## SESSION B

## RESPONSES OF THE NATIONAL INNOVATION SYSTEMS

The session on National Innovation Systems (NIS) examined the globalizing forces on an economy's NIS, its effects on the research enterprise, and the actions taken by countries in addressing its impact. Effects on R&D investments in the public, private, and nonprofit sectors, foreign direct investment flows, intellectual property issues, and other policy initiatives specific to an economy were included in the presentations.

Topics addressed by the various presenters included globalization forces impacting their economy's NIS; composition changes in the research enterprise; drivers of technology investments; and development of cooperation mechanisms.

# LESSONS FROM NEW ZEALAND'S EVOLVING INNOVATION SYSTEM

Rick Christie
Chair
Growth & Innovation Advisory Board





# NEW ZEALAND IN APEC

| | 2003 |
|---|---|
| Population | 4 million |
| GDP | NZD113 billion |
| CPI | 1.5% annual change |
| Unemployment | 4.6% |

## RESPONSES TO GLOBALISATION

| | |
|---|---|
| 1900s | Refrigerated produce to UK |
| 1970s | Diversification following UK entry to EEC |
| 1980s | Financial and regulatory reform |
| 1990s | Corporatisation of institutions |
| 2000s | National innovation system approach |



## NATIONAL INNOVATION SYSTEM APPROACH

- Knowledge creation and technology absorption is complex
- Interaction and collaboration of people, firms and government is necessary over time
- Innovation and entrepreneurship support sustainable competitiveness

## NEW ZEALAND'S INNOVATION HISTORY

An agriculture sector that is efficient and highly competitive due to research and development in public research institutions:

- elite animal genetics
- highly productive pasture species
- agriculture systems
- grazing technologies



## NEW ZEALAND'S NATIONAL INNOVATION SYSTEM

- A strategic approach for teaching and research in tertiary institutions
- Research consortia and centres of research excellence being established to meet the challenges of collaboration and research scale
- Recognition of the need for some measure of non-contestable funding support for institutions to maintain capability in key areas
- Special funds to meet the challenges of Capital Markets

## NEW ZEALAND'S NATIONAL INNOVATION SYSTEM cont…

- Support for promotional activities, the facilitation of exporting and global connectiveness
- Support for sector development to enable a focus on strategically important sectors
- Support for regional development to connect communities to global markets
- These latter three all delivered by New Zealand Trade and Enterprise



## LESSONS WE LEARNED

- Globalisation is a challenge
- Open deregulated economy is essential, but more is required
- Government has a lead role in the innovation system
- Government has a role to provide an overall strategy

## A STRATEGIC APPROACH

- The Growth and Innovation Framework
- Three foci
  - ICT
  - biotechnology
  - creative industries
- Three taskforces
- Regional development and sector strategies
- Tertiary education strategy
- Strengthening support for research and development
- Ensuring a sustainable development approach to policy



## TARGETING INNOVATION STRENGTHS

- GIF itself provides a focus on New Zealand's innovation strengths
- Centres of Research Excellence
- Public–Private partnerships

## ENHANCING INTERNATIONAL LINKAGES

- Public–Private partnerships internationally
- Research institutes with international networks
- Government role to provide information
- Government role to facilitate opportunities



## ATTRACTING VENTURE CAPITAL

- Co-operative agreements
- Venture Investment Fund
- Supporting international promotional activities

# The National Innovation System of the Philippines: Challenges and Opportunities

William G. Padolina, Ph. D.
Deputy Director General for Partnerships
International Rice Research Institute
Los Baños, Philippines

*Conference on*
*National Innovation Competencies and Interests in a Globalized World*
*Broomfield, Colorado, USA*
*25-27 May 2004*

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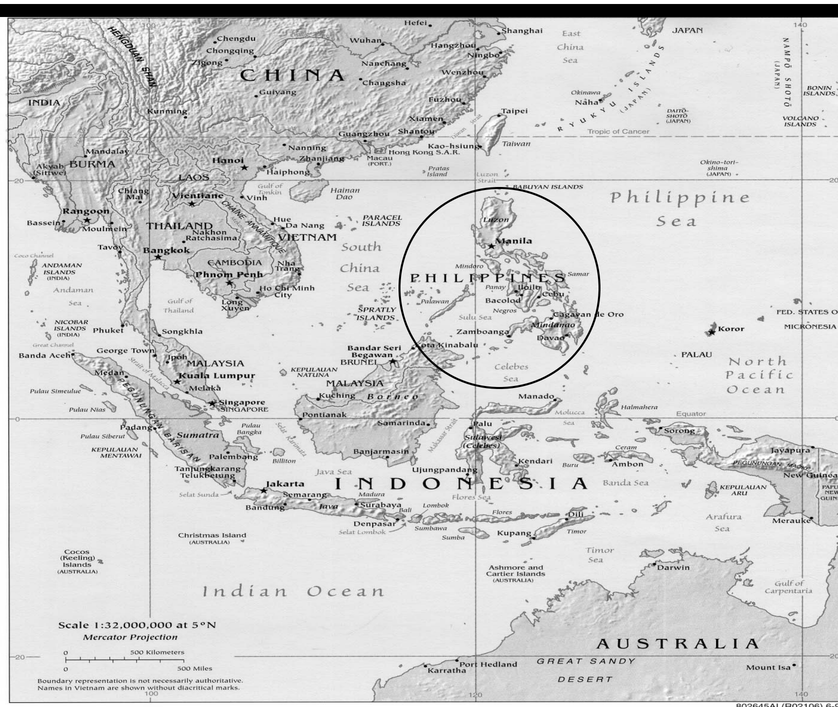
r i c e i s l i f e

INTERNATIONAL YEAR OF RICE

2 0 0 4



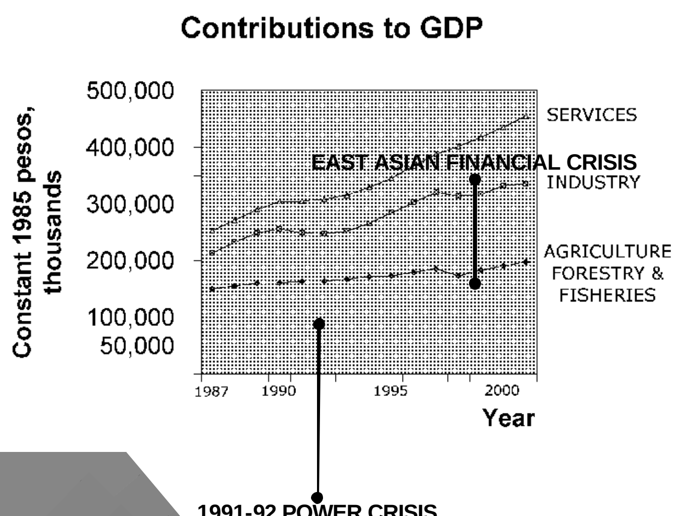

# Outline

1. Introduction and Updates on Philippine Economy and State of S&T
2. Current Initiatives to Strengthen the Philippine National Innovation System
3. Enhancing NIS in Developing Countries in APEC

# Philippines in Figures

(National Statistics Office, 2004)

| | |
|---|---|
| Population (May 2000) | 76.5M |
| Projected Population (2004) | 82.7M |
| Inflation Rate (April 2004) | 4.1% |
| Balance of Trade (Feb 2004) | $5.11M |
| Exports (Feb 2004) | $2.999B |
| Imports (Feb 2004) | $2.994B |
| Unemployment (Jan 2004) | 11.0% |
| Underemployment (Jan 2004) | 17.5% |
| Simple Literacy (2000) | 92.3% |
| Functional Literacy (1994) | 83.8% |
| Median Family Income (2000) | P88,782 |
| GNP (Q4 2003) | P1334.5B |
| GDP (Q4 2003) | P1246.8B |




(Talisayon, 2003)

## Resources

- Development within democratic space
- Abundant natural resources- fertile land, minerals, maritime country
- Young population- more than 50% below 30yrs old

## Philippine Performance in Export Trade, 2000 (Goods and Services)

- 6% of global exports in electronic integrated circuits and microassemblies.
- Companies located in Philippines: Intel, Motorola, Timex, Texas Instruments, aircraft parts manufacture, wire harness manufacture, and vehicle instrument panel design, call centers
- 26.8% of global export market in coconut and palm olein products

# Improvements in Communications Infrastructure

- 1.2 Internet Hosts per 10,000 people (1999)
- 6.5M cellular mobile phone subscriptions as of May 2000
- 9.05 telephones per 100 people (2000)

(World Bank, 2000)

**Table 1: Gross and Net Exports of the top ten export items of the Philippines, 2000**

| Rank | HS Code and product label | Exports 2000 (US$ m) | Net Exports (US$ m) | Export growth 1996-2000 per cent per annum | | Share in world (in per cent) |
|---|---|---|---|---|---|---|
| | | | | Value | Quantity | |
| 1 | 8542 Electronic integrated circuits and microassemblies | 15,485 | 8,184 | 33 | 16 | 6.0 |
| 2 | 8471 Automatic data process mach;optical reader, mach for transcribing data | 4,644 | 4,453 | 41 | 45 | 2.8 |
| 3 | 8473 Parts and acess o/t cover/carryg cases&sim for use with hd 84.69-84.72 | 2508 | 331 | 10 | 26 | 2.6 |
| 4 | 8541 Diodes/transistors&sim semiconductor devices; light emitting diodes etc | 1176 | 935 | 10 | 8 | 3.4 |
| 5 | 8534 Printed circuits | 1049 | 797 | 79 | 48 | 0.8 |
| 6 | 8544 Insulated wire/cable&insul elec conductors w/n fitted w connectors | 647 | 503 | 5 | 11 | 2.0 |
| 7 | 6204 Women's/girls' suits, jackets,dresses skirts etc | 613 | 611 | 8 | 10 | 1.9 |
| 8 | 8708 Parts&access of the motor vehicles of heading nos 87.01 to 87.05 | 568 | 338 | 18 | 14 | 0.1 |
| 9 | 1513 Coconut (copra), palm kernels etc | 464 | 463 | -10 | -3 | 26.8 |
| 10 | 8536 Electrical app for switching (ex fuse, switches etc) not exceeding 1000 volts | 450 | 248 | 58 | 111 | 0.5 |
| | **Total Exports of the Country (All Goods)** | **38,068** | | | | |

(Mani,2002)

# Declining Productivity

- Ranked 52 out of 60 countries in overall ratings in the 2004 IMD World Competitiveness Report
- Declining Total Factor Productivity since the early 90s
- Net food importer since 1994

(World Bank, 2000)

# Low Productivity
# Yields of Selected Crops

- Sugar: 0.7 of Thailand's and the world average, and only one third of Australia's.
- Corn: one-half of Thailand's and two-fifths of China's and the world average
- Rice: three-fourths of the world average, seven-tenths of Indonesia's and one-half of China's
- Coconut: seven-eighths of the world average and seven tenths of Indonesia's

(Intal,2003)

# Human Resources

**Table 20: Achievements in Mathematics and Science by Filipino eighth grade students compared to those from other high technology exporting countries from East Asia in the TIMSS 1999 Benchmarking Study**

| Rank | Country | Achievement in Mathematics | Rank | Country | Achievement in Science |
|---|---|---|---|---|---|
| 1 | Singapore | 604* | 1 | Taiwan | 569* |
| 2 | Korea | 587* | 2 | Singapore | 568* |
| 3 | Taiwan | 585* | 5 | Korea | 549* |
| 4 | Hong Kong, SAR | 582* | 15 | Hong Kong, SAR | 530* |
| 27 | Thailand | 467* | 24 | Thailand | 482 |
| 34 | Indonesia | 403* | 32 | Indonesia | 435* |
| 36 | Philippines | 345* | 36 | Philippines | 345* |
| | ***International Average*** | ***487*** | | ***International Average*** | ***488*** |

(Mani, 2002)

# Philippines ranked 36th in 1999 TIMSS Benchmarking Study with a score of 345.

International Average=487

# Tertiary Education in the Philippines 2000-01

(CHED, 2004)

| FIELD OF STUDY | ENROLLMENT | GRADUATES |
|---|---|---|
| Natural Sciences | 23,569 | 6,826 |
| Math and Info Tech | 218,675 | 28,231 |
| Engineering | 350,664 | 46,794 |
| Agriculture, Forestry, Fisheries, Vet Med | 81,609 | 16,361 |
| Trade, Crafts, Industrial | 7,144 | 4,211 |
| Total S&T | 681,661 | 102,423 |
| Total Enrollment | 2,637,039 | 385,349 |
| % S&T/ Total Enrollment | 25.8% | 26.6% |

**Table 3. Tertiary Education Across Selected Pacific Rim Countries**

| Country | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| China (1991) | 2,124,121 | 0.17 | 80,459 | 3.79 | 59,748 | 74.26 |
| Japan (1989) | 2,683,035 | 2.13 | 85,263 | 3.18 | 54,167 | 63.53 |
| South Korea (1991) | 1,723,886 | 3.83 | 92,599 | 5.37 | 28,479 | 30.76 |
| Australia (1991) | 534,538 | 2.92 | 92,903 | 17.38 | 26,876 | 28.93 |
| Singapore (1983) | 35,192 | 1.13 | 1,869 | 5.31 | 532 | 28.46 |
| Malaysia (1990) | 121,412 | 0.58 | 4,981 | 4.1 | 1,251 | 25.12 |
| Thailand (1989) | 765,395 | 1.24 | 21,044 | 2.75 | 4,928 | 23.42 |
| New Zealand (1991) | 136,332 | 3.78 | 13,792 | 10.12 | 2,863 | 20.76 |
| Philippines (1991) | 1,656,815 | 2.39 | 63,794 | 3.85 | 5,520 | 8.65 |

***Column Definition***:
1) : Number of students at tertiary level
2) : Number tertiary students as percent of population
(3) : Number of post-baccalaureate students
(4) : Post-baccalaureate as % of Tertiary Students
(5) : Number of post-baccalaureate science & engineering students
(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students

(Mani, 2003)

# Philippines(1991)

- 1,656,815 students in the tertiary level – 2.39% of population
- 63,794 Post-baccalaureate students-3.85% of Tertiary students
- 5,530 Post-baccalaureate science and engineering students- 8.65% of post-baccalaureate students

(Mani, 2002)

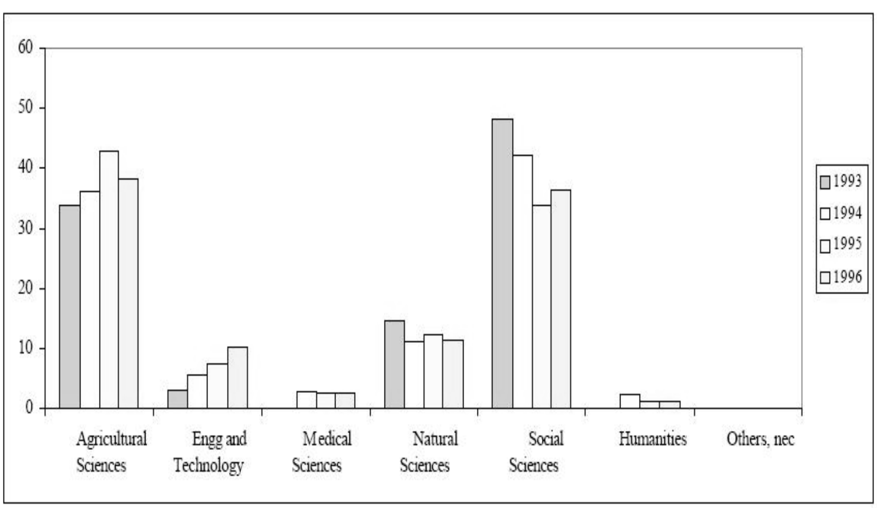
# No. of Doctorates in US

Number of doctorates awarded in science and engineering:

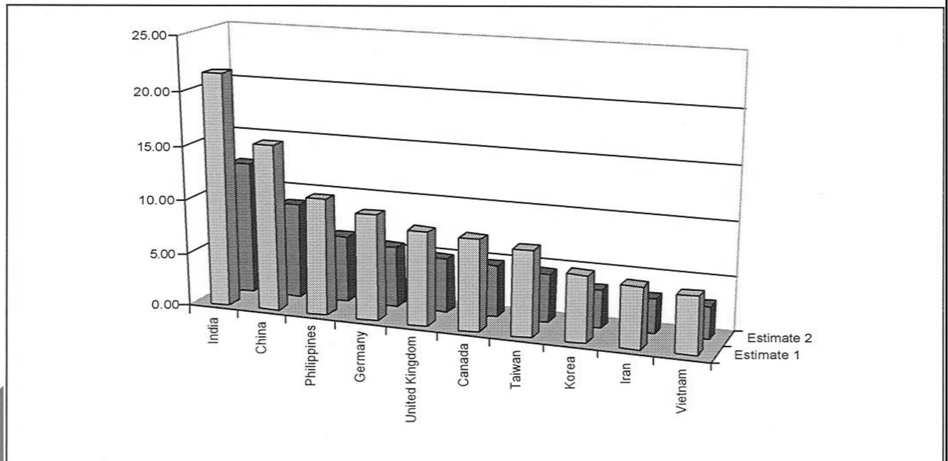
- 1998: 27,283
- 2001: 25,525
- 2002: 24,558

Scientific American, 290(2), 16 (2004)

Figure 1. Phd Personnel, Field of Activity (all respondents, % distribution)




(Orbeta, 1999 )




| | India | China | Philippines | Germany | United Kingdom | Canada | Taiwan | Korea | Iran | Vietnam |
|---|---|---|---|---|---|---|---|---|---|---|
| Estimate 1 | 21.62 | 15.35 | 10.85 | 9.83 | 8.72 | 8.50 | 7.96 | 6.20 | 5.65 | 5.32 |
| Estimate 2 | 12.38 | 8.79 | 6.21 | 5.63 | 4.99 | 4.87 | 4.56 | 3.55 | 3.23 | 3.05 |

**Figure 11: Ratios of foreign born scientists and engineering degree holders in the USA according to country of birth, 1997**

(Mani, 2002)

In 1997, Philippines accounted for 6.21% of all foreign-born science and engineering degree holders in USA

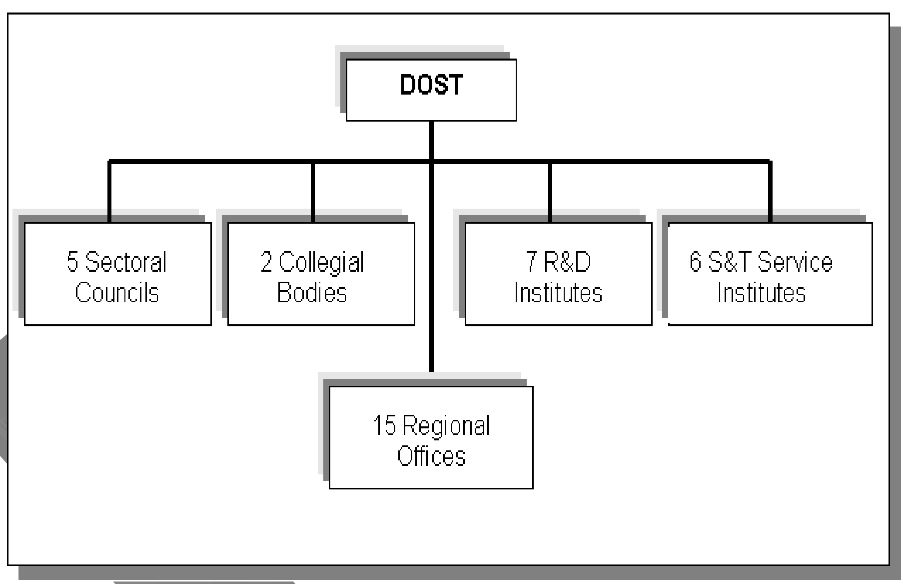
# Current Initiatives to Strengthen National Innovation System in the Philippines

# Resources

- Development within democratic space
- Abundant natural resources- fertile land, minerals, maritime country
- Young population- more than 50% below 30yrs old
- Educational System and Institutions are established
- Biggest export- "high tech" materials
- Companies located in Philippines: Intel, Motorola, Timex, Texas Instruments,aircraft parts manufacture, wire harness manufacture, and vehicle instrument panel design, call centers
- Expanding mobile phone cell sites
- Significant number of highly trained Filipino researchers abroad

# Constraints

- High External Debt
- Declining productivity
- Exports are low value added products- even “high tech” exports have low-value added
- Declining quality of education at all levels
- Weak S&T infrastructure
- Small number of highly trained R&D personnel




(Alabastro, 2004)

