



National Science and Technology Development Plan (2017-2020)

September 7, 2017



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Table of Abbreviations

Abbr.	Full Name
AEC	Atomic Energy Council, Executive Yuan
AS	Academia Sinica
ASC	Aviation Safety Council
BOE	Bureau of Energy, Ministry of Economic Affairs
BOST	Board of Science and Technology, Executive Yuan
CIP	Council of Indigenous Peoples
COA	Council of Agriculture, Executive Yuan
CSPTC	Civil Service Protection and Training Commission
DCS	Department of Cyber Security, Executive Yuan
DGBAS	Directorate-General of Budget, Accounting and Statistics, Executive Yuan
DGPA	Directorate-General of Personnel Administration, Executive Yuan
DIM	Department of Information Management, Executive Yuan
DOIT	Department of Industrial Technology, Ministry of Economic Affairs
EPA	Environmental Protection Administration, Executive Yuan
FSC	Financial Supervisory Commission
GEC	Gender Equality Committee, Executive Yuan
HAC	Hakka Affairs Council
IDB	Industrial Development Bureau, Ministry of Economic Affairs
MND	Ministry of National Defense
MOC	Ministry of Culture
MOE	Ministry of Education
MOEA	Ministry of Economic Affairs
MOF	Ministry of Finance
MOHW	Ministry of Health and Welfare
MOI	Ministry of the Interior
MOJ	Ministry of Justice
MOL	Ministry of Labor

Abbr.	Full Name
MOST	Ministry of Science and Technology
MOTC	Ministry of Transportation and Communications
NCC	National Communications Commission
NDC	National Development Council
NDF	National Development Fund, Executive Yuan
NPM	National Palace Museum
PCC	Public Construction Commission, Executive Yuan
SMEA	Small and Medium Enterprise Administration, Ministry of Economic Affairs



Chapter 1 Introduction

According to stipulations of the Fundamental Science and Technology Act, the Executive Yuan held The Tenth National Science and Technology Conference in December 2016. The conference, under the theme of “Brilliance, Low-Carbon Economy, Well-Being, and Sustainability” was aimed at discussing matters such as current development of science and technology (S&T), overall goals of S&T development, strategies and resource planning at the national level, and development goals, strategies and resource planning of government departments and S&T domains, among other important issues. The consensus and conclusions reached at this conference are hereby translated into the National Science and Technology Development Plan (2017-2020) which, after being adopted by the Executive Yuan, will become the basis in promoting the nation’s major policies for S&T research and development (R&D).

The formation of a nation’s S&T policies vary under different institutions in different countries. In Finland, the Research and Innovation Council plans out S&T policies and coordinates between government agencies to duly carry out goals set by the central government. In Sweden, different governmental agencies plan out specific S&T policies on the issues in their charge, then coordination is conducted by the National Council for Innovation and Quality, resulting in high implementation efficiency. In Switzerland and Denmark, S&T policy planning and inter-agency coordination are conducted by different agencies, so that all agencies collaborate with each other to make action plans to fulfill national goals. In South Korea, the National Science and Technology Council plans its S&T policies, and policy goals are established based on societal

demands, in which case citizen participation is important. In the cases of Japan and Singapore, the Japanese Cabinet Office's Council for Science, Technology, and Innovation and Singapore's Standards, Productivity and Innovation Board both serve as the integrator and/or coordinator, plan out the S&T policy on the demands of all government departments and agencies. Therefore national development goals are consolidated and achieved in an efficient way.

This plan is made with a variety of approaches adopted by the above mentioned fellow countries as references. The Board of Science and Technology of the Executive Yuan (BOST) and the Ministry of Science and Technology (MOST) joined efforts in mapping out the plan. They invited scholars and experts to propose an initial research plan, and then asked following respective agencies (units) to draft out policies and corresponding measures accordingly: the Academia Sinica (AS), BOST, Department of Cyber Security of the Executive Yuan (DCS), MOST, Ministry of the Interior (MOI), Ministry of National Defense (MND), Ministry of Finance (MOF), Ministry of Education (MOE), Ministry of Economic Affairs (MOEA), Ministry of Transportation and Communications (MOTC), Ministry of Health and Welfare (MOHW), Ministry of Culture (MOC), Ministry of Labor (MOL), National Development Council (NDC), National Communications Commission (NCC), Atomic Energy Council of the Executive Yuan (AEC), Council of Agriculture of the Executive Yuan (COA), Financial Supervisory Commission (FSC), Public Construction Commission of the Executive Yuan (PCC), Environmental Protection Administration of the Executive Yuan (EPA), and National Development Fund of the Executive Yuan (NDF). They also proposed necessary amendments to the draft plan with



reference to the conclusions of Tenth National Science and Technology Conference, and suggestions from citizens and experts of the industry, academic and research sectors, and also resolution of the inter-department coordination meeting. As defined in the Fundamental Science and Technology Act, this plan contains the division of labor in strategies and measures, and collation of S&T development goals of all government agencies. This plan shall act as the basis for the government’s policy in promotion of S&T development in the next four years.

