are in full swing in the Thai automobile industry. This situation makes it very difficult to recommend an industry-specific policy which might accelerate the pace of the industry's technological capability faster than the pace dictated by those market forces. Nevertheless, this section tries to come up with a brief policy recommendation by drawing clues from the conceptual framework. Since the wholly Thai-owned firm was especially hit severely by the crisis, the recommendation will be directed particularly at improving the situation of this actor. The first part will delineate the conditions of the Thai automobile industry and suggest necessary institutional improvements, which have to be made before any policy could be successful. Then, assuming that the improvements take place, the second part will suggest realistically what kind of policy can be implemented effectively.

### Institutional Improvement

As interactions among actors have indicated, a policy which has an effect on only one actor does not seem so effective. Interventions have to be made at multiple points and generate a positive synergy to create a favourable climate for technological development. In this sense, before a specific policy is forwarded, it is helpful to reiterate the capability of the government and the situations of other actors, and to propose a basic institutional setting through which industrial policy has to be implemented.

First, the relationships among actors have indicated that the Thai government faces highly efficient, profit maximising multinational corporations. In order to effectively formulate and implement an industrial policy in such a situation, the government must at least have a centralised policy institution, placed above policy-making authority dispersed among the agencies involved, and free from political meddling. Considering that disunity amongst the agencies supervising the automobile industry and an unstable political environment weakened the bargaining power of the Thai government, the improvement of the capacity of the policy-making agency is a prerequisite for almost any policy intervention to be successful. Needless to say, the agency has to be staffed by the industry experts. If not available in Thailand, the government should consider hiring from abroad.

Second, the weak government-business relationship of the Thai automobile industry prevented close exchanges of industrial know-how and government advice, and reduced the opportunities and possibilities of successful intervention. This relationship has to be strengthened by reorganising industry associations and improving their operations. It is likely that a business association functions better under a situation where it has members representing similar interests, there are no other associations of the same kind, and it deals with fewer government agencies, which can co-ordinate and muster co-operation from other agencies involved in issues discussed. From these viewpoints, there seems to be room for improvement in the current arrangement of the industry's associations, which have motley memberships and multiple associations in a single sector. It would be better if the associations were rearranged along the line of industrial sectors: assembling, OEM parts production, and spare parts production. Existing associations can regroup themselves into these three associations through mergers and separations.

Last but not least, for the relationship between the government and the industry, active participation from multinational corporations is important since this actor plays a major role in the industry. Close relations between the multinational corporation and both the government and the Thai firm have to be an integral part of an overall improvement of the government-business relationship.

**Policy Intervention**

It is impossible to exaggerate the importance of the capability of the government and favourable government-business relations for effective intervention. As argued, the government has to intervene at multiple points in the framework at once, co-ordinating the interventions. If the above two points are not firmly institutionalised, a major government intervention is not likely to be effective or may even aggravate the situation. Therefore, in the case that these institutional improvements are not forthcoming, it is better for the government to opt out of industry-specific interventions.

In the post-crisis period, even if the purpose of a policy is to improve the condition of the wholly Thai-owned firm, the policy has to be one which makes use of market forces and can obtain the co-operation of the multinational corporations. This is not as easy as imposing a local content requirement which simply forces the assembler to procure a required amount of local parts without regard to the skill level of the local firm, the strategy of the multination corporation and market conditions. Such a policy cannot be implemented in post-crisis conditions. Even if possible, it will not be a solution as it was not in the past. So policy implementation at the beginning of the 2000s has to be more sophisticated and fine-tuned than those the Thai automobile industry experienced in the past. If it chooses to intervene, the Thai government has to devise a three-pronged strategy, making use of competitive market forces, taking advantage of the technology of multinational corporations, while making a real difference in the conditions of local firm. The difficulty of implementation of such policy is obvious since these three factors have to be satisfied by the government which is deprived of many of its intervention tools after liberalisation, even if we assume it has successfully achieved required institutional capabilities.

The analysis of the Thai automobile industry revealed that the development of the Thai firm was hindered by management characteristics, lack of competitive market forces and a limited linkage with the multinational corporation. The first two conditions are relatively endogenous, and the country seems to have more control over these factors. Besides, as far as the Thai market is concerned, it is already fairly competitive, with increasing liberalisation, and the reversal of this situation is unlikely. The most difficult factor to handle is the last one, the lack of linkages with the multinational corporation. Though not as footloose as portfolio investment, foreign direct investors can change the degree of their commitments to the market according to local conditions. If a multinational corporation finds that the negative consequence of a government policy outweighs the relative attractiveness of the country, it can shift its investment and production priorities to other countries.

As has already been made clear, the fact that it is difficult to interact with the multinational corporation, however, does not allow us to ignore this actor in terms of policy intervention. Multinational corporations are a major source of technology and more importantly, in the case of assemblers, they control the production chain of the whole manufacturing process, being at the top of the production pyramid. Therefore, the focal point of the industrial policy should be to strengthen production linkages between multinational corporations and Thai firms, whilst continuing efforts to improve the management of the Thai firm and develop sound market conditions based on market principles.

Turning to the central point, linkage creation between multinational corporations and Thai firms, the period and extent of government intervention should be minimal, but at the same time the effect of the intervention has to be enduring. It seems that the Thai government does not have enough financial and managerial resources for continuous intervention in such a complex project. Above all, any policy which requires perpetual government intervention is itself a proof of failure since it seems to indicate that the policy is not compatible with market forces. Thus, the government intervention should be temporary and should work as a catalyst to generate a virtuous cycle for linkage creation rather than become itself a source of bringing the two parties together. One such intervention would be to develop technology leaders among Thai firms who can absorb technologies from multinational corporations and disseminate them to their Thai suppliers, as the following figure indicates.

**Figure 4**

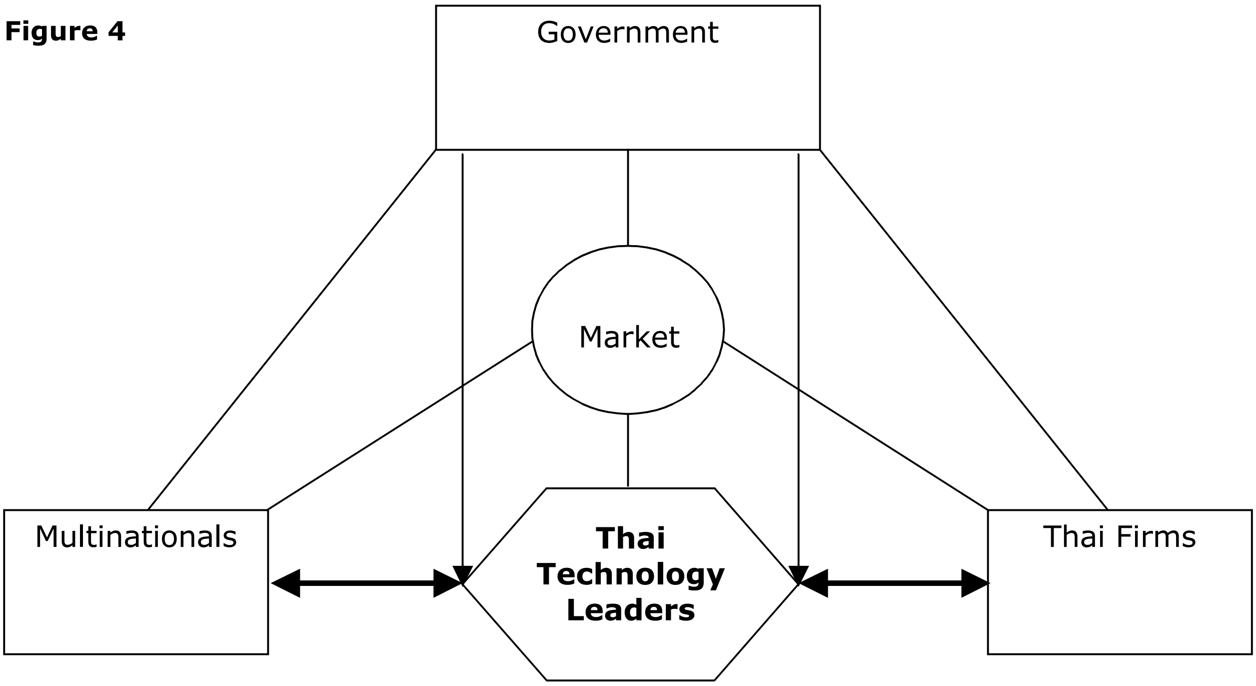



Figure 4 is constructed by adding technology leaders to the original framework. Considering that technological underdevelopment was the key problem preventing the multinational and the Thai firm from creating linkages, this scheme tries to develop technology leaders among Thai auto firms and place them between the multinational corporation and other Thai firms in order to facilitate the absorption and dissemination of technology. In this scheme, although the government's support is crucial at least initially, the intervention by no means forces the parties to form business relations against market principles. On the contrary, the government is to play a role of catalyst and promote linkages through market forces or by strengthening them. In addition, this scheme also fits with the production system of automobile manufacturing, where assemblers transact with a small number of relatively developed component manufacturers who in turn hold business relations with a greater number of parts suppliers. Being compatible with the market system and the industry's production system, this policy seems to have a higher chance of success.

Having these advantages, however, a policy intervention, depicted in figure 4, does require effective action by the Thai government and the efforts by Thai firms for building strong linkages. This scheme will not automatically generate linkages between multinational corporations and Thai firms just by picking Thai technology leaders. The leaders have to be developed and directed so that they can perform the function as linkage creators. The local suppliers have to improve technological capabilities or at least show potential for improvement initially so that they are ready to expand their business relations.

In the Thai automobile industry, candidates for technology leadership are a handful of Thai auto firms who successfully survived the economic crisis and are strengthening their relations with multinational assemblers in the post-crisis period. These Thai firms have had reasonably long experience in the automobile industry, and although the characteristics of family management including business diversification also apply to them, these firms have usually expanded their businesses centred around the automobile industry. Their already established connections with multinational corporations, which prove their relatively superior technological capabilities, and their wide-ranging presences in different product areas of the industry, make them suitable for the role of the technology leader.

In order to help them to acquire higher technological capabilities, which are necessary for expanding the quantity and quality of transactions with multinational corporations, the Thai government, after designating technology leaders, has to provide support for them, accompanied with obligations. Support could include subsidies or tax incentives (or both) for royalty to be paid for technology license agreements with foreign firms, for the consultancy of foreign experts or technological institutions, for building an in-house research and development centre, and for overseas training.

In return, the technology leaders should be obliged to create their own suppliers' associations by closely modelling on the original suppliers' associations in Japan, and every year they should report the number of local suppliers with whom they do business, and the total amount of business transactions with local suppliers. Based on these annual reports from the leaders, the government adjusts financial incentives for each leader upward or downward, or withholds incentives. Through this system, the government expects the leaders to make full use of suppliers' associations and help their suppliers improve technological capabilities by frequently holding seminars, giving feedback and technological assistance to individual firms, and jointly working with suppliers in development and engineering works. Thus, this system as a whole facilitates the dissemination of technology first from multinational corporations to Thai technology leaders and then to local suppliers.

In implementation of the policy, firstly, the government intervention should be temporary, and the period of support to each designated leader should be fixed and announced at the outset so as to enhance the firm's efforts and make the firm show results in a defined period. Secondly, the number of technology leaders has to be large enough to create competitive pressure among them and small enough to make it possible for the government to concentrate their resources. In this sense, designation of technology leaders should be flexible in order to introduce dynamism into the system. The leaders, who accumulate technological capabilities to the level which allows them to expand businesses with multinational corporations without further assistance, should graduate from government support. On the other hand, local suppliers, who develop enough technological capabilities to supply their products directly to multinational corporations, should be designated as technology leaders and be able to receive government support in order to further improve their capabilities and to expand their own linkages.

Finally, along with the implementation of this scheme, the government should create an evaluation team which is independent from the government agencies and staffed with Thai and foreign industry experts. They regularly visit the leader firms and local suppliers to check their progress in technology and evaluate their linkage creations. The information gathered by the evaluation team is reported to the government which uses the information for incentive adjustments.

Once linkages are created, firms start exchanging information and jointly working in parts production in order to maintain quality, which is a common interest of customers and suppliers. Thus, the linkages generated through this scheme are likely to be self-sustaining. As the Thai firms expand business relations with multinational corporations and among themselves, the government intervention should peter out.

This policy recommendation is designed just to tackle the key problem existing in the Thai automobile industry. The government needs also to upgrade education, science and technology, and financial markets, and Thai firm have to modernise their management. Yet, if they are to make progress in these areas, against all the odds, there is still a possibility that the linkage scheme can become a focal point to create a virtuous cycle within the industry and to uplift the dire situation of the Thai firm.

# From national innovation system to local knowledge system: issues of institutional building in Vietnam

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## I. The contextual background

Vietnam as a developing and transitional economy is experiencing the double transition. At the same time, it is moving from centrally planned economy to market economy, and moving from agricultural economy to industrial economy.

The economy is facing multiple challenges of globalisation, with the need to increase the competitiveness of the economy in general and firms in particular. Eventual goals of the country development is the industrialisation and modernisation in about 15 years time, while joining international economic institutions and regimes such as AFTA, BTA, and in the near future WTO.

In addition, the country has aimed at achieving MDG (Millennium Development Goals), to reduce poverty and pursue equitable and sustainable development of economy and society (UNDP, 2003)

As such, we are witnessing several couples of issues that come hand in hand and sometime seem to have conflict of interests. First, the long-term goals for modernisation versus immediate need for poverty reduction. Second, the process of industrialisation versus current agro-based rural development. In the face of imminent international integration, the requirement of international regimes seem to impact strongly the need and interests of domestic productive enterprises. The new context that sees a moving closer to market orientation also requires new kind of capability and skills. The future prosperity of the country will require a new configuration of skills, abilities, and competencies. In addition, the widespread availability and use of information and communication technologies, the speed of scientific and technological advances, accelerating global competition, and much shorter product life as a consequence of changing consumer demands all contribute to the new setting of the development scene. These factors emphasise that Vietnam's successful integration into the global economy and its sustained success in international competition will depend increasingly on effective process and actors for innovation.

## II. Key features of the national system of innovation in Vietnam

In general, the innovation system in Vietnam has some positive features:

- To build up and maintain a substantial system of S&T personnel and institutions to carry out R&D activities.
- To set up a system of supporting organisations for innovation activity such as standardisation, quality control, IPR, information and libraries, consultancy, etc.
- To have some contribution to the production activities, although the impact is still debatable.

Next to these, the system has several key weaknesses and problems:

- S&T personnel are numerous but weak in terms of qualification, structure and location. Problems of aging, waste of research capability, etc. are notable.
- Network of S&T organisations is not structured reasonably, strong imbalance and lack of linkage with each other.
- Despite some improvements lately, poor infrastructure for research
- Quality of research is poor, far from the need of production. Very weak linkage with productive area. Research and development are not initiated from within the production need and cannot serve effectively the need of the enterprises.
- Systems of S&T services, education and training are weak
- Management system for S&T activity needs improvement
- Capability of self-adjustment and respond to change is almost non-existed.
- Overall, the level of development of S&T is still low compared to many countries, far from international standard, even in the regional context.

Some more specific observations could be made here. First of all, the personnel classified as being involved in R&D is quite numerous. The available data and research that has been carried out indicate, however, a number of difficulties, challenges and barriers. Vietnam's existing pool of scientists and engineers is on average quite old. This age distribution is likely to present significant limitations to Vietnam's ambitions over the medium-term. In addition, many Vietnamese scientists and engineers received their training in a different era under an old moulded learning system based on an assumed linearity between science and technology, on the technology of heavy industry and on state planning and control. The aptitudes, skills and technological capabilities required for competition in the international economy are in relatively short supply (Bezanson et al., 2001).

Secondly, there are a large number of established research institutes, including many in both agricultural and industrial research. There are, however, severe constraints to their impact on industry and national economic productivity. The principal difficulty appears to have less to do with the institutes themselves than with the demand side – specifically with the relative absence of dynamic firms in Vietnam that need to draw on R&D resources in order to remain competitive and to grow. In other words, the users of Vietnam's S&T bases are not effectively pulling the providers of scientific and technological resources in directions that would enhance growth and competition. This appears to be the root cause of the weak linkages between Vietnam's mainly state-sponsored S&T institutions on the one hand and firms, including SOEs, on the other. For this reason, research in the Vietnamese national innovation system is mainly 'supply driven'. There is also an important constraint on the supply side: what very modest financing there is for R&D via the state budget is relatively fragmented, resulting in such small amounts being available to individual research projects as to make serious research very difficult.

The Government of Vietnam is clearly aware of these problems. Several studies of national innovation revealed that the shift in social and economic orientations brought on by *doi moi* had resulted in an increased demand for technological services but that the demand was not being met, especially in SOEs, due to the sharp segmentation between production, on the one hand, and S&T institutions, on the other. The studies also highlighted the almost total absence of private input in setting national R&D priorities. Government has been attempting to respond to this situation through measures aimed at closer alignment of the national S&T systems to the needs of the productive sector. Some of the main measures have included:

- Granting authority to R&D institutions to enter into direct contracts with industry and operate like an enterprise.
- According R&D institutions much increased flexibility to develop and provide, in addition to research, a full range of services, including technology transfer, consulting services, experimental and pilot manufacturing, etc.
- Diversifying the potential for the financing of R&D, including the retaining of profits and legal authority to seek bank credit.
- Privatisation of R&D activities (i.e. removal of the previous state monopoly) and a legal framework designed to provide enhanced protection of intellectual property rights.

For the last few years, there have been much more active attempts to reform the innovation system at the national level in adapting Vietnam's science policy and scientific research efforts to the priority tasks of Vietnam's development. The approval and preparation of S&T Strategy to 2010, the projects of reforms of S&T management mechanisms, development of technology market, international integration in S&T, etc. are some key actions. This is aimed at dealing with the legacy of central planning: continuing administrative separation between teaching and research in universities, and lack of linkage between research and industry (firms). The reform process also took place in improving legal framework for innovation. Legal reforms have been undertaken in drafting many key documents such as Law on S&T, and now Law on Technology Transfer, Law of IPR, etc. Other activities in building up the national innovation system include the establishment of S&T Foundation; increasing the international cooperation and integration; sending for training young students in key areas at top international universities; and high-tech development in selected areas like ICT, BioTech, etc. with more application focus.

