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Innovation strategy of science and technology development in Taiwan

The question of how to harness science and technology (S&T) innovation in order to increase national strength and enhance quality of life has become a major policy issue in most of the world's leading nations. Being a country with small population, limited resources, and small scope of R&D as compared to the United States, Japan, and advanced countries in Europe, Taiwan has emerged as one of the world's major suppliers of high-tech information products since the 1990s. In later decade, Taiwan's industry has transferred from labor and capital intensive to technology and knowledge intensive. Credit for the rapid development can be attributed to the government's longstanding policy of technological development and encouragement of private enterprises, academic and research institutions to participate in R&D, the core of innovation.

According to the IMD *World Competitiveness Yearbook* released in 2010, as shown in Graph 1, among the 58 economies covered by the report, Taiwan placed 8th in the overall ranking and 5th in Technological infrastructure and 5th in Scientific infrastructure – two indicators of the nation's true scientific and technological capabilities¹. In the WEF *Global Competitiveness Report* released in 2010, Taiwan ranked 13th in the overall Growth competitiveness index, 7th in Innovation, among 139 countries². The academic performance is illustrated in Graph 2, 3 and 4. Taiwan is ranked around 10 to 20. On the other hand, the innovation performance can be interpreted by the granted patents. The number of US granted patents is illustrated in Table 1, where Taiwan is ranked number 5 worldwide for several years. Considering that Taiwan is a small island, the economic performance and innovation of S&T are excellent.

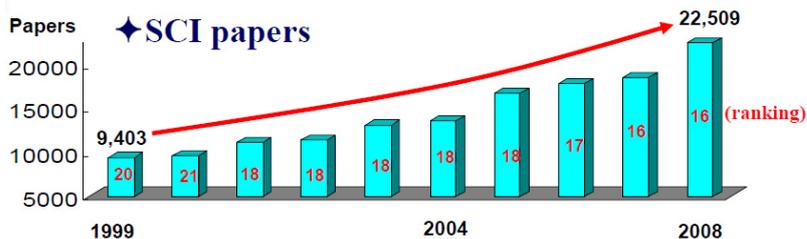
Graph. 1. IMD's World Competitiveness Rankings

Factors/ Sub-factors	SINGA -PORE	HONG -KONG	U.S. /	SWITZER -LAND	AUSTRA -LIA	TAIWAN	CHINA	U.K	KOREA	JAPAN	India
Overall competitiveness	1	2	3	4	5	8	18	22	23	27	31
1.Economic performance	5	4	1	10	7	16	3	23	21	39	20
2.Government efficiency	2	1	22	3	4	6	25	29	26	37	30
3.Business efficiency	1	2	13	7	5	3	28	26	27	23	17
4.Infrastructure	11	23	1	3	18	17	31	15	20	13	54
(1)Basic Infrastructure	17	25	11	6	19	21	12	22	20	18	53
(2)Technological infrastructure	2	3	1	14	25	5	22	13	18	23	38
(3)Science infrastructure	12	28	1	9	16	5	10	8	4	2	34
(4)Health and Environment	18	23	20	3	14	24	54	19	27	11	58
(5)Education	13	30	21	4	9	23	46	19	35	29	58

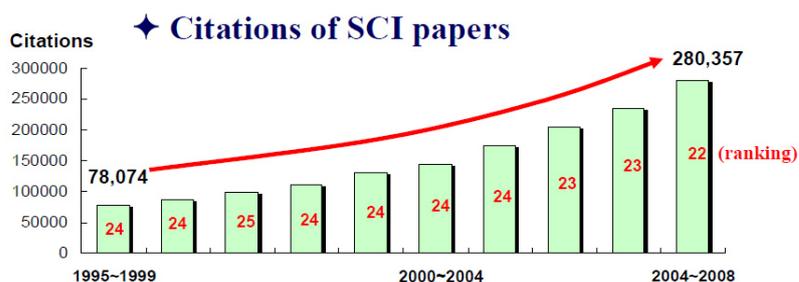
¹ World Competitiveness Yearbook 2010. International Institute for Management Development.

² Global Competitiveness Report 2010–2011, World Economic Forum.

