# STRATEGIC ASSESSMENT OF INDONESIAN TECHNOLOGICAL POLICY: AN ANALYSIS FROM TECHNOLOGY TRIANGLE FRAMEWORK

**by**

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Submitted to the Alfred P. Sloan School of Management and the School of Engineering in Partial Fulfillment of the Requirements for the Degree of

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ABSTRACT

It is well known that technology is closely related to economic growth in the long run. From perspective at firm level, having technological advantage means to be more effective and competitive.

In the last of thirty years, Indonesia has successfully develop its nation and achieve high economic growth. Along that development process, they also have been building technological capability. Despite of their serious effort to build such as "strategic industries" scenario and recently several competitive research schemes, however the linkage of R&D activities to industrial needs is remaining unclear. It is imperative to have a new framework which put more focus on proceeds technology transfer into industries. In the more fundamental way, they need to create strategic interaction between the provider, the source of knowledge, and the channel to market. The objective of this thesis is to assess Indonesian Technology Policy using Technology Triangle as framework.

Through comparison from SEMATECH and HAN Project, and understanding that effective Technology Triangle needs certain environment conditions, the proposed recommendation are addressed to "off the self" the available technical information and research consortia, and to incentives to "up-front financing" in order to involved in R&D activities.

Thesis Supervisor : Nazli Choucri

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## TABLE OF CONTENTS

**List of Tables and figures**

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In addition, special thanks to my family way down there in Jakarta, Indonesia. Their support was really the most valuable thing that supported my education at MIT. Thanks also to my colleagues at the Bureau for supplying much data for this thesis. Moreover, most of my ideas about the need to have a "real" technology policy emerged from discussions with them.

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## GLOSSARY

**BAPPENAS**. Badan Perencanaan Pembangunan Nasional, or National Development Planning Agency.

**DoD**. Department of Defense (U.S.).

**FDI**. Foreign Direct Investment.

**Fiscal year**. Starting from April 1 to March 31 the following year.

**GDP**. Gross Domestic Product

**GOI**. Government of Indonesia

**HAN**. Highly Advanced Nation.

**HDTV**. High Definition Television

**IPTN**. Industri Pesawat Terbang Nusantara or Nusantara Aircraft Industry.

**IPRs.** Intellectual Property Rights

**MOS**. Metal Oxide Silicone.

**NRC**. National Research Council.

**OSMRT**. Office of the State Ministry of Research and Technology.

**REPELITA.** Five-Year Development Plan.

**Rp**. Rupiah, the Indonesian currency. 1 US$ = Rp. 2,450 (May 1997)

**SEMATECH**. Semiconductor Manufacturing Technology.

**SRC**. Semiconductor Research Corporation.

**UNCTAD**. United Nations Conference on Trade and Development

# *Chapter 1*

# INTRODUCTION

For the last thirty years, Indonesia has been enjoying stable and high economic growth. In such a process, Indonesia has changed from an agricultural country to become a newly industrialized country. From advanced countries' experience, the pace of the industrialization process is closely related to the extent of its technological capability. Technological development and technological policy, in turn, have become more important to Indonesia than before. Despite its rapid industrialization,there is a need to rethink regarding the direction of technological policy, specifically the linkage between research and development (R&D) activities and industrial needs. Given the complexity of technology and industrial nature, it is not easy to find a generic solution to improve this linkage. Rather than finding one general answer, this technological challenge can be broken down into a few questions. How can we transform R&D activities into industrial advantage? What are the elements of such linkages? How is the national strategy to improve it?

Understanding the importance of such a linkage in the next round of technology development in Indonesia is the basis of this thesis. A new framework of analysis will be used in order to suggest the next Indonesian technology policy. This thesis will provide a strategic assessment of the next Indonesian technology policy using the Technology Triangle as a way to improve linkages among the main technological actors in Indonesia.

First of all, what's the role of technology on economic growth? The impact of technology in economic growth can be best described from a macro-economic point of view. In his highly influential work, Solow found out that technological change has a very significant impact on economic growth[1]. Despite this seminal work, there's no explanation on how to achieve effective technological change.[2]

Moreover, other prominent economists, Robert E. Lucas and Paul Romer, have been trying to explain the role of technology more clearly instead of relying only on its exogenous characteristic. They have identified the importance of new ideas in producing new goods as a potential source of growth. Consequently, it is necessary to support ideas generation. Patents and copyrights will be looked as reinforcing efforts to secure these new ideas. In different ways international trade also plays an important role. New products introduced in one country can generate new ideas and innovations. Moreover, technology embodied in these new products also, in turn, allows a better production process.

Finally, focusing on macro-economic theory raised the following fundamental question, What scope of policy implications should be inferred? Gordon summarized these implications as:

> The conclusion is that faster growth is associated with a higher rate of government consumption by either the private or government sector, a lower share in GDP of government consumption spending, higher school enrollment rates, ....
>
> ... The implication ...is that government policies can affect growth rates by taxing consumption, **subsidizing investment and research**, and shifting government consumption to government investment.[3] (emphasis added)

In other words, if one country wants to gain faster growth, the government should put more attention on R&D investment. Yet if the role of government in technology capacity is bigger than the private sectors, the impact of policies is even more complex. Not only as regulators, but also their R&D institutes or laboratories might go down deeper as significant players.

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[1] Gordon, 1993, p. 358 - 363. Education, research, innovations, and other improvements are included in technological change.

[2] Technology was considered as an exogenous factor, something that influences the system yet comes from outside it.

[3] Gordon, p. 363.

Nevertheless, the role of government and its policies lay as one of the fundamental issues of the concept of technological policy.

Countries around the world have been using "technological policy" as a tool for a part of its development process. Specifically in the case of Indonesia, Hal Hill believes that technology policy and development are important in the future.[4] First, Indonesia still and will continue as a net technological importer. There's a necessity for Indonesia to absorb, assimilate, and utilize the inflow technology effectively. Second, the Indonesian export trend also will likely continue to increase. Current Indonesian export are mainly based on endowments such as low wages and natural resources. Conversely, it will face strong competition in the future from other developing countries such as Vietnam, China, and India who have the same endowments. A stronger technology base then becomes imperative in order to maintain the export growth. Third, closely related to the previous issue, such technological capacity should be supported by the appropriate level of skill and technology of human resources. Finally, he also emphasizes that the government's major role will continue in the future. Yet the allocation of this government resources allocation will have significant impact on the Indonesian technology policy.

## Indonesian Development

In terms of its area, Indonesia is one of the biggest countries in the world. It is also the largest archipelago on earth, which consisting of 17.508 islands. From East to West, roughly it is almost the same distance as from the East to West coast of the USA. The Indonesian population now is surpassing 200 million and people are concentrated on the five biggest islands. About 60% of this population live in Java and make it the most densely populated island in the country with 814 people/km$^2$.[5] There are more than 300 ethnic groups widely distributed among many

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[4] Hill, (1995), p. 84.

[5] Central Bureau of Statistic, 1995, p.26, 27. This number includes Madura, a smaller island close to Java.

islands throughout the Archipelago. As a big country, it also has huge natural resources such as oil, copper, marine, and its rain forest area is second after Brazil.

Because it has a remarkable record of high growth, the World Bank has categorized Indonesia as the one of the eight "High-Performing East Asian Economies" (HPAEs). This area is growing faster than all other regions in the world. These so-called "East Asian Miracles," the World Bank concluded, have common ways to achieve such excellent growth, which are maintaining a high level of investment and accumulating human capital.[6] Finally in the case of Indonesia, such growth also was supported by serious effort to reduce population growth.

Regarding its development planning, Indonesia has divided its plans into a Five-Year Development Plan (REPELITA).[7] Since REPELITA I was started in 1969, five REPELITAs have been finished. Now, they are extending this plan to REPELITA VI starting from 1994 to 1999. The very basic concept of Indonesia's development aims to achieve the so-called "Development Trilogy," which is economic growth, equity, and stabilization. In addition, Science and Technology sector has become one of the national priorities in the REPELITA VI.

## Technology and Industrial Development

Many transition countries, including Indonesia, have chosen industrialization as their prime mover of economic growth. Technological change is also well known as the factor behind productivity and in turn economic growth. Yet the solution or process is not as easy as pushing technology to the envelope. Many other aspects should be taken into account. One aspect is, since industrialization levels vary from country to country, the level of technology capability varies as well. Another aspect is endowment factors such as natural resources as a source of comparative advantage. In short it is required to develop technology that is "tailored" to specific

[6] World Bank, 1993, p. 5.

[7] The highest body in the Indonesian legal system is the People's Consultative Assembly, and every 5 years the define the so-called "Guidelines to State Policy" that set the general objective of the next five year development. Basically REPELITA is the implementation plan to achieve the objectives.

development needs and resource availability. This tailoring process is not so easy for developing countries. They have other barriers such as limited human resource capability, amount funds, and inadequate facilities which make it more difficult to build technological capability. Beside that, they also face difficulties in recognizing the market needs.

Regarding the connectivity of technology and industry, the goal is straightforward, especially to transform technological knowledge into industrial outcomes. The next task is to perform institution arrangement as a frame to solve the problem effectively. Consequently, important aspects will be the characteristics and interrelationships of such institutions to ensure the direction of research activities and their effective spill over. Within such a framework the "Technology Triangle" concept emerges. It shapes three nodes: (1) the source of knowledge which produces the possible technology; (2) the potential users of technology who transform it into real outcome; (3) the facilitator, which ensures that the mechanism will work under certain ways of governance, specifically promoting the utilization of technology.

It's obvious that the implementation of the Technology Triangle will depend on a specific country's problems and institutional arrangement. Since its success depend heavily on how the interplay works among those three nodes, the Technology Triangle should be conducted effectively within the common goal e.g. national needs, sustainability of the relationship to achieve competitiveness, and specifically to facilitate technological transfer. Experience from industrial countries shows that an effective Technology Triangle can play an important role in increasing competitiveness, innovative capability, and help technological changes happen. Hence it is necessary to use the Technology Triangle as a part of industrial development. In another words, it is essential to put the Technology Triangle as national priorities.[8]

[8] This Technology Triangle part relies heavily on Choucri, 1994, and endorsed by UN Commission on Sustainable Development in 1995 (UN, 1995).

## Overview of the Thesis

This thesis is arranged in seven chapters. In this thesis, I choose the Technology Triangle as a basis for an alternative framework for Indonesian technological policy. Accordingly, the analysis presented in this thesis starts from the performance of Indonesian economic development, focusing mainly of industrial development as the engine of growth. Given the current condition, the next challenge facing this development process will be discussed. Since the main pillar of economy is trade, the last section in Chapter Two also includes the aspect of competitiveness. In this section, I include literature of review of the determinants of competitivenessas well as the role of technology to enhance industrial competitiveness.

The third chapter will be a talk on technology policy in Indonesia. Moreover, I will show the different approaches of Indonesia's technology policy, between the "strategic" industrial policy that emphasizes the importance of choosing particular industries to boost technological advancement; and the new "R&D policy" that emphasizes the establishment of an R&D system. Developing countries usually have a generic problem, technology and industry are often fragmented. This problem also happens in Indonesia, and it brings into the central issue of this thesis, the concept of the Technology Triangle as an alternative to current research "schemes."[9] The Technology Triangle explains the importance of making good relationships with the main three actors of technology policy, which are government, industry, and the university or public R&D institute.

It is obvious that the Technology Triangle is not a single system. It is a part of the technological policy. Hence discussing the theoretical framework of technological policy is inevitable. In Chapter Four, two theoretical frameworks of technology policy based on neo-classical economic theory will be given, the Bell and Pavitt's model, and the UNCTAD. Moreover in

[9] Research policy or program usually in the form of a set of mechanisms such as certain procedures, goals, actors, and so on. Instead of using the word "research institution" (which practically means certain rules) to explain the policy, I prefer to use "scheme."

Chapter Five, the experience of U.S. and Korea will enrich the idea of how the Technology Triangle can be applied in different ways.

In applying the Technology Triangle, the issue of institutional arrangement matters. Chapter Six will discuss mainly what kind of institutional arrangements should be performed in order to make it work effectively. After discussing technology policy, especially the Technology Triangle, this thesis will invent with some key policy recommendation.

# *Chapter 2*

# INDUSTRIAL DEVELOPMENT

## The role of industrial development

### *Indonesia's Economic Performance*[10]

Since REPELITA I was initiated, a continuation of serious efforts to improve economic performance has become a prime national goal. Over the past decade (1985 - 1995) it has had 7.1 percent average GDP growth. Moreover, in the last few years economic growth was higher than that average number. The growth rates for 1993, 1994, 1995 were 7.3 percent, 7.5 percent, 8.1 percent respectively. In fact, it's one of the highest economic growth rates in the world. In contrast, in 1993 population only grew at 1.73 percent. This is an indication that wealth per capita increased significantly. Compared to other parts of the world, developed countries achieved 2.1 percent economic growth in 1994, and the average growth of the developing world was 5.9 percent in 1995. Some highlights of the Indonesian development performance is shown in Table 1.

Throughout the last four decades, Indonesia has been applying many economic policies. Pangestu has divided Indonesian economic development into several periods. Certainly in Table 2, there was a time when Indonesian economy used to be dependent on oil and natural gas as its biggest export commodity. Yet along the development process the figure of oil export contribution decreased from about 75 percent a decade ago to 22 percent in the fiscal year 1995/96. Oil and gas are no longer the prime commodities.

[10] The data from this section relies heavily on GOI, 1996, p. I/4 - I/5, and World Bank, no year.

TABLE 1. INDONESIAN DEVELOPMENT PERFORMANCE[11,12]

| | 1970'S | 1990'S |
|---|---|---|
| Population | 119.21 million (1971) | 179.38 million (1990) |
| Population growth | 2.4% (1971-80) | 1.6 % (1990-95) |
| Life expectancy | 46.5 years (1974) | 63.1 years (1995) |
| GDP per capita | $70 (1968) | $980 (1995) |
| Poverty | 40.1% (1976) | 13.7% |

The turning point began when the oil price declined in the 1980s. Consequently Indonesia started to apply various deregulation policies, which in turn triggered high economic growth and specifically the private sector development. As a part of this growth process, foreign direct investment (FDI) also played an important role and increased sharply. The government of Indonesia has perceived that FDI provide a source of capital needed for its development.

In addition, poverty proportion has also successfully been reduced from 60 percent in 1970 to 14 percent currently. In sum, Indonesia has achieved broad-based growth and high GDP growth, along with improved social welfare conditions, and significantly reduced poverty.

Given the current economic performance, World Bank recommends that Indonesia should give more attention to these particular macro issues[13]:

- *maintaining the high economic growth with macro stability and enhancing competitiveness.* Given that the economy is undergoing transformation, which in the sense of competitiveness it's shifting from cheap labor and raw materials to technology and high skills to improve efficiency and productivity. Future growth looks promising as long as the government continues to deregulate, especially to attract foreign and domestic investment.

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[11] Hill, 1996, p.

[12] BAPPENAS, 1995, p. 1, 8, 21, 29

[13] World Bank, no year, p. 2 - 3

## TABLE 2. ECONOMIC POLICY CHANGE[11]

| Period | Change in External Environment | Macroeconomics Policy | Trade and Industrial Policy | Ownership and Government Regulation |
|---|---|---|---|---|
| 1958-65 | | Growing instability and ending with hyperinflation; foreign exchange control | Strongly inward oriented | Nationalization; state dominated economy; strict control over private domestic and foreign investment |
| 1967-73 New Order Rehabilitation and Stabilization | | Successful stabilization, open capital account | Moderately outward oriented (beginning of import substitution policy) | Liberalization of domestic and foreign investments, some rationalization of state-owned enterprise (SOE) |
| 1974-81 Oil Boom | Sharp increase in oil prices 1973, and non-oil commodity boom 1973-79; second oil prices 1979 | Maintenance of macroeconomics stability, although some inflation from lack of sterilization of oil revenue | Growing inward orientation (increasing import substitution) | Increasing share of public investment and SOE; growing restriction on foreign and domestic investment |
| 1982-85 First External Shock | Decline in oil prices; decline in primary commodity prices | Macroeconomics stabilization; fiscal austerity, devaluation and tight monetary policy | Strongly inward oriented, proliferation of non tariff barriers | Continued reliance on SOE and regulation on market economy |
| 1986-88 Second External Shock | Sharp oil price decline and continued decline in primary commodity prices; Yen appreciation; shock on eternal debt | Continued macroeconomics stabilization; devaluation, tight monetary policy and balance budget | Shift to outward oriented economy | Deregulation of custom and imports, relaxation of foreign and domestic investment regulations; reduced reliance on SOE and public investment |
| 1988 - now Non oil led Recovery | Stable oil prices; further decline in primary commodity prices | Maintenance of macroeconomics stability | Further shift to outward oriented economy | Deregulation extended to investment, finance, maritime and other areas; initial steps toward SOE reforms |

- *promoting greater equity and enhancing human resource development.* Even though the development process has reduced the amount of poor people, there're still 28 million people

[11] Pangestu (1996), p. 153. This periodization also will be discussed in the next section

who live in absolute poverty. Other important issues are providing proper education, and health service.

