BRIEFING TO THE NATIONAL ADVISORY COUNCIL ON INNOVATION

INTERNATIONAL SCIENCE AND TECHNOLOGY SCENE
TRENDS AND POLICIES IN THE MILLENIUM

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This document provides a brief overview of international trends in Science, Technology and related policies. It has been prepared on the request of the National Advisory Council on Innovation (NACI) for its strategic planning session of February 2002. The main sources of information appear in the references and provide further details and elaboration.

1. There is a clear trend internationally towards a knowledge-based economy. Nations around the world are asking "what policies and resources are needed to survive and prosper in a global knowledge-based society". Their response is to increase investments in knowledge. Investments in knowledge, defined as public and private spending on higher education, expenditure on research and development (R&D) and investment in software, are extending from Nigeria to Korea and from Finland to United States.

   In the OECD countries, investment in knowledge accounts for 4.7% of the OECD-wide GDP. During the 1990's investment in knowledge increased by 3.4% annually while investment in fixed capital increased by only 2.2%.

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Table 1: Investment in knowledge and gross fixed capital formation

1998

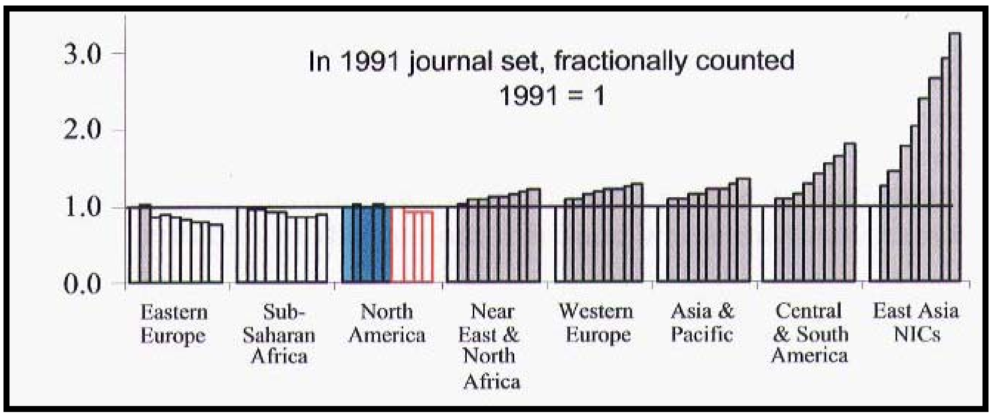
	Investment in knowledge					Gross fixed capital formation
	As a percentage of GDP, 1998				Average annual growth rate 1991-98	As a percentage of GDP, 1998
	Total	R&D	Software	Public and private spending on higher education		Total
Canada	4.7	1.6	1.6	1.5	2.6	19.6
Mexico	1.5	0.4	0.4	0.7	..	20.9
United States[1]	6.0	2.6	1.5	1.9	3.9	19.2
Australia	3.9	1.5	1.2	1.2	4.0	23.8
Japan	4.7	3.0	1.1	0.6	2.6	26.8
Korea	5.2	2.6	0.4	2.2	..	29.8
Austria	3.5	1.8	0.9	0.8	6.3	23.5
Belgium	3.7	1.9	1.4	0.4	..	20.9
Czech Republic	3.3	1.3	1.2	0.8	..	28.1
Denmark	4.6	1.9	1.5	1.1	5.9	20.5
Finland	5.2	2.9	1.2	1.1	6.8	18.7
France	4.1	2.2	1.2	0.8	3.0	18.3
Germany	4.2	2.3	1.2	0.7	2.2	21.3
Greece	1.7	0.6	0.2	0.9	10.1	21.6
Hungary	2.6	0.7	1.0	0.8	1.6	23.6
Ireland	3.1	1.4	0.5	1.1	10.2	21.9
Italy	2.1	1.0	0.5	0.6	-0.6	18.5
Netherlands	4.3	2.0	1.7	0.7	3.8	21.7
Norway	4.0	1.7	1.2	1.0	5.6	25.0
Portugal	1.8	0.6	0.4	0.8	5.4	26.2
Spain	2.2	0.9	0.5	0.8	4.3	22.9
Sweden	6.5	3.8	1.9	0.8	7.6	16.0
Switzerland[2]	4.8	2.8	1.5	0.5	3.2	20.0
United Kingdom	3.9	1.8	1.3	0.8	3.6	17.4
European Union[3]	3.6	1.8	1.0	0.7	3.1	19.9
Total OECD[4]	4.7	2.2	1.2	1.2	3.4	21.0

1. Education data includes post-secondary non-tertiary education (ISCED 4).
2. Average annual growth rate refers to 1992-98.
3. Average annual growth rate excludes Belgium.
4. OECD total refers to the available countries and the average annual growth rate excludes Belgium, Czech Republic, Korea, Mexico and Switzerland.
5. 1995 US dollars using purchasing power parities.