## III. Using knowledge for development and knowledge system

It can be without hesitance to say that as such, a national system of innovation for Vietnam is taking shape, with or without certain elements. However, when it comes to the contributions and real and immediate impact for many economic and social activities, more are moving toward using knowledge for development notion.

The point is that it is learning and organizing for learning that matter in acquiring technology. The same applies to knowledge. Developing countries do need to gain access to the modern technologies of information and also to global information. But it is not access to the technologies or to information itself that makes the difference in terms of development. What does make the difference is the capacity for and the process of absorption and ongoing learning. The research on technology transfer and the processes through which new knowledge is incorporated demonstrate that the central requirements for success are organizational and cultural change. Learning to learn and creating organizational structures that facilitate learning are the critical components for the transfer of technology and knowledge (Bessand & French, 1999).

Knowledge is undeniably becoming one of the essential ingredients of both wealth creation and improvements in the quality of life in the majority of countries of the world. For Vietnam to take full advantage of this will require a strategy that goes far beyond obtaining new hardware and gaining access to information systems. It will require enhanced capabilities to perform five tasks with regard to knowledge. These are the ability to create knowledge; acquire knowledge; assimilate knowledge; use knowledge; and to diffuse knowledge.

In a special context of Vietnam, the need for more local specificity of knowledge and use of knowledge system seems to bear more importance. Not all kind of readily available knowledge can be adopted and implemented. Important point here is that knowledge should be selectively localised and the creation and use of knowledge resources and system be geared to the specific needs of circumstances and users.

In this vein, issue of knowledge management comes into the focus. The collection, processing, distribution and use of information and documentation is a professional business. The whole concept of knowledge management helps to deal with the issue of knowledge in more systematic way. For Vietnam (and for other developing countries) these requirements pose particular challenges. First, the 'culture' of knowledge management in Vietnam is strongly grounded in an antiquated model that is in need of major transformation. This is the linear model that functions on the basis that knowledge is created in one set of institutions (e.g. universities and research institutes) and then used by others in a different set of institutions (e.g. firms or public services). The underlying idea is that knowledge is generated in one area by researchers and knowledge producers and then used in another area by policy makers. Secondly, effective knowledge management is not only a question of bringing about better connections between existing institutions (e.g. between knowledge producers and knowledge users), it is also a matter of the suitability of existing institutions. The institutional structures of knowledge management in Vietnam are generally governmental and rigid, not very dynamic and therefore slow, whereas knowledge based economies are based on institutions that process knowledge in 'real time' and whose decision makers are capable of agile policy responses to new knowledge and changing circumstances.

Increasingly, since the 1970s, industrial countries have been abandoning the linear model of knowledge. The viewpoint of many international firms, which are more and more operating in Vietnam too, is that they need immediate access to research and knowledge that will allow them not only to deliver low-priced goods and services of greater quality and diversity, but also to retain and expand their 'market share.' This, they have concluded, cannot be achieved without integrating research, industrial design and production and ensuring continuous innovation and improvements. Throughout the world, firms have restructured their departments of research, applied research, engineering and strategic planning and have integrated their functions more into their production departments, some retain the focus on core competence and outsource the rest. This could be the appropriate opportunity for both host economy like Vietnam and multinational companies to cooperate.

Using knowledge concerns not only firms and farms, but the policy making circles as well. There are some main features of the new 'knowledge societies' as they relate to decision making and decision makers that should be taken into account. The speed at which knowledge is being created is unprecedented. Instead of rigid hierarchy structure, networks have become the organisational basis for policy-making. Process of policy making and implementation has also become more complex and difficult. This requires that the knowledge system be designed and operated flexible and dynamic accordingly.

This brief assessment indicates that integration into the global market is accompanied by industrial, financial and policy processes that become more knowledge and information intensive and more dependent on information technologies. Old approaches that focus on the provision of bits of knowledge and information (i.e. filling important gaps) may be helpful but they are unlikely to promote widespread development. Much broader approaches are needed that aim at the underlying requirements for institutional and even cultural changes and the development of the human capabilities needed for effective creation, acquisition, assimilation, use and diffusion of knowledge and technology.

Some authors even argue in this direction the concept of social intelligence where every member of the society is to gather intelligence for their use in systematic, organised and effective way is the most suitable for knowledge and innovation (Didjer, 1991). This in fact is very much a key philosophy of the learning society and learning economy.

## IV. Some selected critical issues:

Among many notions of the innovation and knowledge system, there are several selected issues that needed to be paid more attention in Vietnam.

The lesson from around Asian economies is that technological learning was imperative to success and it was continuous. International factors have created numerous and quite easy opportunities for relatively low-cost industrial production sites to integrate into the world economy. The international context today is different, there has been a dramatic fall in the demand for unskilled labour and raw materials per unit of industrial production. More demand for skilled labour is increased.

An effective economic and incentive regime is also imperative to attract and retain direct foreign investment (FDI). Although FDI represented a relatively modest proportion of total investment in the newly industrialised countries, its technological effects were exceedingly large. FDI was the most important factor in opening up export markets to these economies. Research also shows that the multinationals frequently acted as demonstrators and role models for local companies. Some foreign operations were responsible for extensive training of engineers and managers, and for transferring skills. Experiences of companies like Honda Vietnam demonstrated elsewhere in this workshop revealed this. There is also evidence that local engineers trained by FDI investors left the parent firm to set up their own companies (often to supply the subsidiary with components or some kind of technical services, thereby creating important backward linkages). As such, the learning from foreign investors begin to take place in Vietnam (Hung, Ha and Ca, 2004).

To increase competitiveness of the economy and firms, and to attract FDI, the solving problems related to IPR is critical. This could lead to a more favourable environment for doing business, not to mention about the pre-condition for entering certain institutions of the international integration.

With enterprise as the centre of the innovation systems, the entrepreneurship became a crucial dimension of the competition. Demand led innovation must be the overall direction and set the tone for the whole range of activities in R&D. This is still an issue that Vietnamese innovation system need to improve.

Majority of Vietnamese firms are small and medium enterprises (SME), including various ownership of state, cooperative and private. Development of linkage, networking and clustering of the organisations should be able to help with increasing sustainability and competitiveness of firms via cooperation.

As mentioned, related policies of 'implicit' nature are at least as important as 'explicit' policies. Studies in dozens of industrial countries have shown consistently that successful linkages between technological behaviour and industrial enterprises are as much determined by a country's fiscal, trade and education policies ('implicit' S&T policies), as by the more explicit technology policies and strategies. This is even more so in the context of Vietnam where dynamic firms are the one who pull the technology, knowledge and innovation. Certainly their behaviour is decided by macro-economic setting and a range of different implicit policies for innovation.

## V. Conclusion

Innovation system in Vietnam needs a dynamic review and adaptation to the constant and fast changes of the national and international context. Experiences show that it takes time for the society like Vietnam to absorb the new vision and concept suggested by international experts (System of Innovation is one of such examples) and turned them into own action by the local efforts. Without this slow, but firm, "policy assimilation" attempt to make changes could be short lived.

In addition, focusing only on macro innovation system probably is not enough for having a profound impact and lasting change. To turn the actions aimed at the macro level into something more concrete at the micro level with more localized and specific nature is necessary. The regional, sectoral innovation systems seem to become more useful concept. The move toward local knowledge system with more specificity, more local content is a natural step after national innovation system.

Above all, the building and effectively operating the whole set of institutional framework is the basis for these systems. Institution building is critical in developing knowledge system, promote innovation and learning via impacting behaviour of firms managers, policy makers and investors.

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# China's Innovation Systems Reform and the Development Strategy

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# I. Introduction: China's Science & Technology Policy and Institutional Reform

Recent China has attracted world attention for its advancement in science and technology, particularly when the media reports on its success in the rice-genome decoding project and the first manned space flight. China's economy recovery is an old story: people now keep an eye on the state of its development in high-tech space. Not a few people even share the view that China enters a new stage of growth by creating a new industry based on IT, biotech, nanotech and other technologies; that is to say, the Chinese are "leapfrogging" into a knowledge-based economy if their ongoing institutional reforms toward that goal end well.

For the last two decades, Deng's allies and successors have been considering advanced science parks as a key instrument to reform national innovation system. They first deployed many science parks all over the country, among which a well-known example is Haidian Science Park, a.k.a. China's Silicon Valley; and then they started to recruit workforce to work in. To do so, they restructured existing education and science institutions and consolidated human resources scattered not only all over the nation but also across the borders. The government used industrial promotion and other tax incentives to call researchers working overseas back. As a result of these reform efforts, realizing China's greater presence in the world economy, many multinationals from the United States, European Union, and Japan started to open their R&D operations in and around the science parks in Beijing, Shanghai, and other larger cities. These foreign-affiliated organizations now started to build close relations with neighbor Chinese universities.

Upon his decision to shed the stagnant old regime and embark on bold reforms for sci-tech-based industrialization, Deng and his allies realized the mobilization of human resources was the key to success. This is why Central Government consolidated able workforce in strategically selected R&D fields; modernized R&D facilities; and called back high-skilled researchers and professionals from overseas. Generous R&D support is proved right, and improvements are visible: more patents are applied and more papers are in major science magazines, albeit Chinese share is not ranked with the level of the industrialized countries yet. The number of sci-tech papers by Chinese authors also increases: it was ranked fifth in 2002, following the United States, Japan, the United Kingdom, and Germany (source ISTP). According to the SCI statistics, it has kept climbing to almost an equal level to the leading industrial countries in the last decade.

Still, it may take time for Chinese sci-tech capabilities to reach the level of industrialized nations, partly because R&D expenses and R&D workforce are insufficient. In terms of impact factor, scientific papers written by Chinese authors are far less influential compared with those written by the Western and Japanese authors. Chinese technological development is rather strong, probably because the Chinese are adept to network knowledge with overseas fellows. Notable fields include computer software, genome and nanotech studies. Biotech advancement is not as high as many might suppose. Like most East Asian countries, China is not as good at biotech as IT although their biotech patent applications increase maybe because of reputation of the rice genome decoding.

**The 7th Mid- and Long-Term National Sci-Tech Program from 2006 to 2020**

The first Chinese efforts to adopt modern science began in the early 20th century. But, as evidenced in the Shenzhou V space project and decoding of the rice genome, the current progress in science and technology owes much to the institutional reforms since the 1980s when Deng Xiaoping decided to break away from a systemic fatigue of the centrally planned economy. Deng, declaring "science and technology are the number one factors in the productive force," reorganized most of national universities and research institutions into more capitalistic-like, non-state enterprises. These freer enterprises can dispatch researchers to most needed areas as a hub of interactions between domestic and foreign scientists, and in turn enhanced national sci-tech productivity.

A drastic policy change was witnessed in 1985 when Central Committee declared reform and opening-up policies, placing an emphasis on sci-tech-based industrialization. Important points include:

- Deregulation of institutional restrictions imposed on R&D institutions and promotion of individual discretion of researchers.
- Higher mobility of human resources and promotion of inter-organizational collaborations.
- Incentives and preferential taxation to provoke competitive research and industrial environments.

So far these goals have been only half reached, but it is noted China remains consistent in the directions set forth in Deng's grand design of reform policies.

Currently Wen Jiabao's government is preparing the 7th mid- and long-term national sci-tech program for the period between 2006 and 2020. It is said the first plan (1956-68) was developed by a team of more than 700 scientists under the guidance of Chou En-lai. For the 7th national sci-tech program, far more than 700 science experts from the Chinese Academy of Sciences and premier universities join and discuss the future of sci-tech development in 20 different working groups.

## II. China's Reform of State-Owned R&D Institutions: University Liberalization and Promotion of Industry-University Cooperation

China's sci-tech driven growth strategy requires officials to bolster its education and training systems through university reforms. In 1994, the State Council issued a policy statement called "Program for China's Educational Reform and Development." One of the most important aspects in it is the government grants independently enforceable, decision-making authority to higher education institutions under the principle of self-responsibility. Then the People's Republic of China Education Act enacted on September 11 1995 followed. In Article 31, it grants corporate status to formerly state-owned higher education institutions; that is, academic and vocational schools shall be given corporate status upon their registration of incorporation so long as they satisfy due requirements.

This incorporation of higher education institutions came from the basically two motives of the central government: first to streamline universities scattered throughout the country on a ministry or provincial basis by introducing the principle of competition; and then to reduce the fiscal burden of Beijing by extending revenue-earning choices so local universities can more freely finance themselves without subsidies.

The central government also eased regulations and standards with regard to the establishment of schools to cope with diversified educational needs in the rapidly changing society. After these reforms, the number of universities in the whole nation remained around 1,000 until 2000. However, in the process of university consolidation, newly-established private colleges and universities have grown in number as more and more people want higher education. After the Enlarge Recruit Scale policy implemented (a measure to enlarge university enrollment where students not reaching a passing score of the entrance exam can also enroll by paying a staged "complement" fee), there were startling rises in university enrollment. Some suspect, albeit former Deputy Premier Li Lanqing, a purportedly central figure in these educational reforms may have thought improvements in higher education would sustain China's growth in economy, his intention was to take advantage of university enrollment as a remedy for unemployment among the younger generation. Others worry China must pay the cost of the Enlarge Recruit Scale policy as ballooning university population outpaces job creation and causes serious hiring slump in the future.

Most of new universities established after 2000 are in Beijing, Shanghai and other big cities. They were funded and privately operated under the tutelage of local governments. The aforementioned educational reform program stipulates China authority shall increase this type of non-state educational institutions in parallel with state-operated universities. Particularly increasing in number are vocational training institutions. For example, the Neusoft Institute of Information in the Dalian Software Park provides extensive training for future IT and software development professionals. This college was co-founded by Northeastern University and its IT spinoff Neusoft Group to leverage Northeastern University's expertise in education to address a constant shortage of high-skill IT professionals.

The State Council has gradually delegated operations of universities to local authorities while consolidating principal universities under the jurisdiction of the Ministry of Education. Considered by many as the essential of the university reform stipulated in the 9th 5-year development plan, the "211 Project" effective from 1996 aims to achieve a sci-tech driven national development by bringing the market mechanism to the academic. For this end, the central government designates 100 universities a prioritized institution (and specific disciplines a strategic discipline) and extends support for them in cooperation with local agencies. This privatization movement constitutes part of incorporation of university in which the government less intervenes in the administration of university to meet diversified educational needs of the market.

**"Prioritized Universities" in the 211 Project and Growing Regional Disparities in Education**

Chinese universities still have a number of hurdles to overcome; for instance, there are unsettled issues concerning the ownership of properties between the government and universities while the governance of academic institutions is increasingly promoted. Newly established private universities which are authorized to confer academic degrees also face similar ownership issues, and as is the general case with other business and university-launched venture firms in China, with the exception of Tsinghua University and Peking University which clarify the ownership of assets by, for instance, being a stockholder of their affiliated corporations.

Facing a thrust into fierce competition, a majority of the Chinese universities must try every means they can to increase revenue or receive government's fund support. Creating a university venture firm is always a choice but too risky for many as they have little experience in private business operation. In transition to the market economy, they also feel funding basic researches increasingly difficult because commercialization of such studies takes time.

Many universities, however, realize their future depends largely on the expansion of basic studies and have common concerns the deterioration of long-term basic research in general is a possible threat to China's competitive advantages. Although the government in response announced a policy to promote basic research, some of the 211 Project prioritized universities have already strengthened association with foreign firms who provide financial backing for them. The inclination to foreign capital is thought by many to grow further as the government encourages those universities to do so.

Most of the 211 Project prioritized universities are situated in Beijing, Shanghai, and other coastal cities. They have played a significant role to send able workforce extensively in the coastal China, resulting in intensification of regional disparities between the shoreline and the rest of the country. The central government attempts to solve this problem through its Grand Development of the West policy, in which midland universities are required to contribute more to regional development. Nevertheless, most of these universities suffer severer financial difficulties to do so.

Thanks to the Enlarge Recruit Scale policy, more students come to the prioritized universities from almost every corner of China. This contributes to extending regional gaps in terms of educational quality. As a result, midland universities only send fewer competent graduates to the society.

Today the central government tacitly permits the decentralization of educational administration to local jurisdiction to control its vast land and diversified cultures, expecting local and provincial universities to activate regional economy. The reality is, however, jobless youngsters increase in the underdeveloped West, and the influx of able manpower to Beijing and Shanghai never stops. It is thus an urgent need for China to try all conceivable means to bolster regional universities to the level of the U.S. state universities that make a great contribution to their respective local communities.

On the positive side, the Chinese universities in general have propelled progress in industry-university collaborations. Given an increasingly liberalized environment, they become able to place the right people in the right jobs: more people are exchanged between academic institutions and their affiliated business firms, and these organizations hire more people from overseas, both Chinese and foreigners. To help this continue, the government has provided Chinese students and researchers overseas with subsidy and tax incentives.

For further advancement of the Chinese universities, it is a key to make their recruit and personnel systems more flexible so they can hire and train able workforce more, especially in context of cooperation between universities and state-operated institutions. At the same time, China could be better off only when regional gaps between the coastal areas and the rest of the country narrow and the 211 Project prioritized universities reach world-class educational and research capabilities.

**Development of University-Launched Venture Firms: Separation of Education and Business Management and Industry-university Joint Efforts**

In China, universities' involvement in business operations started in the 1950s when "Juggling Work and Study" was a national slogan. Peking University, for instance, launched a university-operated factory and sent its students in science and engineering for practical training. This factory became fairly profitable in the 1960s.

In 1992, Deng's famous "Speech after the Southern Tour" called for bold market opening and across-the-board economic reforms to let market forces play a greater role in a socialist economy with Chinese characteristics. Immediately after the speech, the State Council manifested its intention to expedite incorporation of universities and development of university-launched venture firms. Many universities, in response to an abrupt atmospheric change to a free economy, scrambled into creating startup companies. According to the Ministry of Education figures, sales of university-launched venture firms in 1992 amounted to 2.9 billion yuan from 1.7 billion yuan in the previous year, and then climbed to 37.9 billion yuan in 1999. To sustain this boom, the State Council implemented tax breaks[1] for university-launched venture firms through income tax reduction[2].

Over the past two decades, Chinese universities, especially sci-tech institutions, have expanded their business involvement; from vocational training factories in the 1950s, then service firms such as printing, publishing, and guesthouse operation, and now to venture firms that facilitate the transfer of technology from academia to industry.