- *managing resource sustainability.* As the economy grows and the industrialization process goes on, pressure on the environment also increases. Environmental protection should get more emphasis in the future.

### *From an Agricultural to an Industrial Country*

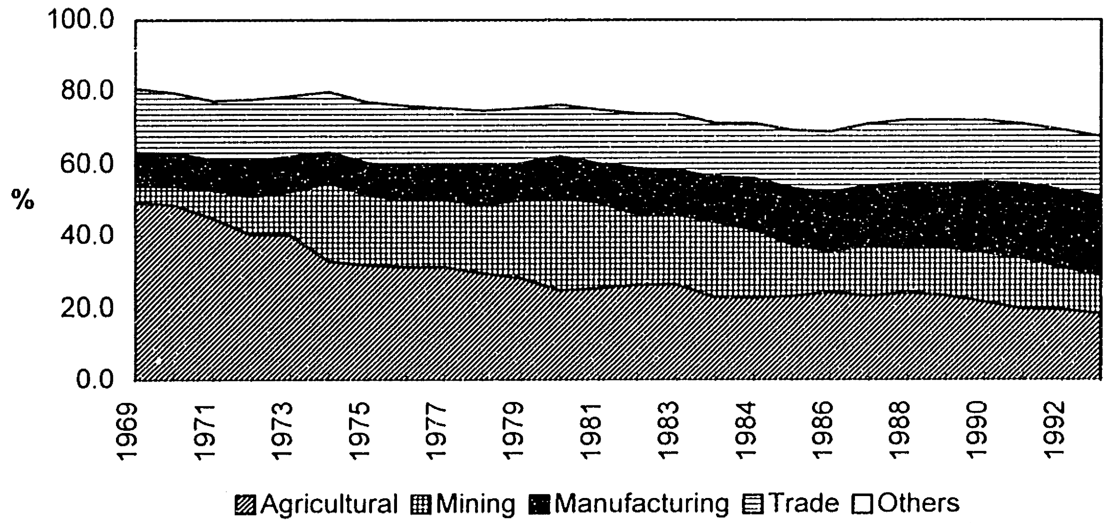
Traditionally, Indonesia was an agricultural country. Yet its economic growth has changed the Indonesian economic structure. In fact, agriculture is no longer the engine of growth; its role has declined significantly. On the other hand, the role of manufacturing has been increasing continually. Figure 1 gives the major contributors to the GDP.

Certainly Figure 1 implicitly explains another aspect of Indonesian development, the shift of the sectoral focus. Put differently, it also explains the transformation in Indonesia's economic structure. It's clear that in earlier years, the focus of national development was to increase agricultural output. Once agricultural development was secured, the mining sector successively took its role, the so-called "oil boom" period. In sum, in these periods endowment factors such as fertile land and natural resources have become the engine of growth.

Similarly with the declining role of agriculture, Indonesian population structure also has changed considerably. The composition of rural population declined from 83 percent in 1970 to 69 percent in 1990. In contrast, the composition of urban population was increased from 17 percent (1970) to 31 percent (1990).

The most important thing happened when the oil price crashed in the middle of the 1980s. At that time, the Government started to deregulate the economy particularly to attract investment but also to promote exports, specifically non-oil goods exports. This extensive program has reduced the dependency on oil and gas as the prime export commodities very significantly. On

FIGURE 1. SECTORAL CONTRIBUTION TO GDP[15]




Note : Current price. Year before 1983 based on 1973 price. Year 1983 and after used 1983 price.

the other hand, such regulation triggered another hallmark of Indonesian development, the rise of manufacturing industries.

The contribution of manufacturing industries to the GDP has increased from 12.7 percent in 1983 to 21.0 percent in 1990, or a 69-percent increment within 7 years! Within the same period, "others" contributors' share also increased from 26.4 percent to 29.2 percent.[16] Combining these two industrial groups, hence industrial share also increased by 11.1 percent, from 39.1 percent in 1983 to 50.2 percent in 1991. In short, Indonesia has became a newly industrialized country. Put differently, Indonesia now is undergoing economic transformation. Industry itself now is the engine of growth and accounts for more than half the GDP.

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[15] BAPPENAS, 1995, p. 37.

[16] "Others" contributors are construction, transportation and communication, banks and similar institutions, housing rents, government and security, services, and utilities including electricity, gas, and drinking water. Combined with manufacturing, it can be called industry in a broader sense. Actually the number can be higher since trade also includes hotel and restaurant which also can be belong to industry.

It is very interesting to go deeper into the manufacturing industry and find out what kind of transformation is happening there. In the sense of technology capacity, industry can be divided into high, medium, and low intensity. High-intensity technology are pharmaceutical, machine and turbines, office equipment and computer, radio, TV, communication devices, aircraft, and scientific instruments. Medium-intensity technology includes basic chemical, electric and non-electric machinery, cars, and non-basic chemical. Food and beverage, textile, paper, non-metal mineral, basic metal, ship, other equipment made from metal excluding machinery industries are low-intensity in terms of technology capacity.

First, the composition of those kinds of industries is shown in Figure 2. Since 1985 manufacturing output has been dominated by low technology, particularly food and textile products. The high growth of low-intensity technology industries implies that industrial competitiveness is still based on cheap labor instead of high and skilled labor. Interestingly, the contribution of each kind of industry remains the same as shown in Table 3. This "monotone" fact implies that even though manufacturing industries grow, in fact there's no transformation in the structure.

Finally, such rapid industrialization and skewed technology structure raise important questions, What will be the challenge in the future? Why has the total manufacturing contribution to the GDP increased dramatically and is enjoying high growth while the structure of the industry is still the same? It is an indication that the level of technology did not increase vertically but has spread horizontally.

## The Next Challenge for Industrial Development

### *Globalization and Free Trade*

The world economy in the last two decades has been facing a dramatic change. The globalization of the market is at hand. A worldwide transformation process is driven by trade and capital market liberalization, globalization of corporate production and distribution, and technological changes that are quickly eroding international barriers and allowing bigger goods, services, information, and capital flows.

The impact of this globalization process is enormous, and every country has to deal with it. The nations of the world are becoming increasingly open and interdependent. The impact is liberalization reducing the "autonomy" of any government in applying its policy, specifically industrial policy.

FIGURE 2. MANUFACTURING OUTPUT[17]

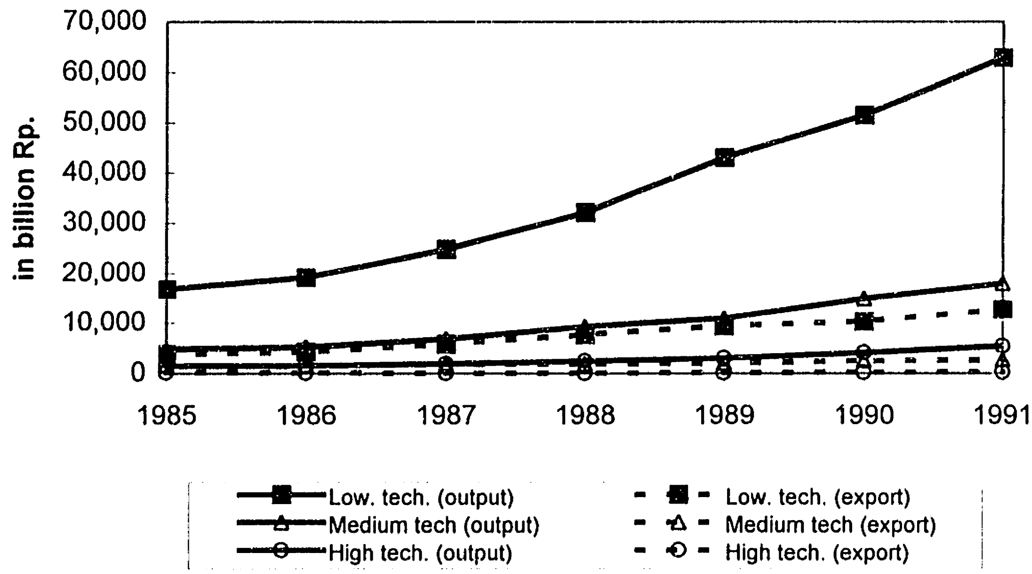
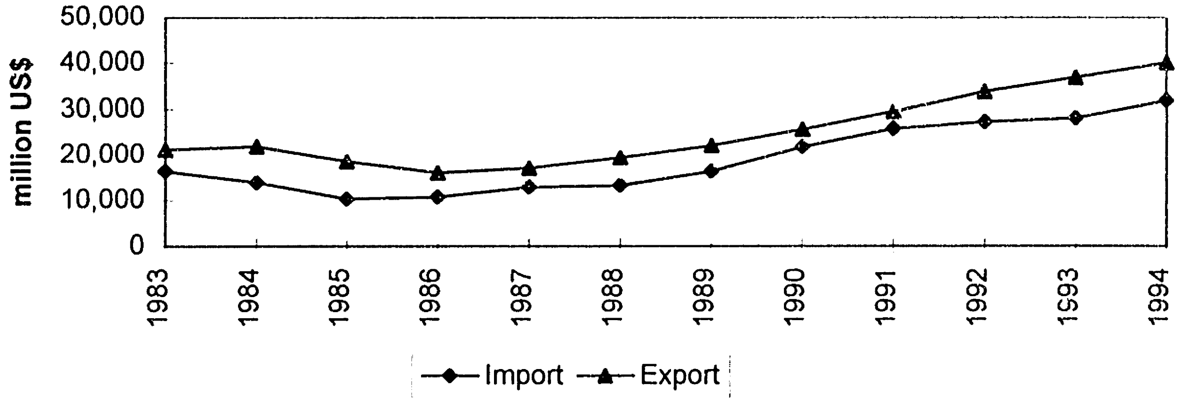



TABLE 3. MANUFACTURING OUTPUT BY CONTRIBUTION (%)

| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
|---|---|---|---|---|---|---|---|
| High | 6.4 | 5.9 | 5.7 | 5.6 | 5.3 | 5.8 | 6.3 |
| Medium | 20.9 | 20.1 | 20.3 | 21.1 | 19.1 | 21.1 | 20.8 |
| Low | 72.8 | 74.4 | 74.0 | 73.3 | 75.4 | 73.1 | 72.9 |

[17] STAID, 1994, p. 126. It's for large- and medium-scale industries.

FIGURE 3. INDONESIAN IMPORTS AND EXPORTS[18]



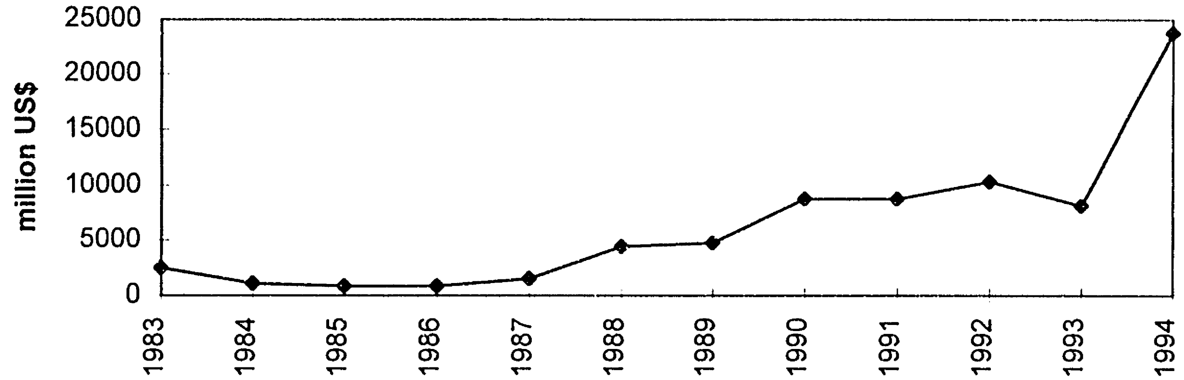

One important sign of globalization is the extent one country opens its market to foreign goods. Such openness can be expressed, among other things, by the flow of goods across its border. The value of Indonesia's exports and imports has been increasing for some time.

Another indicator that is also commonly in used to express the level of globalization is the flow of foreign direct investment (FDI) coming into a country. Since other East Asian countries have become the predominant destination of FDI, attracting this FDI will be more complex than it used to be. The level of competition among countries to attract FDI will also increase.

Since 1967, Japan has been the largest investor to Indonesia. Following Japan is the group of Newly Industrialized Economies (NIE) such as Singapore, Hong Kong, and Taiwan. Figure 4 provides the data of realized FDI on a cumulative basis from 1967 to 1994. In that period, the FDI reached more than US$ 8 billion. The five highest sectors were Chemical, in first, followed by Metal Goods, Basic Metal, Textile, and Paper respectively.

[18] UNIDO, 1994, p. 483.

FIGURE 4. FDI FLOWS[19]




From both figures, it's quite clear that this trend will likely continue to grow in the future. Among other things, due to FDI strategic contribution to national economic growth and employment, the GOI really wants to increase the number. Another important thing is that Indonesia wants to continue its liberalization process. In 2020 Indonesia will fully accept free trade as decided at the APEC Summit Meeting in Bogor. Yet, it goes faster than the APEC requirement. Under the ASEAN Free Trade Area (AFTA) agreement, by the end of 2003 Indonesia will reduce the tariff barrier to 0 - 5 percent. However, free trade will influence Indonesian exports and imports as well as its economy.[20]

The source economic growth is not only manufacturing, but also comes from natural resource utilization. As I explained earlier, this sector used to be the engine of growth. The contribution of natural resources is ranging broadly from direct exports e.g. crude oil or indirectly such as energy resources. In the next part I will discuss this topic.

***Natural Resource Utilization***

Indonesia is not only a big country but also very rich in natural resources. As noted earlier, mining is one of the largest contributors to Indonesia's economy. The mining industry's role is

[19] Pangestu, 1996, p. 116.

[20] For example Ramasamy (1994) has calculated that intra-ASEAN imports will increase by 6% due to the commitment to AFTA. Imada (in Ramasany, 1994), predicts a higher number that inter-ASEAN import will increase to 55.2%. Nonetheless, Indonesia's imports will be influenced due to its commitment to Free Trade.

substantial to boost exports, augment state revenues, regional income, and expand business opportunities. The GOI has been encouraging the promotion of both private and foreign investment in the mining sector.

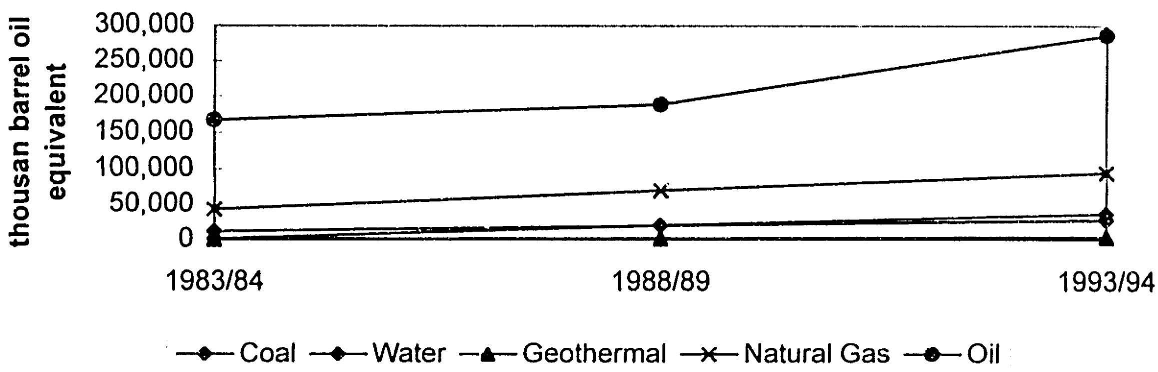
The dominant natural resources for Indonesia are oil, gas, and forestry products. Indonesia is the biggest natural gas exporter in the world. After 1991 the value of its natural gas exports has exceeded oil. In Java island, gas has became a substitute for oil mainly for big industries. Besides fuel purposes, natural gas also become raw material for several industries, mainly fertilizer industries.