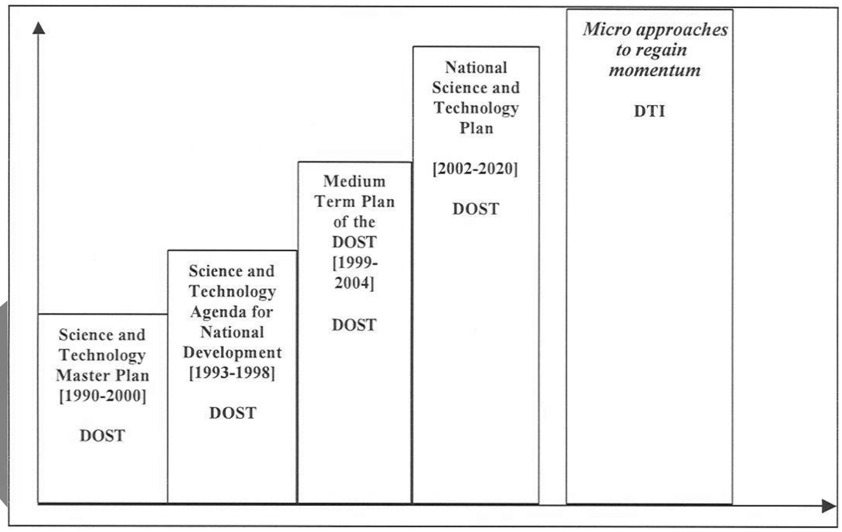
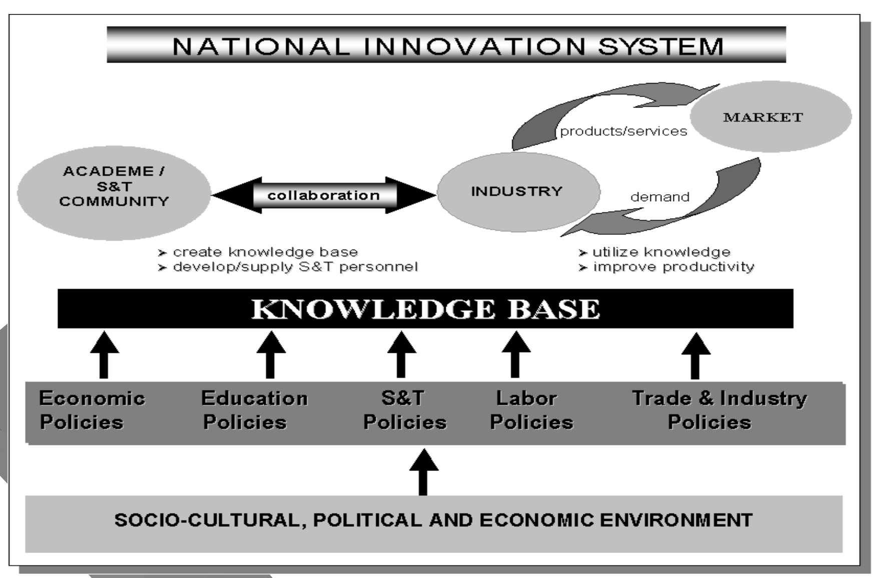
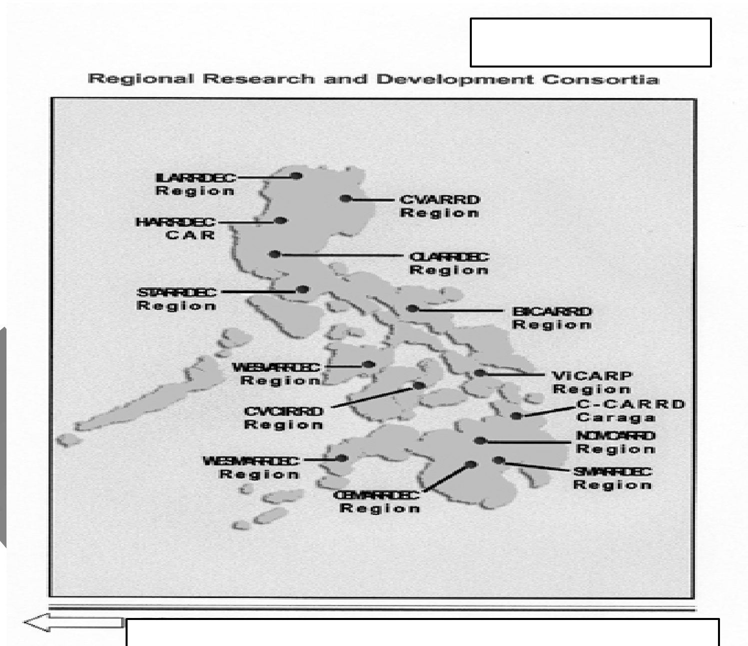



Figure 10: Evolution of innovation policies in the Philippines since 1990

(Mani, 2002)




(Alabastro, 2004)




(PCARRD, 2004)

# Science and Technology Coordinating Council

# Virtual Centers for Technology Innovation

Information Technology

Microelectronics

# Modernization of S&T Facilities

- ESEP- teaching and research labs in institutions of higher learning
- Tool and Die Center
- Metrology Laboratory
- Regional Food Testing Labs
- Packaging Center
- S&T information infrastructure

# S&T Human Resource Development

- ESEP- Engineering and Science Education Project
- Philippine Science High School System
- Project RISE
- S&T Undergraduate Scholarships
- DOST Sectoral Council Graduate Scholarships
- Balik-Scientist Program
- Magna Carta for Scientists and Engineers in Government

# R&D Funding

- DOST Grants-in-Aid
- DOST Sectoral Council Grants-in-Aid
- Commission on Higher Education Research Grants
- External Grants from Foreign Sources
- Loans
- Research Budgets of State Universities and Colleges
- Research Budgets of other Departments- Agriculture, Environment, Agrarian Reform
- Private Sector R&D Funds
  - Industry
  - Universities and Colleges

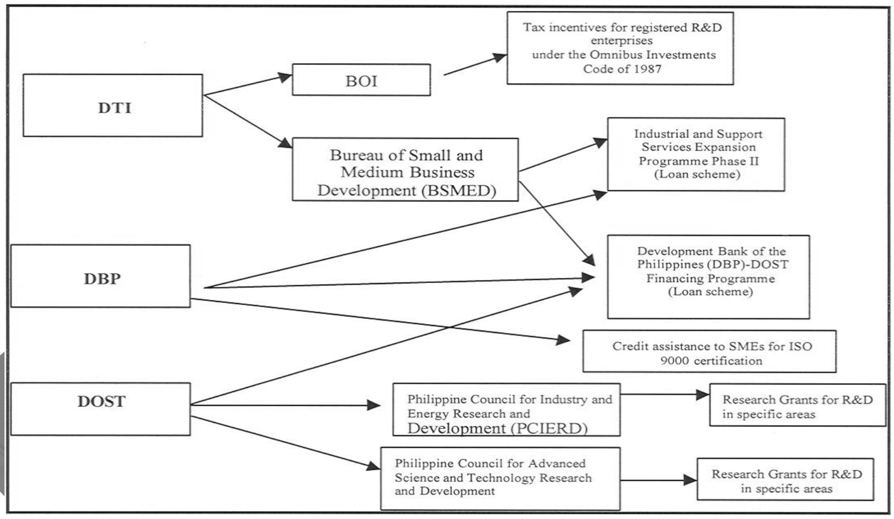



**Figure 12: Illustrative list of Financial Incentives for Technology Development in the Philippines, 2002**

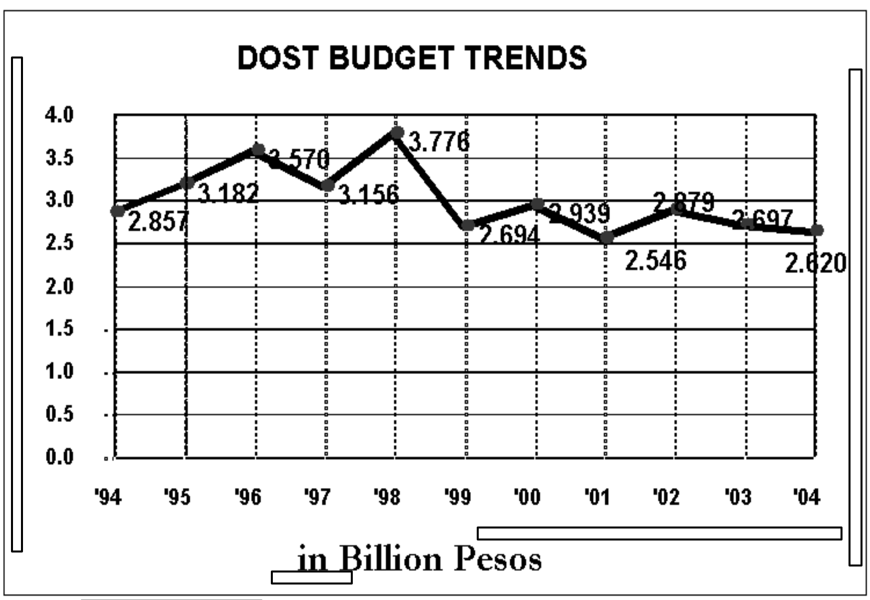
(Mani, 2002)

| Country | R&D Expenditures as % of GDP |
|---|---|
| South Korea (1996) | 2.82 |
| Japan (1996) | 2.80 |
| USA (1997) | 2.61 |
| Australia (1996) | 1.80 |
| Singapore (1995) | 1.13 |
| New Zealand (1995) | 1.04 |
| Hong Kong (1996) | 0.61 |
| Malaysia (1996) | 0.24 |
| **Philippines (1996)** | **0.15** |
| Thailand (1996) | 0.13 |
| Indonesia (1994) | 0.07 |

(Mani, 2002)

| Country | Scientists and engineers in R&D (per million population) |
|---|---|
| Japan (1996) | 4.909 |
| USA (1993) | 3.676 |
| Australia (1996) | 3.357 |
| Singapore (1995) | 2.318 |
| South Korea (1996) | 2.193 |
| New Zealand (1995) | 1.663 |
| Hong Kong (1996) | 454 |
| **Philippines (1996)** | **226** |
| Indonesia (1988) | 182 |
| Thailand (1996) | 103 |
| Malaysia (1996) | 93 |

(Mani, 2002)




(Alabastro, 2004)

## Proposed National Innovation System (NIS)

- Public R&D Laboratories
- Industrial Laboratories
- Educational and Training Institutions
- Science Policy Institutions
- Judiciary
- Financing Institutions

## Functions of NSI

- Creation/Discovery of New Knowledge
- Technology Transfer
- Finance
- Upgrading of S&T Facilities
- Human Resources Development
- Development and Application of new technologies
- S&T Governance

# Promote Innovation in Developing countries by providing International Public Goods in Science and Technology

# Role of Government

Ensure Science and Technology Security

Indigenous Capacity to Solve Technological Problems

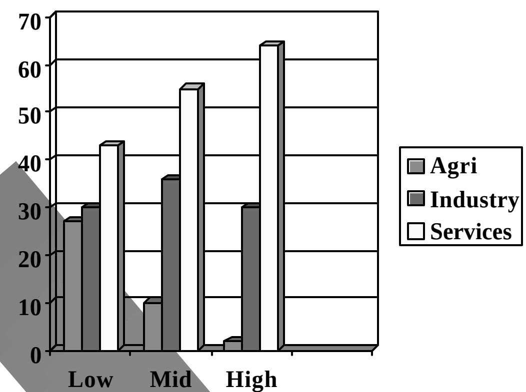
Human Resources

Physical Facilities

Access to Information

Funding

# Global Shift to Services




Source: World Development Report 2000/2001
http://www.worldbank.org/poverty/wdrpoverty/report/tab12.pdf

- High-income countries have become essentially **service** economies
- Validation of Colin Clark hypothesis
- Note: service sector is **knowledge-intensive**

# The Global Economy is Changing

- Production and trade are shifting towards services, which are inherently knowledge-intensive
- Knowledge content of goods and services is increasing
- Western industrial model is increasingly unsustainable
- Value of knowledge assets has surpassed value of tangible assets in most firms
- Networks have changed the nature of business
- Organizational learning has become essential for organizational survival
- The source of national, social and corporate power is shifting

Talisayon, 2003

International Public Goods provides access to new knowledge to enable development

- Agriculture
- Industry
- Services

CGIAR
Consultative Group on International Agricultural Research

Produces International Public Goods

- Freely shared and available to all
- Non-exclusive
- Non-competitive


# Impact of CGIAR

- Generates new knowledge for developing country researchers
- Provides training opportunities in new science
- Green Revolution
- Management and conservation of plant genetic resources in food and agriculture
  - Maintains the largest gene banks in the world

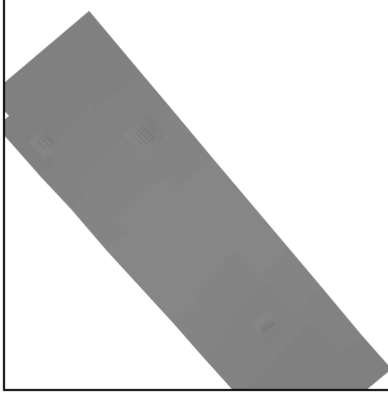
When Progress is moving as fast as it is now, recalling its victims is difficult.

Michael Lewis

## Proposal

- World Science Council to facilitate flow of new knowledge to achieve Millennium Development Goals
- Assist in the management of the S&T entry requirements to effectively participate in the world market

Thank you



# The National Innovation System of the Philippines: Challenges and Opportunities[1]

By

**William G. Padolina, Ph.D.[2]**

Global developments underscore the important role of science and technology: world trade has been liberalized, exerting pressure for innovation; economic activity has become knowledge-intensive, requiring competence in the emerging technologies; elaborately transformed manufactured products, developed through the individual countries' systems of innovation, have become the major items in world trade, making the capability to add value the basis for competitiveness.

The observation that the elaborately transformed manufactured products such as pharmaceuticals, electronic equipment and motor vehicles are the major players in the growth of world trade underscores the role of science and technology in enhancing national capability to exploit new manufacturing techniques. The importance of technology is increasing in a knowledge-based economy. Rapid and continuous improvements in products and manufacturing techniques, as well as, efficient marketing strategies, give business the competitive edge.

Robert Solow was awarded the 1987 Nobel Prize in Economics for his excellent work which showed convincingly that the most important factor that accelerated the rate

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[1] Paper delivered during a conference on "National Innovation Competencies and Interests in a Globalized World" sponsored by APEC, US Department of Commerce, Office of Naval Research International Field Office, in collaboration with the Colorado Institute of Technology, CIBER, University of Colorado at Denver. Broomfield, Colorado, 25-27 May 2004.

[2] Deputy Director General for Partnerships, International Rice Research Institute, Los Baños, Laguna, Philippines

of development of the advanced countries was the use of superior technologies in improving productivity. It seems that this conclusion has been largely ignored by developing countries as their investments in science and technology continue to be very low.

Landau(1988) described the emerging trends in technology development as follows:

a. New technology is spreading faster that ever before among countries because of a much shorter and accelerated technology transfer process.
b. The country which is the source of technological innovation is not necessarily the first to undertake its commercialization.
c. Industrial technology has taken root in many places throughout the world and the sources of supply of inputs are also global.
d. Transnational flows of money are now also able to penetrate almost any market in the world, instantaneously exposing a country's policies to external market forces.

In the past, science and technology have been marginalized and the cumulative effects of such neglect are now being felt. Some of the major problems and difficulties that beset us are now surmountable because creative science and technology-based solutions and policy reforms.

**THE PHILIPPINES**

The Philippines is an archipelagic nation in Southeast Asia with a population which was 76.5M in 2000 but is projected to grow to 82.7M by 2004 (National Statistics Office, 2004). The total land area of the Philippines is around 300,000 sq. kilometers and is surrounded by the South China Sea and the Pacific Ocean. The functional literacy rate as of 2000 was 83.8%.

The GNP as of the fourth quarter of 2003 was PHP1334.5B and the GDP as of the same period was PHP1246.8B. The median family income as of 2000 was PHP88,782. In February 2004, exports totaled USD2.999B and imports, USD2.994B. (National Statistics Office, 2004).

Around 53.3% of the 820,960 establishments in operation in 2000 were in the wholesale and retail trade, followed by manufacturing establishments at 15.3% of the total. Hotels and restaurants follow at 10.9%; other community, social and personal services at 5.0%; real estate, renting and business activities at 4.9%; health and social work at 3.5%; financial intermediation at 2.9%;, transport, storage and communications at 1.9%; and all others at 2.3%.(National Statistics Office, 2004).

The Philippines trades mainly with Japan, the United States, and Singapore. The top exports as of May 2004 are electronics products, articles of apparel and clothing accessories and ignition wiring set and other wiring sets used in vehicles, aircrafts and ships. The top imports consisted of electronics products; minerals, fuels, lubricants and other materials; and industrial machinery and equipment. (National Statistics Office, 2004)

According to the National Statistics Office (2004), the number of farms in the country decreased by 2.36%, from 4.61 million in 1991 to 4.50 million in 2002. The decrease was noted in seven out of the seventeen regions of the country. The 4.50 million farms stretched to 9.19 million hectares of agricultural land or an average size of 2.04 hectares per farm. In 2002, 7.64 million hogs and 115.18 million chickens were raised.

The productivity and competitiveness of the agricultural and fisheries sector have declined over the years. Labor productivity in agriculture has been stagnant, rice production continues to be inadequate, coconut productivity has declined as well as productivity in fisheries. The Philippines became a net agricultural importer as early as 1994. Between 1997 and 2000, rural poverty incidence increased by three percentage points, an increase of 382,000 households, and rural income distribution has worsened. (National Economic and Development Authority, 2001)

In 2000, the services sector accounted for 46.7% of total employment; industry, 16.5%; and agriculture 37.1%. (National Economic and Development Authority, 2001)

The number of telephones per 100 people in the Philippines increased from 2.01 in 1995 to 9.05 telephones per 100 people in 2000. Furthemore cellular phone subscriptions reached 6,454,359 in 2000 and the number of internet hosts per 10,000 people has risen steadily from 0.25 in 1992 to 1.2 in 2000. (National Economic and Development Authority, 2001)

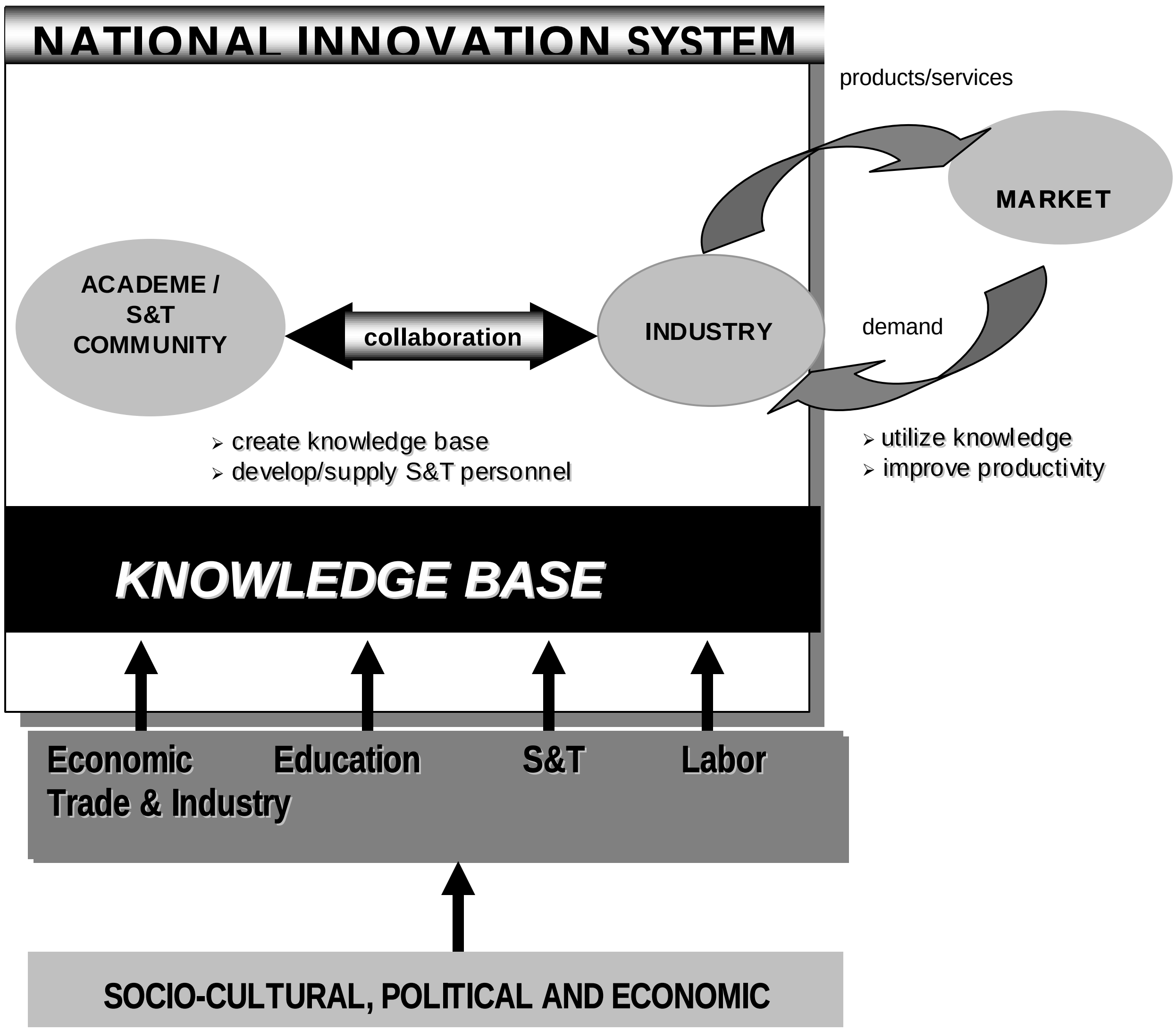
## THE NATIONAL INNOVATION SYSTEM OF THE PHILIPPINES

This paper will deal mainly with the National Innovation System (NIS) as it applies to agriculture and industry.

Dr. Estrella F. Alabastro (2004), currently the Secretary of Science and Technology, views the Philippine National Innovation System to consist of the interaction of many factors (Figure 1). The socio-cultural, political and economic environment provides the context for the formulation of appropriate economic, education, S&T, labor, trade and industry policies that collectively affect the rate of generation of the country's knowledge base. The academe and S&T community are the producers of knowledge which will be used by industry. These interactions determine the capacity of the economy to produce products and services for changing market needs.

Dr. Alabastro explains that new conditions call for new science and technology policies. The key policy challenge is to boost productivity and growth through increased knowledge-intensive economic activities while maintaining social cohesion. Worldwide, governments have pursued fiscal, regulatory and institutional reforms to promote innovation particularly among private business firms, to support research and development as a national strategy in expanding the stock of knowledge, to make the science and technology enterprise more efficient and effective, and to improve the functioning of the innovation system as a whole.

**Figure 1**
**The National Innovation System**
**(Alabastro, 2004)**



The Department of Science of Technology

The task of overseeing and monitoring the National Innovation System lies primarily with the Department of Science and Technology (DOST). The DOST was established to "provide central direction, leadership and coordination of all scientific and technological efforts in the country" as well as "formulate S&T policies, programs, and projects in support of national development priorities."(Executive Order No. 128, 30 January 1987).

The forerunner of DOST is the National Science Development Board (NSDB) which was created on June 13, 1958 under Republic Act 2067; and later reorganized on March 17, 1982 into the National Science and Technology Authority (NSTA) under Executive Order 784. The NSTA was eventually elevated to cabinet level based on Executive Order No. 128 signed by President Corazon Aquino on January 30, 1987. This marked the mainstreaming of science and technology in the government's policymaking and service delivery processes.