Graph. 2. SCI Rankings of Publications from Taiwan [3]



Graph. 3. Citations of SCI papers



Graph. 4. Rankings of Publications from Taiwan [4]

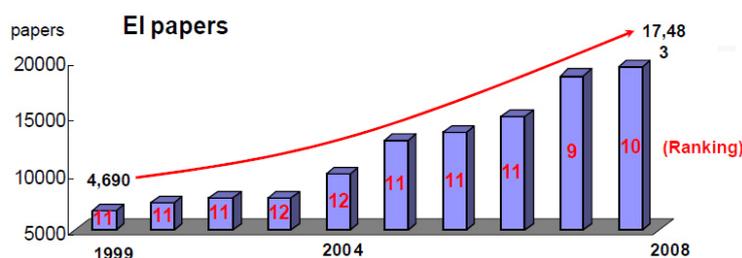


Table 1. Number of U.S. Granted Utility Patents and Rank by Countries, 2010³

Country	USA	Japan	Germany	Korea	Taiwan	Canada	UK	France	China	Israel
Cases	82382	35501	9000	8762	6642	3655	3175	3140	1655	1404
Rank	1	2	3	4	5	6	7	8	9	10

Policymaking Mechanism. The development of science and technology requires a steady influx of resources. The majority of Taiwan's industries are small- and medium-sized enterprises, with limited resources for R&D. Therefore, the government plays an important role in the integration of resources and in supporting budgets for research and development. In particular, a proper course of development in science and technology hinges on the government's policies and effective use of resources. The National Science Council (NSC) is the highest government agency in Taiwan responsible for promoting the development of science and technology. It has three main missions: 1. Promotion of national S&T development; 2. Support for academic research; 3. Development of science parks. The governing body of the NSC is the «Council Meeting», comprised of eight to 14 members. These members include the Minister without Portfolio in charge of S&T affairs, leaders of research institutes, heads of central government agencies, scholars, and various experts. Council Meetings convene to discuss important matters concerning science and technology,

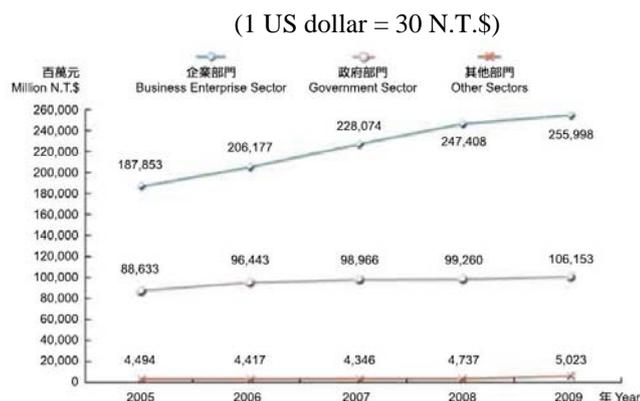
³ US Patent and Trademark Office.

such as policies, integration or allocation of resources, major programs, and major legislation. Resolutions of the meeting are used as the basis for planning more integrated and consistent national S&T policies.

Scientific and technological development can be divided according to the level of research into basic research, applied research, experimental development, and commercialization. Apart from playing the key role in directing S&T policy, the government also serves an important function in conducting upstream and midstream research in S&T development. Upstream research consists primarily of basic research conducted by Academia Sinica and colleges/universities under the Ministry of Education (MOE); midstream research mainly consists of applied research and experimental development conducted by the research units of government agencies, especially Ministry of Economic Affairs (MOEA), the R&D departments of state-run businesses, and specially commissioned nonprofit research institutes; downstream research consists of experimental development and commercialization as conducted by private enterprises.

Concerning the resources of science and technology development, the business enterprise sector contributed the highest percent, almost 70%, followed by the government sector. Looking at the types of R&D in Taiwan, technological experimental development accounted for the greatest percentage of national R&D spending at 64%, followed by applied research at 26% and basic research with the smallest percentage at 10%, as shown in Graph 5 and 6.