Another energy resource is coal, and Indonesia also has huge resources of coal. Since the early 1980s coal production has increased dramatically from below one million tons to more than 28 million tons in the fiscal year 1993/94. Yet, although coal resources are so huge, many of the deposits are small and not suitable to be exploited commercially. The following figure is the figure of energy consumption by source.

Certainly from Figure 5 the total consumption of energy is raised dramatically. The number has doubled from 223 million to a 449 million barrel oil equivalent. Industrial development definitely need an appropriate supply of energy. Fulfilling this need will become the next challenge for Indonesia.

Besides energy resources, Indonesia also has lots of minerals such as gold, silver, tin, nickel, and copper. Yet because usually the world market is controlled by multinational companies and its nature huge in scale, the investors are usually from foreign countries, except for tin. The production of these minerals also has increased progressively. Moreover, many new mine deposit sites have been identified and examined. However, in sense of technological change, the pace is not so quick as opposed to manufacturing industries.

FIGURE 5. ENERGY CONSUMPTION BY SOURCE[21]




However, improper mining procedures can cause another problem, the threat to environmental functions. Furthermore, given the fact that industrial-sector growth will likely continue, industrial pollution will also increase. Besides industrial pollution, other waste such as human waste and vehicle emission, if not well controlled, also may threat on health and human welfare. If these conditions get worse, in turn it will reduce industrial growth as well as human recovery cost such as health cost. World Bank estimated that the cost to reduce the mortality rate due to water pollution problems, specifically the diarrhea problem in Jakarta, is about $38-735 million per year.[22]

A related example is environmental degradation due to over-exploited forest land. Wood products for a long time also become a primary export commodity of Indonesia. Its contribution to non-oil exports is relatively stable. In 1985 the export of this commodity was US$1.2 billion or 20.5% from total non-oil export, and in 1994 the value was raised 5 times to US$ 6 billion, or 19.8 percent of total non-oil export. Such exploitation has been causing 0.6 million hectares of deforestation each year.[23]

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[21] BAPPENAS, 1996, p. 94.

[22] World Bank, 1994, p. 257.

[23] Ibid., p. 51.

Protecting the environment or in better words, doing sustainable development, is the next crucial task. Technology can contribute significantly not only to this problem but also to maintaining industrial growth as an engine of growth.[24]

### *Technology Content and Value Added*

Technology has a very close relationship with other aspects of economy, industry, and human resource capability. If one wants to increase his output, there are two things to do. First, use more resources so he can produce more. Second, put a serious effort to get more output for any single unit of input, or in other words, increase the productivity. In short, technology change can affect economic growth through productivity improvement. Now such a concept is widely accepted, that technology is one factor behind economic welfare as well as capital and labor.

In the beginning technological change was identified as an "exogenous" or "residual" factor, something that come from an unknown sources, or in his article, Griliches mentioned it as "measure of our ignorance."[25] Obviously many questions have been raised among scholars. There are basic problems regarding this theory particularly that it's not clear how technological change occurs, and consequently, that there's no explanation on how to generate it. This discussion leads to a new theory called the "new endogenous growth theory," which tries to look at "technical change as an outcome of market activity in response to economic incentives rather than just assuming that technical change drops exogenously from the sky."[26]

Along the way of this maturation process, technology has been viewed differently than it originally was. The United Nations Conference on Trade and Development (UNCTAD) describes the role of technology very broadly as:

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[24] In 1994 World Bank published two books on Indonesia, "Indonesia: Sustaining Development," and secondly "Indonesia: Environment and Development." Those books mentioned very little about the role of technology in sustainable development. They emphasized only the choice of technology (second book p. 137) and as an example they compared caustic soda production using old mercury cell and new membrane transfer technology. Within this framework, it's clear that the policy implication will be toward giving incentive to the private sector to use the clean technology rather than How to support environmental technology development in Indonesia as a part of sustainable development.

[25] Griliches, 1996, p. 1329.

[26] Gordon, 1993, p. 360-361.

> Technological change affects productivity, the amount and composition of output, levels of employment, the skill profiles of the workforce, the degree of competitiveness and trade flows.

In the micro level, technology also has a huge impact, as well as at the macro level. The difference in "technology content" can also cause difference in value. Consider the following example, a car production process. Through this process, complex technologies embodied in the manufacturing process transform many raw materials into a brand new car. The sale price will be higher than the material cost. In short, "value" has been added and it's because of technology, labor, and capital in that particular process. Consider another example, window glass and armored glass. The technology level for the second is much higher than the first one, as well as capital and skilled labor. As a result, the selling price for armored glass is much higher than window glass.

This concept can explain sufficiently the difference between the before and after production process, and also what kind of input needed in order to make the process work. It implies that everybody should pursue high-tech industries, something that is unlikely to happen universally. Nonetheless, such a concept is not sufficient if one deals with the very basic nature of modern economy, the competition.

## Competitiveness

### *Firms Level*

"Competition is at the core of the success or failure of firms."[27] So begins Michael E. Porter in one of his seminal books, the *Competitive Advantage.* Using industries as his level of analysis, Porter addresses two issues regarding the basis of competitive strategy. First is the *attractiveness* of industries, in the sense of its profitability and what factors determine it.

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[27] Porter, 1985, p. 1.

Secondly, what determines *relative competitive position* within an industry.[28] Firms should have competitive advantage, which means the ability "to create its buyers that's exceed the firm's cost of creating it. Value is what buyers willing to pay, and superior value stems from offering lower process than competitors for equivalent benefits or providing unique benefits that more than offset a higher price." Then sustaining competitive advantage can be either low cost or differentiation.

The very basic concept of Porter's analysis is the in so-called "Five Competitive Forces," which are the entry barriers of new competitors, the threat of substitutes, the bargaining power of buyers, the bargaining of suppliers, and the rivalry among the existing competitors. These five forces determine industry profitability because they influence the element of return of investment such as the prices, cost, and required investment of firms in an industry.

Instead of using added value, Porter offers a more comprehensive approach, the "value chain" along industry structure.[29] The fundamental idea of a value chain is as a way of presenting the building of value (as related to the end customer) along the chain of the activities which go to make up the final product offering to the customer. Since the goals of competitive advantage are low cost or product differentiation, a firm's activities should be divided into strategic activities to address both goals. It expands not only in the production process, but in any activity from inbound logistic until services, at all levels. Technology, again, plays a powerful role in determining competitive advantage and can contribute in any activity. The important role of technology can be seen in Figure 7.

***National Level***

What is competitiveness in the national level? In his other seminal book, "The Competitive Advantage Of Nations," Porter pointed out that :

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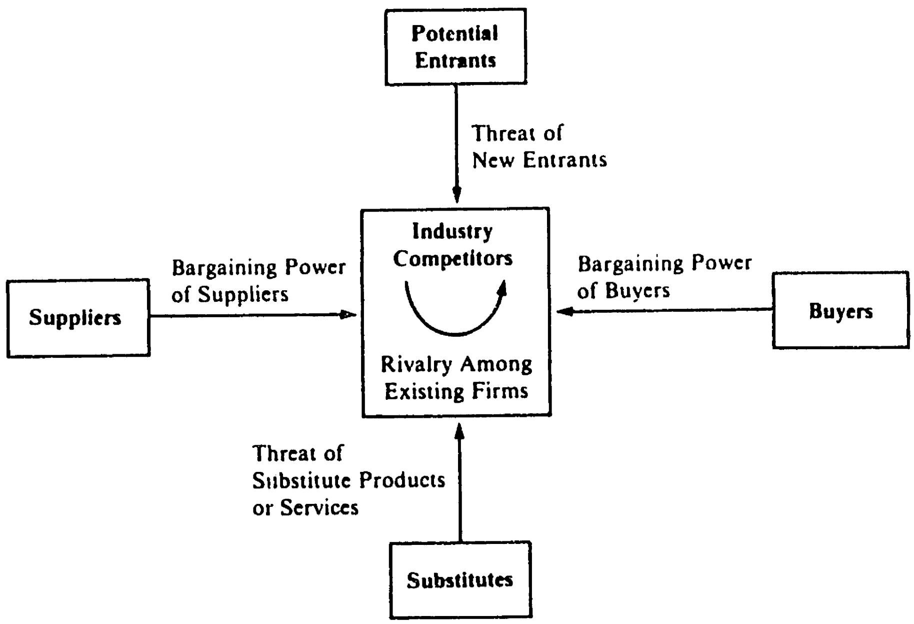
[28] Idem, emphasize added.

[29] Porter, 1985, p. 166-169.

> The only meaningful concept of competitiveness at the national level is national productivity. Arising standard of living depends on the capacity of a nation's firms to achieve high level of productivity and to increase productivity over time. ... Sustained productivity growth requires that an economy continually upgrade itself.[30]

FIGURE 6. FIVE COMPETITIVE FORCES THAT DETERMINE INDUSTRY PROFITABILITY[31]




Porter indicates that increasing standard of living is the central issue and comes from a higher level of productivity. Export goods from such a productive industry should be the focus. A nation should focus on these industries instead of directly increasing the whole national economy. In short, he concludes that to increase, competitiveness at industry level is the prime objective.

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[30] Ibid., p. 72

[31] Porter, 1985, p. 5.

Based on his study of ten countries, Porters believes that in order to be successful at the international level, industry needs a certain environment. Such an environment can be best described by its determinants, which are :

- Factor condition

  The nation's position in factors of production, such as skilled labor or infrastructure, which are necessary to compete in a given industry.

- Demand condition

  The nature of home-market demand for the industry's product or service.

- Related and supporting industries

  The presence or absence of supplier industries and other related industries that are internationally competitive

- Firms strategy, structure, and rivalry

  The conditions in the nation governing how companies are created, organized, and managed, as well as the nature of domestic rivalry.

The figure about this "diamond" is shown on the next page.

***Technology and Competitiveness***

David Ricardo has developed an economic theory that explains the importance of comparative advantage. Therefore a country can rely on its "endowments," such as natural resources and low-wage labor. Moreover, Hecksher and Ohlin pointed out that this endowment can have a significant impact on its industry. For example, Sweden has a strong steel industry because its iron ore deposit has a low content of phosphorous. Lower content of impurities makes possible to develop higher quality steel from blast furnace.[32] Moreover, the "technology gap" theory explains that a nation will export to where it has technological lead position, which in turn determines the cost adjustment capability. If this asymmetry will be no longer available, or if there's no longer a technology gap, then the export will certainly fall.[33,34]

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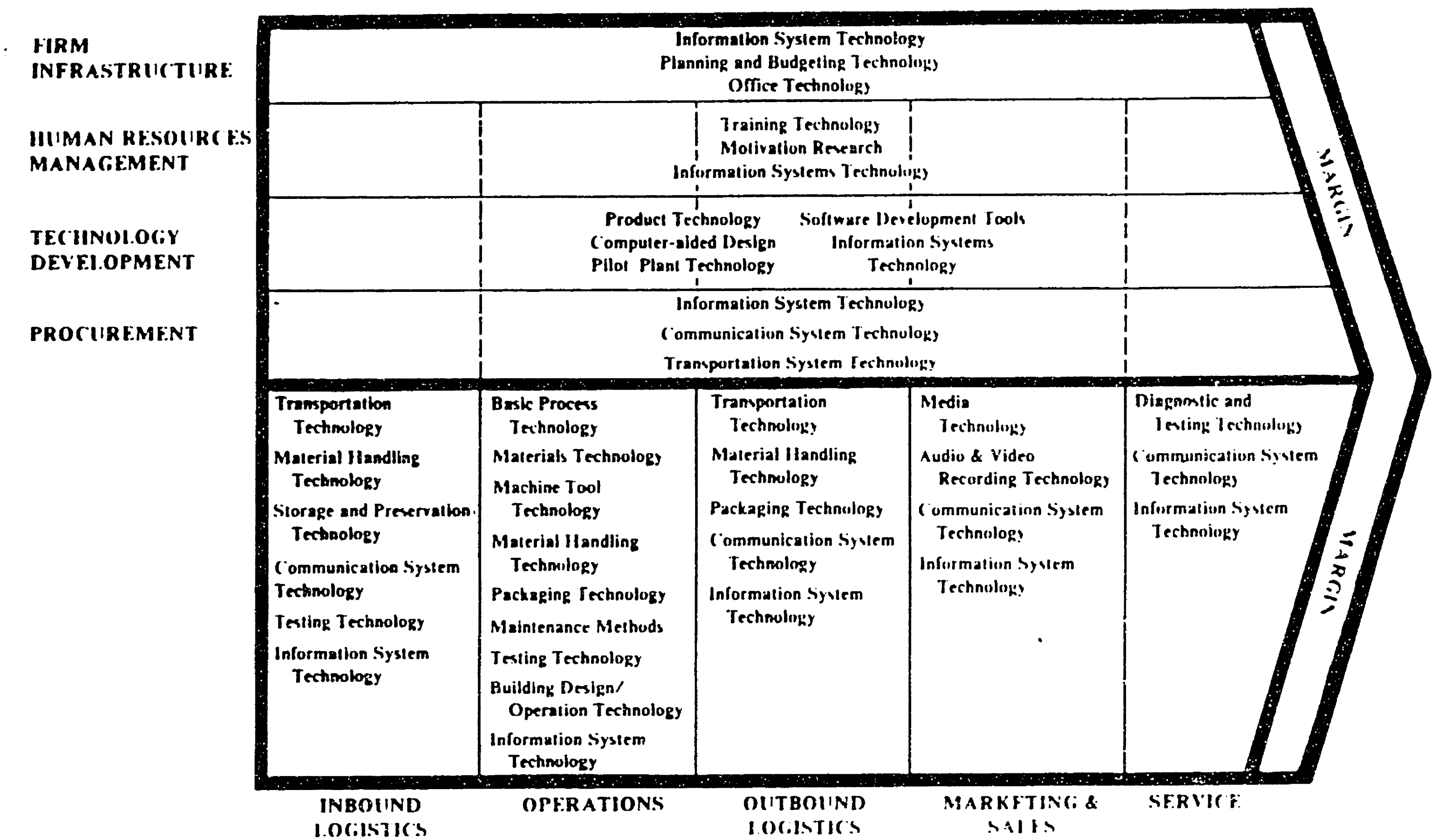
[32] Ibid., p. 10.
[33] Ibid, p. 17
[34] Dosi, et al., p. 141-143.

FIGURE 7. REPRESENTATIVE TECHNOLOGIES IN A FIRM'S VALUE CHAIN[35]



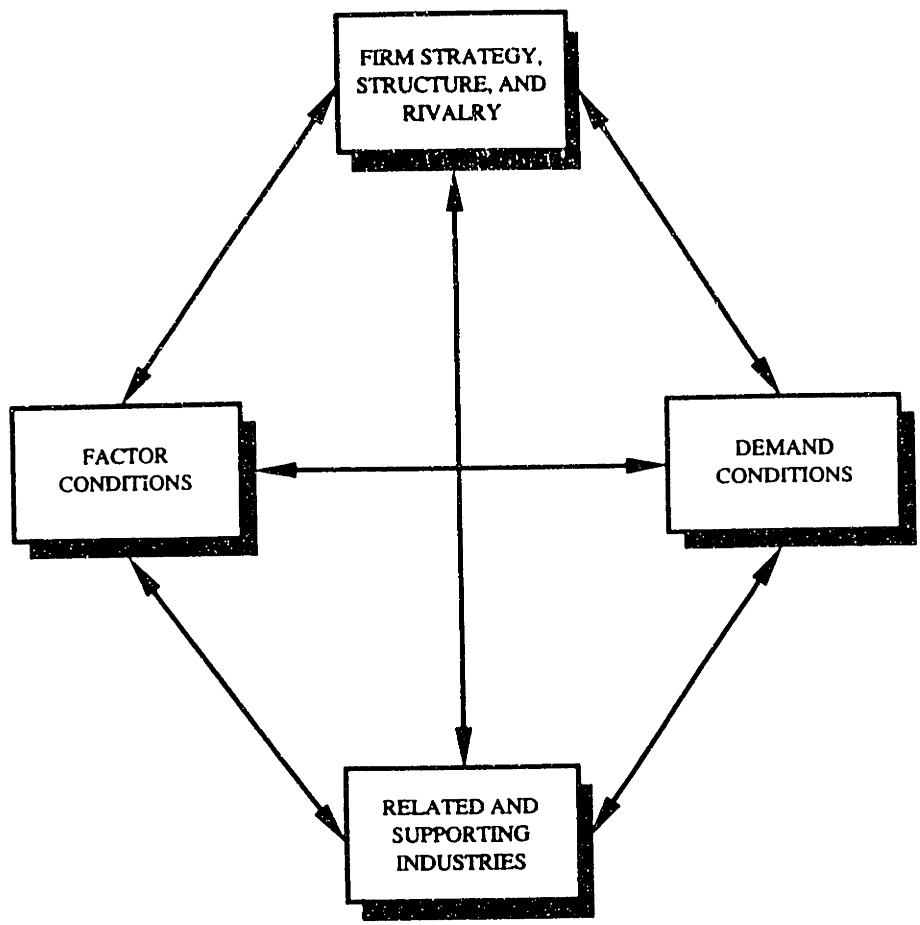

[35] Ibid., p.167.