Currently a majority of startups are high-tech firms that capitalize on their academic R&D capabilities for commercialization of the seeds of new technologies. According to the government ѕ statistics in 1995, approximately 700 out of 1000 Chinese universities run one or more venture firms. Among them, 300 universities operate more than 2,000 high-tech firms with net sales of 36.8 billion yuan and a profit of more than 3.5 billion yuan in 2000. Net sales from these high-tech firms account for 75% of total income of university-launched venture firms. These university-launched venture firms use 230K workers and 78K of them work are sci-tech specialists and researchers. They reward their mother universities with 1.685 billion yuan and pay the government an income tax of 2.5 billion yuan. High-tech orientation and profitability of university-launched business are still apparent in a 2001 statistics. Possible reasons behind such orientation to prosperity of high-tech firms in an increasingly market-driven, deregulated environment include:

- First, the Chinese market long lacked the needs to commercialize the seeds of new technologies, if any, that universities possessed. In the Soviet innovation system that pre-reform China followed, the people had little idea to capitalize on intellectual property. They did not realize the importance of developing R&D capabilities, and there hardly was technology transfer between academia and industry. Then Deng ѕ China abruptly opened up the market, and universities in response had to start commercializing their technological assets. All this stimulated demands in the sleeping market.
- Second, high-tech turned around universities ’finance. Universities secured their own revenue sources while the government cut subsidies for higher education. They started to sustain their finance by marketing their intellectual properties and directly controlling profits from their venture businesses.

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1 With regard to the qualifications for tax break, the official documents, No.(78)1238 of Ministry of Education, No.(78)373 of Ministry of Finance (December 21, 1978), and No.52 of the State Council (1980), collectively stipulate the government eases income tax for earnings of educational organizations, including university-launched enterprises, from "juggling work and study" activities.

2 "The People's Republic of China Corporate Tax Interim Regulation (State Council Law 137, December 13, 1993)" defines corporate income tax must be paid for a sum of earnings from corporate production, operation, and other activities based on the predetermined rate. Income tax rate is 33%.

Statistics for 2000 and later shows the government has started to differentiate its financial support for universities. It uses more funds for the 211 Project prioritized universities such as Tsinghua University, while newer, emerging organizations such as Northeastern University (Neusoft Group) yield their revenue from industrial consignments. In general, the prioritized universities, especially sci-tech institutions, rely more heavily on government's budget.

Since around 2000, however, some of Tsinghua University and government's education officials have suggested the university administration rethink of direct intervention in their own venture firms. Their rationale is: there are some successful venture firms that went public on the stock exchange before establishing due corporate governance in terms of clarifying ownership issues between university and firm, and these firms have not fulfilled accountability for the market yet. A few even disputed, as university venture firms rely on the brand value of their mother universities, nobody may have any means to identify their true market valuation. All this is the issue of corporate governance that arose in the midst of government's trot to free market by little spontaneous technology transfer and capitalization on academic knowledge. Recently, as discussed in detail later, some of the 211 Project prioritized universities have stepped back and declared, "We are nothing but a shareholder. We won't interfere in corporate management." The government too encourages improvements in corporate governance. It is obvious the Chinese universities-launched venture firms are undergoing their most significant changes since their inception.

## III. China ʼs Reform of State-Owned R&D Institutions: Chinese Academy of Sciences and Other National Institutions

Many Japanese calling for pubic institution reform identify it as an integral part of reforms of national innovations system. Sci-tech research and development are greatly affected by education, taxation, IPR management and other social systems, and how to reform these institutions will determine the motives and performance of R&D workforce. The same holds for China.

The Chinese government has implemented its public institution reforms since the late 1990s. It identifies the Chinese Academy of Sciences (CAS) reform as the single most important project to cap a decade of national research institute reforms; for the CAS is a supreme organ of all public higher-education, academic, and research institutions. Except the CAS, the public institutions were supervised at the level of an individual ministry or agency in the old regime. Officialdom long depressed researchers ’motives and productivity. So, with the reform and open policy that Deng bequeathed, Beijing started sweeping restructuring of the institutions and organizations that governed research activities. In essence, they semi-privatized the public institutions and let market forces work for efficiency and competitiveness. Behind such bold reforms was the fact China needed a new industry and fresh institutions that enable the commercialization of technologies. Otherwise, they didn ʼt think they could sustain its tremendous economic growth.

In May 1999, the State Council privatized 242 research institutions under the jurisdiction of State Economic and Trade Commission: 131 transferred to private business groups, 40 ceded to sci-tech private firms, 18 transferred to intermediary organizations, 24 merged into universities, and 29 ceded to national large sic-tech firm. This large-scale privatization was an important step in the reform of the China ʼs national innovations system. Consequently, current and former bureaucrats realized they could not survive without making money out of their expertise.

**Chinese Academy of Sciences and National Innovation Projects**

Established in 1945, the Chinese Academy of Sciences (CAS) is a giant national scientific research institute. A supreme academic organization, it is the mentor behind natural scientists and high-tech professionals. Around 50,000 researchers work for 108 different locations. As of the end of 2002, the Academy consists of the following divisions:

- The administrative division is responsible for CAS policymaking and supervision of the entire organization. Headquarters in Beijing and district offices nationwide.
- The research division takes care of scientific researches. Each of the CAS subsidiaries pursues its specialized disciplines and expertise.
- Education division operates University of Science and Technology of China in Hefei, Anhui

Province. Also operates the Graduate School of University of Science and Technology of China in Beijing.

- Information and publishing division publishes journals and books and operates libraries.

The Academy has identified its “prioritized” areas of research as life science, nanotech, alternate energy, IT, and space engineering. This prioritization is a reflection of the government’s competitive subsidy system as well as a guideline for the Academy to propel its convergence and evaluation tasks against subsidiary institutions. The Academy is characterized by its focus on basic research, which reflects its central mission since its inception to advance the level of science capabilities of the nation. As a result, the Academy is less active in transfer and commercialization of scientific findings, development projects and practical tests.

The Academy submits more and more patent applications these days, exceeding a national average growth rate in the number of patent application. Most of applications are for inventions as, again, a proof of its focus on basic research. Also the CAS papers are more frequently cited by others and published in major publications. These increments are particularly evident after 1998 when many Chinese researchers returned home from overseas and the research environment became increasingly competitive. That the number of approved patents also increased in the same era proves the Academy’s reforms achieved some positive results.

In terms of discipline of papers to be cited by others, physics and chemistry comprise a majority of citations, followed by biology and material science. Top 10 research institutions reported by both SCIE and ISTP are all the CAS organizations, including the Shanghai Institute of Ceramics renowned worldwide as a researcher and inventor of new materials; the Laboratory of Remote Sensing Information Sciences being a center of space development in China; and the Shanghai Institute of Biological Sciences brought to international attention for its genomic analysis in agricultural biology.

As for finance, the Academy receives more and more subsidy from the government and extends its total revenue. As the model case of national innovational reforms, the Academy attracts a larger portion of R&D governmental funds. In this regard, the Academy works a magic to the public to believe in the reform and open policies: many are inclined to think there is hardly a pain that should accompany the reforms if an old structure like the CAS can be more efficient while increasing revenue.

Despite a decrease in full-time workers, the Academy increases payroll costs. This signifies, in comparison with the old regime, higher salaries are paid to the increasing number of general workers and specialist, including ace researchers with strong performance. It is noted the Academy employ a competitive merit-based system instead of using a fixed salary package.

The Academy has launched a number of the CAS-originated venture firms, including a famous IT firm called Legend. Although mergers and consolidation of these firms are, and will be, in progress because the market requires further streamlining of corporate management these days, the number of payrolls keeps growing. This alone exemplifies the effects and importance of privatizing public research institutions. There is no doubt the Academy will keep its financial feasibility with its administrative capabilities for privatized organizations and overall success of these spin-offs.

Many people keep an eye on the proceedings of the Knowledge Innovation Project that the Academy initiated in June 1998 based on the State Council's decision on commencing an attempt toward the next-generation national innovations system. This is 13-year project phased into three parts: 1998-2000, 2001-2005, and 2006-2010. So far the Academy has implemented reform objectives on a broad scale, including identification of forefront technologies to pursue and strategic directions, organizing focused research projects, and definition of the CAS-wide and institution-specific goals in sci-tech innovation activities. Based on these reform objectives, the Academy boldly reorganized itself and brought a drastic change to the sci-tech research environment in China. More specifically, the Academy holds the following three programs:

- Educational program to train personnel to lead Sci-Tech innovations. It aims to establish a personnel system that meet international standards in pursuit of cost-effectiveness of research, coordinated personnel assignment, adequate incentives, and merit-based pay system.
- Structural reform program to reorganize the national R&D institutions and reallocate their resources. It aims to reorganize the whole CAS structure into five areas; namely, basic science, strategic forefront technology, natural resource/environmental studies, agricultural high-tech, and high-tech related to national security.
- Administrative reform program to reform the administration of the national R&D institutions. It aims to build a modern, internationally-accepted form of administrative organization by, for example, introducing an administrative board and setting up a research fund. It also aims to give stronger power to individual institutions in activities such as budgeting, allocation of resources, planning and management of projects, and recruitment of faculty.

**"World-Class" Research Institutions without "Excessive" Reforms**

Statistics shows the Academy reduced the number of older and less capable workers and researchers. Although the Academy appears to have streamlined itself and achieved rejuvenation of its personnel, most of those workers and researchers still work under it: some became part-timers, some moved to leisurely posts, and the other moved to another CAS-affiliated firm. In this sense, this restructuring is superficial and supposedly-restructured staffs reach mandatory retirement age as a CAS worker.

Nevertheless, the Academy's reforms can be characterized by bold changes to institutional design:

subsidiary research institutions were consolidated after the removal of overlapped research themes and inefficient methods, and a new merit-based pay system was applied to all administrative workers and researchers. Generally older researchers from the old regime were less efficient and capable than young researchers. The Academy gave incentives to promote younger generations, especially those educated overseas; and allowed much latitude in their research. For instance, they are allowed to participate in upgrading public works through public involvement. The Academy bolstered competition both in terms of wage and budget allocation to expedite generational change. Losers in the competition were encouraged to become a part-timer or move to backoffice or a CAS-affiliated private firm. The Academy also applied a stricter evaluation system to backoffice workers, and started a new rule that staffs are recruited internationally if new posts are created or existing posts become available due to personnel transfers.

Some officials of the Academy, however, argue the excessive reforms in the last decade resulted in an excessive pay-for-performance system, and more researchers become confrontational each other and monopolize their findings. Although moderate competition works, researchers also need a free community, both physical and mental, to exchange ideas and opinions on their subjects of research in order for the Academy as a whole to become a world-class research organization. A well-balanced competitive research environment is a necessity for Academy's further advancement.

## IV. China's Regional Innovation System and Torch Program

As part of reforms of its national innovation system, China launched the Torch Program and designated economically important areas a "development zone." This program provides a good example with regard to how the central government tries to utilize the development zones.

The Torch Program's goal of developing new/high-tech industries in China has been chased by dynamic industry-university collaborations based in Beijing, Shanghai and other coastal cities. A typical development zone is the Haidian Science Park (HSP), widely known as China's Silicon Valley, in Zhongguancun located in northwest Beijing. Surrounded by Peking University, Tsinghua University, the CAS research institutions as well as many foreign-affiliate high-tech firms and domestic university spinoffs, the HSP is always recognized as a model for industry-university joint efforts; however, Zhongguancun is not a result of government-led reforms. The true builder of this high-tech town was a herd of privatized sci-tech firms which gathered here spontaneously, and the government later approved Zhongguancun as the core of the development zones in the country.

The history of Zhongguancun as a high-tech concentration started when Dr. Chen Chunxian, a researcher of the CAS influenced by the success of the U.S. Silicon Valley, founded a non-state technology firm under the Beijing Society of Plasma Physics. Backed by the reform and opening-up policy, high-tech firms gathered one after another and formed a symbolic economy zone. Early founders include the famous university IT spinoffs such as Sitong and Lenovo; university joint high-tech ventures like Peking University's PKU Founder and Tsinghua University's Tsinghua Unisplendour Corporation Limited (TH-UNIS). Now 4000-5000 high-tech firms cluster around Zhongguancun, whose gross sales exceed 0.1 trillion yuan. Zhongguancun became the first state-approved, high-tech industrial development zone in 1988, followed by the State Council's recognition of Zhongguancun as a pillar of its slogan National Development through Science and Education in 1999. In fact, most of the policies related to this slogan have been proposed by inforpreneurs and researchers who aim to launch a new business in this area. It appears the government leads the reforms, but actually it has been pushed by the dynamic forces of Zhongguancun.

**Ministry of Science and Technology and the Torch Program**

The Torch Program, with a history of promotion for 15 year by the Ministry of Science and Technology and affiliated agencies, is a major high-tech commercialization program to be implemented intensively in Zhongguancun and other development zones. So far 53 national science parks have been officially approved, each of which plays an important role to nurture a region-level innovation system. Each of the science parks has its own strategy with regional characteristics and, leveraging state-promoted incentives and preferential taxation, courts domestic and foreign high-tech firms. Collectively they are the underlying force of China's dynamic economic growth.

Naturally the science parks face with harsh competition. There are still regional gaps between the coastal area and the rest of China. Beijing and Shanghai particularly enjoy competitive advantages with the high concentrations of capital, high-tech, and brains. To cope with this reality, regional cities have adopted one-of-a-kind strategies. For example, Dalian has historically closer relationships with Japan and focuses on the development of computer software based on the Japanese language in order to strengthen its linkage with the Japanese firms. This example alone shows the science parks are not uniform. They have different goals and historic development; and evolved in accordance with the regional needs and strengths.

Many of the science parks have upped their scale for the past few years. For example, Zhongguancun consist of five different development zones in the Beijing city. Originally, it only covered the Haidian District where Peking University and Tsinghua University are located, but now it is a gigantic zone that extends over the entire Beijing city and its suburbs.

Corporate R&D spending increases, suggesting more capital is placed in high-tech realms; and more firms move to the science parks. This means active high-tech firms increase. All in all, the Torch Program has achieved some positive results.

Foreign companies ("three-capital" enterprises), a true driving force behind economic boom in China, have increasingly come to the science parks since the 1990s. They are still an integral part of the reforms although present mostly in the coastal areas. Chinese businessmen often depict Beijing as "Mao-jacketed Zhongguancun" and Shanghai as "suit-wearing Shanghai." This shows a bit of sense of crisis among them that Zhongguancun would not grow further unless suit-wearing foreigners come to the HSP more. In fact, the percentage of foreign entries in Zhongguancun has decreased since 2000.

Yet, in all the science parks, foreign firms' revenue per company is substantially higher than that of Chinese firms. This is another reason why science parks eagerly court foreign companies. For areas like Shanghai, Shenzhen, and Guangzhou, Taiwan and Hong Kong firms are especially important.

It is important for Chinese university joint venture firms to go into the science park to propel the academia to industry transfer of technology. The number of these firms that actually operate in the science park is still limited, but they occupy more than half of revenue among the entire university joint venture firms. The main source of their revenue is the IT-related business; and biotech-related revenue remains relatively low as biotech is still in its infancy, albeit its high profile. In terms of nanotech, a majority of revenue of the Chinese firms come from new materials business which is easier to catch up, not from advanced fine processing or manufacturing technology.

As universities expectations to the potentials of science parks intensify, the central government officially approves more and more science parks as a base of the Torch Program. Many of these science parks are classified as a National Technology Transfer Center and closely associated with famous universities like Tsinghua, Peking, Tianji, and Shanghai.

**Regional Gaps and Expectations for the Torch Program**

Despite its implication, the China's reforms of "national" innovation system extend regional gaps: Most of major actors of the reforms, pivotal universities and state research institutions, concentrate on the coastal area. For example, R&D concentration in Beijing is as high as the State of California in the United States. The Torch Program emphasizes the importance on the nation's balanced growth, and expects the midland areas to grow as a result of each having a regionally tailored innovation system. In this context, many larger peripheral cities started implementing strategies to become one of the national technopolis. For example, the city of Dalian set up a concept called Greater Dalian, including transforming the Lushun naval port into a commercial one and promoting high-tech based industrialization with close linkage with the Japanese firms. For the reforms to become "national," it is important to support the regional efforts to compete with the capital-rich coastal zones. In other words, the Torch Program must be a long-lasting guideline to correct regional imbalances for sustainable national development of China.

## V. Sci-Tech Human Resource within the Context of Innovation System

Human resource is a central force to bear and spur sci-tech development— this seems to be a lesson Beijing has learned from the experience of "brain drain." To stop the drain, the government introduced a preferential tax and incentive policy to call back sci-tech researchers working overseas. These "drained" brains must be "circulated" to substantiate the Beijing's slogan: National Development through Science and Education.

These preferential measures, however, caused another problem: most companies and R&D institutions scrambled for high skill worker, and it disrupted the labor supply-demand balance. It appears this imbalance remains as long as the "brain circulation" is the driving force behind Chinese economic development.

Beijing then started an initiative to conjure up the domestic workforce so China can be less dependent on such sci-tech remigrants. Now the government signs agreements with multinationals one after another for their comprehensive support in education and training with help from premier universities. Some of the science institutes under the Chinese Academy of Science began to recruit researchers from overseas. In fact, one of these institutes accepted Indian postdoctoral fellows with fellowship support.

**Foreign-Educated Researchers and Hai-Gui's**

Since the beginning of the reform and open policy, two types of workforce, the Xia-Hai's and the Hai-Gui's, have been considered to lead China's economic development: the Xia-Hai's are ex-public workers who become an entrepreneur or high-tech businessman while the Hai-Gui's are foreign-educated, remigrant researchers and businessmen. These labor forces are treated favorably by the government's policy. Especially, the Hai-Gui's are most valued and all central and regional science parks want them. Many Hai-Gui's visit one of the remigrants' venture support offices established in the science parks nationwide.

The number of Chinese students studying overseas had increased until last year until recently. It started to go sideways and at last decreased last year. This is partly because the United States limits the number of foreign students after the September 11th attacks, and partly because the Chinese top universities upgrade their faculty, curriculum, and the level of researches. Many students have come to think they don't need to go abroad.

Meanwhile the number of Hai-Gui's increases, especially in the past few years. This is partly due to the government's remigrant incentive packages; but many remigrants spontaneously began to come home, being aware of China's remarkable improvements in macroeconomic conditions such as the living standards and high-tech job opportunities, particularly in hub cities like Beijing and Shanghai.