There are 5000 employees in the DOST system. Around 2% have doctoral degrees, 9% have master's degrees, and 56% have bachelor's degrees (Padolina, 1998).

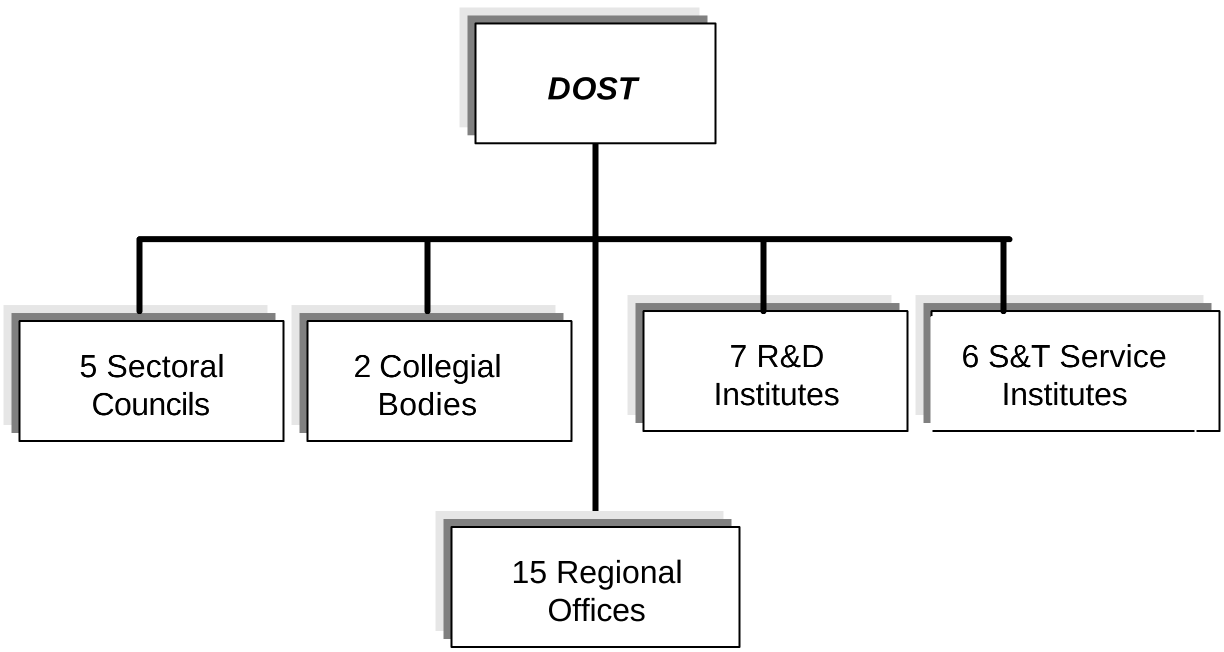
DOST oversees 20 attached agencies, and manages a nationwide network of regional offices (see Figure 2). Its attached agencies include five sectoral councils, one each for aquatic and marine; agriculture, forestry and natural resources; advanced science and technology; health; and industry and energy. Two collegial bodies, the National Academy of Science and Technology and the National Research Council of the Philippines are attached to DOST. The seven research and development institutes are in the fields of advanced science and technology; food and nutrition; forest products; industrial technology development; metals; nuclear research; and textile research. The six S&T service institutes are for weather monitoring and

**Figure 2**

**Organizational Chart**

**Department of Science and Technology**

**(Alabastro, 2004)**




forecasting; volcanology and seismology; specialized science high school; science education; S&T information; and technology application and promotion. Today, the Department manages and maintains 15 regional offices and 78 provincial science and technology centers nationwide.

**S&T INITIATIVES OF SINCE 1986**

In the administration of President Corazon C. Aquino, science and technology were regarded as a means to help revive the economy. The Medium-Term Philippine Development Plan (1987-1992) stated that “science and technology resources shall be utilized by both public and private sectors to meet the objectives of economic recovery through its programs of sustained economic growth." This objective was translated into an S&T Master Plan for the period 1991-2000 that defined a three-pronged strategy: first, the massive technology transfer from the domestic and foreign sources to modernize the production sector; second, the intensification of S&T activities in high priority sectors to upgrade R&D capability; and third, manpower development with an S&T social and intellectual culture, institution building as well as the development of S&T infrastructure.

In order to achieve coherence and to assure synchrony of the S&T activities of various line departments, the Science and Technology Coordinating Council (STCC) was created in 1989. The STCC is composed of 10 members of the cabinet, eight representatives from the private sector, two representatives from academe and is chaired by the Secretary of DOST. It renders a yearly report to the President during a special meeting in the last quarter of the year.

Also, Republic Act No. 6959, the law that established the Provincial Centers for Science and Technology in all provinces and the S&T incentives for private investors under the Investment Priorities Plan (IPP) was approved during the term of President Aquino.

The administration of President Fidel V. Ramos focused the science and technology development efforts at "enabling the Philippines to attain the status of a newly industrialized country (NIC) by the year 2000". In 1993, the Science and Technology Agenda for National Development (STAND) was launched with the following priority areas identified: 1) the 8 export winners as identified by the Department of Trade and Industry; 2) the 10 basic domestic needs as identified by the President's Council for Countryside Development; 3) the 3 support industries; and 4) the coconut industry on which one-third of the population depends.

The major legislative measures passed during the Ramos administration were: 1) Republic Act 7459 or the Inventors and Inventions Incentives Act that allows for tax holidays, subsidized loan rates and other incentives for inventors; 2) Republic Act 7687, the S and T Scholarship Act of

1994; and 3) Republic Act 8439 or the Magna Carta for Science and Technology Personnel in Government.

The DOST Medium Term Plan under the administration of President Joseph Ejercito Estrada, was designed towards utilizing science and technology to support the government's poverty alleviation program and guided by the vision of a "competent and competitive science community with a social conscience". A hallmark of the Estrada Administration's programs in S&T is the Comprehensive Program to Enhance Technology Enterprises (COMPETE) (National Economic and Development Authority,2001).

## SCIENCE AND TECHNOLOGY IN THE ARROYO ADMINISTRATION

In 2001, President Arroyo declared that "technology is the foundation of future economic development" and directed the formulation of the National Science and Technology Plan (NSTP) 2002-2020.

The Plan has identified milestones over the short, medium and long-term period as follows:

-By 2004:

- improved access to quality S&T services;
- higher productivity and competitiveness for Philippine products and industries;
- creation of technology-based enterprises in the regions;
- S&T-based solutions to pressing national problems;
- and greater S&T awareness and support among leaders and policy makers.

-By 2010:

- world-class capabilities in ICT;
- technological leadership in ASEAN in the fields of biotechnology, materials science and microelectronics;

- adequate number of quality scientists and engineers in the country;
- robust technology-based and knowledge-based industry sectors; globally competitive products;
- quality S&T-oriented higher education sector;
- top performance in science and math;
- highly-developed culture of innovation and S&T consciousness; enhanced private sector participation in S&T/R&D activities;
- a national R&D budget of 1% of GDP.

-By 2020,

- a well-developed S&T-based SME sector;
- world-class universities in S&T;
- internationally recognized scientists and engineers;
- and model status for S&T management and governance.

The NSTP will adopt the following strategies:

1) Niching and clustering
2) Addressing pressing national problems
3) Developing S&T human resources
4) Providing support to SMEs
5) Accelerating technology transfer and utilization
6) Building and upgrading S&T infrastructure
7) Strengthening government-industry-academe-civil society and international linkages
8) Improving S&T governance Promoting and popularizing S&T

Moreover, the NSTP identifies the following priority areas for S&T development (the sectors are listed in no particular order):

1) agriculture, forestry and natural resources
2) health/medical sciences
3) biotechnology
4) information and communications technology
5) microelectronics
6) materials science and engineering
7) earth and marine sciences
8) fisheries and aquaculture
9) environment
10) natural disaster mitigation
11) energy
12) manufacturing and process engineering

**CURRENT INITIATIVES TO STRENGTHEN THE NIS**

Three major programs are being implemented by DOST to enhance the NIS. These programs are:

1) the Small Enterprise Technology Upgrading Program or SETUP,

2) the Technology Incubation for Commercialization or TECHNICOM Program;

3) the Technology Support Program for E-Governance or SUPRE-GOV.

Small Enterprises Technology Upgrading Program (SETUP)

Of the 820,960 registered enterprises in 2000, about 99.6% were classified as micro, small and medium scale enterprises (MSMEs). MSMEs account for 69.6% of total employment generated by registered enterprises.(National Statistics Office, 2004)

Through the SETUP, all technology transfer efforts of DOST agencies are being focused on enhancing the productivity of SMEs initially in six identified priority sectors, namely: food processing; furniture; fashion accessories, gifts-toys-housewares; marine and aquatic resources; horticulture; and metals and engineering.

SET-UP hopes to assist MSMEs improve their productivity and competitiveness through the:

a. Infusion of new/advanced technologies to improve operations of MSMEs;

b. Provision of limited funds for technology acquisition;

c. Manpower training, technical assistance and consultancy services;

d. Design of functional packages and labels;

e. Assistance in the establishment of product standards including testing;

f. Database information system.

Technology Incubation for Commercialization (TECHNICOM)

The Technology Incubation for Commercialization (TECHNICOM) Program is a comprehensive and unified program to enhance commercialization of technology by facilitating the transfer and commercialization of promising R&D results of government R&D institutes, academe and the private sector. The program involves the provision of a complete set of support activities to encourage researches with commercialization as end objective by:

- stimulating technological innovation;
- strengthening the capacity of enterprises to tap and adapt promising R&D results;
- increasing private sector investment and adoption of government-initiated R&D breakthroughs;
- maximize benefits from government's investments in R&D activities.

In 2002, as part of the TECHNICOM Program, DOST institutionalized the intellectual property protection and technology management in the national R&D system. The guidelines for Intellectual Property Management were updated, a purposive inventory of the Department's intellectual property assets was undertaken and a training program was initiated on intellectual property management and commercialization. DOST has also linked academe and other members of the S&T community in nurturing an IP culture.

As a result, 29 out of the 98 pending patent applications by the DOST since 1988 were filed during the Arroyo administration. Seven out of the 18 patents assigned to the Department since 1987 were granted in 2001-2003 period. At the national level, patent applications from Filipinos have increased from 946 in 2001 to 1,285 in 2003. Moreover, as % of the total patent applications, their share has significantly increased from 25 % in 2001 to 62 % in 2003 (Alabastro, 2004).

Technology Support Program for E-Governance (SUPRE-GOV)

The Technology Support Program for e-Governance or SUPRE-GOV was conceived to provide technology support to e-governance in accordance with the Medium-Term Philippine Development Plan (MTPDP). A newly organized Commission on Information and Communications Technology (CICT) will lead in the application of ICT in government processes and services; the support for the development of electronic products including the accompanying software; the establishment and enhancement of the government portal; the development, organization and standardization of data bases; and the development and utilization of information systems for priority local government applications. As an overall strategy, linkages between the academe, the private sector, and government units for collaborative undertaking towards the widespread use of ICT in governance will be established.

In April 2002, only 266 or 66% of the 379 national government agencies (NGAs) had websites. Moreover, only 51% of the total 79 provinces and 115 cities and a measly 3% of the 1,496 municipalities were online (Alabastro, 2004).

With DOST as the lead agency, website templates were made available to government agencies. These templates were user-friendly facility equipped with website content management system (WCMS) that allows easy updating and uses the less costly open-source software. A series of training workshops on website development were conducted nationwide.

In July 2003, 98.4 % of national government agencies, 100 % of provinces and cities and 64.6 % of 1,496 municipalities had websites. State colleges and universities also had 100 % web presence. Efforts continue to improve the quality and functionality of the websites(Alabastro, 2004).

Other ICT Initiatives

In June 2000 the “Philippine Research, Education and Government Information Network” or PREGINET was started and now serves as a nationwide broadband network with 3 exchange points and 20 regional access points interconnecting not less than 80 institutions from government, the academe and the private sector and enabling them to undertake collaborative R&D in areas such as networking technologies, distance education, telemedicine, agriculture and disaster mitigation.

The PREGINET is connected to the Asia-Pacific Advanced Network (APAN) at 1.5 mbps via leased line. The APAN is a high-performance network consortium founded in 1996 to facilitate and coordinate the development, deployment, operation and technology transfer of advanced network-based applications and services in the research and education community of the

Asia-Pacific region. Through this APAN link, the PREGINET's local partner institutions are given access to the Science, Technology and Research Transit Access Point (STARTAP), the largest interconnection of research and education networks in the world (Alabastro, 2004).

Thus, PREGINET is now increasingly being tapped as a broadband research and education network for IP applications such as videoconferencing, videostreaming, and IP multicasting. The PREGINET would also serve as the backbone for "Open Academy for Agriculture" and will facilitate access to the information resources to be made available by the Philippine E-Library Project.

### Virtual Centers for Technology Innovation

During the Estrada Administration, the Virtual Center for Technology Innovation in Information Technology was established to undertake human resource development and enhance R&D leading to high-value ICT products and services. Also, a Virtual Center for Technology Innovation in Microelectronics Design was set up to build the capability of local electronic companies, and research and academic institutions in microelectronics design through technical training and equipment certification program focusing on the manufacture of intricate, complete and original electronic product design. (National Economic and Development Authority, 2004)

## S&T HUMAN RESOURCE DEVELOPMENT PROGRAMS

Human resources are vital to the development of science and technology. The development of a workforce that is talented, ingenious and adaptive is of great importance in national development. A critical mass of highly trained scientists and engineers will provide the indigenous capacity to generate new knowledge for the NIS. This section describes recent initiatives to attain the goal of increasing the number of high quality scientists and engineers in the Philippines.

The Philippine Science High School System

DOST administers the Philippine Science High School System which is located in 8 different places in the country. Using a highly selective entrance examination, talented high school students are trained rigorously in science and mathematics.

The Undergraduate Scholarship Program

Under the undergraduate scholarship programs in science, engineering, mathematics and science teaching being implemented by the Department through its Science Education Institute (SEI), a total of 5,258 graduated in the 2001 – 2003 period and 1,538 graduated in March 2004 (Alabastro, 2004).

Project RISE

Since 1998, the Department through the SEI has been implementing the Rescue Initiatives in Science Education or Project RISE that is designed to increase the teachers' knowledge of subject matter at the elementary and high school levels. Project RISE has raised the proficiency levels of a total of 14,643 science and mathematics teachers, 4,176 of them in the 2001-2003 period (Alabastro, 2004).

Project MUST

The Mindanao Upgrading of Science Teachers Project or Project MUST is designed as a 90-hour teacher training program conducted during summer months to improve the competence and capabilities of elementary and secondary teachers in schools predominantly attended by Muslim students and other ethnic groups. The program develops the teacher's innovativeness and creativity in coming up with lessons that are culture based, and in developing instructional materials using local resources. In 2001-2003, a total of 3,825 teachers benefited from Project MUST (Alabastro, 2004).

Engineering and Science Education Program

The implementation of the $85M World Bank and OECF funded Engineering and Science Education Project (ESEP) was completed in June 1998. As of that date, ESEP produced 3554 short term trainees, 1,077 diploma degree holders, 513 master's degree graduates, and 51 Ph.D. graduates. A total of 72,296 books and library materials and 569 journals and 1024 pieces of science equipment worth $27M were delivered to participating institutions. Thirty laboratories in tertiary institutions were upgraded, and 110 high school science laboratories were built. Eight libraries of universities and colleges were electronically linked.

Other Projects in Science Education

The Department through SEI continued to implement other programs like the Faculty Development Program for selected Teacher Education institutions, Physics Teaching Scholarship program and the Computer Literacy Program through which 181 public secondary schools have received computers, printers, data switches and software. Moreover, it also actively supports the SEI's Youth Science Programs that promote partnerships with the private sector, motivate students, teachers and schools to engage in scientific endeavors through science and math competitions, and to develop a science culture among the youth and the general public (Alabastro, 2004)

Other S&T HRD Programs

Also forming part of the Department's S&T HRD programs are the Scientific Career System (SCS) established within the civil service pursuant to E.O. No. 784 dated 17 March 1982 and the Balik-Scientists Program (BSP).

## MODERNIZATION OF S&T FACILITIES

Access to well-equipped laboratories is vital to the conduct of research and development. The rapid pace at which more precision instruments are being made available facilitates data gathering and processing in research. Thus it is important for the NIS to always take stock of developments in order to maintain updated laboratories. Furthermore the geographic spread of the Philippines poses a challenge on how these laboratories are going to be deployed.

Electronics Testing and Calibration Center

Established in 1996 as a cooperative undertaking of DTI, DOST and the Semiconductors and Electronics Industry Foundation, Inc. (SEIFI), this center is located in the premises of the Industrial Technology Development Institute (ITDI). Operated jointly with SEIFI, the local industry requirements for calibration and testing of precision instruments for semiconductor manufacture are being handled at the facility.

National Chemistry Instrumentation Center

Funded by ESEP, this $1.2 facility at the Ateneo de Manila University houses state-of-the-art 400MHz Nuclear Magnetic Resonance Spectrometer and a High Resolution Mass Spectrometer. These equipment are designed to facilitate research activities involving the elucidation of the structure of molecules.

Materials Science and Engineering Research Center

This facility is located at the University of the Philippines Diliman and is equipped with $4M worth of sophisticated equipment for materials science research. This includes equipment for molecular beam epitaxy, plasma-enhanced chemical vapor deposition and raman spectroscopy.

Tool and Die Center

In June 1997, the Metals Industry Research and Development Center (MIRDC) received a $5.5M grant from JICA to establish a tool and die center, the first in the country. The training center has been equipped with state-of-the-art equipment and machinery designed to help upgrade the plastic molding tool technology in the country.

The Meycauayan Jewelry Training Center

A $200,000 common service and training facility for the fine jewelry industry was established jointly with the Meycauayan Jewelry Association to help improve the quality of the fine jewelry products produced in the Municipality of Meycauayan in the province of Bulacan, the fine jewelry center of the Philippines. Aside from training, the facility will house equipment which can be used by jewelers who are interested in improving their product quality.

The Ceramics Training Center

In support of the the decorative ceramics industry, DTI and DOST, in cooperation with the Ceramics Export Manufacturers Association, Inc.

(CREMA), established a Ceramic Training Center at ITDI to provide training, production technology development and transfer to the local ceramics industry.

Regional Metals Testing Centers

Under the supervision of MIRDC, these centers provide metal testing, quality control, consultancy, and training services to SME's belonging to the metals and engineering sector. These centers are located in Bacolod, Cebu, Cagayan de Oro, Davao, Urdaneta, and Quezon City.

Regional Food Testing Laboratories

Located in the DOST Regional Offices, these laboratories provide services for physical, chemical, and microbiological analysis of food products. These laboratories assist the SME's engaged in the food business in preparation for compliance with global standards under the WTO.

Pilot Gamma Irradiation Facility

The Philippine Nuclear Research Institute is upgrading its gamma irradiation facility to 120,000 curies. This facility is now being used for the sterilization of selected medical products.

Disaster Preparedness and Hazard Mitigation Programs

The Philippines is prone to natural disasters. To mitigate the adverse effects of these natural disasters DOST operates the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and the Philippine Institute of Volcanology and Seismology (PHIVOLCS). PAGASA closely monitors the occurrences of tropical depressions, tropical cyclones and monsoon rains. PHIVOLCS monitors the occurrences of earthquakes and watches the behaviour of several active volcanoes.

S&T Promotion and Information Services

DOST has an active public information program. The Department continues to support the S&T information initiatives of its agencies. Among these are the Agriculture and Resources Information Network (AGRINET) of PCARRD; the Health Research Development Information Network (HERDIN), the E-Health Digital Library and the Multipurpose Community Telecenters (MCTs); the ScINET Union Catalog of the S&T Information Institute (STII) that serves as the DOST's Library Portal; the Aquatic Resources Management Information System (ARMIS) of PCAMRD, the Central Visayas Information Network (CVISNET) initiated by DOST Region VII; and the Eastern Visayas Information Network (EVISNET) by DOST Region VIII, among others.

## INNOVATION IN AGRICULTURE

The drive for technological modernization in an increasingly competitive global environment has, in a sense, diverted attention away from the more fundamental aspects of development.

In the rush for industrialization in the last decade, hectares upon hectares of precious croplands made way for the construction of roads, factories, and buildings. As a result, farmlands are decreasing. This necessitates urgent and concerted efforts to increase productivity of the country's remaining farmlands to avoid food shortages and malnutrition.

The goal is to make full and efficient use of land and other natural resources through sustainable agricultural practices and environmental conservation. The task of modernizing and sustaining the region's agricultural production and food self-sufficiency depends on the national agricultural research and extension system in order transform the farm into one of the most technology- and information-intensive systems around.

The Philippine National Agricultural Research and Extension System (NARES)

The NARES in the Philippines is a constellation of institutions that includes the Department of Science and Technology, the Department of Agriculture (DA), the Department of Environment and Natural Resources (DENR), State Universities and Colleges (SUCs) and the Department of Agrarian Reform (DAR). These agencies together with others have been organized into Regional R&D Consortia.

As part of DOST, the Philippine Council for Agriculture and Natural Resources Research and Development (PCARRD) coordinates and monitors all agricultural research and extension activities in the Philippines. PCARRD does not perform in-house research but provides grant money and monitors agricultural research activities nationwide. Also located at DOST is the Philippine Council for Aquatic and Marine Research and Development (PCAMRD). which perfoms the same functions as PCARRD but for fisheries and aquatic resources research and development. Both these sectoral councils make sure that projects are aligned to the goals of the Medium Term Philippine Development Plan (MTPDP).

The research institutes are under the administrative control of the Department of Agriculture are: the Philippine Rice Research Institute, the Bureau of Plant Industry, the Bureau of Animal Industry, Bureau of Fisheries and Aquatic Resources, the Carabao Research Center.

The Department of Environment and Natural Resources has the Ecosystems Research and Development Bureau, the Environmental Pollution and Monitoring Bureau. The Department of Agrarian Reform oversees the development of agrarian reform communities.

The Agricultural Extension System of the Philippines has been devolved to the local governments. Provinces, municipalities and cities have absorbed the extension system and supports the activities of the Provincial Agricultural Officers(PAOs) and the Municipal Agricultural Officers( MAOs). They have to link with the Department of Agriculture and the other sources of the agricultural innovations.