As mentioned earlier, Porter argues that national competitiveness should not be generated and maintained for all industries. Hence technology policy should underpin particular industrial development. In short, technology policy will be targeted and selective, effective, and complementary to industrial structure.

Extensive discussion in this chapter has introduced the importance of "interface" between industrial and technology development. If Indonesia wants to develop its industry successfully, technology policy should be "aligned" to industrial needs. This is the insight about the direction of technology policy.

In Chapter Three I will present the current Indonesian technological policy to give the picture of the situation in Indonesia. Chapter Four will be dedicated to an in-depth literature review of the role of technology in economic development. Both chapters will address the central issue of this thesis, the Technology Triangle.

FIGURE 8. THE DIAMOND[36]




[36] Ibid., p. 167.

# *Chapter 3*

# INDONESIAN TECHNOLOGY POLICY

## Current Technology Policy

The previous chapters have discussed the importance of technology and how it can contribute to industrial and national development. However, the following task is to enter upon technology policy itself. How does the function of Indonesian science and technological institutions link with the rest of economy? In this chapter I will review Indonesian technological policy, emphasizing the very basic concept that they is used, the current policies, and finally recognizing its weaknesses. In addition, it's inevitable to discuss the idea from the most prominent person in Indonesian technological policy, Mr. Baharuddin J. Habibie, the Indonesian State Minister of Ministry Science and Technology since 1979 to present.

Along its development path, Indonesia has been developing its Science and Technology capability seriously. It was started in 1973 when the first State Ministry of Research, now the Ministry of Science and Technology, was established. Successively, the Center of Science and Technology Development was formed in 1976, the Agency for the Assessment and Application of Technology (AAAT) was created in 1978, followed by National Research Council (1984), Inter-University Centers (1985), Agency of Strategic Industries (1989), and Indonesian Science Academy (1990).[37] Beside these institutions, government of Indonesia has been putting considerable effort into developing its technological infrastructure such as through its many ministerial R&D institutions and its laboratories.

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[37] Priaadi, 1994, p. 34-35

Indonesian technology development is heavily influenced by so the called "Habibie's view." Habibie believes that the focus on development should be on human development.[38] He pointed out that human development should be toward fulfilling basic human needs, enhancing utilization of resources available, producing goods or industrialization, providing security, and providing the needs of mental aspects such as religion, culture, and philosophy.

Then he concludes that science and technology development should be focused on those five priority areas : (1) Basic Human Needs; (2) Natural Resources and Energy; (3) Industrialization; (4) Defense and Security; (5) Social, Economy, Culture, and Philosophy. Furthermore, any areas will be detailed by four aspects which are : (a) land; (b) ocean; (c) air and space; and (d) environment. Finally Habibie's view crystallizes in the so called "National Research Matrix." Identifying activities within this matrix is the main aspect of Indonesian technology policy.

The matrix works at activity level. For example, research for food is on of Basic Human Needs. Consequently, rice research will be at Land's column. Research on fish for food purposes (as opposed to extracting the oil) will be located at Sea column. On the intersection cell between Basic Human Needs's row and Land's column intersection, all rice research activities will be listed there.

Moreover, he argues that technology should be developed and applied only to solve concrete problems. His vision suggest that Indonesia should develop its indigenous technological capability. In line with this vision, protecting infant industry before it's capable to compete internationally is acceptable to him.[39] In order to develop an indigenous technology, Habibie points out that there are four steps of transformation to be done in order to build indigenous capability. First, using the available technology. Second, the integrating of such technology to

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[38] Habibie, 1986, p. 42-43.

[39] Furthermore in the same article Habibie asked that "People should give a chance to its growing national industries to learn, have experience, make mistake, and healing from any child disease." This idea is subject to be debated between Habibie's opponent and economists.

FIGURE 9. THE CONCEPT OF NATIONAL MATRIX

| | Land | Sea | Air and Space | Environment |
|---|---|---|---|---|
| Basic Human Needs | | | | |
| Natural Resource and Energy | | | | |
| Industrialization | | | | |
| Defense and Security | | | | |
| Social, Economy, Culture, and Philosophy | | | | |

design and produce new products. Third, developing technology to launch new products. And finally, the basic research.

There are two requirements for an industry to be chosen as a "transformation vehicle," the possibility to penetrate more deeply in technology and industrial structure; and the availability in the domestic market of chances to grow before competing internationally. Given the Indonesian situation, these industries are transportation (aircraft, ship, train, automotive) supported by the steel and parts industry; the telecommunication industry, which should be supported by the electronic industry; the energy industry; the mineral and plantation processing industry;[40] agricultural machinery; the defense industry; and other industries that can generate economic activities such as housing and construction. Moreover the government designated ten

[40] For example -- palm oil, sugar, petrochemical and cement industries.

state-owned companies as "strategic industries" and Habibie acts as the Chairman of the Board of Agency of Strategic Industries.[41]

This "intervention policy" obviously raised many criticisms mainly from economists. It is one of the most debated topics in Indonesia between "technocrats" and "technologist." The airplane industry -- Nusantara Aircraft Industry (IPTN) -- is the first thing that always raises economists' question. For example, the aircraft industry might be one of the largest investments in Indonesia[42] yet the return is not known. IPTN has changed from simple assembly to air-frame fabrication. Despite the successful accumulation of technological capabilities, the commercial side is not so good. Lack of sufficient managerial capability, including poor financial performance and inter-firm linkage is the main problem of IPTN.[43] In line with the Kendrick study, World Bank's study on industrialization in Indonesia indicates that

> This concentration of "high tech" activity may have been inefficient and costly and may have drawn effort and resources away from traditional industries that were the mainstay of the economy. ... Such "big push" strategies on technology have often been wasteful, even in advanced industrial countries.[44]

In short, these "strategic" industries are too broadly defined. The impact make it difficult to define the span of technology policy. While this controversy still continues,[45] there're some people who think that the efficiency of research activities really matters. This view basically comes up from the budget consideration. When they compare spending and results, it appears

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[41] The Agency of Strategic Industries monitors these strategic industries which are IPTN (aircraft), PAL (shipyard), INKA (train), Krakatau Steel (steel), INTI (telecommunication), LEN-LIPI (electronic), Barata Indonesia (machinery), BBI (engine and engineering construction), Dahana (explosive), and PINDAD (weapon).

[42] McKendrick, 1992, p. 39. Until mid-1987 the figure was predicted between US $900 million to 1.5 billion. From 1987 to the present, IPTN has prepared two big programs, N-250 and N-2130. Considering the tremendous capital needed to develop new aircraft types, the figure might be still the largest one.

[43] Ibid., p. 51-66.

[44] World Bank 1992, p. 43.

[45] In early of 1997, FAA rejected IPTN's latest development, the N-250. IPTN needs to make some modifications first if it wants to get an FAA certificate. N-250 is the transformation at stage 3, which is developing new technology to create new products. IPTN also wants to create a joint venture with GE and other companies to open a new plant in Alabama, USA.

that not only is usefulness limited, but also the quality of research itself is low. For example, Indonesian scientific publication shares only 0.012 percent with all nations' publication.[46]

In 1991, there was a survey in order to understand the current position of the research system.[47] The result showed many weaknesses facing the Indonesian research system :

- duplication and overlap of research activities
- there's no open selection system to assure objectivity
- under-utilization of human resources and facilities
- limited number of appropriate human resources
- there's no strong inter-sectoral linkage

On the other hand, based on the evaluation of research proposals, other facts also were found :

- many researchers face difficulties writing the idea in a proposal, mainly the "flow" of proposal, its logical thinking as well as methodology, and data interpretation such as weak statistical techniques application
- lack of a clear research focus
- lack of relevance between literature review and topics
- proposal writer might not the researcher who will conduct the research
- and there's research plagiarism

To summarize the "old" research system needs improvement as well as an increase in the quality of research itself. The "old" research system was designed to support ministerial tasks. At that time many ministries created an R&D agency to support their work. Some of them were really good. For example, the Agricultural Research and Development Agency (under the Ministry of Agriculture) is the center of rice research. On the other hand, such a system tends to isolate those institutes, e.g. pay excessive attention to its ministerial duties. A related weakness is minimum cross-agency communication.

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[46] Gibbs, 1995, p. 92.

The following illustration describes the fragmented picture of the national research system. If a (government) researcher wants to propose a research project, he first has to submit his proposal to the planning bureau within his agency/ministry. Through an internal evaluation process, all of the prospective ministerial research proposal will be submitted to various bureaus at the National Development Planning Agency (BAPPENAS). This system has three weaknesses particularly:

- no linkage with the national priorities, or priorities did not transfer to research activities
- no clear role of NRC and the office of state ministry of research and technology (OSMRT)
- no clear guidelines because the evaluation was based on the closeness to ministerial jobs

The "new" system was designed to address those weaknesses. In the "new" system, the power of the NRC was strengthened. It defines national priority as well; consequently, it also defines which research is "on the right track." NRC has became the center of the proposal selection process. The process itself consists of two tiers. It conducts proposal selection mainly by relying on peer review to assure the quality, and chooses which proposals fit with the national priorities. Finally they submit the result to OSMRT, which in turn suggests a list of national, governmental research projects that should be funded. In short, enhancing research quality and empowering the role of the NRC were the focuses.

In such a process the instrument policy strategically was National Matrix which guides all governmental research. In 1993 the government published a detailed version of National Matrix. Improvement was made in 1995, particularly breaking down the Matrix into annual activities. The basic idea was to keep track on research progress and to assure budget continuation.

As the mechanisms is improved, increasing the quality of research become the next task. Research proposals should be evaluated by peers, and institutionally by the NRC. This is being done two ways : (1) improving the current research or in-house research; (2) creating new

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[47] This part relies heavily on Soendoro, 1995.

schemes to encourage researchers to do better research. In the past few years the government has launched several new schemes as listed in the following table.

Any scheme (except One Gate Policy) is sort of bundled with incentives. Two main incentives are offering higher wages, and commitment from the government (particularly OSMRT, BAPPENAS, and the Ministry of Finance) to provide the fund within the specified years. New schemes quickly gained popularity among researchers. However, there is "no free lunch." Researchers benefited (from incentives) if their proposal was accepted by OSMRT and NRC. It means they have to form a research team, submit a sound team's proposal, compete with other teams, have a clear goal and must be in line with national priorities, and present their proposal in front of the NRC's peers.

However, the level of competition is very high. Table 5 shows the fierce competition in the selection process for Integrated Research (one of the new schemes). To assure that all researches will achieve the promised output, NRC monitors it on-site and evaluate the research teams quarterly progress report. Several projects were canceled because they cannot meet the expected annual target.

I should make a note on "One Gate Policy." In Indonesia basically it is the National Research System. Every research activity in many ministries, which are funded by the government, should match with national priorities as mentioned in the REPELITA and/or Matrix. The selection process is conducted by OSMRT and NRC (the "one gate") and based on research feasibility and the "matching" process. At the end OSMRT proposes to the National Development Planning Agency (BAPPENAS) a list of research projects. Finally BAPPENAS analyses the impact on the national development and the budget required.

New schemes nonetheless were successful using competition policy as a vehicle to increase research quality. But the whole story above raised an important question, Where was the industry? This fact has become another problem in Indonesian technology policy, which will be discussed in the next sub chapter.

TABLE 4. NEW RESEARCH SCHEMES

| Scheme | Reform Orientation | Nature | Peer |
|---|---|---|---|
| Competitive Grant (1992/93) | University research. | Competitive; long term; problem-solving | Ministry of Education and Culture |
| Integrated Research (1994/95) | Encouraging research in selected fields : biotechnology, material, electronic, earth and environment, chemical and process, and social. | Competition; integrated team with different technical background, labs/agencies/ companies; 3 years maximum. | National Research Council (NRC) |
| One Gate Policy (1994/95) | Improving in-house research in any labs which funded by the government. | Competition; selection based on national matrix priorities. | NRC and OSMRT |
| Partnership Research (1995/96) | Industry-public univs./ govt. R&D insts. Collaboration | Competition; sharing the cost; 3 years maximum | NRC |
| Research Capability Enhancement (1996/97) | University research excluding best universities | Research Package | Ministry of Education and Culture |
| University Research for Graduate Education (1994) | University research particularly | Competition; graduate team (professor - student); post-doctoral research | Ministry of Education and Culture |
| Voucher Program (1994) | University applied research | Competition, focusing on small industry problem, ready-to-be-applied research | Ministry of Education and Culture |
| Medical Research Initiative (1996) | Medical universities | Health problem-solving, long term, limited topics (tropical disease) | NRC |
| National Strategic Program (1997) | Advanced Technology | Long term; high-tech; sharing cost; national goal. | Many agencies, particularly NRC, MOST, BAPPENAS, Ministry of Industry and Trade. |

Note: (year) means the beginning fiscal year.

TABLE 5. APPROVAL OF INTEGRATED RESEARCH PROPOSALS

| Batch | Proposed | Approved |
|---|---|---|
| I (1993/94) | 251 | 109 |
| II (1994/95) | 1,455 | 139 |
| III (1995/96) | 1,659 | 40 |

Note: (year) means the beginning fiscal year for each batch.

## CURRENT PROBLEMS

In his article in Bulletin of Indonesian Studies, Hal Hill believes that Indonesia does not have a technological policy.[48] He points out that technology policy basically is a set of policies designed to strengthen, adopt, and apply technology. It is interesting to quote what he thinks about technology policy in Indonesia:

> Indonesia does not have a 'technological policy'. As in all countries, technology policy -and industry policy more generally- is the sum of a range of macro and microeconomic interventions. Some have technological objectives, while others have incidental and often unintended effects on technological development.
>
> It must be stressed again here that the general economic policy framework is the most important factor in the development of technological development of technological capability. That is, factors which influence a country's rate of economic growth, its investment rate, its degree of international orientation, and its stock of skilled labor are likely to be major determinants of the pace of technological progress.

This view is from a typical economist who thinks to support economic growth properly, technology needs sufficient human resource capability, amount of capital, and good trade and industrial policy. Nevertheless he identifies the crucial problem in Indonesia, the lack of

[48] Hill, 1995, p. 110.

technology policy itself. Although he thoroughly discussed the Indonesian technology policy, he did not discuss the role of R&D. This is the missing link of his analysis.

It is interesting to observe that the structure of the technological effort in Indonesia is on the government side rather than private firms. Government-owned R&D agencies, whether R&D institutes or public universities, play bigger role in Indonesia. Partly because they have better human resources, partly because of the amount of investment that has been made for a long time. The Manufacturing Industrial Census for 1995 shows that only 17.9% of large and medium industry has R&D activities.[49,50] Moreover, in the fiscal year 1994/95 the government R&D spending was Rp. 1,125 billion, comparing with Rp. 245 billion by manufacturing industries. Most importantly, government manpower also has better quality than manufacturing industries. Table 6 below shows the dominant role of government R&D agencies in terms of manpower.

TABLE 6. NATURAL SCIENCE AND ENGINEERING MANPOWER[51,52]

| | Government R&D Institutes (1992) | Public University (1992) | Manufacturing Industry R&D Unit (1994) |
|---|---|---|---|
| Ph.D. | 590 | 775 | 53 |
| Master | 1,935 | 2,400 | 210 |
| Bachelor | 12,260 | 15,250 | 3,670 |

Government's researchers also dominate in many new schemes. For example, for Integrated Research (Batch II), private firm's researchers only 4 out of 535 researchers. Even government-owned companies are better than private firms, with 14 researchers got involved in Batch II.