This plan is divided into eight chapters. It begins with the “Introduction” as the first chapter, followed by the second chapter — “Status and Review of Current National Science and Technology Development”. The third chapter is the “Goals and Vision”, in which it sets the four major goals of having revive economic dynamics through innovation, develop robust smart living technologies and industries, foster and recruit talent with diverse career paths, and enhance the innovation ecosystem for scientific research. The fourth chapter is “Strategies and Important Measures”, through which eighteen strategies are established under the four major goals with detailed explanation of important measures. The fifth chapter “Strategies and Division of Labor for Important Measures” introduces the responsible departments/agencies of all strategies and important measures. The sixth chapter “Science and Technology Development Goals of Government Departments and Agencies” briefly introduces the S&T development goals of respective government agencies. The seventh chapter “Planning for Central Government’s Distribution of Funding and Resources for Science and Technology” explains the government’s overall technology budget. The eighth chapter “Implementation and Effectiveness Monitoring” introduces the procedures

of national and agencies' promotion of S&T development plan and how effectiveness and impact are monitored. Appendices are also attached to explain the S&T development goals, strategies, and budget and resources allocation of respective government agencies.



Chapter 2 Status and Review of Current National Science and Technology Development

1. International Scenario

Developed countries around the world are now at a stage of stagnated economic development. Although emerging countries are now thriving because of industrialization, which has boosted global economic growth, the substantive effects are still very limited. Furthermore, as the global demographic structure changes, problems such as aging societies and low birth rates in developed countries will inevitably result in a decreasing labor force and an increasing demand for medical care; other social issues resulting from sluggish economic growth are also gradually surfacing. In the process of international development, all countries around the world must face issues such as climate change and natural disaster prevention, ecological environment protection and resource depletion, and epidemic diseases and new viruses. Therefore, major countries now have high hopes for innovative technology development to be introduced to deal with these issues domestically and internationally, while simultaneously hoping for new developments to boost industry and economic growth.

Governmental and industrial sectors have invested in R&D for innovative technology with the aim of improving human welfare and satisfying the demands of industrial development, examples of which include automated, intelligent factories that improve productivity and mass customization, intelligent robots that respond to the lack of labor and satisfy the medical demands of an aging society, and advanced sensors that monitor and help prevent natural disasters. Since Germany's

introduction of Industry 4.0, innovative technologies arising from the demand in industry and social development have increased rapidly, such as artificial intelligence (AI), the internet of things (IoT), cloud computing, big data application and analytical prediction, and 3D printing.

Digitalization and intelligentization have gradually become the main global trends in innovative technological development, comprising interdisciplinary R&D and multifaceted applications. For example, AI has expanded from its original application in robots to intelligent decision-making systems, the rise of intelligent apps, and virtual personal assistants. The application of these technologies has also changed from satisfying manufacturing and production demands in the beginning to service and management decision support demands. International technology foresight studies have shown that existing innovative technologies will further evolve to transform current lifestyles and industrial development.

Future social and industrial demands will rapidly push forward innovative technology development. In the process of global demographic transformation, developments in machine learning, deep learning, and natural language processing will make AI the major driver that transforms human lives. Furthermore, advanced natural disaster detection devices that respond to climate change and wearable sensor devices that monitor human health have also contributed to the intelligentization of sensors. The large amounts of data produced by the development of these intelligent sensors will also dramatically increase storage and calculation capabilities, which will further advance cloud computing into fog computing, thus creating more space for the



development of big data application and analysis.

Furthermore, because of exhaustion of gradual global energy and resources, the main trends in future green energy and recycling technology will include the use of perovskite solar cells, innovative recycling materials, nanomaterials, and resource recycling technology, whereas innovative biomedical developments such as neurotechnology, synthetic biology, and implant technology will help humanity fight new diseases and viruses. Innovative business models in the digital economic development era will facilitate development of IoT-related technologies such as innovation in digital platforms, cloud computing, and 3D printing techniques.