There are around 114 state universities and colleges in the Philippines. The University of the Philippines at Los Baños, CLSU, Leyte State University and the University of Southern Mindanao are the leading institutions of higher learning which have research programs in agriculture.

While the infrastructure for research and development in agriculture in the Philippines is more developed than that of industry, the Philippines is still a net importer of food. However, in the first quarter of 2004, reports indicate that the agricultural sector grew by 8.1% compared to a growth rate of 3.43% for same period last year( Felix, 2004). The Secretary of Agriculture attributes this growth to the use of modern farm technologies, improved seeds and other farm inputs and adoption of proper policies.

## THE S&T BALANCE SHEET-THE CONSTRAINTS

It is evident that several components of the National Innovation System are in place, but continue to function with much difficulty with the following major constraints:

- R&D investments has declined to 0.15% of GNP from 0.22% in 1992 with around 63% being done by government(Alabastro, 2004; Patalinghug, 2003). This results into very limited opportunities to absorb scientists and engineers. The trend of government budget support to DOST is reflected in Figure 3.

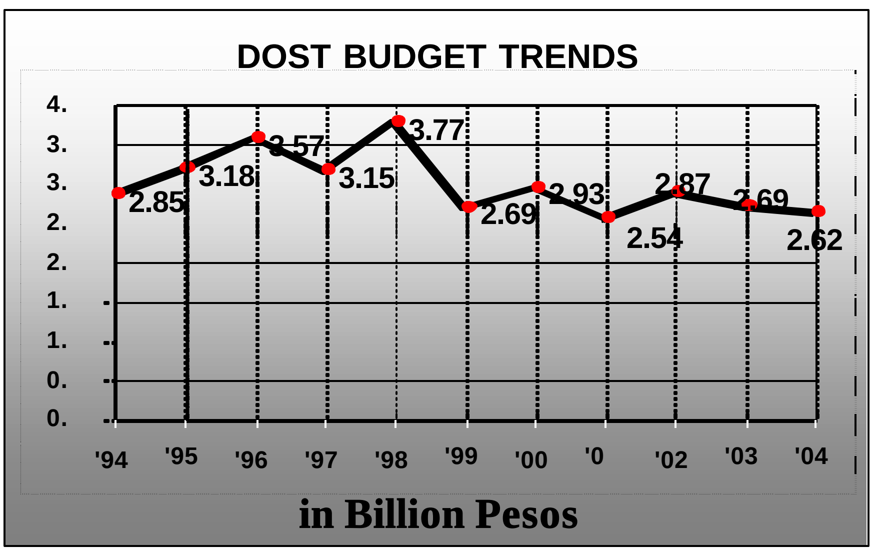
- As of 1996, R&D personnel level was at 226 scientists and engineers per million population up from 155 scientists and engineers in previous years;(Alabastro, 2004)

- There is a shortage of scientists in the fundamental disciplines of chemistry, physics and mathematics but a relatively large pool for biology.

**Figure 3**

**DOST Budget Trends, 1994-2004**

**(Alabastro, 2004)**




- Around 30,000 engineering graduates are produced every year but their skills are not responsive to industry needs especially in engineering design. For science and engineering graduates less than

1/3 are working as professionals in their field of training (Science Education Institute, 2002).

- Only 981 doctoral degree holders are involved in R&D. Only 0.6% of private sector personnel doing R&D have Ph.D. degrees (Science Education Institute, 2002).

- Science teaching at all levels—elementary, high school and college needs to be improved. Less than half secondary science school teachers are qualified to teach.

- Labor productivity is the lowest compared to Thailand, Indonesia and Pakistan. Total factor productivity has had a negative contribution to growth (Cororaton and Cuenca, 2001)

- Laboratory facilities for instruction and research need to be upgraded.

- The Philippines accounts for 0.035% (rank 51) of the share of mainstream journal articles published in the 3300 most important scientific journals in the world (Gibbs, 1995).

- A weak legal environment to serve a framework for technology based transactions and to settle disputes has deterred technology-based companies from establishing their operations in the Philippines.

## THE CHALLENGE: MANAGING SCIENCE AND TECHNOLOGY DEVELOPMENT TO MEET ECONOMIC GOALS

Within a liberalized trade regime, the broad-based and usually long-term concerns in science and technology development that involve training, research and development, and technology transfer and commercialization, need to be managed with a clear and coherent strategy so that the science and technology sector can align their efforts to the needs of the market forces.

The need to focus is underscored by the limitation of our resources. While we would allow free market forces to operate, our resources are inadequate to fully support efforts that will allow us to cope with a complex and rapidly-changing situation in all fronts of the global market. Furthermore, there exist differences among nations in the level of development of factors that influence competitiveness, like science and technology.

In the Philippines, it has been noted that in a way, industrial targeting is being practiced in the formulation of the Investment Priorities Plan (IPP) and the Industrial Development Plan (IDP). There are mixed feeling about the success of the IPP under the aegis of the Board of Investments. It is too recent to try to make any judgments on the success of the IDP, but an assessment may be in order on the government's selection of export winners.

There also exists a National Science and Technology Plan, but implementation has been difficult due to the absence of a comprehensive National Agri-Industrial Development Plan which is expected to serve as the framework for medium- and long-term interventions in under the NSTP.

It is therefore of utmost importance that even as we recognize the importance of increasing support for the development of science and technology in the country, we formulate a clear and coherent agri-industrial development strategy which shall provide the directions for convergence to maximize the impact of initiatives from all sectors.

There are many examples of world-class operations of elaborately manufactured products which exist in the Philippines today (Padolina, 1998). Some of these are:

- Motorola, Philippines manufactures semi-conductor products and is engaged in software development. This facility has won the Golden Award of Motorola for four consecutive years, making it the world's top rated Motorola operations.

- Timex, Philippines located in Cebu supplies 90% of the Timex watches in the world and has been rated tops worldwide.

- Locsin International, introduced seagrass as a material for furniture and received special awards for design excellence and innovative use of indigenous materials. Its market includes North America, Europe and Asia.

- Republic Asahi Glass Corporation, the first manufacturing plant in the Philippines to be certified IS0 9000 for all areas of operation. The float glass plant in the Philippines is considered as one of the most advanced in the world.

Many factors contribute towards the attainment of high standards of operations. The availability of a highly trainable workforce proficient in both spoken and written English is often cited as a distinct advantage of operating in the Philippines. Rapid improvements in the physical infrastructure primarily energy, transportation and telecommunications have also been important considerations. Observers say that the Philippines must work hard to build the capability for third wave technologies.

The Final Overall Ranking of the Philippines in the 2004 World Competitiveness Report was No 52 out of 60 countries, which continues the downtrend of its ranking since 2000. In terms of its infrastructure, which includes basic, technological, scientific and human resources to meet business needs, the Philippines ranks No. 59 out of 60 countries. Michael Porter(1990) in "The Competitive Advantage of Nations" argues that improved productivity results from a combination of interventions and policies put together at the right place and the right time and supported by an infrastructure whose positive effects have accumulated over time (World Competitiveness Report, 2004)

## CAPACITY BUILDING FOR INNOVATION

Four major areas of concern in the development of science and technology in the Philippines have been identified by Cororaton(1999) as follows:

- Low R&D investments, inefficient allocation of limited resources and inadequate R&D manpower;
- Institutional weaknesses as a result of poor management and leadership;
- Policy lapses and failures;
- Poor statistical and information system

The promotion of technology cooperation in order to foster sustainable development must be anchored on knowledge-based capacity building to enable society to establish a system for innovation.

In striving towards a sustainable strategy for development, poor countries that struggle to keep body and soul together find it difficult to l come up with an innovative idea and have the energy to pursue it. The culture of poverty is characterized by shortages, fear of tomorrow, empty stomachs, lack of opportunities. Poverty and hunger are marked with shame and humiliation. There is a severe lack of capital, goodwill and interest.

Poverty generates conflict between the people in the urban and rural areas. For developing countries, it is therefore under severe constraints that sustainable development strategies have to be designed.

In addition, S&T capabilities of developing countries are far too limited to deal adequately with the enormous problems of development. Only 4% of the world expenditure on R&D and about 14% of the world's supply of scientists and engineers are in developing countries, where more than 80% of the world's people live.

Furthermore, very often, interventions are focused on debt and currency problems of developing countries. What is overlooked is the failure of local corporations to deliver world-class returns on capital. This may be traced partly to a weak S&T base because many of these countries have barely reached the innovation stage.

It is therefore, very important that in fostering technology cooperation, the following are considered:

a. Technology and education are necessary but not sufficient assets for development. These provide the platform within which a knowledge-based development plan can be sustainable.
b. Technology cooperation should be initially focused to meet the minimum basic needs. Without these needs being provided, it will be difficult to expect a significant portion of a nation's citizenry to participate in the development process.
c. Technology cooperation be provided to allow developing countries to cope and be agile with economic changes and allow them to pursue a means of livelihood.

In the end, it is expected that technology cooperation serve as a means of empowerment of the disadvantaged sector and as the centerpiece of poverty alleviation.

## IMPERATIVES FOR TOMORROW

In defining its vision for the future, the Philippines must be guided by the strong need to develop an innovative, technology-driven and information-intensive economy in Southeast Asia. Such an economic foundation is essential if we are to improve our overall quality of life and create the opportunity for rewarding employment and fulfilling lives for generations and generations to come.

Private sector must play the central role in inducing and sustaining economic growth and job creation, but many other players must contribute to encourage and sustain innovation. As scientists, we have been thrust into the limelight of affairs and will inevitably assume active roles in providing the innovations to sustain competitiveness in agriculture, manufacturing and the services.

The science we generate and the technology we build should provide our country a strong foundation that can withstand the foreseen external shocks as a result of rapid economic integration. To keep our local economy strong and vibrant amid the structural adjustments that occur in this age of globalization, the Philippine leadership must recognize the crucial need to reengineer our science and technology agencies into more aggressive, entrepreneurial organizations committed to ensure knowledge and technology transfer to business in agriculture and industry. We need to be always relevant and efficient.

Thus it is imperative that institutional constraints and shortcomings be addressed in order to foster growth and innovation across research disciplines and economic sectors, as well as between suppliers and producers of technology. Organization structures must be rationalized by establishing definite and quantifiable performance indicators, and hastening need-to-response cycles. This internal strategy entails a conscious evolutionary process with no end in sight; otherwise, complacency and sloth spell our downfall into redundancy and irrelevance in this age of heightened competitiveness. Again, we must exert all efforts to bring about the necessary changes within our system.

Technology is the key to producing at the lowest cost with the highest quality at an optimum volume for the right market. Innovation grounded upon our firm grasp of science and technology will help create jobs and facilitate the integration of economic with environmental goals to enhance the quality of life in the Philippines.

There are new challenges which we must face. First, there is an increasing trend for information to be designed for sharing, especially through networks. Second, same observers say that demand for knowledge workers will increase and that these knowledge workers will begin to manage knowledge flow. Thirdly, it is also increasingly felt that boundary layer standardization will become widespread, with regional and global standards for almost all products gaining increasing attention.

Allow me to conclude with a thought from Albert Einstein, and I quote:

> " It is not enough that you should understand about applied science. Concern for the man himself and his fate must always form the chief interest of all technical endeavors; concern for the great unsolved problems of the organization of labor and the distribution of goods in order that the creations of our minds shall be a blessing and not a curse."

I hope we recall these wise thoughts whenever we cope with the stresses of this intensely competitive environment.

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# New Science and Technology Policy for Korea in the Global Innovation System

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Deok Soon Yim, Ph.D.
Research Fellow
yimdeoks@stepi.re.kr

STEPI Science & Technology Policy Institute

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## Ⅰ. R&D Globalization

1. Driving Forces of R&D Globalization
2. Current Situation of R&D Globalization



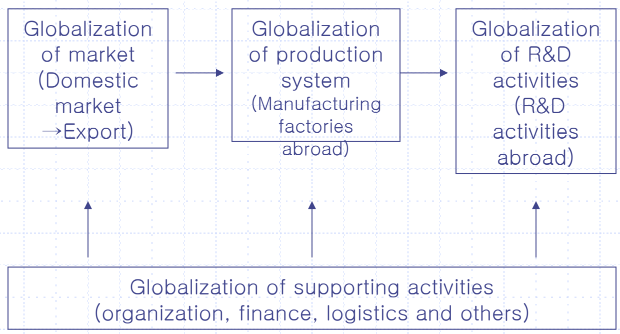


## 1. Driving Forces of R&D Globalization

- New features of R&D activities: complex, large scale, high-cost, and high-risk
  - Strategic cooperation to share high-risk
  - Joint establishment and use of large equipments
- Geographical decentralization of knowledge and information
  - Global access to new knowledge and technology
- Market-oriented R&D activities
  - Technology development to meet market demands
- Increasing international R&D cooperation among developed countries

# 1. Driving Forces of R&D Globalization

- Growth of Multinational companies(MNCs) and R&D Globalization








# 1. Driving Forces of R&D Globalization

- The purpose of establishing foreign R&D centers in U.S.A

| Reasons | Industries | | |
|---|---|---|---|
| | Electronics | Automotive | Biotechnology |
| Acquire technology | 1 | 2 | 1 |
| Keep abreast of technological developments | 2 | 2 | 1 |
| Assist parent company in meeting U.S. customer needs | 1 | 1 | 3 |
| Employ U.S. scientists and engineers | 2 | 3 | 2 |
| Follow competition | 3 | 3 | 4 |
| Take advantage of favorable research environment | 4 | 4 | 1 |
| Cooperate with other U.S. R&D labs | 2 | 3 | 2 |
| Assist parent company in meeting U.S. environmental regulations | 4 | 1 | 4 |
| Assist parent company's U.S. manufacturing plants in procurement | 4 | 2 | 4 |
| Engage in basic research | 3 | 4 | 2 |

Note : 1=extremely important, 2=important, 3=neutral, 4=unimportant
Source: DOC(1999)

## 1. Driving Forces of R&D Globalization

- There are diverse purposes for establishing research centers in U.S, depending on the categories. However, in general, to make the best of S&T manpower in U.S, to follow competition and to utilize good research condition are the main reasons





## 2. Current Situation of R&D Globalization

### R&D Investment

- International cooperation of national R&D businesses is being driven while investment in the regions or countries where S&T talents, research centers, equipments and technology are concentrated.
  - Share of inward foreign R&D investment in major countries (%)
    - U.S 15%, Japan 0.3%, UK 17%, Canada 14%, France 8%, Korea 0.06%
  - Share of international cooperation of national R&D businesses (%)
    - UK 50%, Germany 25%, Sweden 25%, U.S 10%, Korea 1.3%
  - R&D investment of foreign companies in U.S.A increased rapidly from 6.5 billion dollars to 19.7 billion dollars.

## 2. Current Situation of R&D Globalization

### ◈ Manpower

- High-quality S&T manpower are attracted and utilized regardless of their nationality.

[U.S]

- Immigration law was revised to attract foreign quality S&T talents, upper limit of visas for those of high education has been extended to 195,000 (2000~2002). About 27,000 young foreign scientists are working as Post-Doc researchers. (About 50% of total Post-Doc researchers are foreigners)
- In case of engineering faculty, 37% of professors and 24% of graduate students are of foreign nationality.





## 2. Current Situation of R&D Globalization

### ◈ Manpower

[Japan

- In the last 5 years (1996~2000), 10,000 foreign Post-Doc researchers have been utilized.
- RIKEN (The Institute of Physical and Chemical Research, a representative one of Japan, plans to extend its share of foreign directors and researchers in research department to the level of ⅓ of total directors and to ⅓ of total researchers each
- S&T International Exchange Center was established in Tsukuba research town for housing and education of foreign scientists

## 2. Current Situation of R&D Globalization

### International Joint Research

- To cut the cost to develop technology and to share high risks, international joint research of large-scale research businesses and strategic technology alignments are increasingly made.
  - The numbers of strategic technology alignments are 6,570 in U.S, 1,729 in Japan, 1,036 in UK and 119 in Korea.
- Joint research of scientists, mainly in basic science, is actively driven.
  - The percentage of joint research papers of scientists with different nationalities (1995)
    - Sweden 39%, Italy 35%, Germany 33%, Korea 21%(1999)
  - In the last 50 years, scientists with different nationalities were Nobel prize joint-winners in 60 Nobel prizes out of 147.

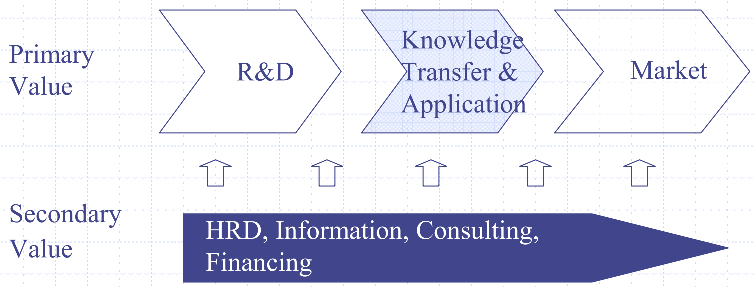


## Ⅱ. Changes in National Innovation System

1. National Innovation System
2. Changing Roles of Innovation Actors
3. Features of Changing Innovation System

## 1. National Innovation System

- Produce knowledge→ Transfer → Market and other relevant bodies (Innovation Activities and Actors)




Source: Deok Soon Yim (2002)





## 2. Changing Roles of Innovation Actors

- Changing role of University
  - Producer of scientific technology and knowledge → The role as user added
- Changing role of Government
  - Corrector of *market failure* → Corrector of *system failure*
- Changing role of Industry
  - Focus on applied technology → Focus on basic science

## 2. Changing Roles of Innovation Actors

- Growing importance of organizations irrelevant to technology
  - Market, financial institutions, consulting firms
- Growing importance of external sources
  - Multinational companies, foreign universities, overseas Korean researchers





## 2. Changing Roles of Innovation Actors

- Complex relations of organizing bodies in the system
  - Not linear relation of "R&D → Market" but "non-linear interacting process" in which innovation bodies interact in diverse ways
- The importance of multi-layered innovation power
  - The power to integrate internal/external 'resources' such as capital, manpower, knowledge&information, and to create new scientific technology is important

## 3. Features of Changing Innovation System

- Reconstruction of national innovation system following globalization trend
  - Conversion to open-door national innovation system
- Competition by Innovation Clusters
  - As competition got intense around innovation clusters centered in specific regions, relevant innovation organizations conglomerate around these regions

    (Silicon Valley, Zhongguancun, Silicon Wadi, Daedeok Science Town)



## Ⅲ. Competition by Innovation Cluster

1. Why Innovation Cluster?
2. Policy for Innovation Cluster Development

## 1. Why Innovation Cluster?

- Development process of Innovation Cluster
  - As market and innovation actors interact, innovation arises and the actors clusters around specific areas.
  - Innovation cluster has its competitive advantage in network, economy of scale, economy of speed, and diffusion and practical use of knowledge.
  - Even in digital era, where distance barrier doesn't matter any longer, technological knowledge is created, transferred and put to use around the clusters.
  - Cluster can be regarded as a kind of Reduced National Innovation System.





## 2. Policy for Innovation Cluster Development

- Many Gov't are trying to develop the innovation clusters artificially
  - Because it gives the brand power, momentum, core place for the innovation of whole nation
  - Successful innovation cluster can be the gateway for the global innovation system

## 2. Policy for Innovation Cluster Development

- Early Investment Type
  - Japan- Intellectual Cluster Prosperity Plan
  - China- Gaoxin High Technology Industry Development Area
  - Taiwan- Hsinchu Science-Based Industrial Park
  - Malaysia – MSC(Multimedia Super Corridor)
  - Singapore – Science Park I, II, III
  - Viet Nam – Hoa Lac Hi-Tech Park
- Mid-term Support Type
  - Finland – Oulu Techno Park
  - India – Software Technology Park



# Ⅳ. Current Situation of Korea

1. Major R&D Indicators
2. Current Situation of R&D Globalization

## 1. Major R&D Indicators

- R&D Expenditure
  - R&D expenditure of Korea as a percentage of GDP is higher than that of other countries, but total expenditure is remarkably low – 1/11 of Japan, 1/21 of U.S.

(Unit : million $)

| | Korea ('01) | Japan ('00) | U.S. ('00) | Chinese Taipei ('99) | China ('99) | UK. ('00) |
|---|---|---|---|---|---|---|
| Total R&D Expenditure | 12,481 | 142,013 | 265,322 | 6,100 | 67,890 | 26,758 |
| Ratio (Korea:1) | 1.0 | 11.4 | 21.3 | 0.5 | (million yuan) | 2.1 |
| Percentage of GDP | 2.96* | 2.98 | 2.70 | 2.05 | 0.83 | 1.86 |

Source: MOST, KITA, MOST (China)
* : Estimate



Ⅳ. Current Situation of Korea

1. Major R&D Indicators

- R&D Expenditure Source
  - Most of R&D expenditure is supported by non-government bodies and the share of foreign investors is minor.

(Unit: %)

| | Korea('01) | Japan('00) | U.S. ('00) | Chinese Taipei ('98) | U.K.('00) |
|---|---|---|---|---|---|
| Government·Public | 26.0 | 27.2 | 31.8 | 39.2 | 34.4 |
| Private | 73.5 | 72.4 | 68.2 | 60.7 | 49.3 |
| Foreign | 0.5 | 0.4 | 0.0 | 0.1 | 16.3 |

(China: Enterprises 49.6%, Institutes 38.5%, Higher Education 9.3%, others 2.6%)

Source: MOST, KITA, MOST (China)

## 1. Major R&D Indicators

- The Number of Researchers
  - The number of Korean researchers is less than that of researchers of other countries – 1/4 of Japan, 1/8 of U.S

| | Korea ('00) | Japan ('99) | U.S. ('97) | Chinese Taipei ('99) | China ('99) | U.K. ('98) |
|---|---|---|---|---|---|---|
| No. of researchers | 159,973 | 642,992 | 1,114,100 | 89,000 | 822,000 | 158,671 |
| No. of researchers per 10,000 people | 34 | 52('99) | 41 | 40 | 7 | 27 |

Source: MOST, KITA, MOST (China)





## 1. Major R&D Indicators

- With the increase of R&D investment in late 1980s, Korea has successfully got out of its developing phase.
- Total R&D investment as a percentage of GDP since late 1990s is almost equal to that of advanced countries.
- Rapid growth in R&D investment and in size was remarkable. But in accumulated know-how and quality, there's still big difference from advanced countries.