[49] BPS and PAPIPTEK-LIPI, no year p. 1-3.

[50] The document in my hand is the manuscript one. Yet the data shows that within 5 years the R&D share of private industry is relatively stable. The previous data hypothetically stated that industrial R&D consists of 20% of national R&D funding (STAID, 1994). Industry spends six time more (approximately Rp. 1,720 billion) on "production engineering."

[51] STAID, 1994, p. 110 & 112. The source for the first two columns.

[52] BPS and PAPIPTEK-LIPI, no year, p. 6. The source for the manufacturing industry column.

TABLE 7. THE BIG EIGHT IN INTEGRATED RESEARCH (BATCH II)

| Rank | Institution | Researchers involved in Batch II |
|---|---|---|
| 1 | Bandung Institute of Technology | 105 |
| 2 | Gadjah Mada University | 79 |
| 3 | Indonesian Institute of Sciences | 51 |
| 4 | Bogor Institute of Agriculture | 36 |
| 5 | University of Indonesia | 30 |
| 6 | National Atomic Energy Agency | 23 |
| 7 | Agency for Application and Assessment of Technology | 15 |
| 8 | Nusantara Aircraft Company (IPTN) | 11 |

Table 7 shows the Big Eight of Integrated Research (Batch II). All of them are public universities or R&D institutes with the exception of IPTN (a government-owned company). These eight institutions contributed 65 percent from the total researchers for Batch II.

How close is the Indonesian R&D result to industrial application? According to a recent survey on Integrated Research, most researchers think that the product of research is relatively close to application.[51] Even 23 percent think that the product can be applied immediately after publication. Another important result is better communication across agency. No less than 74 percent of researchers think that now they have better communication across-agencies. Even 80 percent of researchers commented that they need to communicate regularly. It implies that strong bonding among researchers is developing. As additional information, this is the figure for Integrated Research, the most prominent research scheme in Indonesia.

In spite of the bigger effort that the GOI have provided, the national matrix that they have developed, the schemes and incentives that they have created, and the good opinion of researchers, still the linkage between this government R&D and industry remains very weak.

[51] Djoko and Simamora, 1996, p. 18, 25, 27. Such feedback study is rare in Indonesia. Again, Integrated Research is the toughest research scheme in Indonesia. It offers the highest wage and the US$ 40,000 maximum/year grant.

Industry rarely uses the R&D product developed by government R&D institutes. The focus of current technology policy represents pure "supply side," which loses its touch on industrial purposes. Having the importance of technology in economic development, it is imperative to think about a new framework for technology policy, and how to link it among actors -- the government and their R&D institutes, the university, and industry. Put differently, Indonesia needs more solid concept.

When speaking of applying a concept on the national level, it is well understood that public policy matters. In the next Chapter I will discuss frameworks of technology policy, and emphasize the role of government.

# *Chapter 4*

# REVIEW ON TECHNOLOGICAL POLICY

In 1987, Henry Ergas used a question as the title of his article, "Does Technology Policy Matters?".[54] The close link between technology and economics, and the fundamental process behind technology progress will be discussed in this chapter.

Many seminal works have shown that technological change induces economic growth. For example, in his study of the period 1909-1957, Robert Solow pointed out that technological change had contributed about 87.5 percent of the increase in per capita output.[55] *Technological change* or *technological progress*, as Solow put it "any kind of shift the production function,"[56] in turn increases productivity. Nathan Rosenberg defines it by its nature as "it constitute certain kinds of knowledge that make it possible to produce: (1) a greater volume of output or (2) a qualitatively superior output from a given amount of resources."[57] Basically from economic point of view, technological change is really a broad definition, anything that increases productivity beside capital and labor including education, research, innovation, and other improvements such as better management and organization.

Recent studies indicate that the contribution of technological change should be adjusted because by its nature, technology can be embodied in labor or capital. For example, Boskin and Lau's study suggest that there are strong complements between technological change and capital

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[54] Ergas, 1987, p. 191. Ergas did not answer the question directly yet he studied the taxonomy of technology policy for mission oriented (e.g. French) and diffusion oriented (e.g. Germany) countries. He implies that technology policy "matters" in different ways depending on orientation.

[55] Gordon, 1993, p. 360.

[56] Griliches, 1996, p. 1328.

[57] Rosenberg, 1992, p. 3.

formation. Moreover, based on their recalculation for France, West Germany, Japan, the UK, and the USA, technological change contributes, on average, about 70% of economic growth. Their findings also show that technological change is capital saving rather than labor saving.

To summarize, technological change is the most important component of economic growth. Given the importance of technology in the economy, its impact on worker displacement is not as bad as people think. Hence, to develop a reliable technology policy is more than necessary to any government, particularly those of developing countries.

In the sense of technology policy, What's the difference between advanced and developing countries? First, the source of technological change such as education level, stock of capital, and trade flows. Secondly, the direction of the technology transfer, usually supported by the presence of market-related institutions to assure the utilization of an R&D result. Regarding these issues, two insights will be discussed in the remaining part of this chapter. First, the Accumulation-based view with its stress on the learning curve. Secondly, the Capacity-building view which emphasizing the changing process from technology transfer to technology capacity building (TCB).

## The Accumulation-Based View[58]

As I have discussed in previous chapters, the new thinking on the nature of technology has changed from an exogenous to an endogenous view. Basically it means that to grow properly, technology needs many things. One important aspect is "accumulation," in the sense that if one wants to built a car, he needs proper knowledge about machines, metal, and electricity, up to arranging the parts to be fit with others.

This view begin with the question, What is the nature of technology? First, having technology means the ability to do things better, hence it is not similar to knowledge. Technology is not

[58] This part is draws heavily on Bell and Pavitt (1992).

equal with research because this is usually not enough to do things better. The central activities of technology are development, design, production engineering, and also learning by doing. Secondly, it is unique in the sense that the purpose of one technology cannot be generalized. It's about specific plant and products. It is segmented. An extreme example is that pharmaceutical technology cannot be applied to produce a car. More importantly, as knowledge, technology is cumulative. It is based on past experience.

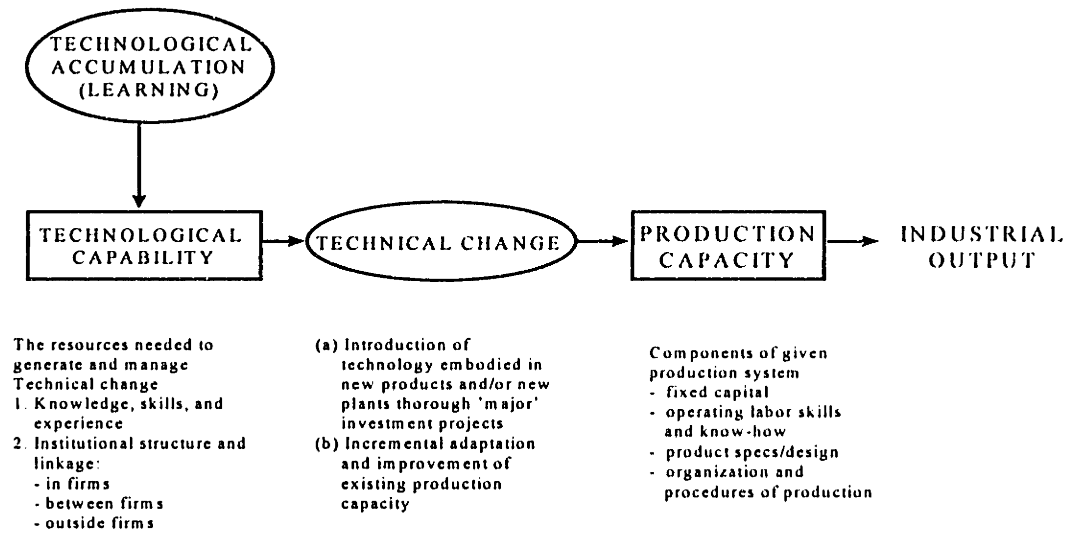
The nature of technology raises two important aspects. First, the better place for technology is in the production unit, and it also means mainly within the firm. Second, for developing countries it is imperative to understand how technology is diffused.

Consider the following example. If a company uses new equipment, the first thing to do is to adopt the basic technology capability, which is embodied in the equipment. After they reach mastery in such original technology, they may change some parameters for specific purposes e.g. to maximize the utilization of the equipment. As the improvement effort continues, the "learning curve" also increases. If we look into many successful firms, this continuous improvement and the level of the learning curve contribute significantly to win competition.

Bell and Pavitt identify four stages regarding this diffusion process.[59] Firstly, firms must accumulate knowledge -- particularly skill and know how -- to operate the new equipment or process. Secondly, as market demands change, further productivity improvement such as adjusting operation parameters, e.g. input, process, and output, will be done accordingly. This stage needs a deeper knowledge level and also the intensity of experience gained previously. Third, mastery in such technology allows firms to do substantial technical change, for example, to shift to become the input material supplier, conduct similar projects with a different process or parameter sets, or even the producing of a new product. Afterward, the final stage is the "innovation" stage which allows companies to develop a new process or product totally

[59] Bell and Pavitt, 1992, p. 5, 6.

FIGURE 10. BASIC CONCEPT OF TECHNOLOGICAL ACCUMULATION[60]




differently from the original product specification. Such an accumulation process is described in Figure 10.

### *Technical Change*

Technical change, which also means better productivity, plays an important role in industry. As defined by Bell and Pavitt, technical changes "encompass any way in which technology is incorporated into the production of firms and economies."[61] It implies that : (1) it can be gained through acquisition of new equipment or adopting new processes; (2) incremental change; or both.

Finally, maintaining a continuous effort is indispensable if one wants to move along the technology trajectory. It's an evolutionary process and depends on insitutional aspects such as the process of contacting with outside knowledge resource, and the behavior of the market.

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[60] Ibid., p. 8.

[61] Ibid., p. 7.

### *Accumulation at Firm's Level*

The modern business world is characterized by, among other things, by a shorter product cycle, better product quality, and the capability to respond to market needs. Productivity in producing and delivering the product is the basis of competition in the market. In short, nowadays the level of technology accumulation is one of the basises of a company's position in the market.

Since the nature of technology is to do something better than it used to be done, cumulative, and also specific, the central unit of this view will be at the firm level, not others. Not at the government, national, or regional level. Competition and rivalry have been forcing firms to incorporate, learn, and utilize technology effectively to survive and come up with desirable profit. Recognizing the central role of firms is crucial in order to design technological policy.

Technical change can also be generated from outside. Firms seek and tap into outside sources of technological knowledge. Another place is from domestic sources such as R&D institutes, and universities. Such linkage also helps those laboratories and university to focus on real problems instead of being an "ivory tower" without any relation to the user. Another useful source is from linkage within the same industry, suppliers, and the close relationship with its customers. This kind of market knowledge helps firms to formulate necessary technological accumulation as well as define technological problems more precisely.

### *The Role of Government*

Accumulation technology does not emerge "from the sky" -- it needs certain conditions before it appears as a part of industrial dynamism. This condition can be found from inside the firm e.g. the suitable education level of workers, or from outside conditions, e.g. the market condition. In both cases, the role of government can not be ignored.

Emphasizing the central issue, the government has to realize that the accumulation process take place at the firms' level. It localizes there, incorporates, innovates, comes up with the product, and competes in the market to get a sufficient return. Quoting Bell and Pavitt, failure to identify this very basic concept can cause a reduced impact of technology policy.[62] Consider the following example. Research in one R&D laboratory owned by the government, say comes up with wonderful new technology. When they introduce the new technology, however, industry does not show any interest to utilize it because it lacks special skill, or equipment, has difficulties to get the material, and other impediments. In short, knowing the problems at firm level is necessary to avoid technological accumulation problem.

Secondly, technological accumulation can be fostered by building linkage among firms. The linkage is usually based on trade relationships. But the most important thing is information flows from a firm to other firms. For example, one large firm set relationships with certain specialized suppliers. In such a network, all supplier firms can "learn" form the big customer. On the contrary, the big firm get the appropriate quality input from suppliers that know what they want. In such a condition, the boundary of technology accumulation is widening. In short, spill-over happens.

Thirdly, level of knowledge matters. Investment on education and training contribute significantly to technological accumulation. It is evident that the better supply of human capital leads to the better technology accumulation.

Fourthly, in close relationship to knowledge is the need to build the linkage between academic research and industry. Interestingly, Bell and Pavitt stressed the importance for developing countries to develop basic research. They argue that the main benefit for basic research is not the publication itself, but also "a supply of scientists and engineers with problem-solving skills, comprising background knowledge, familiarity with research methodologies and instrumentation, and membership of informal and often international networks of professional peers."[63] Consequently, they propose the building of strong, local academic research and encourage advanced education like post-graduate training.

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[62] Ibid., p. 25.

[63] Ibid., p. 28.

Fifth, given the uncertainty of the learning process of technological accumulation, it is necessary to provide suitable incentives to cover up such risk. There are two issues here. It is potentially valuable yet risky to acquire a new and competitive high-technology product. The other is a focused trade policy to create local demand in the early stage of learning. In short, technological policy is not a "supporting" policy to trade and industrial development, but deals with them very closely.

In sum, these five aspects -- lowering the barrier at firms level, firm-to-firm linkage, adequate education, industry-university, and sharing the risk -- nonetheless, address the role of government.

## The Technology Capacity-Building View[64]

### *Issues in Recent Technological Policy*

What is the basic fact of technology? It affects a wide array of economic activities; it is one reason behind economic growth, the basis of competition for firms to sell its products and services, and the like. This view begins with two questions : (a) how can developing countries acquire and gain mastery over new technology; (b) how do technology transfer and the accumulation of technology capacity affect competitiveness at the enterprise and national levels? For the purpose of this thesis, the discussion will be limited to the second one, particularly the role of government.

Based on the past experiences of developing countries, UNCTAD points out that there are several characteristics of successful technology capacity building at the firms' level, among others :

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[64] This part draw heavily on Chapter II UNCTAD, 1996, particularly Chapter II. Basically this reference is a literature review focusing on technology capacity building in developing countries.

- Learning ladders

  Better performance to do the same job or being capable of doing a more complicated one.
- Tapping into the knowledge network

  Technical information is critical for firms. In developing countries the availability of technical information might be a serious problem.

To avoid the lack of technical information, industry in developing countries might utilize the network as described in the following table below.

Given the importance of the firm and its network in the TCB framework, what kind of national system which provide best support to achieve high-gear TCB? UNCTAD pointed out that there are three big issues: (a) national incentive structure to generate innovation; (b) human resource development and supporting R&D institution; (c) intellectual property rights (IPRs).

Similar with Bell and Pavitt's, this view also considers the macroeconomics condition as an influential factor for incentive structure. A healthy macroeconomics condition is imperative if one country wants to facilitate technology capacity building and competitiveness.

Another important aspect of the incentive structure is the availability of a body which can set the policy and guidance of the national effort to accumulate technology. Moreover, this body might :

- assess the linkage of education to technology capacity building
- provide information to accelerate technology accumulation
- create a network among public R&D, universities, and firms, and encourage consulting services

Furthermore, such a body can offer other incentive schemes such as tax reduction to encourage R&D activities, strategic projects, government procurement controlling, and the like.

TABLE 8. THE IMPACT OF NETWORKING[65]

| Type of Establishment | Impact |
|---|---|
| Subcontracting | useful exchange of technical information particularly enhancing the "buyer-seller" relationship |
| Workforce mobility | Labor circulation or acquisition of good - quality workers foster the flow of technical know-how |
| Equipment supplier | Accelerating the process of technology accumulation by offering new equipment coupled by suitable training |
| User-producer relationship | Close and intimate relationship is important to the flow of more detailed information |
| R&D | Supporting to incorporate frontier technology and solve crucial problems |
| Consultancy | Providing new insight |
| Informal linkages | Increase the "value" of information and opening opportunities |
| Strategic alliances | Sharing the cost, risk, and resources will reduce uncertainty |
| Intra-enterprise linkage | Assure the better flow of information within firms |

As discussed many times before, preparing good human resources is necessary if one country wants to build its technology capability. The goal of a human resource policy in developing countries usually is to develop a national plan that relates human resource and TCB. Given the national objective, this plan typically tries to formulate the need for resources, develop a program to reduce the scarcity, and optimize between demand for input in one side, and production and distribution of output at the other side. In the case of a developing country, it is clear that the role of government for preparing this kind of policy is crucial.