In terms of funding, the vast majority of students go abroad on a private basis as the number of government-sponsored students is limited. Many of government-sponsored students are selected and sent by the ministries or their affiliated agencies such as the CAS. The number of these students stays almost flat in association with the agreements and exchange programs with the recipient countries. So a large portion of the increase of Chinese students studying overseas is occupied by those who are privately-financed or financed by their company. This trend continues as long as the Chinese income level rises.

The most popular destination is the United States, followed by Japan and individual EU countries. The Chinese students account for more than 10%, and near 15% inclusive of Taiwanese, of sci-tech doctoral graduates in the United States. Many began to pay attention to the networks of the U.S.-trained Taiwanese and Shanghai IT professionals as they greatly influence the flow of information, capital, and human resources in the East Asia. In fact, the triangle of Silicon Valley, Shanghai, and Hsinchu of Taiwan, as Dr. Saxenian of the University of California pointed out, may have greater implications to the future of mainland China. Also in Japan, a majority of sci-tech foreign students are from mainland China; but it may take some time until intellectual networks as ones between Silicon Valley and Shanghai are shaped in Japan due to the lack of preconditions.

Beijing's preferential measures for high-tech professionals overseas have been conducted on a ministry basis. For example, the CAS enforced "100 Plan" which grant subsidy to researchers in their 30s to 40s working in the front lines overseas if they return home. Without these researchers coming home, the famous rice-genome decoding project couldn't have succeeded.

**Institutional Reforms Associated with Sci-Tech Human Resources**

China has faced with low mobility in domestic labor due to obstacles like the family registration system. So to mobilize sci-tech human resources, the State Council permits provincial authorities to apply preferential treatments to sci-tech professionals. For instance, under the Shanghai's postdoctoral incentive policy, if researchers and entrepreneurs move to Shanghai from another province, they can exceptionally receive a family register in Shanghai. Having a family register in somewhere outside one's hometown (in fact, family) is very prestigious (exceptional) in China.

The government's support for students coming back from overseas include assistance in the startup support centers as well as grants for research and initial funding. Also, it actively hosts career conferences in China and overseas and provide job information in cooperation with overseas student organizations and recruiting services.

Overall, a tremendous influx of labor from midland continues in hub cities in the coastal areas; especially, R&D workforce has intensively shifted to the eastern and coastal high-tech cities. This trend appears not to stop for coming year.

The Chinese government has implemented a series of institutional reforms since the decision on the sci-tech based modernization in 1985. These reforms broke free of rigid national research institutions; improved the overall employment situation; and thus increased the mobilization of human resources across organizations. However, as a relatively few people move from national research institutions and universities to industry, the Chinese industrial R&D workforce still remains weak.

The ultimate goal of reform and opening-up policies is, by establishing a competition-based flexible labor market, to achieve the labor supply-demand balance through the market mechanism. Albeit only half done, these social reforms have improved the Chinese labor rigidified under the planned economy, and built up the infrastructure to match the right person to the right place in society, including able researchers coming back from overseas. These improvements allowed the Chinese sci-tech R&D forces to play rapid catch-up in the past decade.

A good example of the strengthening of the Chinese sci-tech R&D forces is the National Prioritized Laboratory Program. This program aims for flexible R&D job reallocation with competitive research funds. Once a research project is certified as a prioritized laboratory, its principal investigator (PI) may set up a research team at his/her discretion, except the team must be comprised of resident and temporary researchers. Like a similar system in the United States, the PI is given authority to decide everything with regard to the research project, including procurement of facilities and employment of assistant staffs.

**Foreign Capital-Backed R&D Centers and China’s Strategies for Development of Human Resources**

In parallel with calling back the Hai-Gui’s from overseas, the Chinese government has attracted high-tech multinationals like Microsoft and Intel and promoted the construction of foreign capital-backed R&D centers. Government officials are convinced such measure would enhance its R&D workforce with help from experienced foreign experts and professionals. A few years ago, China’s State Development and Reform Commission and Microsoft announced the Great Wall Plan in which the US company assists China’s software development education and training. This is a typical example of an increasing foreign influence on the Chinese high-tech industrialization.

Recent Microsoft’s pushes forced other tech-giants like Nokia and Motorola to sign education and training, as well as R&D, joint efforts with China. This trend in expanding joint R&D and educational ventures appears to intensify for several reasons, including that there is a bunch of able R&D labor unfound in China; that such workforce is relatively cheap and in an urgent need in China; and that the enhancement in R&D capabilities would up China’s appeal to foreign prospects in high-tech industry.

China has a smaller able R&D workforce in the industry sector. As a means to push more researchers to the industry, the Chinese government has privatized and sold a lot of national institutions. However, such measures do not necessarily encourage R&D activities in the private sector. Quantitatively OK, but qualitatively so-so. In fact, if almost obsolete research institutions are transferred, degradation of R&D workforce in the industry may result.

Many foreign firms are not shortsighted: They maintain a long-term perspective to cultivate and nurture the next generation of sci-tech workforce. Actually most of their R&D operations in China have dedicated staffs to build link-ups with Chinese universities and research institutions. This stance is shared with the government officials in the United States and Europe. Examples include: Germany's Fraunhofer-Gesellschaft is active exchanging researchers between Germany and China; Germany's Max Planck Institute and Volkswagen Foundation co-established Shanghai Institute for Advanced Studies within the CAS as an international, multidisciplinary research center; and the Ministry of Education of France signed a researcher exchange program with Tsinghua University last year.

## VI. Conclusion: Challenges and Perspective

As observed above, China's reform and open policy has been successful so far; but there are still several hurdles to bolster their development in science and technology:

- First, China needs to minimize regional gaps. The vast majority of R&D resources and operations concentrate in Beijing, Shanghai, and other coastal areas. The Chinese government should leverage the powers of sci-tech so the midlanders are not left behind in the economic growth.
- Second, China needs to improve a national innovation system in which education, R&D, industry-university linkage, and IPR management function in a balanced manner.
- Third, China needs a more open, free research environment as R&D activities become complex and intricate. Such a need is gradually recognized after incidents like the SARS scare.
- Finally, China needs to relax researchers. Currently Chinese officials discuss what else they can do to call people back to mainland, in response to criticism that the excessive reforms resulted in an excessive pay-for-performance system, and more researchers become confrontational each other and monopolize their findings. In the world's highest level of research environment, researchers are not in the tense competition. Rather, they form a free scientists' salon and exchange ideas and opinions on their subjects. But in China, some Hai-Gui's argue, people won't disclose their findings until publication, caught in a nearsighted competition for a better performance score.

The author believes whether these problems will be solved or not holds a key to Chinese sustainable development in science and technology— a success in the context of their embracing "science-based economic progress."

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## Akira Goto's Summary (Session 2)

Hello. As time presses and you all may be impatient for coffee break, I will end this session by briefly commenting on the previous discussions. I have a couple of points to mention: One, the importance of improving systems and general conditions to support the market mechanism; two, the importance of industrial and technology policies that promote interaction between different economic actors.

As for the first point, I must express deep respect to all previous Vietnamese speakers who emphasized the importance to adapt the Vietnamese industrial, legal, business conditions to the market mechanism. The market mechanism looks wasteful in the short-term perspective; but, as modern history proves, it is actually far more efficient than any other economic system in the longer run. However, without adequate underlying conditions, no market economy can work effective and make people materially and mentally prosperous. So the top priority is to establish a social environment in line with market principles.

In his keynote address, Dr. Doanh insisted it was very important to prepare and implement adequate corporate, competition, and patent laws. It is very much so, but there are two points you need to be careful from the experience of failure of Japan.

First, implementation and operation of new laws and systems are crucial than preparing or changing them because maintenance requires far more time and energy than creation. Japanese government made the patent law in the 19th century and the competition law in 1940, but their enforcement began, or just became possible, during 1970's or 1980's. It is a very tough work to establish a fair market system by substantializing the spirit of those laws in everyday economic activities. Precisely because it's tough, the operation of law is crucial.

Secondly, updating systems and laws is important, too. Technologies, international environment, and domestic market condition — everything changes quickly these days and makes systems and laws outdated soon. In the worst case, they may become an obstacle for future growth. Naturally every nation needs to update its systems and laws and adapt them to the newer environment. This is a tough work, too, at least in Japan. There have been reform efforts, but they are hampered by high barriers thrown up by the politicians combined with vested interests that have grown under the existing laws and systems. Slashing away this sort of resistance is no easy job.

To put it short, the market mechanism is a system of change; and thus, you need to address it with a package of measures; that is, making, operating, and updating necessary laws and social infrastructures.

The point two is about industrial and technology policies. As our four discussants have already made it clear, everyone stresses the importance of linkage, networking, cooperation in different economic actors. One national innovation system comprises foreign multinationals and domestic companies — big and small, modern and household. It also requires collaborative relationships among university and government researchers and private corporations.

As Dr. Ca emphasized, new knowledge is an outcome of learning process; and, in this light too, interactions between different actors are indispensable. Dr. Gwen stressed the roles of engineers. In my paraphrase, as a bridge between science and industry, engineers play a key role in the context of business-academia collaboration. Dr. Haraguchi gave us a case study in Thailand with regard to how we can foster local firms so they can successfully collaborate with foreign companies. Dr. Sunami talked about how Chinese universities and government research institutes in the post-reform era actively connect with the industry.

All these discourses converge on the significance of mutual collaboration of the actors that comprise the national innovation system, and deepening it. As a famous architect said, “God is in the details.” Our “godlike” knowledge is left unfound, untapped, or scattered across the points of production, distribution, and sales. To facilitate innovation, you need to find and integrate such pieces of knowledge into a unified context; and, in that context, devise strategies and policies to substantialize them. All industrial and technology policies must be oriented toward strengthening this knowledge integration and linkage of the economic actors. In this sense, I totally agree with what our four discussants suggested.

Well, my speech is almost done. Before I leave, I have one more thing to share with you. As we heard today, learning foreign technology policies is quite important. For example, in his famous study on the very successful association system of collaborative research in Japan, particularly in semi-conductor and computer industry, Dr. Sunami points out things developed in a reciprocal fashion: Bureaucrats of the MITI of Japan first adapted the original form of this association from England; and then England and the U.S. started to learn this “Japanese” collaborative research system under the stimulus of Japan’s success. This is a good example of how mutual learning of policies is fruitful. I believe today’s symposium is one good example of mutual learning, and deeply thank all the participants here, especially HOF, NISTPASS and other Vietnamese people for giving me such a precious occasion. Thank you.

Dr.Nguyen Manh Quan Co-chair-2 Ministry of Industry

Thank you Prof. Akira Goto for quite short and correct comment related to the content of the second part "strategies and policies in technology innovation and enterpreneurship" and Part II finished 4 presentations.

We have received several questions concerning the topics covered in part II, like in part I in the morning. We have to say that the 10 minutes reserved for part II is over. Please take a rest and continually discuss part IV. If we have some free time left at the end of part IV, we will have the open forum then and the speakers will answer all your questions, we do encourage all participants to write down all your questions and pass them on to the Secretariat. Please write your name, email address or office fax number so that in case we have no time to answer your questions this afternoon, the lecturers can reply by email or fax.

Once again, I would like to thank our speakers, and Prof. Akira Goto for ensuring the success of part II of this forum.

# ENGINEERING CAPACITY BUILDING FOR SUSTAINABLE DEVELOPMENT POVERTY ALLEVIATION AND INTERNATIONAL INTEGRATION.

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## 1. INTRODUCTION.

I have the pleasesure to make the presentation of my paper in the International symposium "Innovation, Entrepreneurship and Link-up Implementation for Developing Countries". The theme of this symposium is most appropriate for our development. The developing countries today are facing with poverty, hunger, disease, civil strife, illiteracy, natural disaster, contamination of soil and water, deterioration of environment, lose of biodiversity, pollution of air and many natural resources are in critical use. Their people lack of access to education, healthcare, employment, energy, food, house, water, sanitation… The market of Science, Engineering and Technology is not available. The competitiveness of Vietnam is low, lack of skilled workers, qualified engineers and ethical code. Quality of education and service is low, corruption, damaged of buildings, settlement of roads, collapse of structures… have the same reason : Low quality of people, lack of expertise, engineering capacity, responsibility, transparency and ethics. The innovation of new idea, new way of thinking, new engineering solution, new management and technology are not yet the key of promotion. All above factors threat the property, safety, security, integration and sustainable development.

This paper make the general review on the actual situation, challenges and suggestions for future development. We all together "Bring the Enjoyment and Quality to the life".

## 2. ACTUAL SITUATION AND CHALLENGES.

***Division of the world population.***

| Classes of people | GDP in US$ per capita.<br>(Purchasing Power Parity Corrected) | No of People |
|---|---|---|
| 1. The Poor | < 4000 | 4 Billion. |
| 2. The Transitional | 4000 – 1600 | 1.2 Billion |
| 3. The Rich | > 16000 | 0.8 Billion |
| | | **Total : 6.0 Billion** |

***Consumption of Energy and Materials.***

| Classes of people | World Consumption of energy | World Consumption of Materials |
|---|---|---|
| The Rich 20% | 86% | 86% |
| The Poorest 20% | 1.3% | 1.3% |
| | | |

***The Gap between the Rich and Poor.***

| Classes of People | Wealth | Energy Consumption | Carbon Emision |
|---|---|---|---|
| **The Rich** | 9 | 8 | 8 |
| **The Poor** | 1 | 1 | 1 |

***Statistic figure of our world.***

| Character and Index | No of People |
|---|---|
| Daily income of less than US$ 1.00 | 1.3 billion |
| Daily income of less than US$ 2.00 | 3.0 billion |
| Food insecurity | 0.8 billion |
| HIV positive | 50 million |
| Water scarcity | 1.0 billion |
| No access to commercial energy | 2.0 billion. |
| | |

***GDP of Vietnam in 2003 and 2004 (estimated) are show in the following Table.***

***(Billion VND)***

| | 2003 | 2004 | % of Increasing |
|---|---|---|---|
| Total | 336.242 | 362.092 | 7.7 |
| Agriculture forest and fish | 70.827 | 73.309 | 3.5 |
| Industry and Construction | 129.399 | 142.601 | 10.2 |
| Services | 136.016 | 146.182 | 7.47 |

***Total Capital of Investment (Mil Billion).***

| | Plan 2004 | Implemented | % Increasing in comparison with 2003 |
|---|---|---|---|
| Total | 249.3 | 258.7 | 17.7 |

| | | | |
|---|---|---|---|
| State | 142.0 | 145.0 | 17.9 |
| Private | 67.0 | 69.5 | 19.6 |
| FDI | 40.3 | 44.2 | 14.5 |

***Comparison of the Economic Development (2003 – WB)***

| Country | GDP (Billion US$) | Per Capita (US$) | Emission of $CO_2$ Million of Ton |
|---|---|---|---|
| China | 1417 | 1100 | 2790 |
| Japan | 4390 | 34510 | 1184.5 |
| Sweden | 258 | 28840 | 46.9 |
| Thailand | 136 | 2190 | 198.6 |
| USA | 10946 | 37610 | 5601.5 |
| Malaysia | 94 | 3780 | 144.4 |
| Korea | 576 | 12020 | 427.0 |
| Vietnam | 39 | 480 | 57.5 |
| World | 34491 | 5500 | 22994 |
| Low Income | 1038 | 450 | 2066 |
| Average Income | 5732 | 1920 | 9129 |
| High Income | 27732 | 28550 | 11804.3 |

***Corruption Perception Index (CPI) according to the Transparency International Corruption perception Index (CPI is from 1 to 10, the lower is the worse).***

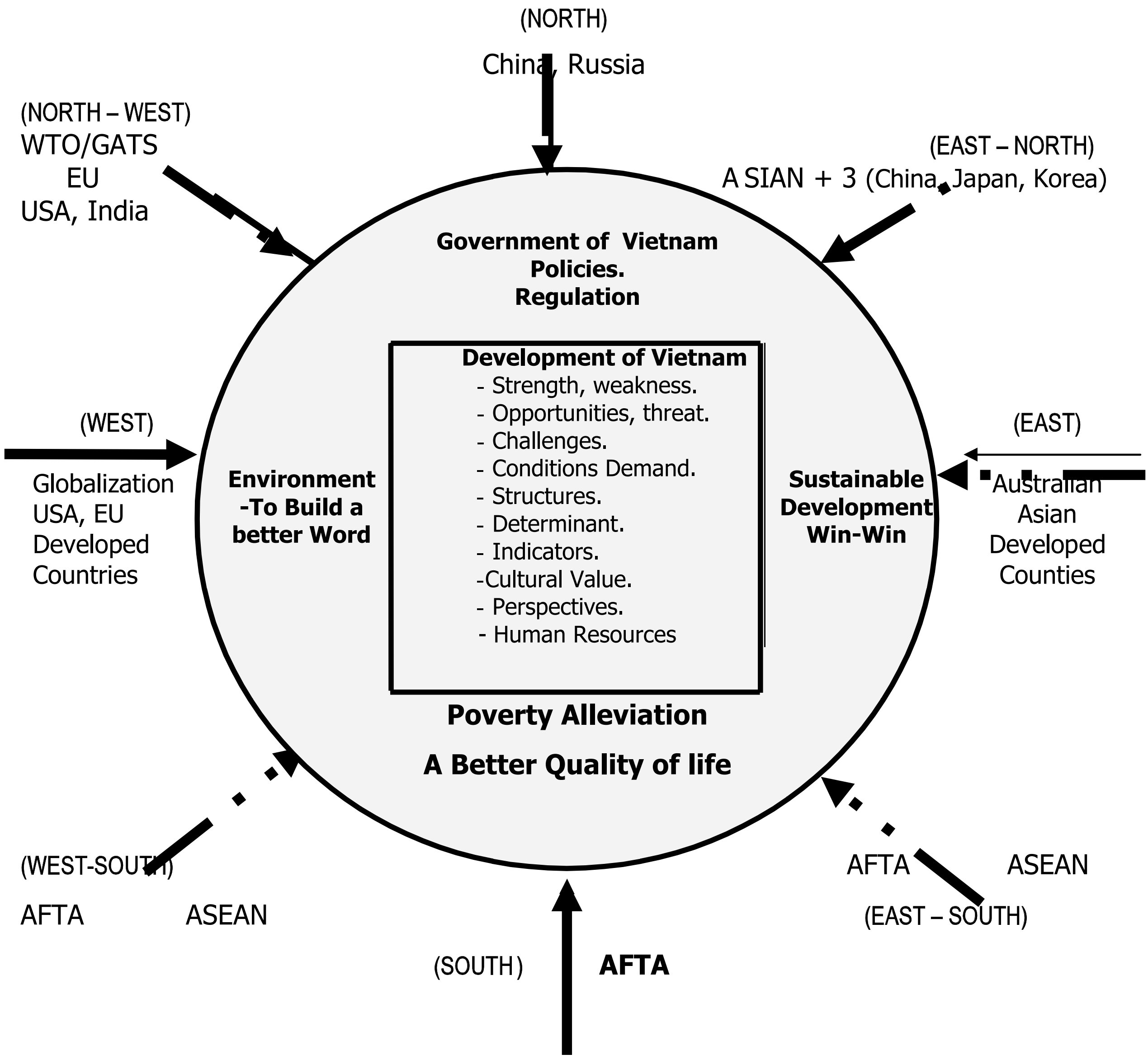
| Country | Clarification | CPI |
|---|---|---|
| Finland | 1 | 9.7 |
| Sweden | 6 | 9.2 |
| Singapore | 5 | 9.3 |
| USA | 17 | 7.5 |
| Japan | 24 | 6.9 |
| Korea | 47 | 4.5 |
| Cuba | 62 | 3.7 |
| Thailand | 64 | 3.6 |
| China | 71 | 3.4 |
| Vietnam | 102 | 2.6 |