## 2. Current Situation of R&D Globalization

- U.S patents by country, 1982-1996

| Inventor Country | No. of U.S. Patents(1982-96) | Share of U.S. Patents(%) |
|---|---|---|
| All patents | 1,276,351 | 100.00 |
| United States | 694,796 | 54.00 |
| Japan | 257,627 | 20.00 |
| Germany | 103,801 | 8.10 |
| United Kingdom | 37,301 | 2.90 |
| Chinese Taipei | 10,836 | 0.85 |
| Australia | 6,037 | 0.47 |
| Korea | 5,899 | 0.46 |
| Israel | 4,072 | 0.32 |
| Hong Kong, China | 725 | 0.06 |
| Ireland | 671 | 0.05 |
| Brazil | 615 | 0.05 |
| China | 533 | 0.04 |
| Singapore | 354 | 0.03 |
| India | 310 | 0.02 |
| Malaysia | 86 | 0.01 |

Source: DOC(1999)





## 2. Current Situation of R&D Globalization

- R&D globalization is well shown in the fact that the percentage of US patents of foreign R&D centers had increased 7.9% from 1920 to 1939, 8.1% from 1940 to 1968, and 14.5% from 1969 to 1990. Now, the percentage of foreign researchers and corporations reaches almost 50% of total U.S patents (MOST, 2001).

- The percentage of Korea is no more than 0.46%.

## 2. Current Situation of R&D Globalization

- International Joint Research

Collaborative country of international joint research initiated by MOST

(Unit: Million Won, Case)

| | | '85-90 | '91 | '92 | '93 | '94 | '95 | '96 | '97 | Total | Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Japan | R&D expenditure | 5,417 | 390 | 1,295 | 865 | 799 | 1,568 | 824 | 1,430 | 12,588 | 24.20 |
| | No. of cases | 117 | 10 | 23 | 15 | 16 | 21 | 16 | 26 | 244 | 26.90 |
| Russia | R&D expenditure | 78 | 2,220 | 1,757 | 1,800 | 739 | 1,109 | 688 | 680 | 9,071 | 17.44 |
| | No. of cases | 1 | 18 | 22 | 23 | 13 | 15 | 11 | 11 | 114 | 12.57 |
| U.S. | R&D expenditure | 3,953 | 595 | 652 | 342 | 379 | 1,295 | 761 | 955 | 8,932 | 17.17 |
| | No. of cases | 81 | 11 | 7 | 7 | 8 | 15 | 13 | 20 | 162 | 17.86 |
| Germany | R&D expenditure | 3,175 | 395 | 598 | 730 | 408 | 518 | 200 | 687 | 6,706 | 12.90 |
| | No. of cases | 54 | 7 | 7 | 9 | 5 | 6 | 4 | 8 | 100 | 11.03 |
| France | R&D expenditure | 1,845 | 315 | 241 | 40 | 140 | 94 | 93 | 145 | 2,913 | 5.60 |
| | No. of cases | 41 | 6 | 4 | 1 | 3 | 2 | 2 | 3 | 62 | 6.84 |
| China | R&D expenditure | – | – | 135 | 60 | 266 | 598 | 335 | 847 | 2,268 | 4.36 |
| | No. of cases | – | – | 1 | 2 | 6 | 8 | 5 | 14 | 36 | 3.97 |
| U.K. | R&D expenditure | 927 | 144 | 140 | 190 | 110 | 98 | 80 | 335 | 2,024 | 3.89 |
| | No. of cases | 16 | 3 | 3 | 4 | 3 | 2 | 2 | 7 | 40 | 4.41 |
| Canada | R&D expenditure | 340 | – | – | – | 110 | 310 | 196 | 220 | 1,176 | 2.26 |
| | No. of cases | 6 | – | – | – | 2 | 4 | 3 | 4 | 19 | 2.09 |
| Chinese Taipei | R&D expenditure | 301 | – | – | – | – | – | – | – | 301 | 0.58 |
| | No. of cases | 10 | – | – | – | – | – | – | – | 10 | 1.10 |
| Others | R&D expenditure | 803 | 63 | 205 | 410 | 554 | 1,286 | 1,041 | 1,672 | 6,034 | 11.60 |
| | No. of cases | 29 | 2 | 5 | 10 | 13 | 17 | 14 | 30 | 120 | 13.23 |
| Total | R&D expenditure | 16,839 | 4,122 | 5,023 | 4,437 | 3,500 | 6,876 | 4,218 | 6,998 | 52,013 | 100.00 |
| | No. of cases | 355 | 57 | 72 | 71 | 69 | 90 | 70 | 123 | 907 | 100.00 |

Source: STEPI



Ⅳ. Current Situation of Korea

## 2. Current Situation of R&D Globalization

- In the case of international joint businesses initiated by MOST, China and Japan are becoming the most important countries for research cooperation.
  - In 1997, Japan was the first target of joint research of Korea, and China the third. Joint research with Japan and China was more than 30% of total research.

## 2. Current Situation of R&D Globalization

### ◈ Current situation of Corporate R&D centers in Korea and challenges

- Recently, MNCs in Korea have increasingly established R&D centers or research centers (or extend functions). (Korea Industrial Technology Association, 2002)
  - At the end of 1999, the share of foreign corporate R&D centers out of all the corporate R&D centers(4,810) was 9.9%. 1.2%(60 centers) of these foreign corporate R&D centers were 100% invested by foreign corporations.
  - Especially, corporate R&D centers invested 100% by foreign investment corporations are increasing. There are 102 as of the end of March 2002.





## 2. Current Situation of R&D Globalization

- However, R&D investment as a percentage of sales shows that corporate R&D centers of foreign companies are not being actively established compared with domestic corporate R&D centers.

  (※ Especially, R&D investment as a percentage of sales of 100% foreign investment companies is remarkably low)

  - The reasons for establishing R&D centers are focused on solving present S&T problems and supporting rather than developing new technologies.
  - At the moment, many of the foreign investment companies regard Korea as the ground to advance into Asian market. Korea is also partly regarded as the potential strategic position of Asia in R&D activities for the future.

## 2. Current Situation of R&D Globalization

- The major barriers in Korea, which foreign corporative R&D centers feel, are as follows:
  - Securing high-quality research talents
  - Joint research with Korean corporations
  - Educational environment for the children of foreign researchers (Ki Kook Kim, Deok Soon Yim, 2000, STEPI)





## 2. Current Situation of R&D Globalization

- Increasing share of foreign investment corporations in R&D indicates that Korea is rising as the strategic position for R&D in Asia, which is distinctive feature compared with the past.
  - However, until now, R&D activities of foreign corporations in Korea have focused on developing technologies to meet domestic demands, following the order and indications from head office. Therefore, it is necessary to find the way which can make Korea as the center of R&D activities.
  - In addition, it is necessary to create favorable environment initiated by government to attract foreign investment corporations, to make them hire talents more and to make high technologies transferred.

## V. Future Direction



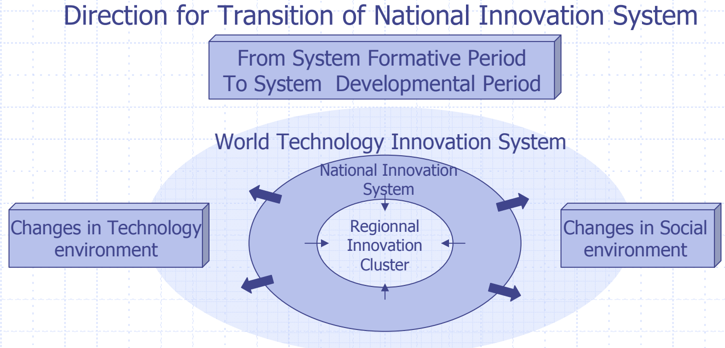




## 1. Transition of National Innovation System

- Transition to open system internationally and cluster-upbringing system domestically

Direction for Transition of National Innovation System




Source: Young Ja Bae, Wi jin Song, Deok Soon Yim(2002)

## 1. Transition of National Innovation System

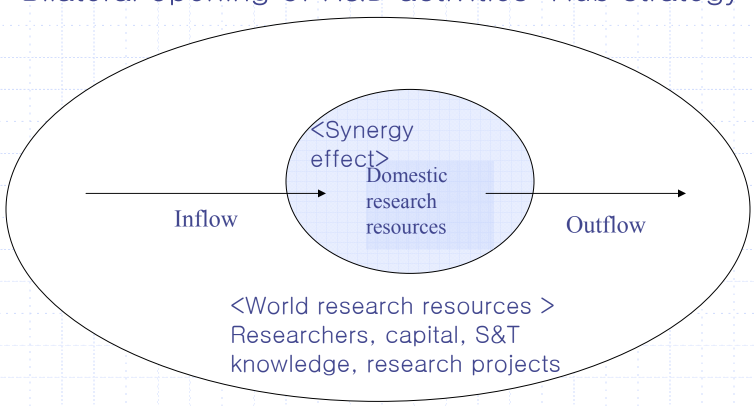
- International level
  - Open system
  - Hub strategy
- National level
  - Increase input level of S&T resources and raise efficiency
- Regional/Industrial level
  - Extend to national level through developing innovation clusters starting with regional level





## 2. R&D Hub Strategy in Northeast Asia

- Bilateral opening of R&D activities: Hub strategy



## 2. R&D Hub Strategy in Northeast Asia

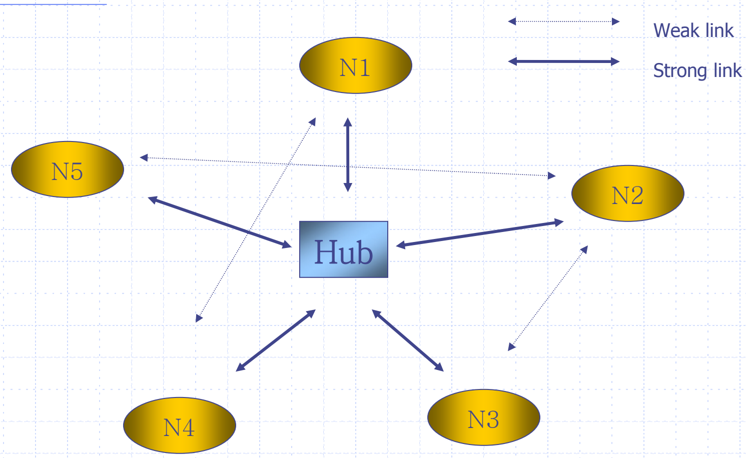
- What is Hub strategy?
  - Increase Inflow & Outflow at the same time
  - Create overseas networks and make them connected to Korea
  - Achieve synergy effect

- Open-door strategy --> Hub strategy
  - Black hole policy → Hub policy
  - From existing absorption strategy to the strategy to increase external/internal bilateral flows





## 2. R&D Hub Strategy in Northeast Asia



## 2. R&D Hub Strategy in Northeast Asia

- Why Northeast Asia?
  - Powerful economy + High technology
- Win-Win scenario for three countries: Korea – China-Japan
  - Complementary and competing relations of industries and technologies
  - China has big market while its corporate R&D activities are relatively weak. Japan has maintained its exclusive system to develop internal technologies under economy recession.
  - Korea has its competitive advantage in manufacturing technology and corporate R&D activities.
  - Both threatening and opportunity to Korea
- Other factors
  - Historical and cultural similarities
  - Geographical approximation





## 2. R&D Hub Strategy in Northeast Asia

- The goal of R&D hub strategy in Northeast Asia
  - To use foreign S&T resources efficiently
  - To contribute to world S&T development and to participate in solving worldwide problems
  - Partnership of Korea-China-Japan in S&T cooperation
  - Korea as the Center of Excellence of R&D activities

## 2. R&D Hub Strategy in Northeast Asia

- Can Korea emerge as R&D hub?
  - Can it attract MNCs?
- Driving forces
  - Complementary players (Korea–Japan–China cultures, distance, development stage of industries)
- Barriers
  - S&T leadership of Korea
  - Close and exclusive culture of Korea
  - Rapid growth of China (Shanghai or Beijing as hub?)





## 2. R&D Hub Strategy in Northeast Asia

- Emerging China
  - Plenty of researchers and rapid growth

| | Corporation | University | Government R&D | Total |
|---|---|---|---|---|
| No. of Research Institutes | 10,926 | 3,241 | 7,984 | 22,151 |
| No. of Manpower (10,000) | 309.9 | 168.8 | 276.5 | 755.2 |
| No. of Researchers (10,000) | 149.0 | 161.0 | 175.5 | 485.5 |

| Field | Gap | 2006 Year Forecast |
|---|---|---|
| Mobile Telecommunication(CDMA Terminal) | 2–3 years | same level |
| Semiconductor(DRAM) | 6–8 years | 2–3 years |
| TFT–LCD | 3–4 years | 6 months–1 year |
| Network Equipment (Access Net) | 2–3 years | same level |

Source: S. B. Hong (2003)

## 3. Policy for R&D Hub

- <R&D>
  - Extension of collaboration
  - Free exchange of researchers
- <Industrial Policy>
  - Preferential treatment to encourage FDI and R&D activities
  - Encouraging domestic companies to develop technologies abroad
- <Infrastructure>
  - Improvement of living and cultural factors
  - English language
  - Administrative service related with R&D





## 3. Policy for R&D Hub

- Attracting and utilizing quality S&T talents from MNCs' R&D centers
  - Suggest excellent working condition (e.g. 1 million won support for 1 research member hired, English-speaking international school)
  - Upbringing S&T Special Area
- Establishment of Korea-China-Japan S&T Cooperation Committee
  - Establishment of the Northeast Asia Joint Research Center
- Driving BESETO (Beijing-Seoul-Tokyo) International Collaboration Development Program
  - Proposal of International Collaboration about a matter of interest of Korea, China and Japan's Association
- Making focal R&D point in China and Japan
- Collecting and applying S&T information systematically

## 4. Issues of Global Innovation System

- What is the end of Global Innovation System?
  - Main players?
  - Effects of GIS: speed of innovation, cost of innovation, quality of innovation
- Are there any conflicts of interest?
  - Are MNCs helping national innovation activities or exploiting national R&D resource?
- How to incorporate National Innovation System into Global Innovation System?
  - The role of gov't?
  - How to utilize MNCs, universities?



# Thank you!

# Any Questions?

# Internationalization of R&D Investment in Korea

YoungJa Bae
Konkuk University, Korea

APEC Workshop
2004. May. 25-27.

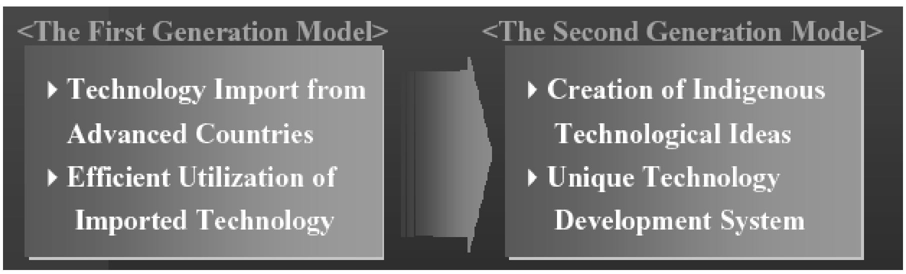
- Korean Model of Technology Development

Korean industrialization is usually considered as " a process of learning" or " industrialization based on learning rather than on invention or innovation"

That is, Korea's strategy has been the introduction of advanced technologies from foreign sources for assimilation and improvement, while promoting the development of a domestic capacity for technological development

# Searching for a New Model

- **Recently, the demand for a new model of technological development has been increasing in Korea in order to go further beyond the catching-up stage, in the context of the rising difficulty in the technology transfer from advanced countries and the emergence of knowledge-based economy**
- **Paradigm shift "From Imitation to Innovation"**




- In Korean context, innovation means, in particular, technological capabilities for creating the generic and high-value added component technologies

- Various efforts to upgrade national innovation systems

-increasing R&D investment

-cultivating creative R&D manpower

-effective networking among GRIs, firms, and universities

-building up the regional R&D clusters

-supporting small and medium venture firms

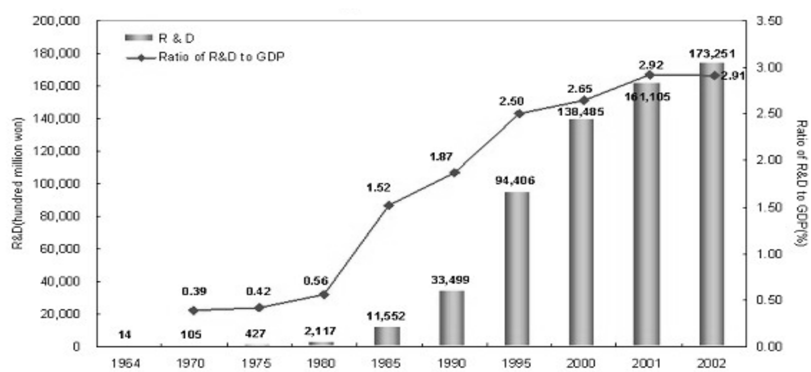
-opening up NIS and linking to global innovation systems

Korea started a national R&D program in the early 1980s and its R&D programs have evolved through various stages

o Evolution of the National R&D Program in Korea

| | Formative Stage (1982-85) | Take-off Stage (1986-90) | Mature Stage (1991- ) |
|---|---|---|---|
| Policy-orientation | Technology-push | Technology-push (major) and Demand-pull (minor) | Harmonization of Technology-push and Demand-pull |
| Program type | Responsive R&D (Bottom-up) No directed R&D | Mainly responsive R&D, with a smaller share of directed R&D | Harmonization of directed and responsive R&D |
| Performer | GRIs | · GRI, with the participation of industries and universities<br>· International joint research | · GRI, university, and industry<br>· Globalization of R&D |

**R&D expenditure which had decreased a little with the IMF crisis in 1998, recovered in the year 2000 to the 1997 level, and reached an all-time high in 2002. R&D expenditure as a percentage of Gross Domestic Product (GDP) is 2.91% in 2002**

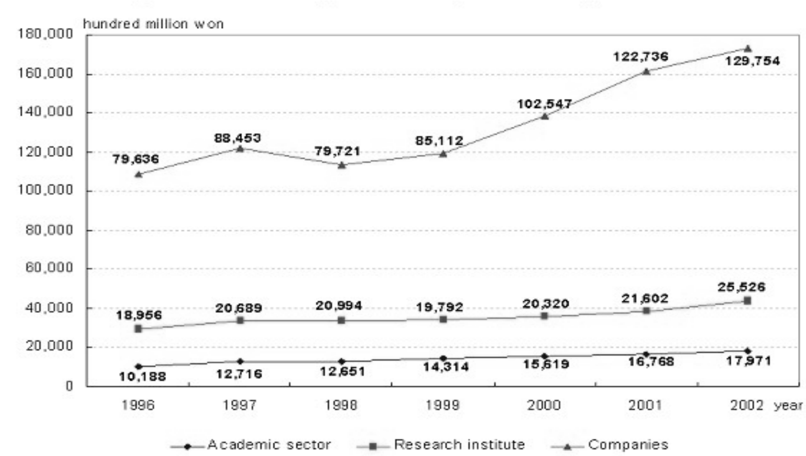


**Of the total R&D expenditure in 2002, the government and public sector provided 26.3% and funds from private sector constituted 73.3%**

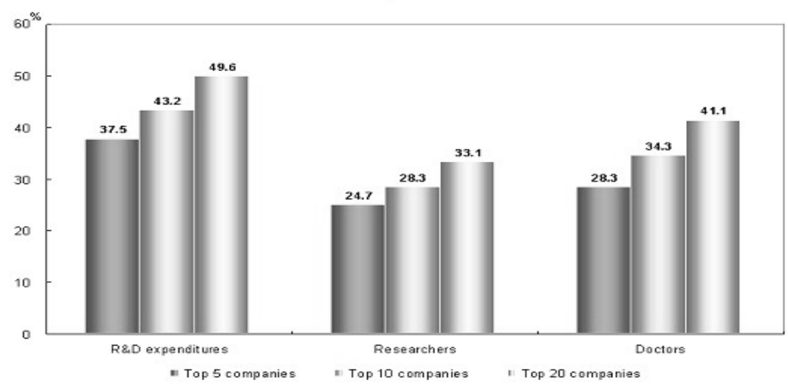
(unit : hundred million won)

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|
| ○ Total R&D expenditure | 94,405 | 108,781 | 121,858 | 113,366 | 119,218 | 138,485 | 161,105 | 173,251 |
| ○ Government & public source | 17,795 | 23,977 | 28,507 | 30,518 | 32,031 | 34,518 | 41,874 | 45,484 |
| - growth rate | 41.6% | 34.7% | 18.9% | 7.1% | 5.0% | 7.8% | 21.3% | 8.6% |
| ○ Private source | 76,597 | 84,667 | 93,233 | 82,764 | 87,117 | 103,872 | 118,474 | 127,004 |
| - growth rate | 15.4% | 10.5% | 10.1% | △11.2% | 5.3% | 19.2% | 14.1% | 7.2% |
| ○ Foreign source | 13 | 136 | 118 | 84 | 70 | 95 | 757 | 763 |
| ○ Gov.&pub. : Private | 19 : 81 | 22 : 78 | 23 : 77 | 27 : 73 | 27 : 73 | 25 : 75 | 26 : 74 | 26 : 74 |

**Of the total R&D expenditure in 2002, public research institutes used up 14.7%. Universities and colleges spent 10.4% of the total, and the industrial sector 74.9%**



In 2002, of the total industrial R&D expenditure, the top 5 companies took up 37.5%, top 10 companies used 43.2%, and those in the top 20 expended 49.6%, respectively, showing relatively high concentration ratio of R&D investment by big firms




In particular, Korean government has tried to globalize national R&D system by designing various policies.

Ex.