It is also apparent that the quality of R&D institutions in developing countries are weak, and "isolated" without suitable linkage and relevance of their practical goals. UNCTAD has identified these impediments of R&D institutes in developing countries :

[65] Ibid, p. 15-19. Adapted and derived from those pages.

- Poor linkage and lack of relevance

  Falling in this category is focusing too much on "technology push" instead of trying to get a better perspective of "demand pull." Moreover, the level of commercialization of the R&D result is too small. In short, it lacks market orientation and does not contribute to economic development.
- Organizational efficiencies and policy coordination

  These institution also lack of focus, have budget limitation, and bureaucratic organization which leads to inefficiencies.
- Limited capability to choose best R&D projects

  R&D institutions lack of capability to pick the best R&D project, excessive focus on basic research, and often missing the useful result due to providing resources below the minimum requirement.

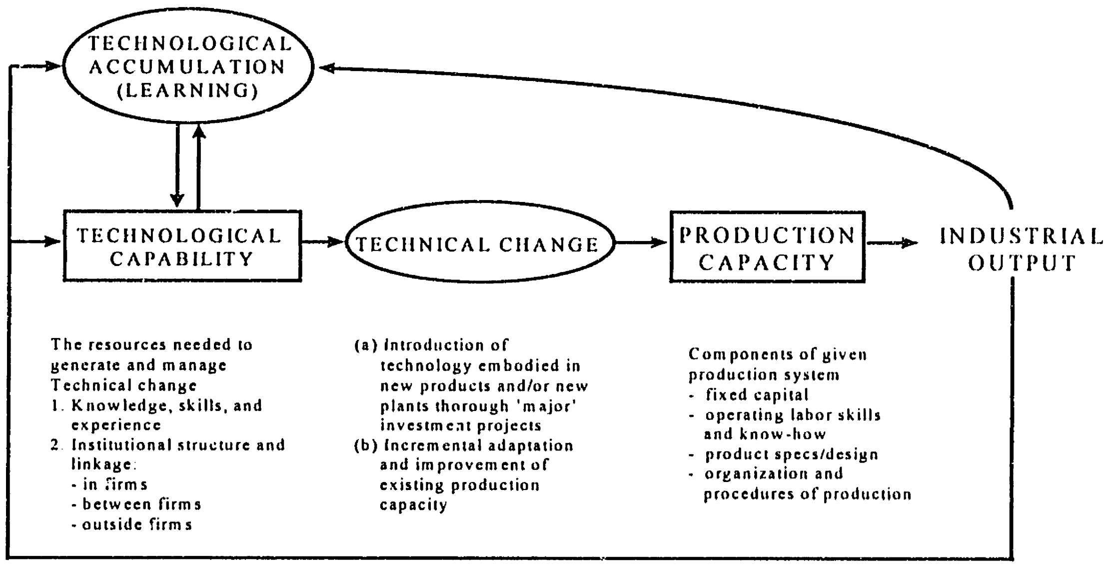
Finally, IPR establishment has an indirect impact on technology capacity building. Strengthening IPR can reduce the conflict between developed and developing countries by kind of building "trust" between each other, which in turn allows developing countries to gain easier access to developed-country knowledge. Yet it is unlikely to apply a single rule of IPR for all countries. The level of IPR will be vary across countries. However, IPRs in developing countries will be better as their economies grow.

***Modification of Pavitt's Model***

Although Bell and Pavitt's graph provide useful insights of the accumulation process, as a representation of model it has weaknesses :

- The learning process is too linear. The first criticism is that the chart does not have a time limit. Consider this example: as a consequence of linearisation, accumulation could happen in the 1950s, incorporate in 1960s, perform technical change in the '70s, and gain better industrial output in the 1980s.

FIGURE 11. REVISED TECHNOLOGY ACCUMULATION CHART




- Bell and Pavitt mentioned continuous improvement many times; in contrast, such crucial is not implied in the chart. Along the process there must be a lot of experience gained, yet it's not clear where the feedback to improve this accumulation process takes place.

The revised chart is shown on as Figure 11.

## The Technology Triangle

Both views in the previous parts gave insight into the important aspect of technology policy, the accumulation of technology at firm and national level in order to deliver better service or products, and the importance in having a solid industrial environment toward technology capacity building. In the case of the role of government, there's still many questions remaining :

- Many examples show that public R&D institutes usually have better facilities as well as good human resources. Can we incorporate public R&D in technological accumulation at the firm level? UNCTAD indicates that part of this answer is the lack of "market-related institutions," which give guidance to the direction of resource utilization.
- To what extent should national plan be described? In some countries it is practical to develop such a plan since few "strategic industries" are dominating the economy such as *chaebols* are in Korea.[66] If the industrial structure is so diverse, developing such a national plan is extremely difficult. Moreover, such a plan can lead to future mistakes because industrial structure is heavily influenced by the economic condition, e.g. the mismatch between technical education and industrial growth.
- Innovation is widely believed to be behind sustaining competitiveness. The bottom line is how to encourage innovation activity at the firm level ?
- Finally, given the importance of industry, and the current effort of public R&D institutes, what is the policy implication for the government to correlate both actors?

For developing countries, these questions create crucial needs for a new framework. A new framework that strategically relates technology actors, focuses on applicability whether industrial or market needs, utilizes effectively technology infrastructure and human resource capability. A framework that carry technology accumulation as its characteristic and can be used effectively toward technology capacity building. Finally, from the government's points of view, it means a framework which is very worth to being supported toward the national goal. From this configuration of ideas, the Technology Triangle emerges.

***Justification for the Technology Triangle***

The process of information that comes to firms, as a production function, can be divided into two tier processes: (a) from the market mechanism into the firm, which is chosen selectively toward the firms' purposes; (b) incorporate by organizational mechanism that can to create

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[66] In 1984 the Big Ten chaebols sale contributed to 67 percent of the Korean GNP. Amsden, 1989, p. 116.

better utilization of the firm's asset. To be effective, this process should be referred to a market situation.

Such a process can be best described by three dynamic mechanisms. The dynamic market brings the latest condition of one's firm to the competitive position. The knowledge dynamics which deal with processing the idea, framing the boundary of work, and seeking the proper solution. Thirdly, the interaction between all players, or, to put it differently, the governance structure which connects all nodes of market-related institutions. Strategically, there are three players in such a network. The "Technology Triangle" consists of the source of knowledge which provide the "brain-power" for advanced knowledge, the firms which deals with production functions as well as with market mechanism, the "environment-provider," which assures that such linkage will work. This "Triangle" should be based on strong binding forces.

Within such a conceptual environment above, the Technology Triangle finds its ground as :

> The term "Technology Triangle" refers to effective and strategic interaction among (a) institutions of science and technology; (b) business and industry; and (c) institutions of governance. Each node in the Technology Triangle has a special relationship to the entire system—with responsibilities, outputs, and impacts—and each is linked to the others in a "supplier-buyer" network.[67]

The Technology Triangle is also strategic and effective since it is tailored to a user need (there will be customers), and is unique and difficult to replicate (enhance the competitive position). The next question: What are the attributes of the Technology Triangle? First it performs a coordination task. Second, it will spread the risk among all players. Third, it will provide more access to technology information.

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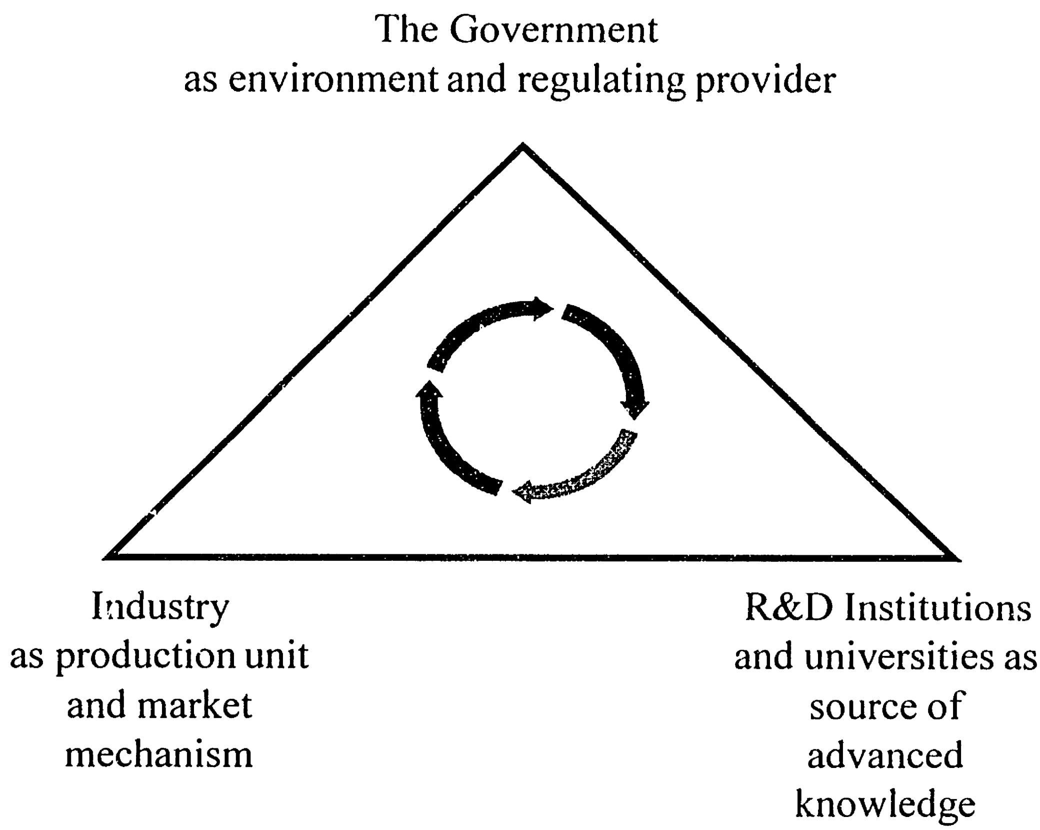
[67] Choucri, 1993, p. 1-2

FIGURE 12. THE CONCEPT OF THE TECHNOLOGY TRIANGLE



# *Chapter 5*

# INTERNATIONAL COMPARISON

The Technology Triangle has been widely accepted around the world as the alternative concept in doing R&D. It provides the linkage not only between the source of knowledge and the production unit that utilizes the knowledge into the market mechanism, but it also gives the perspective of the substantial role of the outside environment performed by the government. Because socio-economic contexts differ among countries, so does the format of the Triangle. Consequently the Technology Triangle takes different forms, and the mechanism within the Triangle will determine its effectiveness. Put differently, there are various ways to "fill-in" the Technology Triangle.

In this chapter I will present two cases, Semiconductor Manufacturing Technology (SEMATECH) from the USA, and the Highly Advanced Nation (HAN) project from South Korea. For the purposes of this thesis, the focus of discussion will be limited on how the Triangle takes its form and the interaction among players.

## SEMATECH

Semiconductor Manufacturing Technology (SEMATECH) was formed based on the following story. In 1980 nine out of the ten biggest chip manufacturing companies were US companies and the semiconductor manufacturing-equipment market was equal to US$ 888 million. In the next ten years the story changed. The market grew five times bigger to US$ 4.1 billion, but five of the six largest producers were Japanese companies. The Japanese magically had gained the market share from about 20% in 1980 to 45% in 1990. On the contrary, U.S. companies' market share has been reduced from 80% in 1980 to 42% in 1990.

The needs to have strong semiconductor industries staying ahead in the global marketplace then intertwined with political support. Put differently these were the needs to have "native" semiconductor equipment suppliers to meets defense requirements, the technology challenge from the Japanese, and the employment problem.[68] SEMATECH was established for a single purpose, to strengthen the U.S. semiconductor manufacturing industry.

In 1993 SEMATECH announced that it have already made a breakthrough - successfully making processing equipment capable of producing a microscopic transistor with a line width of 0.35 microns. This achievement established them as the world leader in miniaturization technology. In 1995 the direction of leadership totally been changed. U.S. companies market share had been restored to 55% in 1995. In addition, SEMATECH members contribute about 80% of US semiconductor production.

What's the strategic role of SEMATECH? Greg Ledenbach, SEMATECH's Director of Design comments that "Our member companies are driven by competitive pressures to develop higher performance chips that add more features and capabilities, yet keep prices down."[69] Basically SEMATECH is a non-profit R&D consortium of U.S. semiconductor manufacturers. Its current members are AMD, Digital Equipment Corp., Hewlett-Packard, IBM, Intel, Lucent Technologies, Motorola, National Semiconductor, Rockwell, and Texas Instruments.[70] For these industrial members, to achieve manufacturing technology leadership means that they work together and share technological advantage.

What is an R&D consortium ? Raymond Corey defines it as :

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[68] In their 1997 report, the Congressional Budget Office calculated that each 1% loss in world semiconductor market equaled 5,500 jobs lost, and also equaled S$ 200 million tax revenue lost.

[69] Ledenbach, 1996.

[70] Originally SEMATECH members were 14 companies. Few of them resigned during the first years. SEMATECH membership is open, any big semiconductors can join the scheme.

... R&D consortia are self governing, usually non profit organization run for the benefit of their members. The owners are the customers, and their purposes is to develop new technology and put it into practice. Funded /largely by member companies, with additional support often from government resources, they are vehicles for R&D cost sharing in areas of common interest.

In short, firms agree to share expenses and share or jointly produce technical information. As a research consortium, SEMATECH is a separate body. Meaning conduct its management practice,[71] established and owned by its members, equipped with a research facility, which is dedicated to serve the members with technology information.

SEMATECH works with government and academia to develop advanced semiconductor manufacturing processes, materials, and equipment and validate new technology in a "proofing" facility that simulates manufacturing production lines. Results of this research are transferred to consortium members who in turn use it for commercial applications. In sum, SEMATECH is emphasizing manufacturing capability, not on designing any electronic equipment or device. It is important to remember that SEMATECH does not produce and sell any chips at all. It is an R&D consortium.

As noted earlier, originally SEMATECH was born because U.S. semiconductor companies have to do something to regain the market share. They have received substantial support from the U.S. government, particularly Department of Defense (DoD).[72] For the first five years (1988-1992), SEMATECH needed approximately US$ 1 billion. After the issue was widely debated in the U.S. Congress, in fiscal year 1988 President Reagan signed a law to authorize U.S.$ 100 million a year for the first five years of the Federal budget via DoD's DARPA (then from ARPA, its successor) into the consortium. The remaining budget was generated from member's fees.[73] In sum, the operational cost was divided 50%:50%. There has been

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[71] SEMATECH has its own CEO.

[72] A Defense Science Board study indicated that in 1995 the US Companies' market share would reduce to less than 20% if they did not do something to recapture market. (*Technology Review*, 1997)

[73] The contribution from membership fees was calculated as one percent from each company's sales. To eliminate the dominance power of one member, the annual fee was set at US$ 15 million maximum and $1 million minimum.

commitment since the beginning of SEMATECH's birth from both sides, the U.S. Government and industries. This sharing cost is the first "principle" of SEMATECH.

The second principle is, since SEMATECH has to serve its owners, it emphasizes development of semiconductors as opposed to doing basic research, e.g. in semiconductor material. The average length of research is three years. Moreover, it also functions as a demonstration plant, e.g. proving that new technology really works.

Thirdly, they assure that the technology will be utilized fully by all members. For example, member companies will send assignees to work at SEMATECH who will bring their problems, learn something, or develop new technology there. After they accomplish the task, they will go back to the company to develop or "polish" the technology for the company's specific need.

Fourthly, the members are in competition with each other, but SEMATECH does not compete. Its research is only at a "pre-competitive" level and member-driven. Hence, it focuses on processing technology as opposed to product technology. For example, they developed lithography technology (the most critical part of semiconductor processing) to manufacture 0.35 micron line width that makes possible for any member to produce a new, powerful chip. The members in turn "polish" the technology and diffuse it into its production line to create new products.