Table 1 shows that Sweden, USA, Korea and Finland are the most knowledge-based economies while Ireland and Greece had the highest growth rates in knowledge investment during the 1991-98 period.

2. There is a shift in the balance of the international research system away form the traditional geographical research centers. Figure 1 shows the growth in the number of papers (research findings) coming from different geopolitical areas.

Figure 1: Growth in Numbers of Papers 1991 - 1999



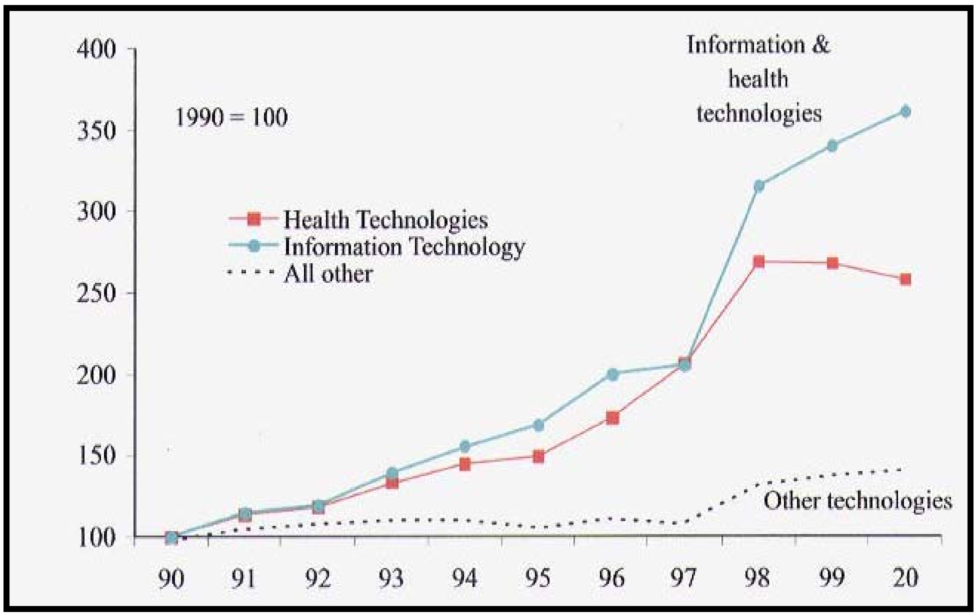
The dynamism of the Asian and Latin American science systems becomes profound. In Eastern Europe, Sub-Saharan Africa and North America scientific publishing is declining in absolute terms. Whilst the decline in Eastern Europe and Sub-Saharan Africa were expected in view of the politico-economic situation in the areas, the decline in North America needs further investigation. The stagnation of the South African research outputs over the last decade is the main contributing factor in sub-Saharan African profile.

3. Information and health related technologies are becoming the mainstay of technological progress internationally. Figure 2 shows the growth in patenting in information technology (computers, telecommunications and semiconductors), health technology (pharmaceuticals, biotechnology, medical equipment) and all other technologies aggregated. It would be hard to overestimate the

dynamism of technological growth in these two technologies. It has been argued that this reflects a drastic change in the way things are done and will be done in the innovation system.

The change affects not only social issues but also science and technology policy approaches and norms. The shift in the balance of technologies in existence and in the source of innovation is and will continue to be affecting priorities and national science and technology plans.

Figure 2: Growth in Patenting



4. Business is becoming the major player in innovation. Because the private sector is closer to the market, and "speed" counts in innovation, the private sector receives particular attention by government. Business is generally perceived as the most appropriate lead-partner in determining future technology directions and thus governments offer direct and indirect incentives to business. Venture capital funds and fiscal incentives are the policy instruments finding support by governments.

5. Scientifically small countries identify technological niches to focus their priorities. While 80% of R&D is concentrated in just five countries (USA, Japan, Germany, France and the UK), small countries like Israel, Sweden and India establish academic and industrial centers of excellence with a high impact in specific technology areas.

Box 1: Information Technology led in India

Prime Minister Vajpayee has called for India to become an information technology superpower within the next 10 years and one of the largest generators of software in the world. Recognising the impressive growth India has achieved since the mid-1980s in information technology, he announced a plan to make IT the primary catalyst to modernise India. The plan's objectives include the following:

- **Information Infrastructure Drive, to accelerate the establishment of a world-class infrastructure through the spread of fiber optics, satellite communications, and wireless networks;**

- **Target ITEX 50, to create more the $50 billion annually in exports of IT software and services; and**

- **IT for All, to accelerate the rate of ownership of personal computers to one per 50 people by 2008, up from one per 5 000 (among the lowest in the world), along with universal access to the Internet.**

India already ranks first in the *World Competitiveness Yearbook 2000* in terms of the perceived availability of qualified information technology workers and of qualified engineers. India is able to draw from a strong human resources base. It ranks 12th overall in the world in total R&D personnel, with 114,400 full-time equivalent workers. In addition, along with those in Singapore, the compulsory science curriculum in India's schools is among the strongest in the world.