***Summary of strength weakness opportunities and Threats (SWOT) of Vietnam (Before WTO/GATS and current situation).***

| Strength | Weekness | Opportunities | Threats |
|---|---|---|---|
| ▪ Abundance of land area<br>▪ Young and growing population<br>▪ High economic grow (more than 7%/year)<br>▪ Dynamic development of private sector.<br>▪ Good contribution to GDP from FDI and private sector.<br>▪ Increasing of export and import.<br>▪ 36% of GDP in investment.<br>▪ Cultural value.<br>▪ Historical lessons<br>▪ Appreciation of foreign people.<br>▪ Good contribution to ASEAN policies.<br>▪ Establish joint-stock companies (state-private, private)<br>▪ Increment of FDI<br>▪ Gained experiences for construction hydropower plan, cement factory.<br>▪ Growth of construction sector is from 10 - 12%.<br>▪ Export of construction materials about 65 million USD in 2003, and import in the same year is 455 million USD. | ▪ Lack of good infrastructure.<br>▪ Weak financial capacity.<br>▪ Technology not as advanced as other country.<br>▪ Lack of research and information.<br>▪ Low quality of education, training and human resources.<br>▪ Lack of professional, skilled workers and good project managers.<br>▪ Lack of track record and experience in large infrastructure projects i.e. highway, tunnel, bridges, airport, refinery, land reclamation, protection of water soil.<br>▪ Lack of finance for investment in large project.<br>▪ No participation of private sector in infrastructure development.<br>▪ Very few BOT projects.<br>▪ Lack of technology and professionalism.<br>▪ Lack of transparency, responsibility and Democracy. | ▪ Undeveloped land.<br>▪ Expansion of infrastructure.<br>▪ Need for skill training.<br>▪ Need for professional registration.<br>▪ Development of material of construction.<br>▪ Government recognition of the sector as an important engine for growth.<br>▪ Major players look at construction opportunities in foreign countries.<br>▪ High chances of getting local project due to "who you know" culture.<br>▪ Local infrastructure project.<br>▪ Venture into other countries because have the financial and technological.<br>▪ Investment in urban development, housing, program, material production, energy infrastructures.<br>▪ Need trends of construction industry.<br>▪ International integration.<br>▪ Increase the number of people for export of labor service (7054 workers are working in Malaysia (2801) and the rest of the world.<br>▪ Want to be the best, better quality of life. | ▪ Too many small players.<br>▪ Corruption.<br>▪ No transparency in tender.<br>▪ Unemployment.<br>▪ Low efficiency of investment.<br>▪ Loan and borrowed money.<br>▪ Low quality of many projects, short time of services.<br>▪ Deterioration of environment.<br>▪ Natural and man-made disaster.<br>▪ Contamination of soil, water, chemical product (dioxin).<br>▪ High cost of land cities.<br>▪ Gaps between rich and poor are extended.<br>▪ About 80% of population has the income less than 1 USD/day.<br>▪ Materialism, individualism... are dominant.<br>▪ No promotion for continuity study.<br>▪ Trade activities in education, research, business.<br>▪ Total borrowed budget is about 13 billions of USD and GDP |

| | | | |
|---|---|---|---|
| ▪ The increasing of turover of a good Vietnamese construction firms is about 20 – 30% per year | ▪ Profit / loss is not clear.<br>▪ Patronage – Client relationship.<br>▪ Lack of regulations, standards, study, law.<br>▪ Definition of value. | | is estimated to be about 39 billions USD/year.<br>▪ Total income from the Tax is about 8 billions USD/year.<br>▪ Every 5 years government need to pay 15000 billions VND for state companies and organization in order to be survive. |

**Diagram to show the study on Competitiveness and Impacts for integration and Globalization**



**3. THE ROLE OF ENGINEERS AND ENGINEERING FOR A BETTER QUALITY OF LIFE AND WE WILL BUILD A BETTER WORLD.**

- Basic infrastructure i.e roads, schools, sanitation, irrigation, clinics, telecommunications, energy etc… are build up by Engineers and Engineering.
- Basic industries, small and medium enterprises (SME) for supply of goods and services to agricultural, natural resources exploitation industries need innovations, science, engineering, technology and expertise of local technicians.
- For the implementation of the above the science, engineering, technology in developing countries need to be reoriented, reorganized with more government support and funding from different sources.
- It is important the role of Academics of engineering and technological sciences, professional engineering and technological associations, industrial and trade associations.
- Science, Innovation need engineering and technology.
- Modern hospitals need sophisticated scanners, life support system, information system, computer system and sanitized environment… These operation and maintenance need engineer and technicians.
- Reduction, Mitigation, Prevention… of a natural disaster need the knowledge and expertise of Engineer and Engineering system.
- The engineers are bringing safe water and adequate sanitation to all people.
- Modern Bioengineering, Eco-Technology, Eco-Materials and sustainable farming system are carried out by Engineers and Engineering solutions.
- Blue revolution in agriculture depends on innovation in water and irrigation engineering. "More crop per drop of water". 70% of world water is utilized for agriculture. (2000 ton of water produce 1 ton of rice and 1000 tons of water produce 1 ton of wheat).
- In India 20% of energy consumption is for pumping water for irrigation.
- Reuse, Recycle, remanufactures… of materials need engineering solution. In the European Countries, it is required to recycle 85% of a vehicles weight in 2005 and rising to 95% by 2015.
- Engineering and Technology transform scientific concept and innovation from the laboratories and theories into system, equipment, devices… into the commercial and financial world.
- It is very important to have a proper understanding of the respective role of Science, Engineering and Technology (SET). The developed countries are responsible for scientific discoveries. The developing countries should pay more attention on engineering and technology that have largely been responsible for wealth creation and to lift the countries out of poverty. Academician Dato Lee Yee Cheong, president of WFEO urge to promote the use of the terminology "SET" in place of "S & T".

- The key factor of developing countries is to build up indigenous engineering construction capability and indigenous engineering human resource for new and existing challenges.

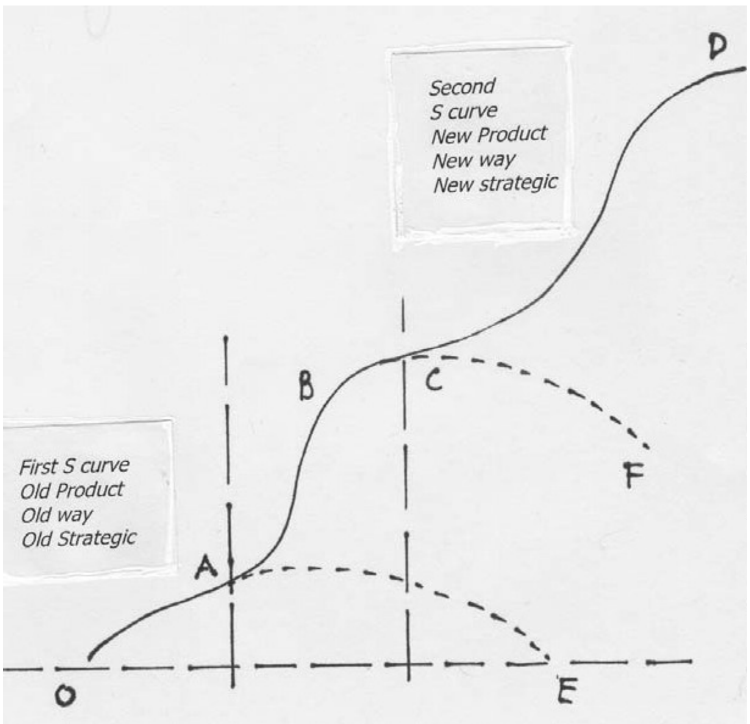
## 4. OUR WAY OF THINGKING.

### 4.1 THE INFLECTION POINT AND S CURVE.

The experiences and lessons learned from the developed countries and the from the west are good for our development. Vietnam had more than 4000 years old. However in the first decade of the 20th century the concept of Science, Engineering and Technology was introduced to Vietnam. Under the French colonial regime (1884 – 1945), French colonialism only stressed trade, exploration of mine and not industrialization. The long time of colonization and war as well as the civilization and cultural flush from the west, have upset the traditional value. Indeed Vietnamese nation has been formed and affirmed by the mixture of an original culture and assimilation, adaptation of multiples cultures coming from outside. To ensure nation building in peacetime, Vietnam need to be "advanced culture strongly market by national identity". Economic progress, innovation, engineering, technology and business do not harm our cultural value. Business and war are different in objectives but both need to be independent of the othe parties. We know that "strategy not being a lengthy action plan but the evolution of central idea through continually changing circumstances".

The changing circumstances may be is from negative to positive and need to pass the inflection point or from convex to concave. Today we have the strategic inflection Point and S curve Theories.

***The Inflection Point and S curve.***




***Time***

A : Inflection Point.

A-B : Business goes on to the new heights (Sustainable development)

B-C : Reduction of the profit and development (transition to the new or to future).

C-D : New S curve need to build up.

E-F : Business declines.

The following observation can be made :

- Science, Engineering and technology need to changed by the S curve or strategic Inflection Point or by both.
- New Product, new business, new opportunities… become old with time.
- It is important to know things are different, something has changed.
- Past is Negative, Future is Positive. We need to keep balance in the Present.
- The managers and engineers need to keep balance and are facing the new changing and challenge. They need to have INNOVATION.
- They also need to know and understand the tangible and intangible Value.
- The Inflection Strategic Point and S curve Theory are the combination of the concepts from the west (Adrew Grove, President and CEO of Intel Corporation) and East (Prof. Choo, Singapore).
- The inflection Point is also the crisis point that challenge every people and company.
- S curve mean sustainable development, safety security… is important find the new opportunities and new challenge.
- We need to know and understand : Who we are, where we are, when we need to have the new S curve for a new development.

4.2 RESPONSIBILITY

The most important responsibility of Managers and Engineers is to build a better quality of life for public's demands. Managers and Engineers need to keep the balance between the development and conservation of nature, make the satisfaction to our generation and future generation. According to the ASIA culture:

- Sustainable development = Keep the Balance of Negative and positive balance
- Stable development = According and follow the Principles of 5 basics materials
- Continuously Development and Renovation = Iching
- Protection of Environment = Respect the Fongsui

In this actual situation, the responsibility and tasks of Vietnamese Managers and Engineers are: To make the contribution for engineering building capacity poverty alleviation, sustainable development, international integration, reduce the gaps between the rich and poor people increasing the competitiveness by engineering solutions and technology transfers.

## 4.3 MANAGERS AND THE ENGINEERS NEED TO PROTEC THE ENVIRONMENT.

The Managers and Engineers need to provide engineering solutions, technology and best Management to use less and less natural resources, less and less waste, reuse, recycle, remanufacture of materials (3R), protection and mitigation of disaster and contamination. Long time ago, the Earth existed only mountain, highland, rivers, lakes, trees, sea... men were living in a caverns mountain, use the rivers as main roads and living by lake, forest and trees. Today, we build up high rise building dams, bridges and roads. This means:

- High rise building = Mountain and highland
- All kind of roads = Rives
- Dams and lakes = Small sea
- Bridges = Cross of old road (river) and new road (high way).

Managers and Engineers need to protect Lake, Sea, Forest, bio-diversity for today and tomorrow.

## 4.4 CODE OF ETHICS.

The Managers and Engineers need to have high standard of ethical code and practice in their professional life: Quality control, reduction of cost, improvement of safety, saving of Energy and water, prevention of disaster, reuse of materials, clean product, eco-materials in order to satisfy cultural value and for people. Asian Cultures referred to the old philosophy to be gentlemen, good man have great value. The Engineers need to be correct, right, she/he need to know the role of Engineer and his/her behavior to the society, environment, colleagues and friends. He/she needs to keep the balance of negative and positive in his/her body, sentiment and knowledge. Please refer to the code of ethics of P.E.

## 4.5 MULTILITERAL COOPERATION, FRIEND OF ALL.

Vietnamese Managers and Engineers are facing the less competitiveness and very complex problem of sustainable Development. We need to make the promotion of the cooperation in many form, multilateral directions. We appreciate the international cooperation with 3 East Asian countries and ASEAN countries. We need to have close friends in near countries. We can work together for the creation of the new knowledge and use new knowledge in practical life. We need to have concrete engineering solution, technology, pilot testing and application of new material, new technology. We need to combile the knowledge and expertise of Scientific, Social, Economical, Science, Engineering, Technology and Management... for creation of real Cultural value. We have 5 basic materials: Gold or Iron, Trees, Water, Fire and Earth. The logic of 5 basic materials is very important for Sustainable Development. Experience and knowledge from Asian countries are important for Vietnam. During the last 10 years, the contributions from Japanese Engineers and business man from Japan are very valuable for Vietnam.

### 4.6 EDUCATION AND INCREASING OF COMPETITIVENESS.

Poverty alleviation, sustainable development, international integration, increasing of competitiveness, natural disaster prevention and mitigation and prevention of corruption need to increase the quality of people. Managers and Engineers, quality of Education and creation, innovation in science engineering and technology . The Engineer needs to study, to build up the capacity. Textbook, curriculum... should be renovated and updated. Teaching and study on knowledge of Environment, Economy, Law, organization, Management and work together. The Engineers need to study professional knowledge, expertise, code of ethics, English, cultural value, and make the Civil Engineering, Geotechnical Engineering, Geo-engineering to be attractive for the future generation. The Asian philosophy for continuously study is important for professional Engineers. The competitiveness is dependent on the human resources quality who are working as Engineers, Corporate Governance, Researchers, Staffs of Authorities, Investor. The Engineer need to provide the driver force.

### 4. 7 ENGINEERING & TECHNOLOGY.

- The Managers and Engineers work always with science engineering and technology. Engineering is the bridge between the Science and Technology. Engineering solutions and technology of Civil Engineering and Geotechnical Engineering need to provide the right answers to the following demands of the life:
- Design and construction of houses and infrastructure projects in flooding area, mountain area, Tay Nguyen, highlands.
- Technology and materials of construction for Schools and Children Garden in poor communities.
- Engineering, Technology and Material for apartment and high rise buildings.
- Protection and prevention of slope stability, debris flow, landslide, riverbank and seabank.
- Dams and lake for water.
- Treatment of water.
- Tunnels.
- Industrial buildings.
- Lightweight concrete.
- Nano Technology, Eco Technology.
- High strength concrete.
- Glass fiber in construction.
- Ferro cement.
- Lime and cement column.
- Band drain.
- Mini pile.

- Embankment in soft soil.
- Offshore construction.
- Treatment of waste.
- Cleaning of contaminated soil and water.

Engineering solutions, technology and Innovations need to be connected to the investment and Production. Feasibility study should be made using an experiences from developed countries. Need to pay very high attention for technology transfer from Japan, Korea, China, ASEAN countries to Vietnam for new technology and new materials.

## 5. PROPOSAL & SUGGESTIONS.

- Registration of Engineers according to ASEAN / APEC.
- Establish the Association of Engineers or Institute of Engineers in Vietnam.
- Establish the program of cooperation with our friends and colleagues for development of projects and application of the research results in real conditions.
- Establish the research Projects and program of cooperation between Vietnam and Japan, using budget from different sources.
- Establish in the new University of Engineering, Technology and Management with the support and help from ASEAN, Japan, Korea, China and other developed countries .
- Establish the Joint Venture Company between Vietnam and Japan for consulting services and technology transfer.
- Formation of the Information system for a better communication and cooperation.
- Increasing the cooperation between Professional Association.
- Participation  the ASEAN Academy of Engineering and Technology.

## 6. CONCLUSION

- The result from this Symposium is appreciated by all participants, our colleagues and friends. The Symposium will be  successful and we are satisfied for all contribution.
- Engineers and Managers play important role for poverty reduction, sustainable development and international integration.
- It is necessary to make use of the results from this Symposium in our professional life.
- It is very important the role of Engineers for future development. Registration of Engineer is important task and challenge.
- It is recommended to have new form of cooperation between Vietnam and Japan:
  + Education and Training.
  + Research.
  + Technology transfer.

+ Consulting services.

+ Investment.

- The gaps between Vietnam and developed courtiers may be  is about 20, 30, 40 and 50 years. We need your help, assistance and contribution from colleagues and fiends from Japan.
- In the recent ASEAN Business Summit in Vientiane, The Philippine's President, H.E Gloria Arroy. Macapagal told "There is only one way forward, not by looking West but by looking inward". We need to understand our culture, our natural and human resources as well as our intangible values for innovations, competitiveness, making our region of Asean and Asia to be a better and high quality place to live. We are in the best position to promote good will, understanding, cooperation and innovation.

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# ECO-TECHNOLOGY— Human Environment Conscious Science & Technology

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## 1. Introduction

Science and technology advanced with a focus on materials and energy from the late 19th century through until mid-1900s. For instance, coal played a crucial role in the European industrial revolution. Burning coal in the newly invented steam engine generated huge power as a result of transformation of heat into mechanical energy. In the 20th century, petroleum became a dominant source for mass-production in heavy industry, and sustained vigorous economic growth worldwide, especially in the West and Japan.