SEMATECH does not limit itself only to manufacturing technology *per se*. Since the more advance chip needs the more complex production facility, it makes sense that it went more deeply to the level of the equipment manufacturing industry. It established the SEMI/SEMATECH, a link between Semiconductor Manufacturing and Material Institute (SEMI) -- the national association of equipment, materials, software, and service suppliers to the semiconductor industry -- and SEMATECH. This SEMI/SEMATECH provides information specifically about the trends of technology development. Hence SEMI members can keep up with the recent trend of manufacturing that is needed by SEMATECH members.

How is the link among SEMATECH and universities or government laboratories? SEMATECH does not do all research solely; indeed, they have research contracts with so-called "Centers of Excellence" (CoEs) -- a number of universities and government laboratories around the U.S. SEMATECH limits itself to short-term applied research. On the other hand, it need sufficient knowledge that only can be generated by doing basic, long-term research. For this kind of research it will provide these CoEs with funds to do particular projects. For government laboratories, the relationship is usually in the form of a direct research contract. For universities it's slightly different. SEMATECH uses another consortium, the Semiconductor Research Corporation (SRC), to put the money there, and SRC distribute the funds to many universities around the USA and Canada that perform research, including MIT. The fund is not only for research but also to support graduate students' research from SRC member companies. Almost one third of SRC financial resources came from SEMATECH.

What's the role of the U.S. Federal Government? From the industrial-achievement angle, SEMATECH obviously is an excellent story about the cooperation of industry and the government. The government provides support but does not get involved directly. Furthermore, William Spencer, SEMATECH's CEO, comments :

> ... the government not only matched industry's funding but it did so in a *very hands-off way*: it sent the funds and put non of the usual restriction on them. The government sponsor, the DARPA, did work with the consortium to establish annual goals and asked for a relatively brief report at the end of each year. But the Agency did not micromanage - it essentially asked industry to manage a federal grant. The General Accounting Office did send representatives here for the first five years, but they left after seeing that the program was well run.[74] *(emphasis and abbreviation added)*

The return of technological development is also interesting. Under SEMATECH rules, all member companies get a royalty-free license to use the patents. Although it has not happened

[74] *Technology Review*, 1997, p. 23-24.

yet, SEMATECH-owned patents can be licensed to nonmembers with the board of directors approval.[75]

Finally, Raymond Corey identifies five important aspect behind SEMATECH's success story.

- conceivable, sustainable, and nationally important mission
- precompetitive level without intervening technological competencies of its members
- outstanding leadership -- especially their first CEO, Robert Noyce, who built support from government agencies and industries
- secured government funding, which focused SEMATECH's efforts on industrial needs
- "homogenous" membership, SEMATECH members constitute of 80% of U.S. semiconductor production, and all member are large companies.

Since U.S. semiconductor companies have regained its position in the world market, SEMATECH interestingly has acted unusually for any consortia. In 1994 SEMATECH members decided not to receive federal funds anymore after the year 1996. Starting from 1997, it will rely only on its membership fees.

It's interesting to ask whether the Technology Triangle is gone from this scheme? If we view SEMATECH's system, yes, maybe no government there. Yet SEMATECH is not alone in that kind of research; there are SRC and Microelectronic and Computer Technology Corporation (MCC) also receive funds and support from the federal government. However, the Texas state government has been supporting SEMATECH and providing it with ultimate incentives.[76] Moreover, the role of government is broaden that not only as Porter put it as "pusher and challenger"[77] but also at certain levels it has become a "maintainer" in the sense that the effort will be sustainable.

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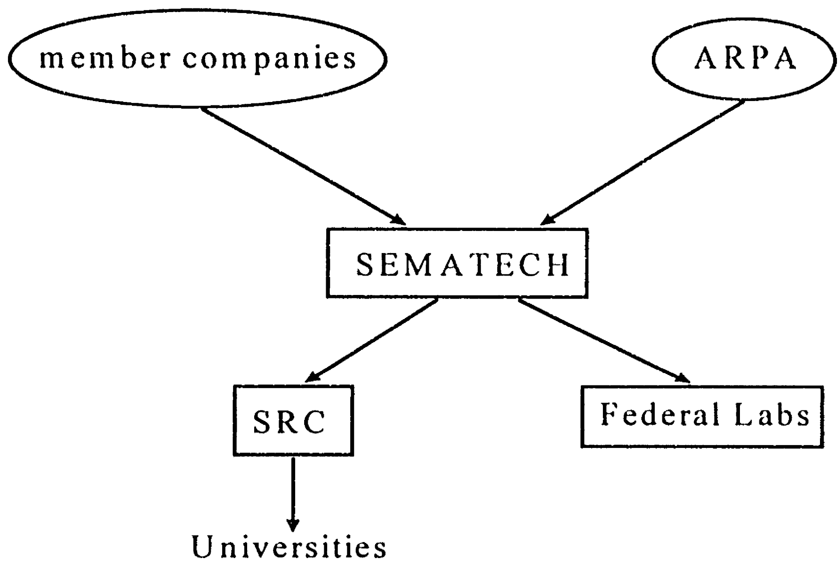
[75] *Solid State Technology*, 1997, p. 46.

[76] Austin was selected as SEMATECH's location among 134 sites around the U.S. One big reason why SEMATECH chose Austin is that Texas state government provided incentive with total amount of US$ 68 million.

[77] Porter, 1991, p. 5.

FIGURE 13. SEMATECH SYSTEM




In sum, the Technology Triangle can be evolutionary. This is an indication that the role of government is not static, but spans from central to local government at different levels of intervention.

## The HAN Project[78]

South Korean economic progress is one of the fastest in the world. The economy grew from US$ 87 in 1962 to more than US$ 10,000 in 1995. Manufacturing goods' contribution to

[78] The HAN case was written form primarily from two sources, Park et al (1996, p. 77-90), and an interview with Mr. Gunsoo Yoon from LG Electronics. He was involved in the LG management team that prepared the HAN Project.

exports has dramatically increased from 14.5% in 1962 to 95.0% in 1989. Substantially it also has jumped from an agricultural country to an advanced, industrialized country.

Korean technology policy is well known as a good example of a systematic and selective one. It began from turnkey plants in the early 1960s, assimilated and upgraded to increase the capacity, and developed new and advanced products. Many of Korean *chaebols* entered the world market, successfully creating supremacy in the market. For example, Samsung is the largest producer of the metal oxide silicone (MOS) memory chip with total sales US$ 7.34 billion.[79]

One of the new initiatives in the Korean technological policy is the Highly Advanced Nation (HAN) project. The HAN project was established in 1992 to leverage Korean science and technology up to levels similar with the G7 countries. That's why some people in Korea also label this project as "the G7 project."

The HAN project has two clear focuses : (a) encourage new technology development to generate competitive products to be introduced in the *future* world market; (b) select key and base technology which can strengthen global competitiveness in the *current* world market. Or to put it differently, focus on products' technology development and fundamental technology development, which is important maintaining the current position as well as securing a position in the future world market.

The interesting question is how it plans to establish such a project? First, selection of potential projects. A planning team called "the G7 Planning Team" was formed by the Korean government consisting of prominent persons from industries, government research institutes, and universities. This planning team identified about 300 potential projects to be executed. The next step was identifying any industries or group of industries that are capable of gaining better position in the world market by doing such "leap-frogging." Moreover, by assessing these nomination list, some precompetitive technologies have been selected. They can develop the

[79] Park et al, 1997, p.4. Quoted from the World Semiconductor Trade Statistic 1996.

technology further to create competitive products based on their customer needs. These technologies were selected due to two main reasons : (a) the technology will improve the level of technology in the related industries; (b) expectation of expanding their share in the world market. However, the team has chosen 60 potential projects. Finally the team conducted a survey and sent questioners to many experts not only to get ideas but also consensus on whether the target is sufficient or not.

The selection process went to the next step, assessing the current industrial strength. The historical performance of industrial group contribution on Korean exports were analyzed to get a sense of what industrial sector they are really strong in. Finally, only 11 R&D projects was selected out of more than 300 projects in the beginning of the process. These 11 projects went to the next step, the detailed planning phase. The new detailed planning teams was formed with a primary task of developing the working plans.

At the same time the government has developed seven guiding principles to transform these 11 technologies into detailed plans :

- the contribution to national competitiveness supporting by the detailed role of companies, R&D institutes, and universities.
- avoid the bias toward one's particular interest using fair peers. However the government has a crucial role in examining the composition of a planning team.
- promote fair competition among R&D professionals. Moreover, in the beginning of research phase, parallel research might be done to achieve the same goals.
- assure that top researchers will be involved in the project
- encourage participants to develop various strategies to achieve the project goal
- flexible plan structure depending on the project type
- encourage the development of "practical" plans including the needs of resources, and mechanisms such as organization, schedule, milestone, and operational approach.

Interest parties such as industries and R&D institutes used these principles to develop detailed plans. The interesting fact is that the selection process was managed and operated by a private firm, LG Electronics. The amount of money that invested in the HAN project is increasing regularly. The amount of investment from the public and private sectors was US$ 230 million in 1992, US$ 309 million in 1993, and US$ 414 million in 1994. The first evaluation was conducted in 1995 from an internal evaluation to an evaluation by private experts. At that time it was reported that no less than 20 government research institutes, 50 universities, and 60 private firms were involved in the HAN Projects. Evaluation was based on relevance and performance, with the weight of relevance ranked first.

Why do companies want to joint the projects? What reward and punishment does this scheme provide? First of all, there is common need to face the increasing intensity of competition, which has pressed them to work together if they want to stay ahead in the world market. Mr. Gunsoo Yoon indicates that the Korean government indeed provided them with incentive. If the project evaluation grade the project as successful, the companies which were involved in the HAN project do not have to repay the money they received from the government. On the contrary, if the evaluation result shows that the project progress is not near their expectation, the companies have to pay back the money.

The contribution of the public and private sector in every project generally is 50%:50%. A project can be divided into several sub projects. A sub project can be divided again into a few research topics. Within this research topic, a leader will be chosen. The selection of the leader is primarily based on which party has the best performance in the area. If any company feels that it needs outside support, particularly to have a research partner, they can arrange an alliance with the universities.

The contribution of any company was decided to be dependent on each others capability and willingness to do the research activities. The budget transfer from the government to the coordinator agencies, which in turn distribute it to participant companies. The whole process is open to the public, e.g. an announcement is advertised in the newspaper.

It is important to note the strategic role of the G7 Planning Committee. This Committee not only selects the 11 projects but also evaluates research topics. Moreover, it monitors the progress of research activities. They grade whether a research activity is good or bad. In short, its role is to define the research priorities, evaluate the research plan, and monitor the progress of research. This can be understood as an effort to assure that every acti   is still on "the right track." To some extent this phenomenon represents the top-down approach in the sense of pursuing national goals.

Finally, the role of the Government of Korea indeed is very crucial in this schema. First, it initiates the project and maintains the strong commitment. Secondly, it provide the incentive and also the punishment of the system. Thirdly, although it is not involved directly in the execution (no ministry is involved directly) they do "assign" governmental R&D agencies as coordinators and determine the direction of the process below. Fourthly, they formed the G7 Planning Committee, which serves as the highest body in this scheme.

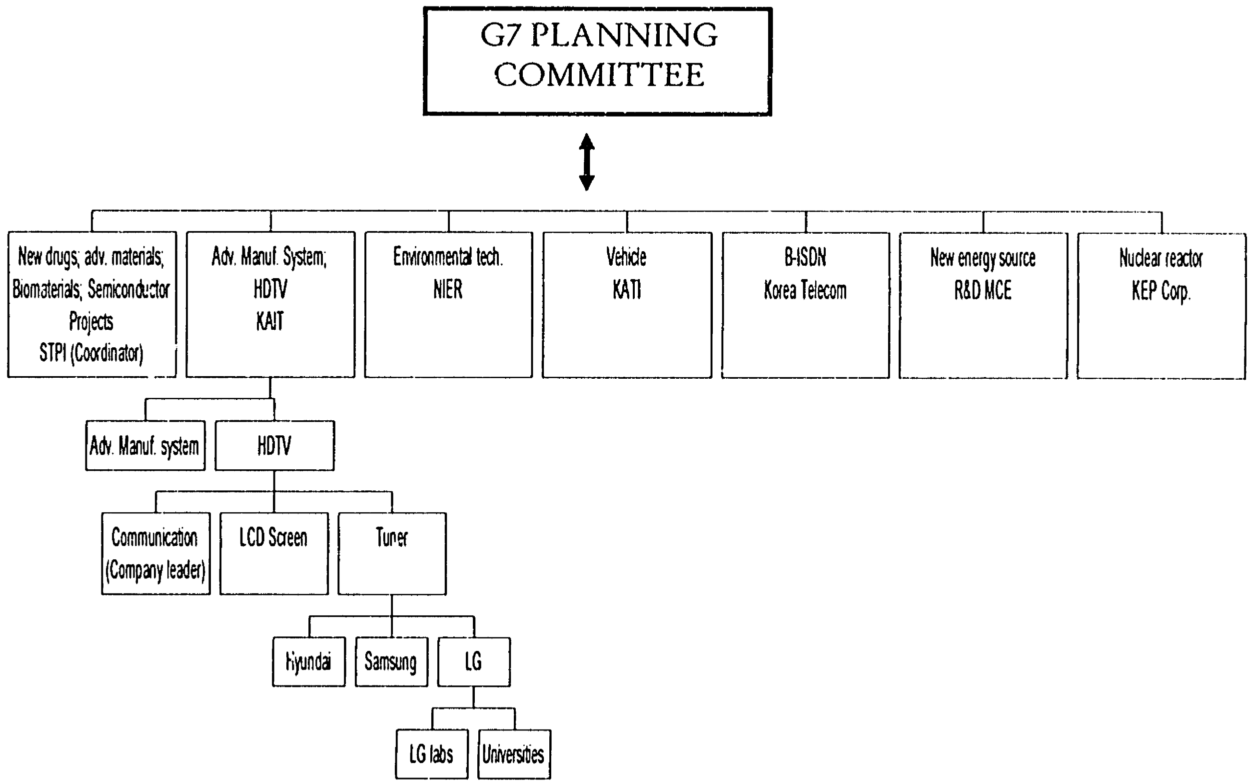
These two cases gave insights on how the Technology Triangle can be formed in various ways. Moreover, based on these two cases and discussion in previous chapters, in the next chapter I will describe the environment of the Technology Triangle.

TABLE 9. SCOPE OF HAN PROJECTS[80]

| Category | | Project | Period | Coordinator | Target Technologies |
|---|---|---|---|---|---|
| Product technology | 1. | New drugs and agrochemical | 1992-1997 | Science and Technology Policy Institute | To develop 2-3 new antibiotics and germicidal agents |
| | 2. | B-ISDN | 1992-2001 | Korea Telecom | To produce prototype products of 10 giga atmospheres |
| | 3. | HDTV | 1990-1994 | Korea Academy of Industrial Technology | Already finished in 1994 |
| | 4. | Next-generation vehicle technology | 1992-1996 | Korea Automotive Technology Institute | To develop electric vehicle with 120km/h speed |
| Funda mental technology | 5. | Next-generation semiconductor | 1993-1997 | Science and Technology Policy Institute | To develop basic and core-technology of a superintegrated semiconductor |
| | 6. | Advanced material for information, electronics and energy | 1992-2001 | Science and Technology Policy Institute | To develop 30 kinds of new advanced materials |
| | 7. | Advanced manufacturing system | 1992-2001 | Korea Academy of Industrial Technology | To develop Flexible Manufacturing System and Computer-Integrated Manufacturing |
| | 8. | New functional biomaterials | 1992-2001 | Science and Technology Policy Institute | To develop process technology of bioactive, new material for commercialization |
| | 9. | Environmental technology | 1992-2001 | National Institute of Environmental Research | To develop core environmental technology |
| | 10. | New energy technology | 1992-2001 | R&D Management Center for Energy | To develop fuel cell system |
| | 11. | Next-generation nuclear reactor | 1992-2001 | Korea Electric Power Corporation | To develop the concept and basic design of new nuclear reactor |

[80] Park et al, 1996, p. 84-85.