Graph. 5. Taiwan R&D Expenditure by Source of Funding⁴



Graph. 6. Taiwan R&D Expenditure by R&D Type



Innovation Strategies. One of the most urgent questions facing Taiwan is, in the face of intense international competition and economic and environmental changes, how it can build on its existing advantages and strengthen its capabilities for the next round of competition. It is certain the industry must actively enhance its technological expertise if it is to move up to the next level of high-tech development and create new opportunities for Taiwan's economic growth. Enhancing S&T innovation must be accompanied by efforts to

⁴ Indicators of Science and Technology Taiwan, National Science Council, Taiwan, 2010.

strengthen the domestic innovation system and forge links with international R&D resources, which will enable industry to leverage domestic and overseas R&D capabilities. In addition, interdisciplinary, integrated technologies and applications can be used to provide innovative services and added value. Companies in Taiwan and abroad are very concerned about their innovation ability, which is seen as a key element enabling a competitive advantage and continued growth. In summary, how to provide a superior industry environment and boost companies' motivation and ability to innovate is an important link in Taiwan's current industrial development strategy⁵.

Several issues connected with enhancing S&T innovation and improving the industrial environment: 1. Development of new-generation high-tech and knowledge-based service industries. While industries centered on «soft manufacturing» enjoy high profits, «hardware manufacturing industries» face strong competition, and find it difficult to increase their profit. 2. Development of an aesthetics economy and promotion of a balance between output and quality of life. Taiwan's industries lack «content» that they can use as a basic competitive advantage, and the country still lacks diversity of creative expression and distinctiveness of cultural elements. Creative industries still account for a small share of GDP. 3. Strengthening of innovation systems, establishment of an industrial innovation environment. Unfavorable phenomena occurring in Taiwan's contemporary innovation environment include low effectiveness of R&D inputs, difficulty in initiating forward-looking research organizations, difficulty in implementing academic technology development projects, need for more attention to innovative activities in industrial technology development projects, need to make faster progress if Taiwan is to reach the goal of R&D funding accounting for more than 3% of GDP, as in the developed countries. 4. Connecting with global innovative R&D resources. At present Taiwan lacks a focused strategy for inducing multinational firms to establish R&D centers in Taiwan, Taiwan's international R&D linkage levels and models await improvement, and Taiwanese firms have few opportunities to participate in international industrial innovation and R&D activities⁶.

According to Taiwan's Fundamental Science and Technology Act, the NSC convenes representatives from industry, government, academia, and research institutions once every four to five years for the National Science and Technology Conference. Based on the current S&T situation in Taiwan, the trends in the international market, and the future needs of the nation, conference participants set key goals and directions for future stages of S&T development. The NSC uses these conclusions to draft overall goals and strategies for expanding science and technology, as well as to draw mid-term plans for implementing specific measures. The NSC then guides various government agencies as they integrate these plans into their own administrative plans and take full advantage of national resources. In the latest Conference, held in January 2009, some important measures were taken⁷:

1. Development of new-generation high-tech and knowledge-based service industries:
 - 1.1. Promotion and interdisciplinary links between high-tech industries, and development of new-generation high-tech industries.
 - 1.2. Creation of distinctive, innovative service models, promotion of the use of technology by industrial services and development of new service networks:

⁵ Alice Chou and Chiu Hsiu-ling, Governmental Strategies for Innovational Research and Promotion of Industrial Competitiveness // Journal of S&T Law Institute, Institute for Information Industry. May. 2008. P. 4–14; Yen-Shiang Shih, Enhancing Technological Innovation, Improving the Industrial Environment // The Eighth National Science and Technology Conference, 2009.

⁶ 2015 Visions and Strategies of Taiwanese Industrial Development. Ministry of Economic Affairs. Department of Technology, 2009. P. 319–333; Yichung Lo, Technology Roadmapping by TPP in Taiwan's 2015 Technology Foresight Project, The IVA Royal Technology Forum 2009 Strategies for research prioritization IVA's Conference Center, Stockholm.

⁷ National Science and Technology Development Plan, National Science Council. Taiwan, 2009.