Policies supporting overseas and foreign R&D at the firm level
- Change from a positive system to a negative system (1984)
- Elimination of the approval requirement (notification system : 1992)
- Foreign M&A allowed (1998)
- Tax incentives for foreign R&D firms (1998)
- Support for Korean firms to do overseas R&D

Joint R&D Program (1985) and S&T Globalization Program (1996) at the government level
- Facilitate international S&T cooperation and joint research
- Support for GRI's overseas research centers
- Support for the inducement of foreign labs
- Long- and short - term exchanges of scientists and engineers
- Participate in the international R&D efforts for global concern

However, we still have a very much closed and not well integrated NIS to GIS in Korea, in particular, in terms of R&D investment …

# Foreign R&D in Korea

The Ratio of Foreign Source in Korean R&D Investment (Million Won)

| | R&D Investment (A) | Foreign Source (B) | B/A (%) |
|---|---|---|---|
| 1989 | 2,817,256 | 1,120 | 0.04% |
| 1990 | 3,349,864 | 839 | 0.03% |
| 1991 | 4,158,441 | 7,376 | 0.18% |
| 1992 | 4,989,031 | 21,603 | 0.43% |
| 1993 | 6,152,983 | 12,381 | 0.20% |
| 1994 | 7,894,746 | 3,071 | 0.04% |
| 1995 | 9,440,606 | 1,331 | 0.01% |
| 1996 | 10,878,051 | 13,635 | 0.13% |
| 1997 | 12,185,807 | 11,796 | 0.10% |
| 1998 | 11,336,617 | 8,432 | 0.07% |
| 1999 | 11,921,752 | 6,972 | 0.06% |
| 2000 | 13,848,501 | 9,501 | 0.07% |
| 2001 | 16,110,522 | 75,722 | 0.47% |

Most, Korea (2002)

# Foreign R&D in Korea

R &D Investment by Source(%)

| | Korea (2002) | Japan (2001) | Germany (2001) | France (2000) | UK (2001) |
|---|---|---|---|---|---|
| Government | 26.3 | 26.6 | 31.9 | 40.3 | 35.9 |
| Private | 73.3 | 73.0 | 66.0 | 52.5 | 46.2 |
| Foreign | 0.4 | 0.4 | 2.1 | 7.2 | 18.0 |

from OECD, Main Science and Technology Indicators, 2003

Where Foreign R&D were invested (2001) (Million Won)

| | Public Research University | Public University | Private University | Private Firms | Total |
|---|---|---|---|---|---|
| Foreign Source | 1,522 | 3,001 | 2,094 | 69,105 | 75,722 |
| | (2.01%) | (3.96%) | (2.77%) | (91.38%) | (100%) |

MOST, Korea (2002)

# Foreign R&D in Korea

R&D Unit by Foreign Firms in Korea (Unit, (%))

| | | R&D Unit | | | | | R&D Unit | | |
|---|---|---|---|---|---|---|---|---|---|
| | | R&D Institute | R&D Division | Total | | | R&D Institute | R&D Division | Total |
| Nation | USA | 46(45.1) | 5(25.0) | 51(41.8) | Industry | Elec. | 42(41.2) | 5(25.0) | 47(38.5) |
| | EU | 35(34.3) | 6(30.0) | 41(33.6) | | Chem. | 30(29.4) | 10(50.0) | 40(32.8) |
| | Japan | 13(12.7) | 5(25.0) | 18(14.8) | | Machinary | 24(23.5) | 1(5.0) | 25(20.5) |
| | others | 8(7.8) | 4(20.0) | 12(9.8) | | others | 6(5.9) | 4(20.0) | 10(8.2) |
| Size | Large Firm | 27(26.5) | 10(50.0) | 37(30.3) | Region | Seoul | 31(30.4) | 4(20.0) | 35(28.7) |
| | SME | 75(73.5) | 10(50.0) | 85(69.7) | | Kyunggi | 29(28.4) | 9(45.0) | 38(31.1) |
| Year of Est. | before '94 | 38(37.2) | 4(20.0) | 42(34.4) | | CC | 18(17.6) | – | 18(14.8) |
| | 95~97 | 17(16.7) | 2(10.0) | 19(15.6) | | KS | 18(17.6) | 3(15.0) | 21(17.2) |
| | after '98 | 47(46.1) | 14(70.0) | 61(50.0) | | CC | 5(4.9) | 4(20.0) | 9(7.4) |
| | | | | | | | 1(1.0) | – | 1(0.8) |
| Total | | 102(100.0) | 20(100.0) | 122(100.0) | Total | | 102(100.0) | 20(100.0) | 122(100.0) |

KOITA (2002)

# Overseas R&D in Korea

Overseas R &D in Korea (2001)

(MillionWon)

| | Foreign University | Foreign Non-profit Org | Foreign Gov't | IO | Foreign Branch | Foreign Joint Venture | Foreign Associate | Foreign RI | Foreign Firms | Others | total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| University | 786 | - | 40 | - | - | - | - | 629 | 32 | 36 | 1,522 |
| Public Institute | 3,558 | 2,267 | 69 | 386 | - | - | - | 3,121 | 2,209 | 298 | 11,908 |
| Firm | 3,718 | 3,285 | 69 | 381 | 18,089 | 5,025 | 36,666 | 189,220 | 214,475 | 77,511 | 548,439 |

MOST, Korea (2002)

# Overseas R&D in Korean Firms (Million Won)

| Company | foreign npo | IO | overseas branch | overseas joint venture | overseas associates | overseas RI | foreign Firm | other | Outward total A | R&D total B | A/B (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| S-Elec | - | - | - | - | - | 130,000 | 91,000 | - | 221,000 | 2,418,234 | 9.1 |
| H Motor | - | - | - | - | 22,394 | 6,485 | 33,018 | 732 | 62,629 | 778,571 | 8.0 |
| E | - | - | - | - | - | - | - | 47,025 | 47,025 | 56,445 | 83.3 |
| K Motor | 258 | - | 773 | 258 | 1,288 | 8,499 | 9,529 | 5,151 | 25,754 | 138,397 | 18.6 |
| S | 228 | - | 683 | 228 | 1,139 | 7,517 | 8,428 | 4,556 | 22,778 | 41,550 | 54.8 |
| L | - | - | 8,159 | - | - | - | 6,497 | - | 14,656 | 63,276 | 23.2 |
| K | 140 | - | 420 | 140 | 700 | 4,620 | 5,180 | 2,800 | 14,000 | 16,000 | 87.5 |
| D | - | - | - | - | - | - | 12,269 | - | 12,269 | 168,250 | 7.3 |
| K | 500 | - | - | - | - | 8,959 | - | - | 9,459 | 45,036 | 21.0 |
| D | 76 | - | 228 | 76 | 379 | 2,503 | 2,806 | 1,517 | 7,585 | 24,110 | 31.5 |
| K | 76 | - | 227 | 76 | 379 | 2,500 | 2,803 | 1,515 | 7,577 | 9,912 | 76.4 |
| H | - | - | - | - | - | 7,269 | - | - | 7,269 | 43,626 | 16.7 |
| S | 26 | - | - | - | 5,327 | - | 273 | 46 | 5,672 | 95,890 | 5.9 |
| S | - | - | 4,494 | - | - | - | - | - | 4,494 | 11,051 | 40.7 |
| E | - | - | - | - | - | - | 4,365 | - | 4,365 | 8,913 | 49.0 |
| P | 39 | - | 118 | 39 | 196 | 1,296 | 1,453 | 786 | 3,928 | 9,322 | 42.1 |
| S | 36 | - | 108 | 36 | 180 | 1,188 | 1,332 | 720 | 3,600 | 262,100 | 1.4 |
| H | 36 | - | 107 | 36 | 178 | 1,175 | 1,318 | 712 | 3,561 | 14,269 | 25.0 |
| S | 35 | - | 106 | 35 | 176 | 1,163 | 1,304 | 705 | 3,523 | 12,463 | 28.3 |
| H | - | 30 | - | | - | - | 3,195 | - | 3,225 | 787 | 409.8 |
| **total** | **1,449** | **30** | **15,422** | **923** | **32,336** | **183,174** | **184,770** | **66,264** | **484,369** | **4,218,202** | **11.5** |

# Foreign and Overseas R&D in Korea

Foreign and Overseas R&D in Korea (2001) (Million Won)

| Total | | Public Research Institute | | Public University | | Private University | | Private Firm | |
|---|---|---|---|---|---|---|---|---|---|
| Inward | Outward | I | O | I | O | I | O | I | O |
| 77,515 | 561,869 | 1,653 | 15,515 | 3,166 | 115 | 2,292 | 1,407 | 70,404 | 544,832 |

MOST, Korea (2002)

Korea's overseas R&D expenditure is seven times higher than foreign R&D investment into Korea. Korean private companies pay 97% of the overseas R&D expenditure while the remaining 2% is paid by the government-funded research institutes. In case of foreign R&D investment into Korea, 91% is concentrated on private sector while 7% goes to universities and the remaining 2% is invested in the government-funded research institutes

Internationalization of Korean R&D investment seems to be still at the stage of laying foundations

Since the late 1990s, Korea has expanded and diversified its base for international cooperation by changing its regulatory framework and expanding support for international R&D programs. However, practical changes have been slow

## Internationalization of R&D as a way for innovation

Is Overseas and Foreign R&D investment a better means for innovation than technology licensing and OEM (in a Korean context ) ?

We need to clearly identify the conditions and mechanisms by which internationalization of R&D could contribute to increase the innovative capabilities of the Korean firms for the creation of indigenous and generic technologies

Is Overseas and Foreign R&D investment just an (not much important) element, or the critical element for upgrading NIS and raising innovative capacities of Korean firms

In Korea, internationalization of R&D is usually included as an item for a new NIS model, but does not seems to be considered as the critical element for upgrading NIS

## Internationalization of R&D: Is it a background and/or a strategy ?

Globalization has pushed the countries and firms to be globally competitive, meeting global standard of innovation activities and in this sense we could see globalization as a pushing force or background

The opening of NIS and CIS and internationalization of R&D investment work better for the countries and firms to gain global competitiveness. To them globalization is a critical strategy for enhancing innovative capacities

However, from the experience and perspective of Korea, globalization has been usually considered more as a pushing force rather than a an important strategy toward upgrading NIS.

We have pursued some particular forms of outward internationalization very actively, but have had an indifference or negative attitude on the other forms of globalization

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In order to take advantage of the growth opportunities offered by the globalization of R&D, it is necessary for Korea to correct its inward-looking practice and closed culture. Moreover, social environment of Korea requires a major improvement to meet the global standards. This is not simply a R&D policy issue but an issue of the entire society that requires a systematic long-term approach

Within this broad context, we need to keep our efforts to restructure framework conditions such as labor market, R&D base, fiscal and financial policies and regulation regime… ) for the creation of a globalized R&D system in Korea

# National Innovation Competencies in Chinese Taipei: Assessing the Impacts of Globalization

**Yee-Yeen Chu, Ph.D.**
**Department of Industrial Engineering Management**
**National Tsing-Hua University**
**Hsin-Chu, Chinse Taipei**

**APEC Workshop on National Innovation Competencies**
**Broomfield, CO**
**May 25-27, 2004**

# Outline

- **Main Historical Trend**
- **Structure of Production**
- **Main Actors in the Field of Innovation**
- **Institution Relevant for Innovation Process**
- **Impact of Globalization**
- **Likely Source of Globalization Impact**
- **Main Strength and Weakness**

# Main Historical Trend

- Industry and Economy
  - Phases of Industrialization Since 1950s
  - Growth in Capacity, Export, and GDP
- R&D Investment
  - R&D Intensity Gains in the 80s
  - Government Investment Plays Important Role
- S&T Specialization
  - Paper Citation
  - Patent Activities

# Structure of Production

- Labor Intensive -> Capital Intensive
- Manufacturing -> Service & Knowledge-based
- Fast Adjustment of Manufacture Structure
  - High Tech Export
  - Heavy Concentration on ICT
  - Need for Rapid Diffusion of Key Technologies (Adoption and Internalization)

## Main Actors in the Field of Innovation

- **Lead State Agencies**
  - **STAG, CEPD, MOEA, NSC**
- **Firms**
  - **Network of SME**
  - **MNC**
- **Research Organizations**
  - **ITRI, CSIST, …**
- **Venture Financing**
  - **VC & Angels**

## Institutions Relevant for Innovation

- **Industrial Networks**
- **Production System**
- **Financial Institutions**
- **Tax Incentives**
- **Knowledge Spill-Over Mechanisms**
- **Education and Training**

# Trend of Increased Globalization

- **Increase Interdependence of Locations and Firms**
- **More Competitors, More Fierce Competition**
- **More Complementary Resources, More Customers**
- **Higher Risk**
- **New Opportunities and Threats**

# Impact of Globalization

- **Production Structure**
  - **Manufacturing Center in Global IT Commodity Chain**
  - **Structure Changes Facing the Rise of an Industrial China**
- **Knowledge Infrastructure**
  - **Increasing Need for Knowledge Creation**
  - **Collaboration among Firms, Research Org, and University**
- **Institutional Set-up**
  - **Incentives for Setting Up R&D Centers**
  - **Business Incubation and Entrepreneurship**
  - **Open up the Financial and Service Market**

## Likely Sources of Globalization Impact

- **Knowledge Input**
  - Provision of R&D
  - Competence Building
- **Demand Side Factor**
  - New Market Formation
  - Demand Articulation
- **Organization and Institution**
  - Networking and Learning
  - "Rule of the Game"
- **Supporting Services to Innovation**
  - Incubating, Financing
  - Consulting

## Strength and Weakness

- **Advantages**
  - Advanced & Sophisticated Industrial Customers
  - Vertically Disintegrated Industrial System
  - Effective Mechanism for Diffusion and Learning
  - Fast Incremental Innovation in Manufacturing
- **Mismatches**
  - Critical Areas of Innovation Infrastructure
  - Capability of Product Innovation
  - Knowledge Producing Capacity on Basic Research
  - R&D Intensity in Non-Electronic Industry
  - Legal Framework Governing R&D Collaboration
  - Transformation of Common Infrastructure

**Thank You**

# NATIONAL INNOVATION COMPETENCIES IN CHINESE TAIPEI: ASSESSING THE IMPACTS OF GLOBALIZATION (DRAFT)

**YEE-YEEN CHU, PH.D.**
**NATIONAL TSING-HUA UNIVERSITY, HSIN-CHU, CHINESE TAIPEI**

## ABSTRACT *

Being one of the small open economies in the APEC region, Chinese Taipei has been able to achieve sustainable growth in spite of a shortage of natural resources and other unfavorable conditions. There has been a complex and innovative set of institutional settings which drives the innovation process in Chinese Taipei The quality of human capital has been seen as the strength. The return migration of high-skilled workers in the fields of science and technology is closely associated with the growth of hi-tech industries. Besides, government-sponsored research institutes, such as Industrial Technology Research Institute (ITRI), provide support for private sector technology upgrading and diffusion; innovation incubators support entrepreneurs at the earliest stage of technological entrepreneurship and help to turn ideas into exportable commercial products. Moreover, the financial incentives encourage companies to undertake R&D, personnel training, and other competence building activities. Benefited from the tax incentives, venture capital grew rapidly in 1990s and speeded up the development of the hi-tech sector. The aforementioned characteristics of Chinese Taipei's national innovation systems (NIS) will be highlighted in the presentation with a special focus on the effects of the globalization.

The trend of increased globalization, as indicated in the increased interdependence of locations and firms, implies "more competitors," "more fierce competition," "more resources available," "more customers," and "higher risks." It could result in both opportunities and threats to industrial firms, research institutes, universities, and government agencies. The trend seems to show its greatest impact on Chinese Taipei's innovation patterns in capturing technology opportunities abroad and capturing global market opportunities. The presentation will outline our initial assessment of the impacts of globalization in four areas: knowledge inputs (provision of R&D; competence building), demand-side factors (new market formation; demand articulation), organization and institutions (provision of networking and learning; provision of "rules of the game"), and supporting services to innovation (incubating; financing; consulting). It will draw on the case study of ICT innovation network in Chinese Taipei to highlight the dynamics of international resource flows and the advantages gained by the multinational corporation (MNC) and the host economies to form a global innovation network, along with the feedback mechanisms that lead to the adjustments and distribution of resources and organization of activities that contribute to "inward" and "outward" globalization. The presentation will then address the issues and challenges in the global innovation network: changing roles of research institutes, universities, and government agencies and the appropriate policy and cooperation mechanisms to generate synergies and cross-fertilization effects.

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* APEC Workshop on National Innovation Competencies and Interests in a Globalized World, Broomfield, CO, May 25-27, 2004.
This presentation is based on Chinese Taipei's research studies of national innovation systems, including the ESF studies of NIS in ten small countries. The research team include: Wang, K., Tsai, M., Liu, C., Luo, Y., Hung, S., Wu, F., Hsu, M. and Chu, Y.

# NATIONAL INNOVATION COMPETENCIES IN CHINESE TAIPEI: ASSESSING THE IMPACTS OF GLOBALIZATION -- BACKGROUND PAPER

## 1. A Brief Characterization of the NIS in Chinese Taipei

Chinese Taipei has been able to achieve sustainable economic development in spite of a shortage of natural resources and other unfavorable conditions. Government participation or intervention has been a significant role in terms of industrial orientations. Initiating from the 1950's, the government has implemented a number of policies aimed at enhancing firms' innovative investment, with notable policy measures focusing on speeding up the development of high-tech sectors. Small and medium size enterprises (SMEs) constitute more than 96% of business concerns, but they seldom conduct in-house R&D. Nevertheless, this disadvantage is not weighty as Chinese Taipei's industrial networks provide ready access both to craft production and technical learning. The substantial presence of transnational corporations (TNCs) is a source of business contracts, technological knowledge, and market information for innovation (Hung, 2002).

Thriving in high-tech industries and SMEs, Chinese Taipei is an important global production center for information technology (IT) and plastic products. It leads the world in the areas of professional OEM chip foundries, semiconductor design, and the production of TFT-LCDs and LEDs. OEM production has brought to Chinese Taipei's sophisticated industrial customers and buyers and improved standards, however; the OEM culture strongly rooted in Chinese Taipei's manufacturers that emphasizes on cost reduction efficiency rather than innovation through value creation may represent a serious obstacle for the advance the knowledge-base of Chinese Taipei's NIS.

There has been a complex and innovative set of institutional vehicles which drives the innovation process in Chinese Taipei. The quality of human capital has been seen as the strength of Chinese Taipei. The return migration of high-skilled workers on the field of sci-tech is closely associated with the growth of hi-tech industries. Besides, government-sponsored research institutes, such as Industrial Technology Research Institute (ITRI), provide support for private sector technology upgrading and diffusion; innovation incubators support entrepreneurs at the earliest stage of technological entrepreneurship and help to turn ideas into exportable commercial products. Moreover, the tax incentives encourage companies to undertake R&D, automation, personnel training, and other functional activities. Benefited from the tax incentives, venture capital grew rapidly in 1990s and speeded up the development of the hi-tech sector. The aforementioned characteristics of Chinese Taipei's NIS will be overviewed in the following discussion.

## 2. Main Historical Trends

<u>Industry and economy</u>

Reconstruction after World War II and the civil War, from 1945 to 1952, the government reformed land policy and raised agricultural productivity. The year 1952 marks the beginning of Chinese Taipei's modern economic growth. From that period Chinese Taipei adopted an export-oriented approach to foster its development. Initially this was based on low-cost labor intensive industry involved in OEM. Over the subsequent five decades the governance of Chinese Taipei gradually democratized and this brought with it many other reforms. For example, the growth of a sophisticated education system which resulted in graduates seeking post-graduate studies offshore. By 1976, Chinese Taipei has prospered to become one of East Asia's leading economic 'Tigers', with real GDP growth averaging about 8 percent per annum for the last three decades. Exports have grown even faster and have provided the primary impetus for industrialization. From 1985 to present, the rise in labor wages, social mobility, and enhanced conflict between laborers and employers, the appreciation of the currency, and Chinese Taipei's higher profile in the international community all contributed to Chinese Taipei's industrialization.

Other initiatives were taken in the early 1970's, when textiles represented Chinese Taipei's leader in export values. Facing with growing international competition and trade constraints, the government foresaw the limits of Chinese Taipei's natural resources and local markets. In recognition of the fact that the private sector was not capable of carrying out R&D, the Industrial Technology Research Institute (ITRI, 1973) and the Hsinchu Science-based Industrial Park (Hsinchu SBIP) were planned. Moreover, FDI has played a major role in the development FDI investment into Chinese Taipei has proved the key driver for expansion of Chinese Taipei's export capacity, technology transfer among industries, and the formation of industrial clusters.

R&D investment

Chinese Taipei now belongs to the league of the big R&D spenders at aggregate national level. R&D Intensity (Gross Expenditure on R&D in relation to GDP) in Chinese Taipei gained significant growth in the 1980s, rising from 0.85 % in 1981 to 1.66 % in 1990, and reached 2.05 % in 2000. Government investment plays a relative important role in the overall R&D investment. 37.9% of Chinese Taipei's R&D expenditure is made by the public sector in 1999, and 61.2% by the private sectors. However, R&D expenditure made by the public sector accounted for 1.1 % of GDP, while the private sector registered for 0.78 % of GDP. Chinese Taipei's university-performed R&D plays a minor role, reaching only 12 % of the total R&D performed in the country. This value is almost half of the 21 % of the OECD average.

The government spends 49 % of the total budget on research programs for the purpose of strengthening industrial competitiveness, and only 9% for improving health and environment. If classified by research type, 22.7% of the budget went for basic research, 33.4% for applied research, and 43.9% for technology development. Non-electronics sectors spend less than 1% of their sales in R&D, but also their R&D intensity has remained flat (and in some cases decreased) in the last five years. Similar trends in relatively technology intensive sectors such as chemical, non-electric machinery, food and metal processing spends. These trends are worrying not only because the numbers are very low compare with international trends, but also because it is expected that as a catching up economy R&D spending should increase continuously.