FIGURE 14. TYPICAL STRUCTURE OF THE HAN PROJECT




STPI : Science and Technology Policy Institute
KAIT : Korea Academy of Industrial Technology
NIER : National Institute of Environmental Research
KATI : Korea Automotive Technology Institute
R&D MCE : R&D Management Center for Energy
KEP Corp: Korea Electric Power Corporation
LG : Lucky-Goldstar

# *Chapter 6*

# INSTITUTIONAL ARRANGEMENT

## The Environment Needed for the Effective Technology Triangle

The Technology Triangle is not an "isolated and single" system. From the cases discussed in earlier chapter, it can take in very different forms and through various institutional settings. Moreover, there are fundamental reasons behind those schemes. First of all, it depends on country's macro-economics condition. If the macro-economic condition is not good, such strategic intervention (particularly when public money is being involved) will not be sustained. Strong and stable macro-economic conditions can reduce barriers for companies to enter the market by providing bundles of fiscal, monetary, and regulation incentives such as tax breaks, low interest rates, facilities, and the like.

Secondly, an adequate level of education and training plays a very crucial role in supporting the technological progress. To put it differently, an adequate human pool is necessary to perform industrial development. Formal education as well as training play important roles. Considering the fact that the higher industrial technology level needs more capable human capital, the role of universities find its place nicely. This can be achieved successfully in two ways: reorient the industry to search for new knowledge from universities, and/or "tie-up" universities to carry out research according to industrial needs.

The role of Government is nonetheless crucial in such configuration. It can be a pusher, challenger, and maintainer. However, it uses incentives heavily as policy instruments. In providing such incentives it has to make it very clear about the time limit. Unstable commitment can be interpreted by private firms as an uncertainty factor, which can cause additional barriers to the Triangle. Finally, the availability of a body as "conductor" particularly to allocate resource function, seems necessary.

Regarding the initiative, it can be either from the government or private firm's side. The important thing is, as mentioned many times earlier, the focus of interaction is with the firms. Enhancing the technology capability at this level is very critical; otherwise, it will lose the main benefit. Industry itself acquires, adopts, accumulate, and masters technology. The new technology will be complementary to the existing one. The process of transfer should be completed and embodied in the production process.

From cases discussed in the earlier chapter, it seems that the economics of scale is matter. It does not mean eliminating small and medium industries from the scheme. But compared with small and medium industries, large industries have more access to financial institutions, better human resources, and also more access to technological information. Moreover, some large companies can become the "core-group," or the machine of the changing process. The case of SEMATECH and HAN project imply that not all of the big manufacturers get involved in the scheme, but there are certain companies that continuously lead as the engines of transformation.

Another topic is the selection of strategic sectors. It is important to limit the scope of technological policy. Common goals should be set, and it means choices should be made. Put differently, it means priority setting. One main benefit of making a clear distinction is that parties can join and consequently will stay with the scheme until the goal is achieved. It is easier to give considerable effort if the scheme is more clear, e.g. to supply it with required resources.

## Innovation System

The innovation system, as Nelson and Rosenberg define it, "to encompass the process by which firm master and get into practice product designs and manufacturing processes that are new to them,"[81] emphasizes the internal mechanism within firms to master the technology and continuously produce new ideas or new things. The latter is not only limited to new products but also includes process improvement and the acquirement the better management practices.

Technology is not something that "comes from the sky." The level of formal education as well as training is important. It is worth to noting here that a higher technology level needs a higher level of human capital. Imbalance can lead to reduced pace of growth.

What's the basis of technological development at the firm's level? Usually the motivation behind technological development is the motive to increase profit as well as improving the competitive position. Hence it is imperative for the government to provide an economic environment particularly to provide a competitive market and encourage companies to apply the best practices in doing business. Cooperation among similar industries is a necessity than a luxury in order to have the benefit of synergy.

Finally there are two aspects that have driven the innovation process indirectly since the beginning. It is necessary to provide resources at "critical level." Moreover, Government R&D institutes and public universities are heavily depending on the governmental budget. It raises the need to have other incentive systems that can be tied up with industry. Consequently, the availability of a body that can deploy resources and give direction toward the common goal is very necessary.

## Application of Technology Triangle

The Technology Triangle is indeed a salient concept to understand how important the interaction between the three parties is and how they relate to each other. Nevertheless from the supply side the focus should be on supplying firms with sufficient technology information and providing incentives in order to push them to create sustainable competitiveness.

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[81] Nelson and Rosenberg, 1993, p. 11.

The Indonesian government owns most of the R&D resources of the country. It's obvious that the delicate task will be to link and align these resources, particularly the government's researcher capability and facilities for industrial needs. Having the Technology Triangle in hand will sort of bridge current missing link between R&D efforts and industrial requirement. Put differently, it makes those resources an important source of industrial technology. Hence the Technology Triangle is the answer of the crucial question of how effective is public R&D spending in Indonesia.

Finally, budget consequences. U.S. Federal and State Governments, and the Korean Government have been using budgetary power to support the Technology Triangle mechanism. Both examples show that budget support is necessary, at least for the beginning phase. On the other hand, they do not really do hands-off. Demanding specific output can always be found in a successful Triangle. In the case of the HAN project, it's even more clear. The achievement of output becomes the benchmark as to whether companies have to pay incentives back or not.

Interestingly, after the system works well, industry might become the prime source of research fund for universities or even government R&D institutes. Consequently, maintaining the resource of funds means that they have to align themselves to help the industry's competitive position. Regarding this issue, the Technology Triangle is an important aspect; if it works well, it can be a self-generating system.

The Technology Triangle raises another important question, Which is the best intervention mechanism to be applied in Indonesia? In the next chapter I will arrange a recommendation based on the concept of Technology Triangle, the current condition of industrial and R&D capabilities of Indonesia, and lesson learned from the USA and Korean cases.

# *Chapter 7*

# RECOMMENDATION

## Summary of Important Points

Learning from advanced countries' experiences, it is well understood that technology is tied to long-term economic growth. In this globalization era, technology also has become the important resource for the competitiveness of products and firms. Focusing on Indonesia, consequently it is imperative for it to continuously build its R&D capability. Since firms compete with each other, all effort should stay focused to increase firms capability.

Along its development path, Indonesia was transformed from an agricultural to semi-industrialized country. Manufacturing sector growth is increasing rapidly and becoming the engine of growth. On the other hand, Indonesia has been building its technology capability. Several strategies have been applied, from strategic industries to various new research schemes that recently have actively been launched.

The development process leads Indonesia to have a large R&D system and pools of researchers. The quality of research recently has been improved through research competition to get grants. Some new technology developed from these schemes are close to the application stage, although that does not mean it's ready to be applied. Generally R&D results and industrial needs are still unconnected. Consequently, the primary objective is to turn this research result into industrial competitiveness. But it is not so easy, technological capability e.g. human capability and research investment at firms level is still low. Since the competitiveness of one country really depends on the competitiveness of its firms, having such a lag can reduce the pace of current economic growth momentum.

Through previous extensive analysis, the Technology Triangle has become the best alternative to be used. Yet as a "mindset" it needs to be transformed carefully into useful programs and schemes to ensure its goal. Despite its strength as a concept, and as the strategic alternative to deploy R&D resources, the successful Technology Triangle depends on the "embedded institutions" to encourage the accumulation of technology. The function of these institutions is particularly to provide the basic relationship which is the buyer-seller relationship. In providing this relationship, the government plays an important role. Government-owned R&D institutions' as well as its public universities' involvement in the Triangle is indispensable. The format of schemes is a sort of politically driven process, which underpins the trade policy and technology policy.

## Intervention Modes

In this Section I will discuss the domain of current intervention by the Indonesian Government and find niches to improve the process. It should be noted first that the following discussion will exclude the strategic industries.

New incentives are being introduced by providing two mechanisms, "quality" and partnership research. Quality research was designed to pursue scientific goals while also promoting quality. The important aspect is using competition extensively as a grant-rewarded mechanism. However, such competition has increased the stock of good researchers.

For partnership research -- the focus of Technology Triangle -- as noted earlier there are two schemes, which are the Partnership and Research Strategic National Program. The first facilitates joint research among universities and or government R&D on one side and industries on the other side. Government initiates the programs and provides it with a "matching-grant" to industrial funds. Universities and government R&D institutes help industries to solve their current problems.

The Strategic National Program basically is the "leap-frog" type, rather similar to the HAN project. There will be certain national goals to be pursued. Universities, governmental R&D institutes, and industries then contribute to support the achievement of the program. Not many things can be told from this story since the government of Indonesia is intensively preparing the format for the new scheme now. Yet this is an indication that government plays an important role, and the process is "top-down" as opposed to solving the problem at the heart of industry itself.

On the other hand, the government also provides incentive in a looser way. A Project called the Industrial Development Technology Program uses "consultants" quite extensively to enhance the technology level of small and medium industries. This is being done by creating dedicated "technology matching office." Small and medium industries that have problems can visit the office, which will help them to find suitable technological partners. The cost of this consultation will be shared only if the companies are satisfied with its work. Through this project the barrier to get the best technical information right at the heart of the industrial problem will be reduced. Yet the process was designed to boost the technology transfer to small and medium industries while developing the consultancy business particularly in technical field and production management.

Above all, most of research projects is scattered in many R&D institutes and universities around Indonesia. Even though they are related to the National Matrix but their orientation toward industrial development is questionable. On the other side, for long years technical information has been accumulated as a result of long time research. This is the first indication regarding the direction of the Technology Triangle.

Another indication is from the Manufacturing Industry Census, which shows that private firms are willing to spend money to do R&D. Yet their effort particularly deals with production engineering. Secondly, the study from Pitono and Simamora shows that most researchers feel that their research is close enough to application stage. Yet the application of R&D result remains low. It's not enough, but it can indicate where the matching point is.

To sum up, basically the government of Indonesia has been using various ways to get involved in the technology development. I argue that the "prime" lack is the accessibility of technical information. Certainly two-way traffic does not happen, and policy recommendation will be arranged accordingly.

## Policy Recommendation

As identified many times earlier, Indonesia urgently needs to shift its R&D orientation and build a close link to support industrial competitiveness. Given the importance of supporting industrial development, the current technology policy, the importance of emphasizing technological accumulation and TCB, and case studies, the recommendation applies at the level of general strategy and policy implication.

The essence of the recommendation is to promote effective policy. The goal of policy itself is to utilize R&D institutes and public universities and "attach" them to industries as the principal vehicle to transform technology transfer into competitiveness. But instead of preparing policy plan (more rigid way), this thesis will try to provide policy guidance on the next technology policy. In addition, it takes into consideration the "exogenous factors" of policy making process in developing countries, in this case Indonesia. It can be derived from the nature of the discipline (e.g. engineering vs. science), or the unwillingness to let industry control the "governmental" research direction.

It is important to note that there're a lot of differences in Indonesian researchers "mindset", from "research-for-the-sake-of-research to technology-should-be-applied." Consequently, not all Indonesian researchers will accept the concept of the Technology Triangle. Another aspect is that in order to be successful, the Technology Triangle seems should be separated from the government structure. Put differently, the Technology Triangle needs to be managed "freely" from bureaucratic and private governance as a trade-off to stay focused on effectiveness. Based on my knowledge and personal experience of Indonesian bureaucracy, such implication cannot easily be applied. The governance structure should be flexible enough, yet meet all requirements set by all nodes.

Although the new thinking tends to conclude in allowing R&D institutes and public universities to receive money from industries, it is supposed to be reoriented toward industrial needs rather than purposefully doing "privatizing public research" in the sense of depending on private funding alone. It does not mean that Indonesia needs to restructure its R&D institutions totally yet in order to fully exploit the existing technology infrastructure. Government R&D institutes still have a "public mission", such as developing new rice varieties, which are public goods instead of commercial product. Yet heavy dependency on the governmental budget make these R&D institutions less "client-oriented," which can lead to the elimination of important buyer-seller relationship. As final note, this recommendation does not intently want to restructure Indonesian R&D policy, but rather to find its place as a guiding document.

The recommendation itself will be based on the following ideas :

- utilize the available technical information to be ready-used by the industry
- encourage the long term research
- encourage the permeable interface between R&D institutes, university on one side as the supplier of technology, and industry on the other side as the user.

***Technology Promotion***

Indonesia has been developing its science and technology capability since the 1970s. Along its development path, a lot of technical information has been generated. On the other hand, the application of such information is very low. Many examples show that public R&D institutes can make important contributions to industrial competitiveness, if they appropriately align themselves accordingly. Hence the first to do is "off-the-shelving" of available information.

"Off the shelf" can be done in three ways :

- let the industry know that some technology is ready to be applied.
- Improve, bundle, and package "immature" technology to be ready to be applied
- Encourage public universities and R&D institutes to "line-up" their technology competency.

*Promote a regular technology exhibition to industrial centers in Indonesia.* R&D institutes and public universities have to "promote" themselves as proven knowledge suppliers. Technological information should be packaged for industrial purposes including the benefits of utilizing the technology. The package, however, should be demonstrated to the prospective industry.

*Provide technology management assistance to booster the diffusion of technology into the production stage.* It is important to address the diffusion process to get the full benefit of new technology. If industry faces diffusion problems, e.g. not complementary with current system, it can ask for help from technology-management experts. The group will act as an on-site consultant and work together with factory engineers to ensure the technology will be fully adopted.

*Help R&D institutes to package the information and make it attractive to industry.* It is suggested that each lab should develop a business plan, which mentions a clear strategic focus regarding a "technology-launching program." Based on this trajectory, immature technology can be continued, polished, and bundled to make it ready to sell.

*Develop technology-marketing centers.* Establishing such offices helps R&D institutes to reorient themselves toward industrial needs as well as makes it easy for the industry to find technical information. Such technical information will be published regularly to keep the industry well-informed with the recent research programs. Moreover, these offices may be dedicated in providing specific technology information for particular industries. This "Industrial Liaison" type will be based on a pure buyer-seller relationship. By paying an annual fee, industries can become members and get access to technology information and research progress in that university or R&D institutes.

***Research Consortia***

The idea of research consortia was generated especially to be applied as an alternative for National Strategic Program. Research consortia themselves particularly spread the risk among members while pursuing technological advantage. The idea will be based on a "marriage" between SEMATECH and the HAN project.

One tough decision will be on choosing the "right" industries. However, there are industries that are proven to be as engine of growth such as textile, and mining industries. On the other hand, the strategic industries cannot be easily be ignored. In the mean time, there are also big processing industries that rely on domestic market such as cement, chemical and metal factories.

This thesis is not purposely to choose other strategic industries, yet base on the analysis of Indonesian industries, there are several direction, which are the ability to export the product, energy, and environment-related technology. The record of exporting the products will be assessed fairly, and also the technology trajectory will be drawn to stay competitive in the world market. The benefit is that Indonesia not only develops strong and particular technology, but it also coupled by linking among firms e.g. strengthen supplier-producer relationship. Industrial associations plays important roles since the cohesiveness among similar industries such as cement association is quite strong.

The design of technology goals should be decided by the three parties. The benchmarking also should be agreed upon first. Moreover, each others share should be very clearly defined. In sum, strict priorities and goals are necessary to assure the direction. A punishment level should be applied yet not as tough as Korean case because it may increase the barrier, at least in the beginning stage.

The Board of Trustees should represent the cooperative work and consist of members from related government institutions and industrial leaders. These members will also acts as "liaison officers" to each agency and industry. Since the program is new, the first management team should build up from innovative, dynamic, highly educated, yet, small teams.

***Incentives***

Regarding incentives, there are several principles that should be born in mind. First, incentives will act as "up-front financing," as a catalyst to assure more acceleration in gaining technological advantage. Secondly, they will focus on R&D institutes' and public universities' situation. Having tied up with governmental budget, make them less likely to be client-oriented. They should be granted with easier access to accept industrial funds. Moreover, this should be accompanied by granting more "autonomous role" in defining technology direction. It does not mean change the National Matrix totally, yet allow the researchers and the industry to contribute more in determining research direction. Autonomous functions also should be granted particularly when providing incentives to its researchers. They are the machine of R&D activities. Popular incentives are subsidies, tax breaks, low interest rates, and the like to reduce the barrier to enter new business. Moreover, some time capital-sharing is also possible, particularly for the consortia because scale usually matters there.

Technical information is the "nexus" of supporting technological advancement in the new research schemes. The most important incentives are assuring the provision of technical information and the accessibility of each R&D institute resource. Consequently, there should be a special survey to "benchmark" the current program and labs' capability. Such information should be codified and will be stored in hard copy as well as electronically. Electronic storage is important since the area of Indonesia is so big and the Internet business is growing very rapidly around Indonesia.

Another aspect is to get the fully benefit of the educational side. It is imperative to absorb any new technology development into a part of learning system including universities. Any scheme should allows assignees from both side (R&D and industry) to learn from each other. Then they will know the problem from the other side.

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