The benefits for the world from India's information technology boom are large. Indians have started more than 770 high-tech firms in Silicon Valley, a number that is growing. It also is creating a large bilateral flow of IT expertise. The compound annual growth rate of the Indian software industry in the 1990s was 42.35 percent, with the software export industry constituting almost 54.3 percent of production.

According to CBS Market Watch, e-commerce transactions originating in India reached $9.7 million in 1999 and are forecasted to reach $4.3 billion by the end of 2004, many of which are destined for North America. India is also working to increase exports of Indian technologies and technical services particularly in the IT area to developing countries in Southeast Asia, the Middle East, Africa and Latin America.

6. Centres of excellence become growth nodes. Because of the increasingly distributed nature of where and how high quality R&D is

conducted, many larger corporations have concentrated R&D activities at fewer locations domestically in favour of offshore locations that possess the right resource or innovation mix for a particular technology. This practice is particularly prevalent in areas that require significant investment and a close connection to basic science, e.g. pharmaceuticals and advanced materials. At the same time, information technology, especially the Internet, allows companies to conduct R&D at numerous locations with a higher degree of strategic and task integration. For R&D in non-capital intensive technologies, such as software, Internet enables more decentralisation. As a result, instead of competing for foreign direct investment (FDI) in manufacturing facilities, many countries like Singapore are competing for FDI in R&D.

7. Countries tend to specialise and focus their research activities to disciplines of interest. Table 2 from the Institute for Scientific Information (ISI) shows the percentage of papers on specific disciplines of countries that produce research papers well over their expected average. Singapore, which produces less than 0.5 of worldwide papers, publishes a national percentage of papers in computer science that is four times the world figure. The results are not surprising for most of the countries – Singapore has positioned itself as the high-tech centre in Southeast Asia, New Zealand is emphasising agriculture, Scotland has become internationally known with Dolly the cloned sheep and so on. A number of countries, like South Africa, however, present pictures that are remnants of their pluralistic science and technology systems.

Table 2 : Disciplines Emphasised in Different Countries

FIELD	COUNTRY	% PAPERS IN COUNTRY	% WORLD PAPERS FOR OVERALL FIELD
Agricultural Sciences	New Zealand	7.01	2.33
Biology & Biochemistry	Denmark	11.87	7.66
Chemistry	Poland	28.50	13.85
Clinical Medicine	Austria	34.10	23.96
Computer Science	Singapore	4.59	1.16

FIELD	COUNTRY	% PAPERS IN COUNTRY	% WORLD PAPERS FOR OVERALL FIELD
Environment/ Ecology	South Africa	5.63	2.44
Economics & Business	England	2.28	1.39
Engineering	Singapore	26.08	7.37
Geosciences	Norway	7.29	2.75
Immunology	Sweden	3.42	1.73
Materials Science	South Korea	10.24	3.66
Mathematics	Israel	4.13	1.74
Microbiology	Scotland	3.58	2.26
Molecular Biology & Genetics	Scotland	4.48	3.08
Neurosciences	Sweden	5.69	3.95
Pharmacology & Toxicology	Japan	3.12	2.25
Physics	Ukraine	39.25	12.27
Plant & Animal Science	South Africa	19.39	6.27
Psychiatry/Psychology	Canada	4.54	2.81
Social Sciences, general	USA	5.74	3.52
Space Science	Chile	8.99	1.22

ISI

8. Public Understanding and Appreciation of Science and Technology are becoming important preoccupation and priority nodes for governments internationally. Public understanding and appreciation of science and technology are influencing directly the career choice of students; science, that is dependant on public funding, cannot be conducted in isolation from the authorities and the community and uninformed public cannot participate in debates for public issues affected by science. Table 3 shows the funding allocated to just one activity related to public understanding of science, namely the science centres in the UK.

Figure 3: Funding for Science Centres in the UK

CENTER	FUNDING* ($ millions)
Millennium Point	$72.20
The Odyssey Project	$64.98
@Bristol	$64.04
The Eden Project	$57.76
The Earth Centre	$56.80
Glasgow Science Centre	$50.54
International Centre for Life	$45.41
The Millennium Seed Bank	$43.32
National Space Science Centre	$33.65
National Botanic Garden of Wales	$31.33
The Deep	$26.71
Our Dynamic Earth	$22.82
Magna	$22.53
The Big Idea	$8.09
INTECH 2000	$6.80
Making It! Discovery Centre	$2.51
Sensation	$2.31
TOTAL	**$611.80**

**From Millennium Commission.*

Source : *Science*. Vol 292..6 April 2001

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