Patterns of scientific and technological specialization

In view of the scientific specialization, the total number of paper published in the Science Citation Index (SCI) gains substantial growth in the past 10 years. The total number produced is 2,724 in 1990, ranking the 29th of the world in terms of quantity. The number increases to 8,931 in 1999, and ranking the 19th of the world. The impact factor is another frequently used indicator to assess the quality of overall research output. Chinese Taipei doesn't show any significant change in terms of impact factor through time. Among the research field, Chemistry, Clinical Medicine, Engineering and Physics are most productive fields within the country, altogether they make up 63.3% (56,263) of the total paper produced. As to the share of total output for the entire field, Engineering, Computer Science, Physics and Material Science are major fields that have larger percentage shares of paper produced in entire the field. For Chinese Taipei in the past twenty years, research fields such Chemistry, Engineering, Clinical Medicine, and Material Science, show relative strength than other research fields.

Patenting activities have greatly expanded in Chinese Taipei. In recent years. Chinese Taipei rose from 11th in 1989 to 4th in 2000 in terms of total patent counts and quality. Much emphasis has been placed on gaining patent rights both for the public research institutions and private industries. Furthermore, Chinese Taipei, led by the US and Japan, is ranked third in terms of IT patents. The distribution of Utility Patent numbers across technological fields shows Chinese Taipei's unique performance in the field of Semiconductors, Electronics, Electrical Appliances and Components. During the period 1994-1998, patent granted to the residents of Chinese Taipei accounted for 4.69% in the field of Semiconductors and Electronics, 4.69% in other transport, 4.3% in Wood and Paper, 3.96% in Textiles and Apparel. The above mentioned fields have large share in the U.S. patent market. Patents granted in the field of Other Transport and Semiconductor/Electronics have strongest technological impact as they have the most frequently cited patents for new technological development.

## 3. The Structure of Production

Looking back at Chinese Taipei's industrial development throughout the last 50 years, we see clearly that between 1960s and 1990s, the economy was driven by manufacture. From 1960s to 1970s, Chinese Taipei industry was basically labor-intensive. From 1970s to 1990s, the industry turned to be investment-intensive. At this stage, Chinese Taipei became a technology follower, especially in the sectors where technology barriers were not high, and a swarm of investments began to pour into these sectors. From 1990s onward, service industry in Chinese Taipei has begun to take hold, leading the knowledge-intensive industry.

Chinese Taipei's manufacturing adjusts the structure very fast in the recent ten years, and the high-tech industry has become the import role to support their economic growth. In view of the export ratio of manufacturing, Chinese Taipei has the highest in its high-tech industry, up to 40.44% in 2001(Wu, 2001). In year 2000, Chinese Taipei's computer and OA equipment industries export value is US$29.2 billion dollars, which is the 3rd export country in the world, next to US and Japan.

Besides, the electronic and communication industry export value is US$33.2 billion, next to US, Japan, and Korea. The phenomenon could lead to crisis. Since Chinese Taipei is a medium-small country, it will be affected more easily by the fluctuation of the global economy if the industry is too concentrated.

In fact, Chinese Taipei's manufacturing industry already has a very sturdy foundation. In 1994, Chinese Taipei was the world leader in the manufacture and export of nine product categories, including computer monitors. Moreover, during the same year it was second in six product categories, including molds; and third in a further three product categories, including personal computers. In addition, local manufacturers have set up more than 20,000 production lines in China and the nations of Southeast Asia. Much of the materials, parts, machinery, designs, and management skills needed by these offshore factories are supplied by Chinese Taipei\. Based on the "Two Great, Two High, Two Low" principle (great market potential, great degree of industrial linkage, high added-value, high technological level, low pollution, low energy dependence), in 1993 the government designated ten emerging industries: information, plans were made to raise the aggregate turnover of these industries from the 1992 figure of US$27.3 billion to US$94.2 billion by the year 2002.

Chinese Taipei's industries are primarily in need of key technologies for use in developing new products, new materials, and new manufacturing processes. These technologies must be acquired on a large scale from overseas during the current phase. It is expected that under circumstances of increasing international competition and greater respect for intellectual property rights, the technologies Chinese Taipei seeks to acquire will be those that the developed nations need to insure the survival and success of their own industries. Consequently, Chinese Taipei will need a strong foundation of high technological standards and highly qualified manpower to serve as bargaining chips for acquiring even more advanced technologies. To insure that technology takes root in Chinese Taipei and to shrink the technology gap between home and abroad, the acquisition of technology must be followed up by R&D activities which lead to new improvements.

## 4. Main Actors in the Field of Innovation

Lead agencies

The development of technological capability depends for its success on initiatives and coordination, therefore it is necessary to have some forms of pilot or lead agency to set the overall strategic directions and coordinate the activities of the various agencies. In Chinese Taipei, STAG, CEPD, MOEA and NSC are among those play important roles in this process.

The Science and Technology Advisory Group (STAG) is the highest level organisation related to science and technology matters, reporting directly to the Premier and the Executive Yuan. It is charged with helping coordinate government, industry, research institutes, and academia at the inter-ministerial level, as well as providing a vision for science policy. The Council for Economic Planning and Development (CEPD) advises the Executive Yuan and has prime responsibility for issues relating to overall planning and economic development, coordination of economic policy, and monitoring and evaluation of development projects, measures and programs. The National Science Council (NSC) is the premier body supporting academic research, development of the science-based industrial parks, and promoting national technology development. The Ministry of Economic Affairs (MOEA) is the government ministry primarily associated with policies and support for industry development. Its major functions encompass the administration of industry, commerce, trade and international cooperation, small and medium enterprises, investment, intellectual property, technological research and development, energy, water resources, mining, standards, inspection, weights and measures, and subsidiary enterprises. Academia Sinica is considered the most prominent academic institution in Chinese Taipei. It is affiliated directly with the Office of the President of Chinese Taipei, but enjoys independence and autonomy in setting its own basic research objectives.

R&D organizations

Over the 1970s and 1980s, the government intensified its efforts to widen an R&D capacity for the new growth sectors. During the 1980s, about 46 to 63 percent of total R&D spending was undertaken by the government, 33 to 52 percent by private enterprises, and less than 1 percent by the foreign sector. A landmark is the establishment of the Industrial Technology Research Institute (ITRI) in 1973. The ITRI, which is the largest public R&D organization on the island, plays a critical role in terms of research and development in information technology. Electronics Research and Service Organization (ERSO) under ITRI is the leading agency in Chinese Taipei's development of information industry. It carries out research on semiconductors and computer hardware technologies. After 1990, ITRI's newly created subsidiary - Computer and Communication Research Laboratory (CCL) - focus on the integration of computer, communication, and consumer electronics technologies. Several of the critical innovations that had spearheaded the emergence of Chinese Taipei's integrated circuit industry had come from within the ERSO/CCL laboratory.

Although almost all computer firms are privately owned, ERSO/CCL was able to take a leading role with identifying particular items on Chinese Taipei's own production frontier. In particular, ERSO/CCL was given responsibility for guiding the development of core technologies and new products, and for training microelectronics/computer engineers, some of whom would then move to industry. The institution also acts as a consultant, and has, on many occasions, set up strategic consortia with local companies.

Firms

Chinese Taipei's industry is based on a network of SMEs. The information industry grew initially out of the strongly insular electronic industry which was long dependent on a pool of Chinese family businesses prevailing in Chinese Taipei's business community. These businesses are typically small and medium-sized, yet have enjoyed preferred positions in the allocation of national natural resources. For example, the Fair Trade Law (FTL), which covers a wide range of market practices and targets unfair competition practices, was not enacted until early 1991. In the process of industrialization, environment protection was from time to time stolen from the side of economic growth. The labor union has been dominated by management, strongly aided by the KMT-party state. Overall, many successful IT firms benefit from a national innovation system which has well-established a sophisticated infrastructure in factor creation. By the middle of 1990s, the Chinese Taipei's information industry had over 5,000 hardware manufacturers, producing PCs and components mostly on an OEM basis.

Unlike Japan and Korea, Chinese Taipei's industrial development was characterized by a more substantial presence of TNCs with their influences on both market demand and technological learning. For the information industry in particular, there are two types of TNCs. First, there are TNCs basing their operation activities in the island. In general, the state has actively used its sovereign power and its control of domestic economy to harness foreign investors to further its political and economic objectives. Through direct foreign investment, this kind of TNCs saw their business activities in Chinese Taipei as a means to take advantage of cheap local skilled human resources and strong peripheral systems. Most of their products are exported to their home country. But as the presence of these TNCs enabled local firms to obtain knowledge from the movement of workers, they have contributed to a continuing learning system of innovation.

The second type of TNCs is composed of foreign buyers operating in environments of radical product change and open standards. In order to reduce production costs, these big buyers rely on Chinese Taipei for the supply of IT parts and integrated systems. In so doing, TNCs as core actors within a global commodity chain (GCC) gain a competitive advantage through innovations that transfer competitive pressures to Chinese Taipei's IT players, operating in peripheral areas of the world economy. However, the role of TNCs in Chinese Taipei's system of innovation should not be underestimated, as access to the networked commodity chain is a source of business contracts, technological knowledge and market information. With access to these resources for innovation, Chinese Taipei's IT firms eventually reversed the pattern of GCC exploitation, making the TNCs (e.g. IBM, Compaq, HP and Gateway) dependent on their manufacturing and innovation skills. For example, being an OEM supplier to Dell allows Compal to increase productivity and improve material requirement system and debt management.

Venture capital for start-ups

The MOEA has responsibility for the Investment Commission, which examines and approves applications for investment and technical cooperation from overseas sources; and the Industrial Development and Investment Centre (IDIC), which seeks out investment opportunities, promotes technical cooperation between domestic and foreign firms and effects strategic alliances. Most of the banking finance is focused on the high-technology sector. The Banks are also highly supportive of investments where a 1:1 government project is involved. Venture capital (VC) as a business came into effect in Chinese Taipei around 1985, with an initial growth rate which was relatively slow; however, some 15 years later, VC has entered a growth period.. There are now around 200 VC funds operating in Chinese Taipei. The government provides a marginal tax incentive to venture capital investments for a period of three to five years. There are several different types of VC-house modeled on the US approach, but most run from money supplied by angel investors. The focus of venture capital investments has been in semiconductors, Internet technologies and biotechnology. The average size of the investments is about $US 1 million (IDIC, 2000).

**5. Main Institutions Relevant for Innovation Processes**

Industrial Networks

Networks of interdependence firms are common features in the Chinese Taipei's system of innovation. The generation of these networks is particularly facilitated by the geographic density characteristic of the island. Science-based Industrial Park (SBIP) is an extensive network of vertical linkages within the industry (though not necessarily within each firm). There are four sub-areas where the Hsinchu SBIP cluster focuses its activities: Semiconductor, Computer Peripherals, Telecommunications, Opto-electronics and Precision Machinery. They are strongly related and generate a strong support for innovation in the cluster.

As Yeung (1998) observes, "in East and Southeast Asia, Chinese business organizations are often embedded in distinctively local business networks. These business organizations…… are supported by other business organizations within the same networks, (from which) they derive bargaining power and strategic advantages". Unlike in either Japan or Korea, Chinese Taipei's business networks are typically informal, personal and plural in that the leading economic actor in Chinese Taipei is the family firm and family-owned conglomerates. According to Whitley (1992) and Wong (1996), Chinese family businesses show a high level of reliance on entrepreneurial networks for access to expert resources and market opportunities. Inter-sector coordination is low, largely confined to personal ties. Subcontract relations are not necessarily long-lasting and tend towards reliance on multiple outsourcing. This is true even for business groups. Though mostly controlled by the owning family through cross-shareholdings, these business-group firms are typically only loosely integrated. Within the groups, these firms are very personal, depending heavily on family-like relations of trust between the owner-managers of each firm or sets of firms. Outside the groups, they tend to rely extensively on subcontracting relations with non-group firms, whose connections to the groups are not necessarily long lasting. Overall, then, the development of market networks in Chinese Taipei is far more sparse, fragmented, personal and opportunistic.

However, in the area of information technology, these networks are understood as important resources because they help economic actors absorb the sources of uncertainty in their industry and in the process reduce the costs of production and transaction (Cooke, 1996). This follows that Chinese Taipei's loosely networked business system has been well-fitted to the global IT industry whose technology paradigms favor flexibility, discontinuity and followship (Langlois & Robertson, 1992; Hornbach, 1996). This kind of institutional mapping in the Chinese Taipei's IT industry can be evinced in comparison with those of the Korean industry. It is well known that Korean IT players provide their industry with a source of large firms and dense industry networks, well organized for mass production. Over the past years, Chinese Taipei's emphasis on craft production and flexibility seems to overthrow the Koreans' strategies of mass production and operating efficiency. Apparently, in an environment where uncertainty is prevalent, success seems to depend not on right strategy but flexibility in moving from one right strategy to another quickly enough.

Thus the Chinese Taipei's business system has institutionalized a flexibility and cooperative industrial network, capable of driving its actors to adopt the technology regime of information technologies.

The Education System

One of the important features of Chinese Taipei's NSI is that the sophisticated education institutions provide an abundance of well-trained populace that makes innovation possible. Traditionally, Chinese people are highly education-oriented. The ethics of "respect for education", inherited from Confucian values, have created a substantial manpower resource potential in Chinese Taipei over the past five decades. Overall, education has not only improved the quality of the labor force so as to enable industries to accept advanced and sophisticated technology, but it has also induced imitation, innovation and invention, so as to raise efficiency and productivity.

With some exceptions, conventionally, after graduation from senior high schools, many of the most talented pupils flock to medical, electrical engineering or management schools of the universities. Likewise, compared with other disciplines, engineering seems to attract more attention. The competition to enter the technological departments of highly claimed national universities has been very keen and this field has attracted bright young men. Electrical engineers are at the helm of many of the leading Chinese Taipei's manufacturing companies, and a technical orientation is pervasive. Typical then to the economy is a high flow of engineering professionalism that impels the technical knowledge diffusion very quickly and the result is a lot of small IT firms. Such an industrial structure is by all means favored by the evolution of information technology characterized by radical technological change, quick response and entrepreneurship.

Financial Institutions

The contemporary business enterprises are founded upon certain capitalist rules which legitimize the owners to control the labor of their employees and the products of their work. The pursuit of financial sources thus lies on the very start to empower entrepreneurial activity. This goes especially for Chinese Taipei's family enterprises, who depend more on borrowing than on equity capital. Chinese Taipei's IT firms recognize further the importance of external finance, as their investments in innovation usually imply high uncertainty and risky. Access to a variety of financial resources has enabled these firms to undertake technology-enhancing investments.

The first importance source comes from the banking system which is directly and indirectly controlled by the state and is extremely conservative. By indicating priority industries or products for bank lending, the state is able to "govern the market" (Wade, 1990). According to Christensen (1992), the Chinese Taipei's financial system then is considered as a "credit based system where financial institutions – mainly banks – transfer savings to investment and with heavy government control and regulation". Chinese Taipei's rigid fiscal policy, however, gave rise to the development of a curb market, which is an unregulated, semi-legal credit market in which loan suppliers and demanders can transact freely at uncontrolled interest rates. In an environment where most bank loans go to state stars or big businesses, many small IT firms depend more on the unofficial curb market at high interest rates, mostly through the use of personal contacts and family connections. Although as a source of finance it is not perfect, the capital of the curb market offers firms, at least, access to flexible financial resources.

In addition to the banking system, the Chinese Taipei stock market since the late 1987 has been increasingly important to IT firms seeking long-term equity sources. The Taiwan Stock Exchange (TSE), the only centralized securities trading market in Chinese Taipei, was open for business in 1962. In 1986, the weighted average index for the first time reached 1,000 points, with an average of 130 million shares traded every day and NT$2.4 billion in daily trading volume. In February 1990, the index reached an all-time high, soaring to 12,495.34 points, with an average of 993 million shares traded daily and NT $132.98 billion in daily market turnover, making the TSE one of the busiest markets in the world. This rapidly growing stock market capitalization has played an important role in helping such public listed companies (PLCs) as Acer, Mitac, FIC and Tatung, raise cheap capital through public funding. Access to this long-term equity source certainly approves IT firms' pursuit of inter-firm cooperation, high R&D commitment and technological specialization.

Equally important to the financing of the information industry is business venturing. By 1994, Chinese Taipei's 29 authorized venture capital firms had invested NT$1,076 million in 385 domestic and foreign technological firms related to computers, telecommunications and electronics. About two-fifths of the investments went to the information industry, followed by electronics (15.6%) and telecommunications (8%) (Pandey & Jang, 1996). Access to a wide network of social relationships allows the VCF to provide the resource of financial and human capital. In particular, venture capitalists are a source of expertise knowledge in the management of innovation. As they can take over the role of monitoring, venture capitalists can help innovators reduce agency costs (Holmstrom, 1989).

Tax incentives

In order to reduce the level of risk that manufacturers were required to absorb when undertaking R&D and personnel cultivation, the Statute for Industrial Upgrading and Promotion was promulgated on 1 January 1991, with the aim of using tax incentives to encourage companies to undertake R&D, automation, and other related activities. At the same time, investment tax credits were offered to investors holding shares in companies in the hi-tech and other important industries, while a five-year tax exemption was also made available to companies within these industries, as well as venture capital companies. As some researchers (Sun, et al., 1997; Wang & Tsai, 1998) pointed out, whether in terms of stimulating expenditure, the impact on the economy as a whole, or the contribution made to industrial upgrading, the Statute for Industrial Upgrading and Promotion has achieved impressive results.

Knowledge spill-over mechanism

R&D alliances emerged in the 1980s but flourished in the 1990s as firms become more willing to cooperate for increasing capabilities (Wang, 1995). By far there are a total of 52 major R&D consortia and other kind of technology-based strategic alliances being formed. ITRI has played an important role in promoting this type of linkage. Technology Transfer Service Centre (TTSC) was set up under MOEA in 1989 to help local manufacturers on acquiring technology and then to speed up the upgrading of domestic industry. The establishment of the Intellectual Property Office (IPO) under MOEA in 1999 was expected to effectively unify the registration, management, and protection of such intellectual property rights as patents, trade marks, etc. Industrial associations have played a critical role as intermediaries between the government and firms. For the SMEs, the government set up the Core-Satellite Development Centre basing on an existing core-satellite operation that many SMEs have developed with the larger (FDI) enterprises. The centre has provided support for technical assistance, information sharing, credit enhancement, training programs, and advanced management methods in production, finance and information to the core-satellite groups.

## 6. Chinese Taipei's Innovation Policies in Recent Decades

The Organization for Economic Cooperation and Development (OECD) announced the coming of the knowledge-based economy in 1996, when was also a turning point for Chinese Taipei to reset its innovation policy. Given a lion share innovation takes in business competitiveness in the new economic paradigm, the government of Chinese Taipei has changed its role to the industry from a supervisor to a collaborative partner with the private sector.

The beginning of Chinese Taipei to pursue industrial technology development systematically can be traced back to 1970s when the government funded non-profit research institutes for R&D on applied sciences and technologies since 1973. The establishment of Hsinchu Science-based Industrial Park (SBIP) in 1980 further brought pragmatic results, and set up a solid base for Chinese Taipei's technology industry development. The government's innovation policy for the two decades to 1990s, despite slightly differences, was principally to offset the insufficiency of the private sector in relevant technologies, and the government's role was to guide the technology development of the domestic industry.

As OECD revealed innovation as a key to improve competitiveness in 1996, Chinese Taipei government has laid special stress on the issue. From 2000 to 2002, it drew programs for knowledge-based economic development and international innovation R&D centers to push domestic economic activities upgrading from a manufacturing base to high value added ones such as R&D, design, distribution and logistics. The government's innovation policy hence focused mainly a collaboration role to inspire the generation and applications of innovation.

In terms of the nature and characters of Chinese Taipei's innovation system, the innovation policy for the past decades and currently can be categorized into the following six items:

### a. Launch of Technology Development Program (TDP) for industrial technology progress

TDP was first launched in 1979 for promotion of technologies required to stimulate industrial development. In accordance with changes in industrial conditions in recent years, the government has encouraged the industry to jointly sketch the scheme of TDP since 1994 to ensure the R&D projects to meet industrial needs. In view of strong innovation capabilities of domestic manufacturers in the technology industry, the government began the implement of industrial TDP in 1997, allowing the private sector to carry out the program. The leadership for innovation was thus shifted to the industry.

**b. Establishment of research institutes for technology development and dissemination**

To lead the industry toward a high value-added and technology intensive direction, the government of Chinese Taipei has set up research institutes by stages to upgrade industrial technologies systematically. The establishment of the Industrial Technology Research Institute (ITRI) in 1973 was, for instance, under this scheme. The tasks of these government-funded, non-profit institutes are changed in accordance with innovation policy adjustment. Before 1985, they were designed for the generation of R&D capabilities. From 1986 to 1999, the major tasks were to bring their R&D results to the industry for positive effects. After 2000, they shoulder innovative and advanced R&D to upgrade the domestic technology industry from a technology follower through process improvement and application development to a pioneer with state-of-the-art technologies. They are also continuing a dissemination role of bringing the R&D results to the industry for commercialization through result demonstration, patent licensing, technology transfer, industrial services, talent providing, derived companies, open labs and incubator centers. In 2000, the government lifted the ban, and allowed the non-profit research institutes to utilize their intellectual properties to make transferring income, speeding up the commercialization procedures of the TDP results.

**c. Establishment of Science-based Industrial Park (SBIP) for technology commercialization**

The first SBIP was established at Hsinchu in 1980. Thanks to such favorable conditions as tax holiday incentives, single-window services and factory land leasing, along with the geographic edge of neighboring rich human and technology resources like ITRI, National Tsinghua University and National Chiao Tung University, the Hsinchu SBIP was an attraction to high-tech investors. Through over two decades' efforts, Hsinchu SBIP is the cradle to make Chinese Taipei the world's third largest information technology (IT) industry and the fourth in semiconductors. In addition to Hsinchu, Tainan SBIP began operational in 1997, and the SBIP in central Chinese Taipei has been under planning in 2002. In accordance with local industrial development conditions, the government is mapping out appropriate industrial clusters in northern, central and southern areas, respectively, and attempts to link them into a science and industrial gallery in Chinese Taipei.

**d. Establishment of an international R&D base for high value industries**

To link Chinese Taipei with international innovation resources while improving its strategic positioning for multinational corporations in global logistics, the government of Chinese Taipei proposed in 2002 the plan of building international innovation R&D bases here. It would encourage international and domestic enterprises and research institutes to set up various industrial R&D centers in Chinese Taipei in fields such as genome research, software design, mobile communications engineering and nano technology applications. It expects to absorb international and domestic talents, technologies, other resources and regulation experiences in addition to the current advantages of Chinese Taipei and make domestic industry more competitive in the world.