In the trend of digitalization and intelligentization, the most critical factor above all else is the cultivation and recruitment of human talent in emerging technology and interdisciplinary fields. This is because talent in interdisciplinary fields is the main driver of technology innovation, and only through cultivation and exchange of these special talents can innovative concepts actually be implemented, thus satisfying demands in social and economic development. Furthermore, technology-related infrastructures will also become the basis for the promotion of digital economies, including 5G hardware and equipment, information centers, and R&D platforms for interdisciplinary cooperation. Technology-related regulations must also advance with the times so as to lead and encourage input into and development of innovative technology.

2. Current Challenges

In recent years, global technology industries have evolved at a rapid pace (e.g., smart machinery and IoT applications), with new technologies being introduced and old technologies being improved (e.g., green energy and biomedicine), which has pushed forward global economic development and in turn created many opportunities for the industry. However, with the rapid growth in the global population, problems such as a lack of resources and energy, environmental pollution, and new epidemics and viruses have surfaced and are now severely impacting human life and welfare.

In view of the overall development and promotion of S&T in Taiwan, we must not only consider factors such as transformation of economic models, change in social structure, and flow of human talent, but also adopt a broader perspective and consider the operation and effects of the scientific research ecosystem. Although Taiwan's economy has now entered a mature stage, its growth has slowed under the influence of a sluggish global economy. The reasons behind this are low domestic demand, high reliance on concentrated exports, and the rise of emerging countries.

In social terms, many food-safety incidents have recently emerged in Taiwan, raising awareness in the general public that this issue must be considered seriously. However, frequent natural disasters and emerging diseases also highlight the importance of disaster prevention and crisis management abilities. At the same time, the demand for data security has also risen because of the propagation of information and communication technology (ICT) products. Furthermore, the problem of



an aging population is becoming increasingly apparent. According to statistical data of Health Promotion Administration (HPA) of the MOHW, by 2026, those aged 65 years and older will account for over 20% of the total population, and Taiwan will then become a “super-aged society,” as defined by the UN, by which time it will be facing scenarios such as a severe lack of labor and an increase in medical and social costs.

As for human-talent issues, Taiwan is currently facing a stage of industry upgrade and transformation, and therefore has a great need to cultivate a new generation of innovative R&D talent to satisfy the demands arising from the digital era. Given the trend of intelligent technology, it is necessary not only to upgrade the professional capability of current talent, but also to further cultivate and attract top interdisciplinary experts to comprehensively support the development of emerging technologies and meet the demands of future technology industries. Furthermore, Taiwan also needs to create an environment that attracts worldwide talent to further safeguard the international cooperation network for scientific research.

In terms of the scientific research ecosystem, Taiwan must conduct thorough and deeper research analysis from different perspectives, such as science development planning, resource allocation, regulation mechanisms, and achievement assessment, to truly understand the different factors affecting Taiwan’s science innovation development. At the current stage, although the public and private sectors have both proactively invested in R&D, policies that map out the nation’s science technology development still need to be transformed and adjusted constantly to suit the internal and external environments, and thus fully maximize the effects of resource allocation. Furthermore, academic

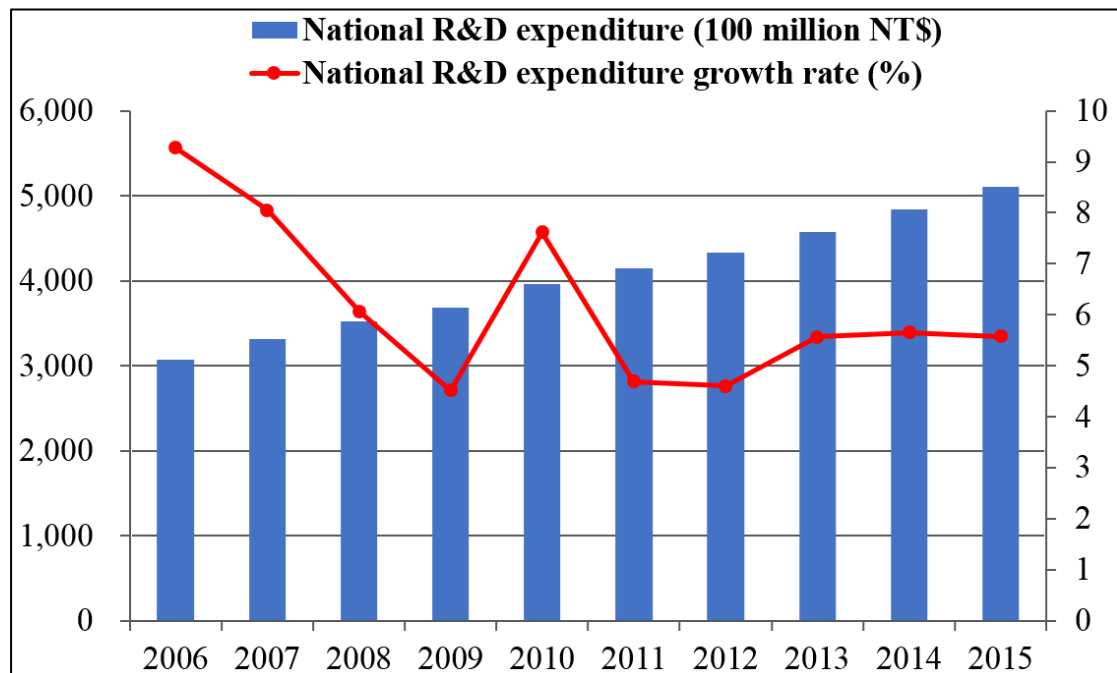
research innovative momentum and achievements must continue to spread to industry, and the innovative R&D value chain must be linked through both the formulation and adjustment of regulation mechanisms, and the expansion and transfer of R&D achievements, so as to strengthen the nation's scientific research ecosystem.