As a result, the environment was polluted and the pollution became a world issue. Mass emission of carbon dioxide and chlorofluorocarbon caused global warming and harmful climatic changes while microelements existing in the atmosphere are said to arouse hormone imbalance inside our body. Given these facts, I would like to emphasize the necessity of a new way of scientific and technological thinking which I would call Eco-Technology, i.e. Human *E*nvironment *CO*nscious Technology. To think about the human environment, we need to briefly look at changes in the paradigm of science and technology.

The original definition of the term Eco-Technology, a merger of ecology and technology [1], may sound different from my implication of Eco-Technology, a framework of scientific thinking conscious of the human environment [2]. However, their ultimate goal is common: Pursuit of science and technology more benign to the human environment.

## 2. Paradigm Changes in Science and Technology [3-6]

Until the mid-1900s in the postindustrial era, Materials (M) and Energy (E) had been the central focus that sets the paradigm of science and technology.

In the 20th century, there were two important discoveries in terms of material: nuclear reactions and semiconductor. Nuclear reactions shifted human understanding in terms of the relationship of material and energy: In nuclear reactions, a small change in the quantity of material releases far more energy than chemical reactions like burning coal or petroleum; and the same is true with the nuclear fusion of hydrogen. Nuclear power plants use uranium fission to yield electric energy. Continuous nuclear fusions of hydrogen happening inside the sun is a mother of existence; and no natural phenomena including human existence are possible without them.

Another important discovery was semiconductor. Electrically speaking, materials are a conductor, an insulator, or a semiconductor which exists in between. Combining semiconductors, transistor devices were invented and replaced the role of vacuum tubes which are made of glass and metal because they can better control electric currents and amplify voltages. Transistors evolved into micro devices like IC and LSI chips for use in computing and telecommunications. This added a new factor, Information and communications (I), to the old M-E paradigm of science and technology (**Figure 1**).

Information-communications technology enabled remote sensing devices and microcomputers to be equipped on artificial satellites: We can monitor environmental pollutions, natural disasters, and military actions from the face of the earth. These capabilities are a fundamental part of modern politics and economic advantages.

Today at the wake of the new century, one more factor, Life (L) including mankind, is being incorporated in the paradigm of Materials (M), Energy (E), and Information and communications (I) (**Figure 2**).

An example illustrates this: Modern doctors can make intact, detailed observations of human organs and brain by use of a scanning technology called the nuclear magnetic resonance computed tomography (NMR-CT) which is empowered by the superconducting magnet. They can also use a superconducting quantum interference device (SQUID) to diagnose minim magnetic field emitted from a patient's brain or heart because the SQUID device is capable of sensing a magnetic field as minim in the order of several tens of thousands as the earth magnetism.

As a natural result, modern science and technology face intricate humanity issues, including bioethics which entails cultural and religious implications. We have restless controversies over possible discrimination against preborn babies by using techniques of genetic engineering, such as producing embryonic stem cells from cloned embryos, or in vitro fertilization.

There is no doubt many genetic scientists work to overcome intractable diseases like AIDS and cancer. But when some of them use their knowledge to choose a "high-quality" egg less genetically prone to cancer from test-tube eggs, we may call it discrimination against preborn babies; or when they use stem cells from human embryos or aborted fetuses for research and treatment purposes, we must still say a human uses another human as a material.

I always ask a question in my university class on bioethics, "When do you think a life begins? When a sperm meets an egg? When they become fertilized? When a fertilized egg grows to a certain degree? Or when it is born out of the womb?"

Advanced medicine can mechanically keep the unconscious alive, and the definition of death here is switching off the life-prolonging device. People see birth and death self-evident because they occur day-in-day-out, but such perception is losing ground as the modern paradigm of science and technology meets the challenge of the Life (L) factor.

Scientists have based their legitimacy on the universality, objectivity, and rationality of science while technologists stepped in and explored every avenue to substantiate scientific findings. The consequence was an endless cycle of technology after technology catching up newer scientific findings. Where universality, objectivity, and rationality prevail, ethical concerns are secondary and the use of scientific knowledge could always be a double-edged sword.

**3. Human Environment**

From the viewpoint of universal truth, human world is vague: Man's sense of value and ethics vary and are strongly influenced by his/her environment, i.e. family, community, country, school, tradition, culture, religion, economic and political system, and so on. Likewise, man's concept of life and death and standard for value judgment reflect the diversity of the natural environment and locality surrounding him/her. So, vague things like human emotions or subjective sensitivity coming from the five senses have been excluded from the scientific and technological thinking which serves the kingdom of universality, objectivity, and rationality.

But who is the protagonist in the paradigm of science and technology? Man. This fact has long been overlooked by scientists and researchers. It is then quite natural robotics engineers confront a huge challenge how to make robots "understand" man's occasional irrationality and emotions. Different cultures perceive life and death differently. What is wrong with this? Do we need to pass a scientific or congressional resolution to authorize a universal concept of life and death? Important thing to remember is experts could not assume entire responsibilities over scientific achievements anymore. Common people need to think and act critically toward scientific developments. As pointed out above, it is prime time for the scientific paradigm to incorporate the Life (L) factor, and there is no doubt the L factor entails man's diversity, emotions, sensitivity, and irrationality.

**4. Diversified Human Environment and Society**

We are accustomed to the cliché that the degradation of the natural surroundings is a major environmental issue. But, if we define the term environment as any circumstance surrounding humans that influences their growth and mentality, the crisis of the environment is not restricted to the components of nature such as atmosphere, water, plants and animals. When we say the protection of the natural surroundings is a top priority, a logical conclusion is mankind is a top victimizer that should become extinct first and the several millions of living organisms on the earth next.

For us to prosper eternally on this planet, what should we do? I suppose it is more reasonable to consider environmental deterioration as an issue of the human environment. The September 11 terrorist attacks in New York induced the military attacks against Afghanistan and Iraq. Some people argue desertification and poverty in those areas produce terrorists. They say terrorism is a result of environmental deterioration. Other discuss ethic feuds underlie the conflict between different value systems. From the standpoint of the human environment, however, terrorism and environmental deterioration are the same in that both threaten the security of mankind [7].

**5. Technology Transfer in Light of Eco-Technology**

When you transfer or import foreign technology to your region, a particular human environment, preparing an acceptance system is a necessity. Ignoring locality, your own culture and way of living, no "universal high-tech" can take root.

The earth is a constellated mosaic of diverse cultures and value systems. The same is true in the SE Asia. Under the banner of universality and rationality, how many intrinsic traditions and cultural experiences did perish from this planet? To think *any* legitimate application of advanced science shall come off anywhere because it is universal is a conventional thinking. Likewise, without considering the local human environment, any regional improvement plan shall end up with an

off-the-shelf, do-what-others-do type of scheme.
To say all new products and high-tech systems are universally adaptive is a supply-side politics that benefits producers and industry and compel consumers and users, and is becoming obsolete. Emerging thinkers recognize not only producers but also consumers have a part in environmental destruction. They see production and consumption as a cyclic system consisting of materials, energy, and the environment; and thus advocate an environment-conscious, recycling society. Both local and global societies can be sustainable only if new technology is transferred *eco-technologically*; that is, we adapt it in a way diversity of local human environments and their intrinsic values are well maintained.

## 6. Conclusion

Eco-Technology is a mother concept that germinates newer areas of study and concepts like Eco-Material and Eco-Balance. It is not merely an extension of ecological science and technology when we step toward a recycling society for the sake of sustainable development of human civilization. Eco-technological thinkers rather think all fields of science and technology in the context of the human environment where man is born, grows, lives, and forms the foundation of life— his/her individuality, locally intrinsic values, and standard for value judgment. The earth is a constellated mosaic of diverse cultures and value systems. Eco-Technological discipline is indispensable to let mankind prosper on the earth for eternity.

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## Figure Captions

**Figure 1. Science and Technology Paradigm until the $20^{th}$ Century.**
**(M) Materials (E) Energy ( I ) Information and Telecommunication.**

**Figure 2. Science and Technology Paradigm in the $21^{st}$ century.**
**(M) Materials, (E) Energy, ( I ) Information and Telecommunication, and (L) Life and Human being.**

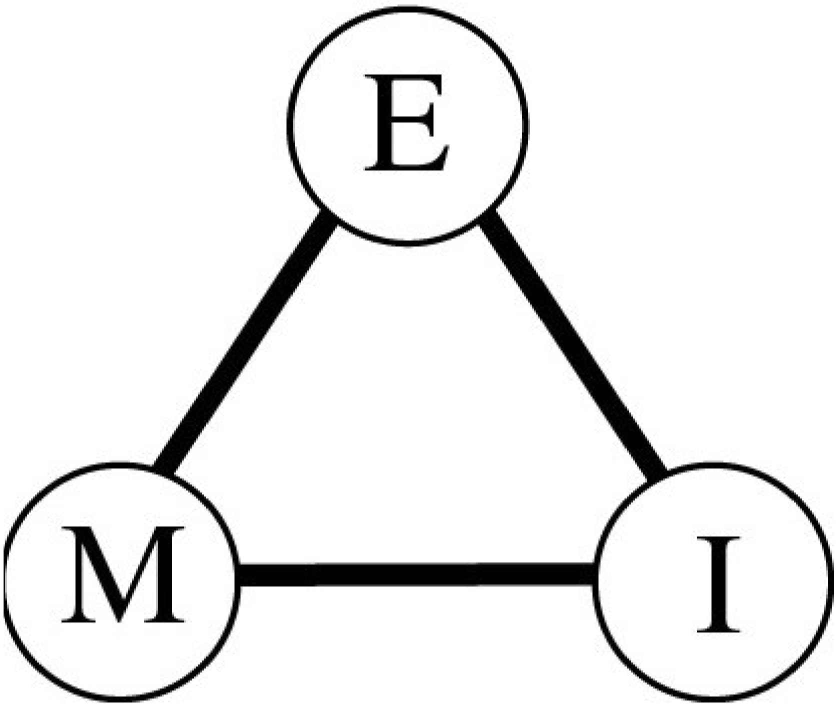


**Fig.1 Science and Technology Paradigm until the 20th Century.**
**(M) Materials (E) Energy ( I ) Information and Telecommunication**

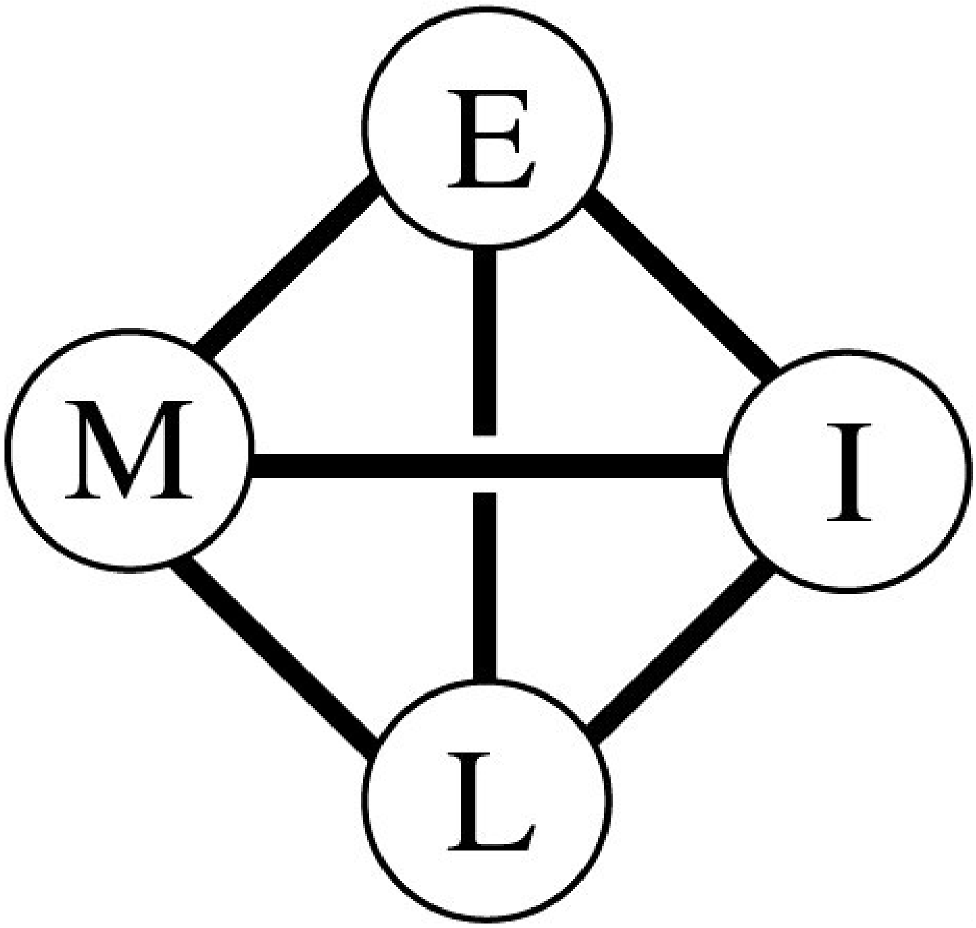


**Fig.2 Science and Technology Paradigm in the 21st Century.**
**(M) Materials (E) Energy ( I ) Information and Telecommunication**
**( L ) Life and Human being**

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## ABSTRACT

The long term aim of our research on "clean vehicle" is reducing pollution emission of in-used motorcycles in Vietnam to limits between EURO III and EURO IV standards. The project is carried out by two stages:

1. Utilization of LPG on motorcycles
2. Application of catalyst converter for post treatment on LPG motorcycles

The present paper focuses on the first stage of the project. For this purpose, an experimental study of combustion LPG-air mixture has been carried out on experimental engines. The result shows that this mixture can be burnt with very low equivalent ratio. The specific fuel consumption is reduced considerably at this limit. This is an important advantage of gas fuel for vehicles running in urban conditions.

For applying the result, a new bi-fuel system (LPG/Gasoline) has been studied and manufactured for adapting LPG on original gasoline motorcycles which are largely used actually in Vietnam. In the system, the LPG in gaseous state at 30mbar is used, no evaporator is needed and the mixture fraction at any regime of engine is controlled by a throttling valve and depression in admission manifold. The gas throttling can be made manually or automatically which allows the motorcycle to run with lean mixture at low load regime. The installation of new fuel system doesn't cause any change of the structure and outside view of the original motorcycle.

In case of necessity, the LPG/Gasoline motorcycle can be easily changed to run on gasoline by turning the fuel valve to gasoline position. Thus, this is comfortable for the users in the first step while the LPG supplying network is not largely installed.

The motorcycle running on LPG with the proposal fuel system has an emission reduction of about 80% of CO concentration and about 60% of HC concentration in comparison with original gasoline running. The durability of LPG motorcycles is better than that of gasoline ones since the gas doesn't wash away the lubrication film. The fuel consumption is tested with 50cc, 100cc and 110cc motorcycles. With 1kg LPG they can run from 90 to 120km depending on road conditions.

Application of LPG on motorcycles is thus an appropriate way to reduce pollution emission and fuel consumption for transport in Vietnam.

***Key Words:*** **LPG, bi-fuel carburettor, motorcycle, pollution**

## INTRODUCTION

In Vietnam motorcycle, main individual vehicles are more than 12 millions actually. According to the forecast, the automobile market in the country will not have an extraordinary develop in next decade. So the motorcycles will be continued in use for a long future. As the urban infrastructure in the country hasn't been well- developed, the motorcycles run usually at low load regime: high fuel consumption and serious pollution emission are thus as result. "Cleaner motorcycles" for these operation conditions is target of our research.

In recent year, many solutions have been applied for automobile for this purpose [1], while there are not many modifications relating to the motorcycle engines. In fact, because of small and compact engines, the advanced technologies applied successfully on automobile engines have difficulty in applying on motorcycles [5]. The application of electrical energy on motorcycles faces another difficulty relating to the batteries capacity which limits vehicles independent operation distances. Fuel cells are actually not practical because of the high cost. Utilization of hydrogen or natural gas NGV with high pressure gas cylinder is not convenient for small size motorcycles. Thus the most suitable solution is utilization of Liquefied Petroleum Gas LPG with catalyst converter for cleaner motorcycles [7], [8].

In fact, utilization of LPG for vehicles is now considered as an effective solution for urban air pollution in many countries. The transformation of gasoline car to LPG one is carried out easily thanks to the existent accessory kits (NECAM, LOVATO... accessories for example) [2]. There is no available similar kit for small cylinder motorcycles actually.

Since 2000, the Environment Protection Research Center has carried out a research project on "clean motorcycle". The long term aim of the project is reducing pollution emission of in-used motorcycles to limits between EURO III and EURO IV standards. The research is carried out by two stages:

1. Utilization of LPG on motorcycles
2. Application of catalyst converter for post treatment on LPG motorcycles

In the present work, we will focus on experimental study of lean combustion of LPG-air mixture and LPG kit to transform traditional motorcycles into LPG or LPG/gasoline ones [6]. The kit is simple, local manufactured, low cost, conserves the structure and outside of motorcycle. The new LPG system allows the motorcycles to run in appropriate regime for economizing fuel and reducing pollution emission.

The essential problem needed to be solved for gaseous fuel application on motorcycles is supplying the mixture with suitable fraction at any operating regimes. For small power engine of motorcycles, the fuel consumption is not quite important so that we can use the gas directly at gaseous state [6]. The gas supplied to the Venturie is adjusted by depression in admission manifold thanks to two vacuum valves one in gas hose and the other in the air one.

## EXPERIMENTAL STUDY

Study of combustion of LPG-air mixture is carried out on an experimental engine which have rectangular combustion chamber 68x34x47mm$^3$. The engine has two transparency windows for light access. The experimental apparatus was presented in our previous works [4].

Fuel supply is done by injection LPG in gaseous state into admission manifold or injection of LPG liquid state directly into the combustion chamber. The figure 1 shows evolutions of flame front and pressure in combustion chamber of the engine of lean mixture combustion. The recognized pressure is shown on the figure 2. The maximal pressure attaints 46 bars when equivalent ratio is 1.05 and it is reduced to 20 bars at lean combustion with $\phi$=0.6. Thanks to gaseous state, the mixture is more homogeny that allows the LPG engine to run with very lean mixture.