### e. Improvement of human resources for industry development and upgrading

The recruitment of overseas scholars as well as fostering domestic human resources aims to provide a solid development foundation for Chinese Taipei's technology industry. To accelerate industrial progress, Chinese Taipei innovation policy lays particular stress on incubation of talents in key industries and of those with multiple domains. The government planned the establishment of industrial schools for the semiconductor industry and digital contents since 2002 to offset the deficiency of human resources in the two key industries. An advanced human resource incubation program for multiple domains was launched in 2000 to fostering R&D and management personnel with science and technology backgrounds.

### f. Construction of e-Chinese Taipei for industrial innovation

From 1999 to 2002, the government of Chinese Taipei proposed the e-Chinese Taipei plan, helping the industry to improve their added value through utilizing innovation and applications of information and communications technologies in their R&D, production, distribution and logistics activities. The policy is to encourage domestic leading companies in the information technology, communications, optoelectronics and semiconductor industries to continue their leadership in develop advanced and exemplifying collaborative R&D platforms to improve the R&D design capabilities while increasing international cooperation opportunities. In addition, the government promoted the A plan to link the IT firms with e-service providers and international IT product purchasers, building an electronic supply chain from product design to procurement. The B plan was also launched to link the IT firms with component suppliers to form an electronic supply chain from resource procurement to production.

## 7. Impact of Globalization – A Preliminary Assessment

Globalization implies "more competitors", "more fierce competition", "more resources available", "more customers", "higher risks", and "higher risks". The trend of increasing globalization could result in both opportunities and threats to industrial firms, research institutes, universities, and government agencies. The trend seems to show its impact on national innovation system (NIS) of Chinese Taipei. The preliminary assessment of the impact in three areas: production structure, knowledge infrastructure, and institutional set-up, is briefly described as follows:

Production Structure

Traditionally, Chinese Taipei's economy was labor-intensive and low-tech-oriented. Even though some high-tech industrial sectors have been placed on the top in the world in terms of outputs, the major sources of industrial competitiveness are based on process improvement and cost down. As the developing economies, such as China ad Thailand, are starting to boom and the marketplaces become more internationalize, many Chinese Taipei's companies move their production plants to China. This is probably the most critical event which indicates the impact of globalization on Chinese Taipei's innovation systems and economy. In fact, the amount of bilateral trade between Chinese Taipei and China has surpassed the one between Chinese Taipei and the U.S. since 2002. As many industrial firms, including those in computer and electronics industries, shift their operations abroad, Chinese Taipei's government begins to shift its attention and efforts to the emerging industries: biotechnology and digital content. Obviously, the latter is something even more related to local contents and culture, and thereby possible resulting in greater competences, and makes the industry rely less on resources abroad.

Knowledge Infrastructure

While many companies move their operations abroad, they realize that they need to enhance their innovative capabilities in order to compete. Therefore, the interactions between industry and universities and research institutes in Chinese Taipei have increased tremendously recently. In the past two decades, the semi-public research institutes, particularly Industrial Technology Research Institute (ITRI), have played a critical role in helping industrial firms to develop required technologies. They are currently trying to upgrade their capabilities by conducting more co-operations with universities, both local and foreign, and research institutes abroad. As to universities in Chinese Taipei, they have been recently encouraged to offer continuing educational programs for the professionals working in industries and to take actions to cultivate students to be more creative. In addition, many foreign universities have been allowed to enter Chinese Taipei to compete with local ones in recruiting students and setting up educational programs. This open policy is believed to enhance the mechanisms for knowledge creation and dissemination.

Institutional Set-up

Responding to the increasing globalization and the coming of knowledge-based economy era, Chinese Taipei's government has pickup the "innovation and entrepreneurship" as one of the most important areas for the efforts to transform Chinese Taipei's economic development. Currently, Chinese Taipei's government provides incentives to encourage both domestic and foreign companies to build up research centers in Chinese Taipei. In addition, the venture capital always plays an important role in creating high-technology companies in Chinese Taipei. Sometimes government provides seed money for investing in the ventures which are still in the very early stage. Furthermore, the Ministry of Economic Affairs has financially supported the establishment of about sixty incubators through which many start-ups receive the assistance from the incubators and the resources of universities. In some cased, foreign MNCs may come to Chinese Taipei to search for the opportunities for receiving royalty fees probably based on their technologies and intellectual properties. Under the circumstances, government might take actions to help protect domestic companies.

## 8. Functionality and Performance

In terms of R&D investment or product innovation, Chinese Taipei may not be at the same level as most of the advanced industrialized countries. However, with an abundance of experienced engineers, Chinese Taipei has made great strides in technological process innovation. As a result, Chinese Taipei's firms have become very competitive, particularly in the information technology (IT) industries. Chinese Taipei is very active and competitive in the patent invention and innovation, however, the added value of products is not good when entering the production/sales stages after the commercialization. It is an indication that Chinese Taipei's industrial technology development is still learning toward "manufacturing" orientation, and R&D is too much emphasized on the "development". That is, concentrating on the research of application development or process improvement, not sufficient in the R&D investment of the stage-of-the-art key products and innovative technology, so that the accumulation of technologies that can create industrial high added-value is not enough, only the low value added manufacturing stage is captured.

From the description of the industrial technology investment and industrial development structure, it indicates that Chinese Taipei's industries are too much concentrating on the international OEM in the electronics and information industries. However, due to the high specialization in the work and the harsh competition, the value added is naturally low in comparison with the countries, which can control the value-added key material, components, R&D and distribution channels.

## 9. Main Strengths and Weaknesses

Advantages

**(1) Advanced and sophisticated industrial customers**: Chinese Taipei's specialization as OEM/ODM manufacturer country has facilitated the presence of advanced and sophisticated industrial customers at the end of the commodity chain. A close relationship has been developed between brand-name multinationals and Chinese Taipei's OEM/ODM manufacturers. This relationship has been a powerful channel of introduction of new technology and skills as the multinationals develop new products and sophisticated standards.

**(2) Vertically disintegrated industrial system**: The system allows new firms to focus on the development of new product ideas, without disturbing the other phases of the production process. Furthermore, economies of scope, rather than economies of scale, reduce production costs for participating firms. The integration of interconnected independent firms creates the possibility of mutual adjustment within the system. This allows firms to handle abrupt crises flexibly.

**(3) Effective mechanism for technology diffusion and learning**: In contrast to many other economies, Chinese Taipei educational system provides a solid base of skills at elemental level. Chinese Taipei has also developed an effective mechanism for technology diffusion and learning. The public sector plays a critical role in build up of basic competence strategic areas. The capability can be fast transferred to the private sector through spin-off ventures and through staff leaving to take up employment in private firms. It is the capability to organize actors through transfer of human capital and various forms of consortia raises the overall capability of technology learning.

**(4) Incremental innovation capability in high tech manufacturing**: Due to this capability, most competitive firms in Chinese Taipei can attract world leaders as partners in the manufacture of cutting edge products, particularly in the Asian region. One of the main opportunities is to move forward Chinese Taipei's incremental innovation capability in high tech manufacturing to a major innovator with a higher capability to undertake radical and major innovations.

**(5) Knowledge and skills associated to the management of production networks:** This creates the possibility to upgrade dramatically clusters in traditional industries such as apparel, textiles and plastics processing where Chinese Taipei can capture an increasing part of the value chain. This issue that have been discussed as the "labor division between Chinese Taipei and China" or "leave roots in Chinese Taipei" is a major opportunity to concentrate, strength and develop those areas where Chinese Taipei will compete based on talent, skills and knowledge.

Mismatches

**(1) Weakness in critical areas of innovation infrastructure**: Chinese Taipei still lags that of most advanced OECD countries in terms of innovation infrastructure, such as the number of computers per capita, computer power per capita, and the number of Internet host per capita. Although Chinese Taipei is already an important producer of intellectual in the world, poor is the protection for intellectual property, which is regarded as one of the most important elements of the common innovation infrastructure.

**(2) Lack of capability of product innovation**: Most Chinese Taipei's companies are basically technology followers, with minor modifications, of the latest product designs developed elsewhere. There is a lack of capability of product innovation in the hi-tech sector. With more than 60 percent of its exports being OEM-ODM production not associated with Chinese Taipei producers' own brand names. The value added activities in relation to these products are mainly in the stages of design and marketing, usually controlled by multinational firms.

**(3) Low capacity as producer of knowledge based on basic and long-term research**: Assuming that Porter's proxy of university performed R&D is an appropriate measurement of the quality of the links between clusters and the innovation system; this seems to be a weakness of Chinese Taipei's NIS. These figures may suggest that Chinese Taipei's universities the necessary capability to undertake long term and basic research that will be required for strengthening the cluster innovative performance in a knowledge-based economy.

**(4) R&D efforts in advanced sectors may be overly exaggerated**: It is important to note that improving products of other countries was the most important source of foreign technology for domestic firms. As it was vaguely defined as improvements on the existing foreign product (i.e., various reverse engineering tactics), were their major sources of acquiring foreign technologies. It is reasonable to suspect that many of the surveyed firms consider their reverse engineering efforts as genuine R&D efforts, which undoubtedly overly exaggerates their own R&D efforts.

**(5) Low R&D intensity in non-electronics industry**: Chinese Taipei's R&D

intensity has not grown in traditional industries in spite the large migration of SMEs of this sector to mainland China. This means that traditional firms are moving the little R&D they perform to China or that the research capability in those sectors in Chinese Taipei is so limited that is not reflected by national statistics.

**(6) Weakness in legal framework governing R&D collaboration**: There are no specific institutional forms of R&D collaboration and the private firms often complain about the difficulties in negotiating intellectual property rights and patenting or licensing agreements in partnerships. As the government licensing of these patents was almost entirely on a non-exclusive bases, many patents were not developed into commercial goods or cervices because non-exclusive licensing did not give the industrial firms the required protection to justify the costs of development.

**(7) Slow in the transformation of the common innovation infrastructure:** Rigidities in the basic elements of the physical infrastructure needed for innovation seems to be an impediment of Chinese Taipei's NIS. Factors varying from monopolies ownership reflected in high prices to inappropriate conditions and incentives for investment seems to threat the sooth functioning of Chinese Taipei's NIS, particularly in relation to other competitors that have tuning up their common innovation infrastructure to offer the best conditions for both, local entrepreneurs and foreign investors.

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# Canada's Innovation System – Adapting to a Global World

Presentation to the APEC Workshop:
National Innovation Competencies and Interests in a Globalized World
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By:
André Manseau
Université du Québec en Outaouais
Canada

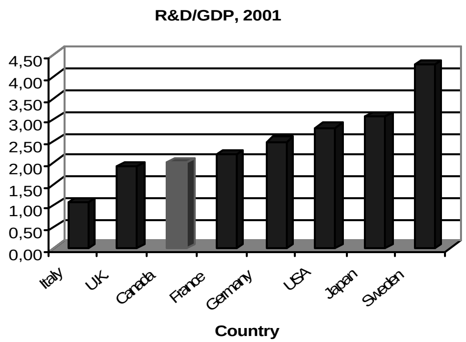
Université du Québec en Outaouais

# Canada's Innovation System – Adapting to a Global World

- Overall structure and key components of Canada's IS
- Globalization effects – not new
- Recent changes
- New national strategies
- Need for enhancing international technology platforms

## Overall Structure

Canada's R&D in the lower end of OECD




Source: OECD, 2003

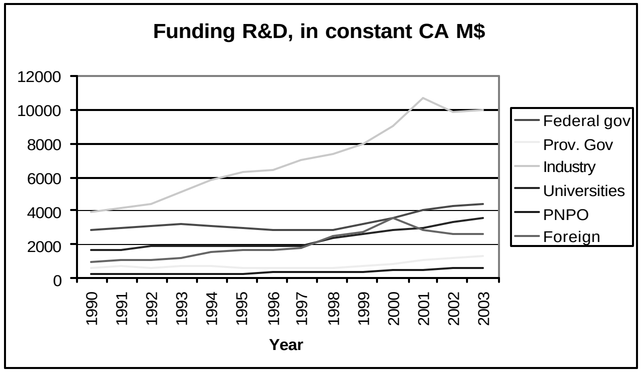
## Canada's Regional Diversity

| Province | % Population | R&D/PGDP | % Industrial R&D |
|---|---|---|---|
| Nfdl | 2 | 1 | 0,2 |
| PEI | 0 | 1 | 0 |
| NS | 3 | 1,4 | 0,6 |
| NB | 2 | 0,7 | 0,3 |
| Quebec | 24 | 2,6 | 29,6 |
| Ontario | 38 | 2,3 | 55,4 |
| Manitoba | 4 | 1,3 | 1,2 |
| Saskatchewan | 3 | 1,2 | 0,6 |
| Alberta | 10 | 1 | 4,7 |
| BC | 13 | 1,3 | 7,5 |

Source: Statistics Canada, 2004

## Key Components

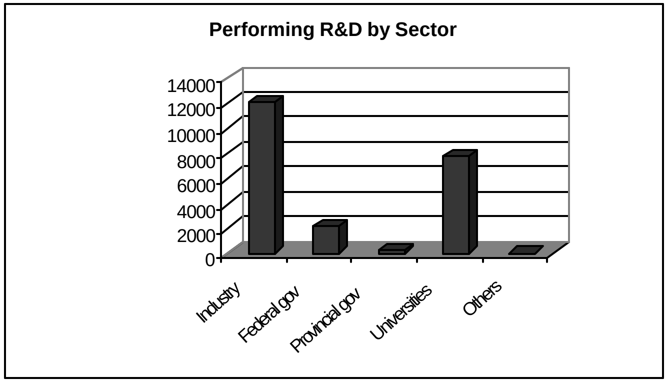
- Recent turmoil in industrial & foreign R&D




Source: Statistics Canada, 2004

## Key Components

- Industry and Universities as main R&D performers



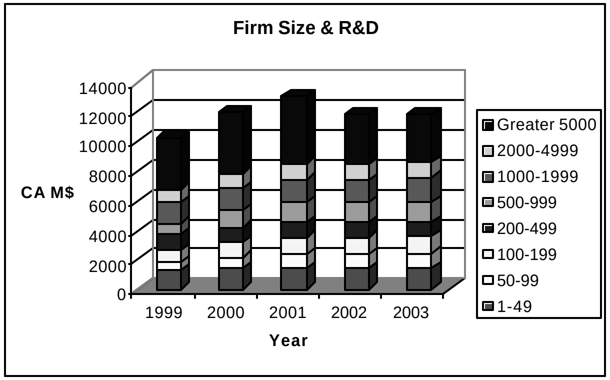

Source: Statistics Canada, 2004

# Key Industrial R&D Sectors

| Industry | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|
| Paper | 113 | 137 | 254 | 252 | 256 |
| Pharmaceutical | 576 | 765 | 881 | 971 | 1051 |
| Machinery | 325 | 362 | 355 | 362 | 378 |
| Com equip | 2278 | 3160 | 3188 | 2035 | 2035 |
| Instruments | 309 | 424 | 443 | 430 | 388 |
| Electronics | 581 | 817 | 878 | 753 | 791 |
| Motor vehicle | 303 | 359 | 306 | 305 | 286 |
| Aerospace | 1129 | 887 | 933 | 875 | 872 |
| Info & Culture | 310 | 352 | 643 | 629 | 628 |
| Engineering | 412 | 406 | 495 | 537 | 508 |
| Computer services | 563 | 731 | 936 | 926 | 946 |
| R&D services | 264 | 390 | 592 | 615 | 639 |
| Health services | 319 | 306 | 317 | 346 | 351 |

# Firm Size & R&D

## - Dominated by large firms, but…



## Globalization effects are not new

- Canadian industry significantly increased their effort in performing R&D, from 1/3 of the GERD in the early 70' to more than 50% in the early 2000s
- In 1969, 75% of the top R&D performers were foreign-owned, compared to only 40% in 1995
- In 1995, Canadian corporations were spending US$1.4 billion on R&D in the USA, about 1/3 of their R&D spending in Canada
- 1992-1994, 3564 patents in Canada to resident inventors and 843 patents granted in the USA by Canadian Corp. , 31% from their foreign subsidiaries (fairly autonomous)

(Source: Niosi et al. 2000)

## Managing R&D in the early 90'

- Importance of partnering

- University: 60% Science model, 40% active in commercialization & users collaboration
- Government: 20% Science model, 20% dedicated to assist public needs, 62% active in collaborative R&D
- Industry: 15% Science model, 50% cie needs, 35% high level of collaborative R&D

(Niosi et al, 2000)

## Increasingly international

Canada net exporter:

- R&D Services – from 2.2 B$ in 1990-1995 to 9 B$ in 1996-2001
- Architectural & Engineering – from 4 B$ in 1990-1995 to 8 B$ in 1996-2001

Canada net importer:

- Royalties % licences – from 12 B$ in 1990-1995 to 14 B$ in 1996-2001
- Tooling & others – from 6.5 B$ in 1990-1995 to 9 B$ in 1996-2001

% of inventions with foreign co-inventors – from 7% in 1980 to 13% in 1999

## Canada's Innovation Strategy National Forum 2003

- Strengthen receptor capacity & commercialization
- Improve access to R&D tax credits and stimulate early-stage investments
- Integrate innovation-related skills in education, expand capacity in the post-secondary system, and improve student financial assistance
- Build an inclusive and skilled work force - Increase access to training and improve foreign credentials
- Support community and clusters development – broadband and information access, enhance learning, engage peoples in strategic projects, invest in instruments

## Federal Budget 2004

- Health, sustainable development and commercialization

- 6.4% increase to university research funding – particularly for promoting commercialization of R&D (an additional 50 M$ for that)
- Programs for improving university student support (loans, interest rates, grants)
- 60 M$ increase to Genome Research
- 800 M$ for environmental technologies
- 25 M$ to NRC for accelerating commercialization of Federal R&D
- Increase of 250 M$ for pre-start and start-ups
- 8% increase for international development

## National Strategies What's missing

- Specific industry initiatives (next presentation)
- Need for enhancing international technology platforms
  - Standard development
  - Funding for International Collaborative R&D (European Framework, USA, NAFTA, etc.)

# Innovation and Entrepreneurship in Mexico

Surviving Innovation/Innovation to Survive

Dr. Jorge Miguel Carrillo Rivera

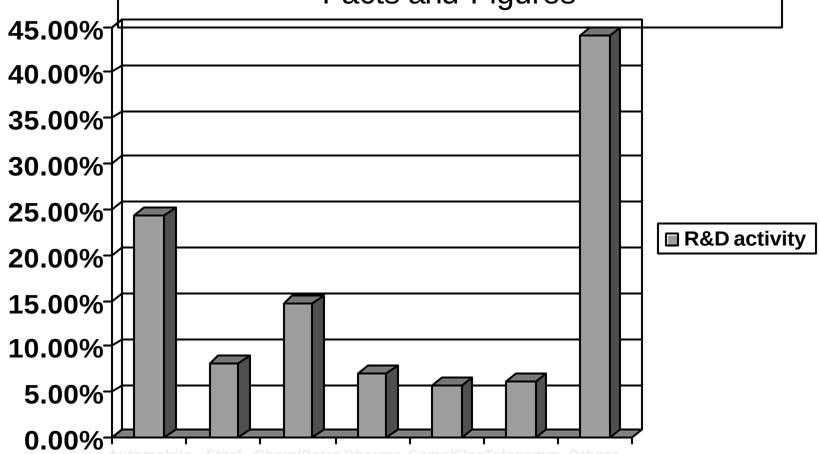
Status of Entrepreneurship and Innovation in Mexico
Facts and Figures

- Mexico, the most entrepreneurial country in Ibero-America (GEM, 2002)
- Mexico, small firm mortality rate: 70% after 36 months of operation (Minister of Economy)
- # of Firms in Mexico: 3 million
- # of Firms with a R&D sustained investment track: 500 (0.016%)
- **Average R&D investment as a % of revenues: 0.18%**

## Status of Entrepreneurship and Innovation in Mexico
Facts and Figures

- **% of GDP invested in R&D 2003: 0.4%** **(OCDE average: 2.3%, China 1.29%, Sweden 4.3%)**
- **Private funds invested in R&D 2003: $1,634 million US (CONACYT)**
- **Public funds invested in R&D 2003: $134 millions US (CONACYT)**
- **Between 1980-2000, 80% of R&D investment was financed by the government**
- **Tax redemption rate available for R&D expenses: 30%**

## Status of Entrepreneurship and Innovation in Mexico
Facts and Figures



## Status of Entrepreneurship and Innovation in Mexico

- **Success stories:**
  - **Delphi (GM), MTC**
  - **General Electric**
  - **Hewlett-Packard**
  - **Comex**
  - **Desc**
  - **Silanes and Sanfer**
- **Trends:**
  - **Pharma (CROs)**
  - **Food**
  - **Automobile components**

## Status of Entrepreneurship and Innovation in Mexico

- **Government Innovation Policy Focus**
  - **Incentive innovation in SME**
  - **Priorities**
    - **Biotech**
    - **New man made materials**
    - **Information Technologies**
    - **Telecomm and Electronics**
    - **Sophisticated manufacturing processes (auto, aeronautics, advanced fibers)**
    - **Developments that combat poverty and wealth distribution**
  - **Use public funds to incentive private R&D investments**

## Innovation and Development Indicators in Mexico)

- 28.4 % of manufacturing enterprises reported some sort of product or process innovation
- 31% innovative firms reported the utilization of new materials as the source of innovation
- 82% of innovations are performed intra-organizationally
- Reported time to market: 12 months

CONACYT Survey, 2003

## Indicadores de Innovación y Desarrollo en México

- Payback time: 26 months (average)
- 66% of total innovation related expenses where used in machinery and equipment
- 71% of innovation funds where provided by the firm
- Manufacturing firms invest 53% of R&D budget in consulting fees and technical assitance

## Indicadores de Innovación y Desarrollo en México

- 16% of innovative firms had a technology related strategic alliance
- 37% of sales of innovation firms are based on improved or new products
- Just 10% of manufacturing firms filed for one or more patents
- 67% of innovative firms use innovation as a way to keep market share
- Main impediment for innovation: RISK (60%)