- 1.3. Effective utilization of Taiwan's information/communications advantages and industry clusters to promote value innovation in conventional industries:
- 1.4. Use of new technology to enhance SMEs' innovative R&D capabilities:
- 1.5. Promotion of technological improvement and innovative models in agriculture in order to boost agricultural value and industrial development:
- 1.6. Fostering a medical service industry with an international outlook
2. Development of an aesthetic economy promoting a balance between output and quality of life:
 - 2.1. Fusion of culture with the aesthetic economy to promote the emergence of aesthetic design-related industries:
 - 2.2. Strengthening of innovation and international brand marketing, enhancing the international image of Taiwan's industries.
 - 2.3. Use of ICT to construct innovative integrated inter-industry applications and services, striking a balance between economic output and quality of life.
3. Strengthening of the innovation system, establishment of an industrial innovation environment:
 - 3.1. Establishment of forward-looking technology development mechanisms.
 - 3.2. Establishment of effective innovative industrial R&D mechanisms:
 - 3.3. Strengthening of mechanisms linking technology creation and utilization:
 - 3.4. Establishment of pioneering demonstration mechanisms for innovative R&D results.
 - 3.5. Establishment of energy-conserving carbon emission reduction industrialization mechanisms.
4. Linkage with global innovative R&D resources:
 - 4.1. Reliance on multinational R&D centers to focus international R&D investment: Encouragement of large international firms to establish R&D centers in Taiwan when doing so benefits the country's R&D advancement.
 - 4.2. Acceleration of use of international innovation to leverage international R&D resources: Strengthen participation in regional and global international cooperation campaigns.
 - 4.3. Encouragement of overseas Taiwanese firms to use Taiwan as their knowledge headquarters:

Visions. With the development of the knowledge economy age, the promotion of S&T development has shifted from «technology-oriented» model to a «needs-oriented» model, and the desired output of S&T development has similarly shifted from «efficiency-oriented» to «innovation-oriented» discoveries. Now that innovation has been established as the goal of S&T development, a growing trend towards the fusion of knowledge, technology, and industrial innovation has gotten underway. In the wake of changes in technology development models, the role of government has also been evolving. While the government chiefly supported the stable growth of existing technologies in the past, it has now shifted its focus to the active encouragement of interdisciplinary science and technology fostering the emergence of an innovation-promoting environment. The development of innovative technologies is quite different from the past pursuit of improvements and breakthroughs in existing fields of science and technology. Instead, the pursuit of innovation is grounded on flexibility and the interdisciplinary blending of technologies. These strategies are formulated with visions:

1. To employ science and technology to shape knowledge-based service industries, and create a high-value employee population and output value. To utilize ICT to make Taiwan a model of use of value-added applications in conventional manufacturing industries. To shift thinking about agricultural technology towards a demand orientation and improvement of production efficiency. To promote the globalization of Taiwan's medical service industries, and establish a globalized medical service industry operating model, administrative system, and service standards suitable for Taiwan.

2. To support the establishment of complete brand value chains and global brands by firms. To promote new directions in crafts design to enrich the monotonous lives of modern people. To rely on value-adding cultural creativity industries to initiate another economic miracle. To transform Taiwan into a «superior living center in Asia», and upgrade «manufacturing Taiwan» into a Taiwan of design, brands, and innovation.

3. To strengthen the innovation system, establish effective risk management mechanisms, promote the industrialization of forward-looking technologies, foster an environment favorable to high-tech ventures, and further re-orient Taiwan's industries from manufacturing to innovation. The first step to realize R&D innovation will be to promote the establishment of internationally-competitive intellectual property rights value-added distribution mechanisms and units; the second step will be to encourage private parties to establish intellectual property management firms.

4. To encourage Taiwanese firms overseas to establish R&D departments in Taiwan, and promote Taiwan as an R&D headquarters location for Taiwanese firms. To help firms to participate in international industrial R&D alliances, recruit international manpower, and accelerate technological upgrading and corporate transformation. To share intellectual property assets created by the R&D centers of major international firms with government funding, so that such results will contribute to Taiwan's industrial revenue.

Although in this article most attention is paid to strategies for enhancing technological innovation and improving the industrial environment, other aspects are extremely important, too, such as how to unite the humanities with technologies to improve the quality of life, how to train S&T manpower, how to improve legal and regulatory systems and integrate S&T resources, how to strengthen academic excellence and pursue sustainable development, etc. More than often international cooperation can facilitate the process of achieving these aims. In many ways Taiwan and Russia are complementary since they are strong in different parts of the S&T development process, from basic research, applied research, experimental development to commercialization. It is crucial for these two countries to identify its role in the global competition hence to make the bilateral cooperation reciprocally beneficial.

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