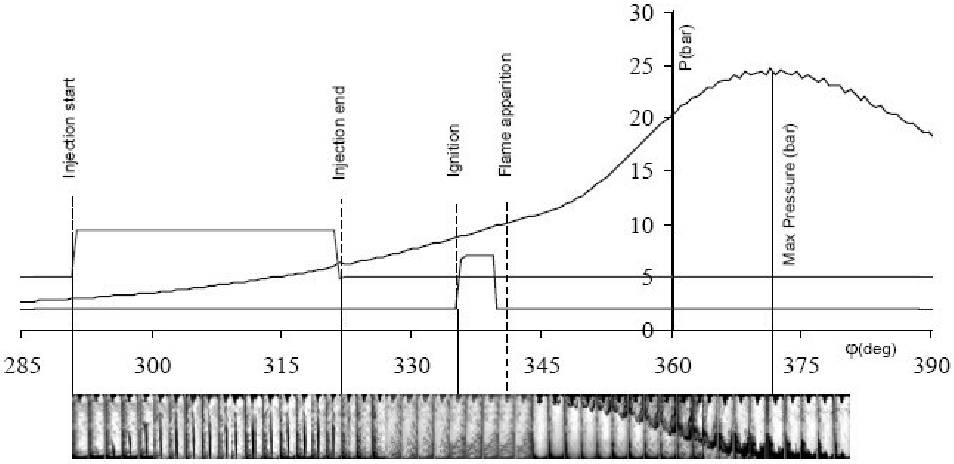


*Fig. 1: Evolution of flame front and pressure in combustion chamber of LPG experimental engine*

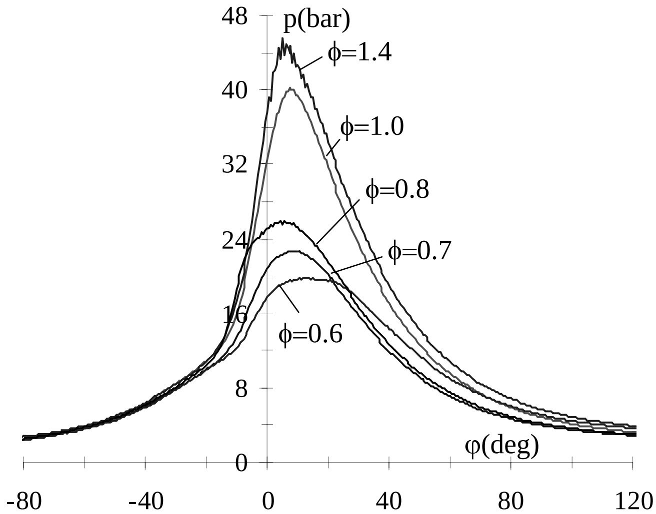


*Fig. 2: Effect of equivalent ratio on pressure evolution (n=1000rpm)*

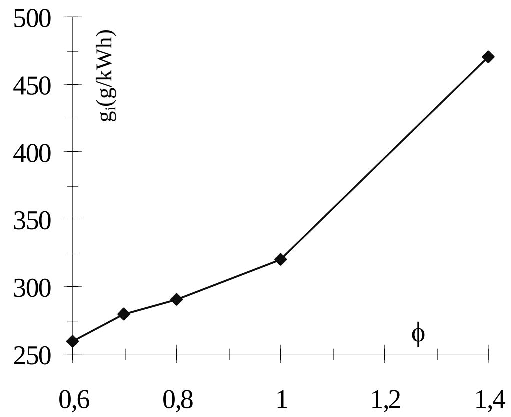


*Fig. 3: Effect of equivalent ration on fuel consumption*

Effect of equivalent ratio on specific fuel consumption is presented on the figure 3. The result shows that the fuel consumption is double when equivalent ratio changes from 0.6 to 1.4. This observation is very interesting in practice. In fact, the motorcycles in urban condition run most of the time at low load regime. With original gasoline carburettor, at this regime the mixture is very rich so that the fuel consumption and pollution emission are too high. In our research we try to solve this problem with our new LPG kit.

## PRATICAL REALIZATION

As we have mentioned, for reducing fuel consumption and pollution emission of motorcycles, the essential problem needed to be solved is supplying the mixture with suitable fraction at any operating regimes. In the LPG system of automobile, the fuel exits the reservoir in liquid state and then vaporizes in vaporizer/pressure reducer system. The gas pressure decreases to a value lightly inferior to atmospheric one. The LPG gas is then aspirated to the Venturie throat by depression as the gasoline carburettor. With this principle, the characteristic curves of LPG carburettor are similar to the gasoline one.

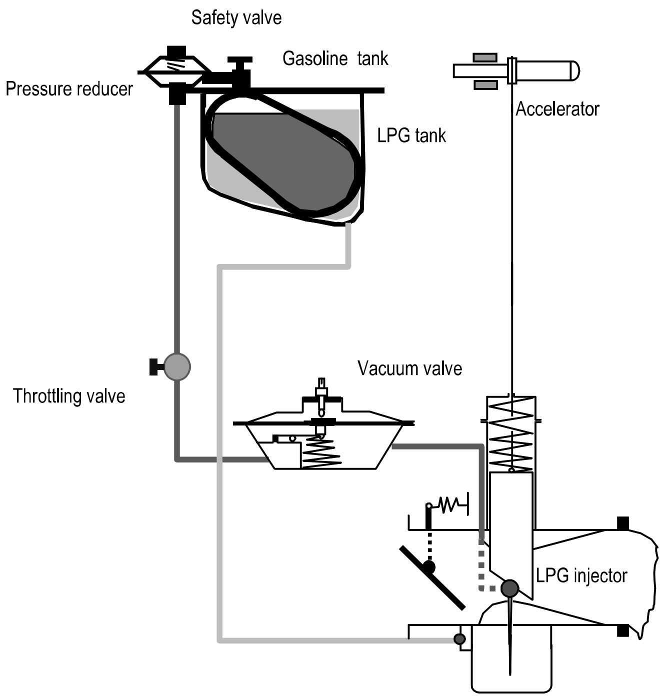


*Fig. 4: LPG/gasoline bifuel system for motorcycles*

For small power engines of motorcycles, the fuel consumption is not quite important so that liquid exiting LPG vessel may be the cause of an excessive fuel. Otherwise, the liquid LPG needs the vaporizer/pressure reducer, the cumbersome apparatus which will not be suitable for limited space of the vehicle. Thus the most suitable for motorcycles is supplying of LPG in gas state with pressure slightly higher than that of atmosphere [5], [8]. The gas supplied to the Venturie is adjusted by both the pressure in gas pipe and the depression in the Venturie. The figure 4 introduces the scheme of LPG/gasoline fuel system. Gas in injected in upstream of the throat via the vacuum valve and gas injector (fig. 5). The gasoline fuel system is no changed.

*Fig. 5: LPG/gasoline bifuel carburettor*

*Fig. 6: LPG/gasoline caburettor with automatic obturating valve*

In the idle regime, LPG gas

passes via the idle system with adjustment screw. When engine load increases, the valve opens gradually the gas supplying exit at the same time with opening of the air supplying section by the air valve device. LPG quantity, so that the mixture fraction, is then controlled by restriction in the valve and the depression in Venturie.

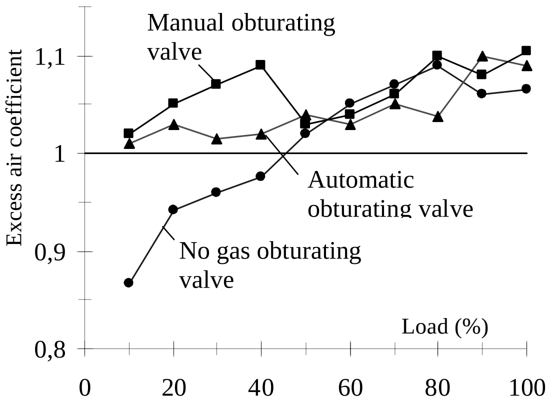


*Fig. 7: Characteristic curves of LPG carburetor*

With this system, the excessive air coefficient increases in function of load. For obtaining an appropriate mixture at low load regime, a manual obturating gas valve is installed in downstream of the pressure reducer. This can be obtained automatically by mounting the valve on guiding device of air controller.

The characteristic curves of the carburettor running with LPG are introduced on the figure 7. In case of no obturating valve, the excess air coefficient increases in function of load. The mixture is rich at low load but it becomes poor at high load. So, for a correct function at high regime, the engine performance at low load regime is weak. To improve this problem, we suggest two solutions:

1. Put a manual gas obturating valve downstream of the pressure reducer;
2. Install an automatic gas obturating valve on the guide pipe of gas control device.

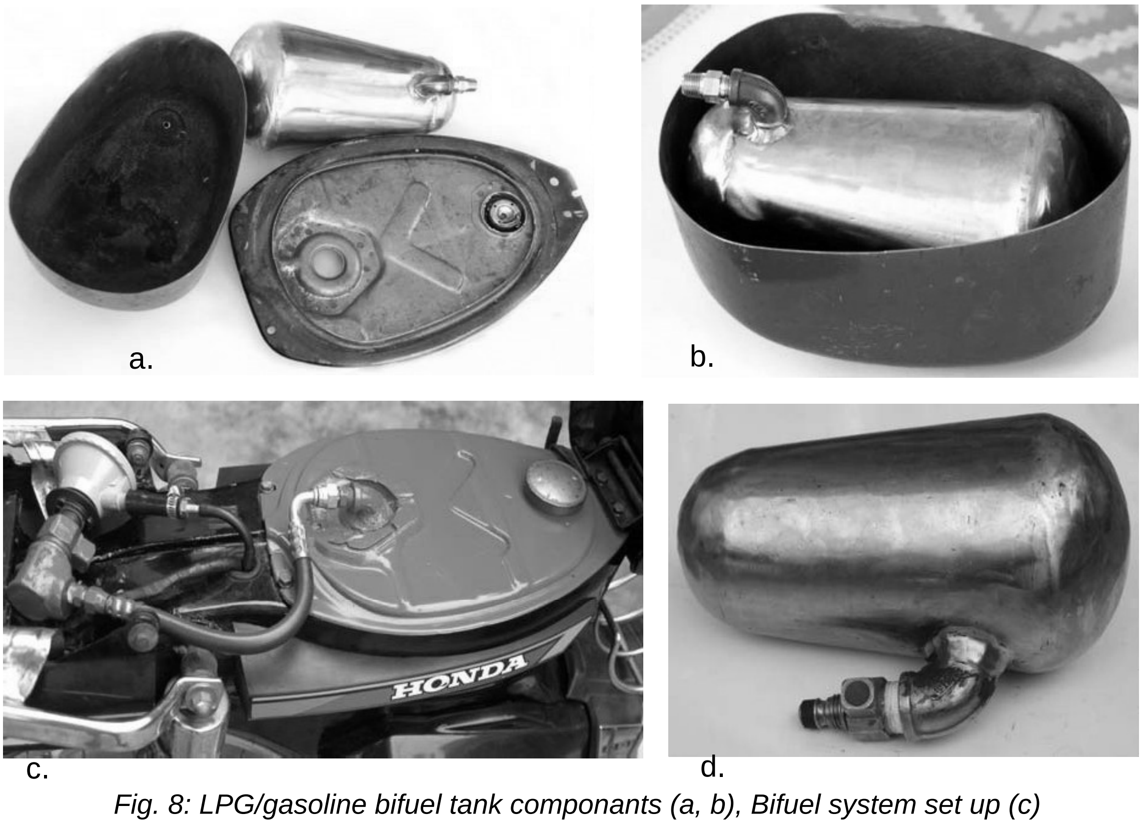


*Fig. 8: LPG/gasoline bifuel tank componants (a, b), Bifuel system set up (c) and LPG tank (d)*

In the second case, the fraction mixture is changed automatically with gas valve open. This solution is more expensive because of high precision of the manufacture of the obturating valve. For reducing the cost, the first solution in preferred. In fact the function of motorcycles can be resumed in two regimes: urban conditions and highway conditions. The drivers can change position of obturating valve corresponding to road conditions.


*Fig. 9: Different possibilities of LPG/gasoline bifuel system installation on motorcycles*

Basing on the principle, we modified the original gasoline motorcycle to bi-fuel LPG/gasoline motorcycle. Fig. 8 shows photos of a real LPG/gasoline tanks. The best solution is the “two in one” fuel tank where the LPG tank is put inside the gasoline original tank.

Figure 9 shows different possibilities of LPG/gasoline bifuel motorcycles. The structure and the style of the original motorbikes are preserved after the new fuel system has been installed.

## PERFORMANCE OF LPG MOTORCYCLES

The LPG motorcycle is tested on testing bench and on road with different operating conditions. The results are as following:

- *Pollutant emission:* Pollution analysis in different operation conditions shows that the CO, HC concentrations of LPG case are inferior than that of gasoline case. Pollution reduction rate may reach from 30 to 80%. Reduction rate is much more when engine load increased. The figure 10 presents the result of CO measure in exhaust gas of LPG motorcycle in comparison with gasoline case. When the engine speed increases, CO concentration in exhaust gas of LPG motorcycle decreases rapidly while it increases in gasoline case. At engine speed of 60km/h, the concentration of CO in exhaust gas of LPG driven case reaches only 25% of this value in gasoline driven case.

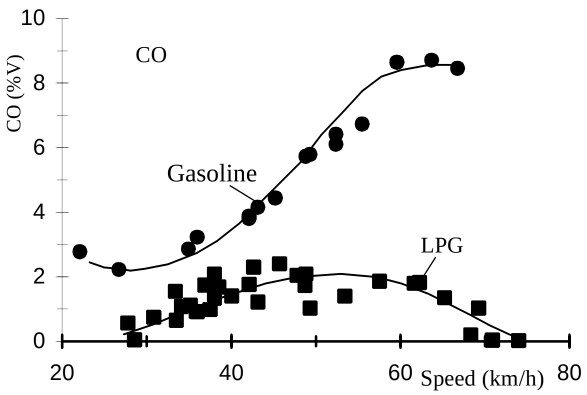


*Fig. 10: Comparison of CO emission in exhaust gas of gasoline and LPG motorcycles*

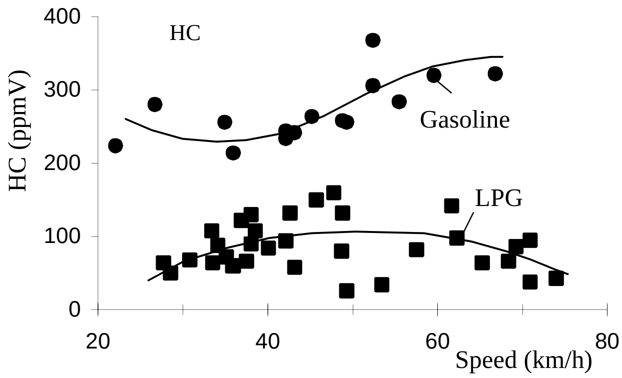


*Fig. 11: Comparison of HC emission in exhaust gas of gasoline and LPG motorcycles*

The figure 11 presents the comparison between HC concentrations given by gasoline and LPG running cases. At 50km/h, the HC concentration of LPG running case is about 50% the value given by gasoline running case.

- *Economy:* The fuel efficiency of LPG motorcycle is presented on the figure 12. The average fuel consumption is 1kg LPG/120km in comparison with 3 litters of gasoline for an 110cc cylinder motorcycle running in the same road conditions. The users' interest depends on the fuel price policy of each country. Some governments applied the special tax regime for LPG used for vehicles. In this case the km cost of LPG running case is much lower than that of gasoline running case. This policy encourages the utilization of LPG motorbikes so it is very significant for pollution reduction.

- *Engine power and longevity:* The power of LPG engines may be reduced to 10% in comparison with original gasoline engines if there is no modification of combustion chamber because of the reduction of volume efficiency due to gaseous state fuel. Since the octane number of LPG fuel is higher than that of gasoline, the compression ratio of LPG engines can be chosen higher. In this case, the engine power can be preserved.

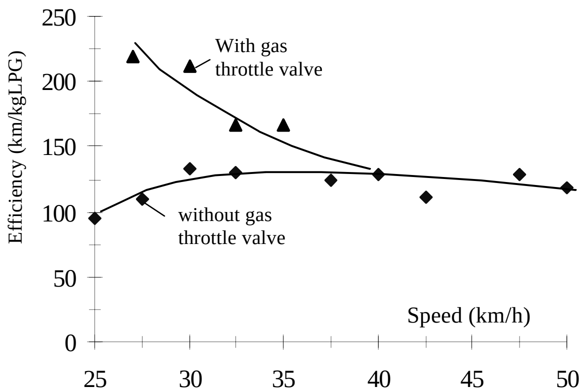


*Fig. 12: Fuel efficiency of LPG motorcycle*

The durability of LPG motorcycles is better than that of gasoline ones since the gas doesn't wash away the lubrication film on the surface of cylinder.

## CONCLUSIONS

The LPG motorcycle using the fuel system presented in the paper has many advantages in both environment protection and economic aspect. The application of this kind of vehicle will certainly reduce urban pollution in countries where motorcycle parks are important such as in Vietnam.

The application of this solution requires the establishment of LPG supplying network and it can be developed quickly if the Government applies a special tax policy to reduce the LPG price for transportation purposes.

*This work is funded by the National Fundamental Research Program, Project N$^o$ 320604*

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# Introduction of Future Study at the Honda R&D

**A Presentation for**
**The Honda Foundation Symposium in Hanoi**
**At 15:00 on February 28, 2005**

## 1. Introduction

We will look at the Honda R&D's approaches to environmental issues in the creation of new motorcycles. In essence, we have focused on how our powertrains can help overcome climatic change and energy issues, including prevention of air pollution and global warming as well as use of alternate energy source in the face of depletion of fossil fuel reserves. It is important then to develop a technology for cleaner exhaust gas; for lower $CO_2$ emissions through higher fuel economy; and for higher use of regenerable energy.

## 2. Efforts for Cleaner Exhaust Gas

For further purification of exhaust gas, it is important to adopt a fuel injection system. We at Honda have developed an electronically-controlled fuel injection system called the Programmed Fuel Injection (PGM-FI). The PGM-FI is a Honda's unique injection control mechanism that supplies engine with fuel at an always optimized air-fuel ratio. The ANF-FI is an example which adopts this PGM-FI system.

### 2.1 New Model "Wave125FI"

Motorcycles used to rely upon an injection carburetor system in which the carburetor supplies engine with fuel and air, using negative pressure resulting from reciprocating motion of engine pistons. Our "Wave125FI" model uses, instead, an advanced fuel injection system in which a pressure pump pressurizes fuel and injects it into the engine.

The PGM-FI for the new "Wave125FI" has five sensors for injection control. Each of them monitors and gathers control information including the state of engine operation, the state of outside air, and the rider's throttle operation to dispatch it to a computerized Engine Control Unit (ECU). The ECU then analyzes the information from the sensors; determines the best amounts of intake air and fuel to inject; and controls the timing of injection and ignition for optimized combustion.

The PGM-FI for the "Wave125FI" has three advantages:

- Fits with air-cooled engines;
- Fits with engines started by kick starter;
- Compact in size and simple in design.

### 2.2 Clean Exhaust Gas

The "Wave 125FI" equipped with the PGM-FI emits CO approximately 1/3, and HC+NOx 1/4 of the 4th Exhaust Emission Control of Thailand regulation figures, thus attaining a very high level of cleanliness. The figures are less than half of the 5th regulation figures to be applied in near future.

### 2.3 Fuel Economy

The "Wave 125FI" maintains the same level of fuel economy in ECE40 mode as the Wave 125, which has accomplished the remarkable improvement of fuel economy from the Wave110. By accurately controlling the fuel injection volume in the practical revolution ranges, the fuel consumption is reduced, attaining approximately 6% less fuel consumption from the current Wave 125 in the actual driving tests in Thailand. Meanwhile in Japan, we introduced this PGM-FI technology in March 2004 for the 4-stroke engine used in the "Smart Dio Z4 50cc" model. To install the PGM-FI in a small-sized engine, we reduced its size and weight and implemented a microscopic control of fuel flow rate. We also lessened the size and weight of the ECU, and adopted a 4-valve mechanism for the first time in 50cc scooter engine to optimize power.

## 3. Efforts to Improve Fuel Economy

We conduct active R&D activities in hybrid technology for motorcycles, four-wheel vehicles, and general-purpose engines. For motorcycles, we have developed a 50cc hybrid scooter prototype. This hybrid scooter's internal combustion engine and direct rear-wheel-drive electric motor function in two distinct modes. In "series" mode, the engine only powers the electric motor. In "parallel" mode, the electric motor assists the engine. This system has attained more than 160% higher fuel economy from the current scooter models.

### 3.1 "Series" Travel Mode

The "series" travel mode is used when rider travels on flat ground and high output is not required; thus, the engine just powers the electric motor. The scooter runs by electric power which is transmitted to the motor on the rear wheel from the engine.

### 3.2 "Parallel" Travel Mode

The "parallel" travel mode is used when high output is required. When accelerated, the hybrid powertrain supplies the engine with additional electric power generated through the regenerative-brake power generation mechanism, and thus helps save gas consumption.

## 4. Fuel Cell Technology

For its entire product areas, Honda has been working toward clean fuel cell powertrains in consideration of switching from fossil fuel to hydrogen as a future energy source.

### 4.1 Usability of Fuel Cell Motorcycles

Aiming to market a green, quiet vehicle like bicycle, makers of electromotive motorcycle reduce its size and weight for ultimate usability. Likewise, Honda aims to create a fuel cell motorcycle as usable as existing gasoline scooters. For this end, we have chosen a 125cc-class scooter, a mainstream commuter in the world, as a flagship fuel cell motorcycle. We have lessened the size and weight of the fuel cell stack by applying our fuel cell stacking technology developed for four-wheel vehicles. We have also applied a centered disposition of electric motor and control unit for a smaller and lighter body.

### 4.2 New Fuel Cell Stacking

In comparison with the four-wheel FCX-V3, the fuel cell stack for the flagship motorcycle has more than doubled the volume-power and weight-power densities. These ratios are the highest level in the world. For a fuel cell to work properly, conductivity must be maintained. To do so, the hydrogen, air, and coolant in each cell of a stack must be stringently sealed, and its lamination layer load must be kept at an optimal level. We have thus molded the sealed compartment with the laminated metal-pressed separators in a single mold while they are used to be assembled separately. The metal-pressed separators are elastic; and by laminating them, their lamination layer load becomes optimized throughout low and high temperature ranges.

In addition, the new fuel cell stack is easier to install because it has a simplified, panel-wrapped structure: We cut the number of parts in half by not using through-bolts and disc springs used to assemble the existing fuel cells.

### 4.3 Capability of Starting in Sub-freezing Temperatures

There are chiefly three reasons for the existing fuel cell vehicles to fail to start in sub-freezing temperatures:

- First, the conductivity of hydrogen ion used in fuel cell deteriorates below the freezing point because sub-freezing temperatures keep hydrogen ions from permeating the fuel cell's electrolytic films and thus fail to generate electricity.
- Second, the conductivity on the contact surface of the carbon separator deteriorates because its contact resistance intensifies as temperature decreases, and thus fails to transmit electricity effectively.
- Third, the fuel cell stack's warming ability was such that ionized water freezes before it warms the fuel cell up. Once frozen, the ionized water bars the fuel passage and hinders electricity to reach the fuel cell.

To overcome the first problem, hydrogen ions need to smoothly permeate the electrolytic films on the fuel cells. Against the shortcomings of the existing fuel cells whose conductivity deteriorates in sub-freezing temperatures, we have developed an "aromatic" electrolytic film whose film resistance is reduced in half of that of the existing electrolytic films and capable of working in a sub-freezing condition.

To overcome the second problem, the fuel cells must be stacked in series; otherwise, like in the case of the existing carbon separators, increasing contact resistance bars efficient transmission of power between fuel cells as temperature becomes lower. To beat these shortcomings, we have developed a metal-pressed separator whose contact resistance, 1/4 of that of the carbon separators, won't deteriorate much in a sub-freezing condition.

The development of the metal-pressed separator helps overcome the third problem: With this we succeeded in simplifying the structure of the fuel cell stack, which results in cutting warm-up time in 1/5 compared to the existing fuel cell stacks.

## 5. Future Goal: 30% Reduction in $CO_2$ Emissions

With our hybrid capabilities, we see a possibility to market hybrid vehicles with a 30% reduction in $CO_2$ emissions. In terms of electric and fuel cell vehicles, we can further reduce $CO_2$ emissions through higher efficiency in hydrogen production.

## 6. Conclusion

Honda will host various events and user-participating races in pursuit of better mobilization. We will also continue to put best efforts in technological and commercial R&D activities. Our motto is "Wise Fun." This should read: Share fun with our customers in an environmentally wise manner, both today and tomorrow. Thank you.

# Summary of SXSH Program

# Xuan Hoa Company

## Introduction

Name of company: Xuan Hoa Company

Address:

Headquater and Factory No.1:Xu©n Hoµ - Mª Linh - VÜnh Phóc

Factory No. 2 : CÇu DiÔn - Tõ Liªm - Hµ Néi

Tel: 0211.863244 Fax: 0211.863019

No. of staff : 932 people

No. of production units: 6 units

The company produces over 300 product types including bicycle parts, interior decoration products (i.e. tables, beds, wardrobe etc). Company's products are sold domestically and exported to many countries.

Value of industrial production: nearly VND 200 billion/year

Design capabilities: Office equipments such as tables, chairs, and cabinets of all kinds .

## Focus of evaluation

Automatic Ni-Cr 3 galvanization production chain

Static-electric painting system

Considering the application of SXSH at some stages of the production chain: galvanization chain, pressorized-air supply system, and water-consuming and energy-consuming stages that the company is focusing on.

## Implementation results

49 SXSH solutions have been proposed

Number of implemented solutions: 45
Number of solutions that need further analysis and study: 4
Number of solution unused: 0

Interior control: 28
Better process management: 6
Replacement of equipment : 3
Replacement of processes: 4
Circulation re-use: 4

# Implemented solutions

**I Automatic Ni-Cr 3 galvanization chain**

1.1.1. Close water valves at the end of the shift.
1.1.2. Adjusting water valves at appropriate levels.
1.1.3. Applying strict bonus-penalty rules to ensure proper operation according to regulation by workers.
1.2.1. Recover cooling water.
1.3.1. Recover circulating water at boilers or use for cleaning stage.
2.1.1. Adjusting hangers and hookers optimally for water draining.
2.1.2. Setting time for automatic controllers according to designs.
2.1.3 Controlling components of solution tanks to the standard level.
2.1.4. Hanging galvanized products at the right water draining place.
3.1.1. Improve the recovered amount by condensing recycled solutions and return to galvanization tanks.
3.1.2. Increasing the number of recovering tanks by changing unnecessary cleaning tanks into recovery tanks (sonic cleaning after Cr galvanization)
4.1.1. Adjusting the air-oil ratio in boilers.
4.1.2. Cooling drying ovens.
5.1.1. Similar to 1.1.3
5.2.2. Improving water treatment at the water tanks of the company.

# Implemented solutions

**II. Detail zinc galvanization chain.**

1.1.1. Changing to reverse cleaning mode.
1.2.1. Adjusting water valves at appropriate level.
1.2.2. Close water valves at the end of the shifts.
2.1.1. Adjusting hangers and hookers optimally for water draining.
2.1.2. Increase water draining time to > seconds10 (due to the fact that the system is manually operated, workers may move the hangers immediately)
2.1.3. Applying strict bonus-penalty rules to ensure proper operation according to regulation by workers.
2.2.1. Repairing and build new water recovery system between two tanks.
3.1.1. Replace the whole production chain.
4.11. Similar to 5.1.1; 5.2.1

# Implemented solutions

**III. Taiwanese static electric painting chain**

1.1.1. Changing to reverse cleaning mode.
2.1.1. Regularly checking chemical and water spaying valves of the surface treatment system.
2.2.1 Controlling components of solution tanks to the standard level.
2.2.2. Hanging galvanized products at the right water draining place.
3.1.1. Technical training and work ethics for workers.
3.2.1. Regular maintenance of painting guns.
3.2.2. Repairing automatic painting system.
3.3.1. Maintenance and upgradation of paint recovery system.
4.1.1. Good production planning to idle chains.
4.1.2. Switch off drying system and conveyor by the end of shift.
4.2.1. Training the workers according to the operation procedures.
4.2.2. Maintenance of equipments and control the burning process of the optimal drying oven..
4.3.1. Removing unnecessary and redundant system.
4.3.2. Maintenance of the whole conveying system.
4.4.1. Reducing the distance between two hangers.
4.4.2. Increasing the numbers of hookers.
4.5.1. Increase the length of the dryers.
4.5.2. Improve the cooling at places of high heat losses.
5.1.1. Install a new phosphatic solution spraying system.

# Implemented Solution

**IV. Pressorized air supplying system**

1.1.1. water cooling circulation system.

**V. Company level**

1.1.1. Improve interior control, implementing cost saving program in the whole company.
2.1.1. Improve the lake of whole company into high quality water treatment system to contain water for production.
2.1.2. Implement the water saving program in the company.
3.1.1. Study to re-use post-treatment drainage water for production.
4.1.1. Improve power supply system for the whole company.
4.1.2. Implement the power saving program in the company.

## Implementation results

**Total investment capital for SXSH program: VND 212.000.000**

**Total economic benefits from SXSH program: VND 1.176.427.115/year**

Reduction in water consumption 30%

Power savings 12,6%

Fuel savings 13,3%

Gas savings 9,3%

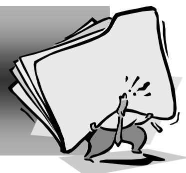
Reduction in chemicals used 3-5%

**Environmental benefits:**

Reduction in water drainage 30%

Reduction in emission ($CO_2$) 10%

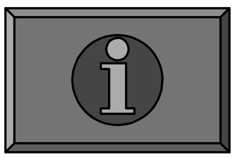
## *Lessons learnt*



Lessons and experiences obtained from SXSH program

Assistance from Vietnam Painting Production Center

(Written by the Company)



# Thank you

Dr.Nguyen Danh Son Co-chair-3 NISTPASS

Professor. Uchida gave an interesting and plausible speech. He introduced two concepts which may be new are "ecological technology and human environment". This version translated into Vietnamese is a bit different compared to English origin. In his opinion, ecological technology is not only link between technology and ecology but also includes changes in technology and science mode regarding to the human environment. Firstly, those changes in science and technology only include raw materials and energy and then also raw material, energy, information, informatic technology modes and finally, in 21st century, the last model is to focus on life of human beings and living quality regarding to worldwide sustainable development. With such interesting ideas, I hope there are questions evoked, please write down your full name, email address or office fax number so that lecturers can reply in the case we have no time to answer your questions right now.

Dr . Bui Van Ga's speech was very attractive and detailed with clear illustrations. Thank you Prof. Bui Van Ga's speech so much. Perhaps, you will agree with me that Dr. Bui Van Ga's presentation is a good example of the importance of technology innovation and improvement in contributing efficiently for sustainable development in Vietnam.

Mr. Horii's presentation was technical, we can easily recognize that behind the technical terms, his message is full with humanity, living standard, especially in the last sentence of his speech. I would like to repeat the slogan of Honda Corporation "Intellectually happy within research department of Honda Corporation" meaning that beside the technical specification, the approaches of Research and Development department is always related to others requirements that are how to make Honda Corporation consumers. I believe that this is a good demonstration of the concept of ecological technology mentioned in Professor Uchida's talk.

Mr. Doan Van Bang's speech is a detailed example in the specific case in Vietnam. It is a general strategy and a cleaner productive principle in a specific firm which contribute to environmental protection and economic advantages of a company in Vietnam. Once more I have to say that this speech is compiled with the help of Dr. Tran Van Nhan, Director of Vietnamese clean production center of Polytechnic University of Hanoi . We have completed 4 reports within the schedule time in the program. According to organizers 'idea, we would like to spend time to discuss. Unfortunately, like other parts, our time is limited right now. To guarantee the time for forum, I warmly introduce Professor. Kunio Nakajima. He will make conclusions of presentations and comment.

According to the forum's schedule, we have to discuss. However, we do not have time enough to discuss and it is the organizers to find ways to solve the problem in this part. To complete part III, on behalf of organizers, thank you 4 lecturers for outstanding speeches, participants and Prof. Kunai Nakajima, my co- organizer. Once more, we long for seeing all of you again to continually discuss these problems.

On behalf of organizers, I would like to give some remarks to close our forum. We have one full day of energetic discussion to complete successfully 3 sessions and have exchanged several crucial problems such as theory of Balance "Âm Duông" between negative and positive, Dong Du movement, cooperation between Vietnam and Japan in particular, Southeast Asia and Eastern Asia in general. We have also discuss problems at micro level on technology of how to manufacture motorbike in this forum. The main topics of this forum is about linkage between technology renovation and enterprises which is very necessary for all nations at any development level. It also indicates closed cooperation between Vietnam and Japan and between Asian economies in future. To follow this forum, as forum organizers we will finish all reports for printing and we will also discuss to exchange with you about our coming activities.

Finally, I would like to express our sincere thanks the for closed cooperation from our co-sponsor, Honda Foundation, to participants, and the organizers, especially the 6 members in Organizing committee who work day and night to make this forum successful. Without their efforts, our forum does not achieve this successful result. To our Institute, we would like to acknowledge Mr. Nguyen Vo Hung, Ms. Chu Thu Ha and Ms. Nguyen Phuong Mai and Mr. Toshio Ban, Mr.Yutaka Ishihara and Mr.Atsushi Sunami from the Honda Foundation who contributed to ensuring the success of this forum. By this, I would like to close this forum today. I wish you all will have a nice evening and enjoyable coming days in Vietnam.

## Kunio Nakajima’s Summary (Session 3)

Hello, I’m Kunio Nakajima. Unlike previous two sessions prior to this one, four speakers talked in more specific topics. You can see environment and energy construct their chief concern.

As Dr. Uchida pointed out, the last hundred years called the 20th century brought us a very good living thanks to mass production of new materials, mass consumption of energy, and the advancement of computerization. In exchange of better life, however, we’ve lost something — something that makes us human. You can name it the integrity of human soul. In a broader picture, science and technology in the last century made our lives convenient, but the other side of coin was mass destruction of nature and human life in which Vietnam was one of the biggest victims. We should not forget about widening of the income gap. Many speakers today mentioned poverty. Poverty is not an intrinsic issue of poor countries; rather, expanding income disparities entail it.

We have a full line of issues. The issue of war — how we can abolish or reduce it — is always discussed in the international community through multinational organizations like United Nations. And after the Environmental Summit in Rio 1993, environment and poverty concerns became a very serious challenge for UNEP, UN Conference on the Human Environment, and other world organizations.

Speaking of my country, fortunately 90% of Japanese people identified themselves as a middle-class person 30 years ago. Those days were a happy age — we bought as many natural resources as we could afford and discarded them without hesitation. Our 90% happiness relied upon the extravagance of resources and the damage to the environment.

We then took on antipollution and environmental measures to solve these issues. This is a background of the auto industry’s efforts as mentioned today. Sentiments of all other industries in Japan also are inclined for 3R’s — Reduce, Recycle, Reuse. We all promote rationalization and efficiency in the production process with less raw materials, energy, and wastes. Similar trends can be found all around the world.

There were two different stories of scooters. First, I felt the LPG-gasoline bi-fuel motorcycle which Professor Ga from Danang University of Technology introduced to us would be a highly innovative product once it comes onto the market. Although technical details are not to my knowledge, this bi-fuel engine is quite something: This is a good example of local adaptation of technology that our discussions since this morning suggest; that is, it suits the regional economic situation and expertise in Vietnam. Probably this topic alone deserves several or more hours of discussion.

Secondly, Honda engineers from Japan introduced an advanced motorcycle that runs on hydrogen energy. We have seen they have tried various options and reached a fuel injection system with the highest combustion efficiency that can produce the best mileage.

The last section was about a wastewater treatment system in the coating and galvanizing plants. The treatment of vast quantities of wastewater has been also a longstanding problem for Japanese companies, especially small manufacturers. Academic-industrial alliance teams were formed. They are overcoming it through the reduction of pollution load, for example, by using a smaller amount of water, recycling and reusing wastewater. As the coating industry must use nickel and chrome, the alliance teams then developed an environmentally benign technology not discarding the waste of used nickel and chrome outside the plant. Currently used in many sites in the world, as I hear, this technology becomes a new export item from Japan.

When asked what they expect in the 21st century in various surveys, most of the Japanese respondents name three things: Suppression of environmental catastrophe, avoidance of energy crisis, and personal health. These are not Japan-specific but universal concerns in the modern world. All the four lectures in the last session were about such universal concerns, and I learned a lot from the insights of the experts. Although my summary may be rough and insufficient, I am proud being here to have shared these wonderful discussions with you. Thank you.