In summary, as the external environment rapidly changes, society will have higher expectations of governmental policies. Taiwan's immediate problems requiring resolution are as follows: how to assist industries in improving their degree of autonomy in upgrading key technologies and increasing their added value to maintain industry growth; how to facilitate development and application of new energy technology to meet the global consensus on fighting global warming and marching toward the goal of a nuclear-free homeland; and how to further relax regulations and safeguard the scientific research environment, attract and cultivate more human talent, and how to solve the problems of talent shortage and outflow.

3. Current S&T Development, Achievements, and Review

(1) Current S&T Development

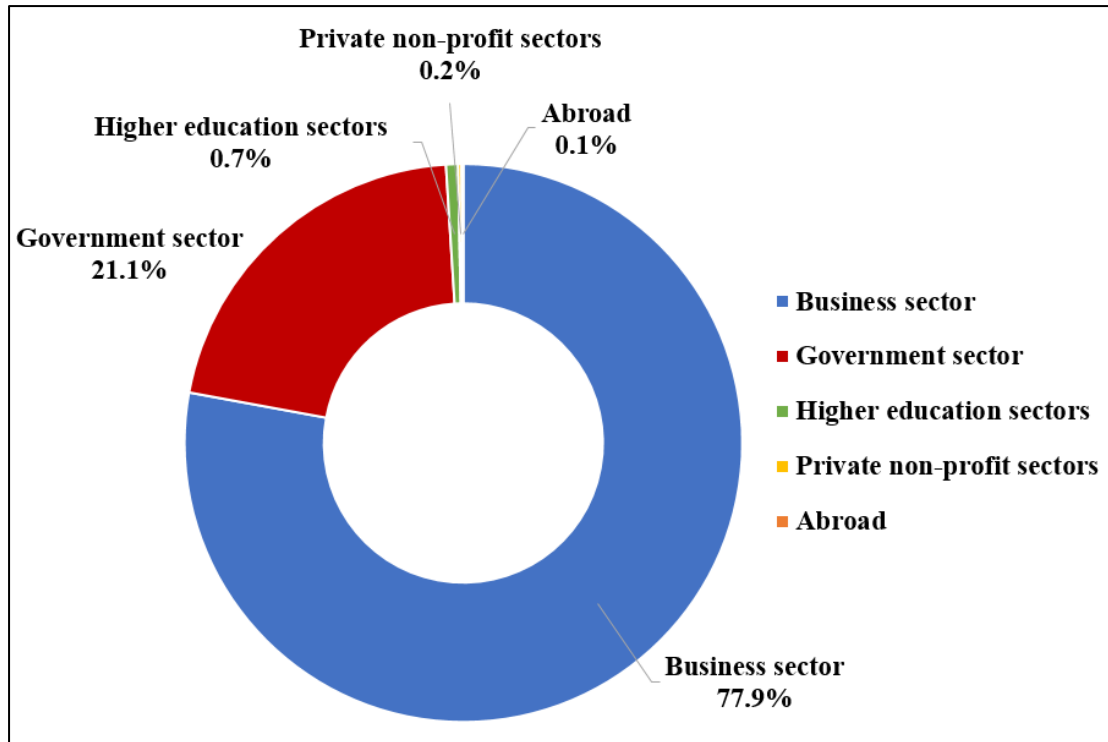
Taiwan's national R&D expenditure over the past decade (Figure 1) shows that public and private sectors are reasonably proactive in innovative R&D activities. The national annual total R&D expenditure was NT\$ 307 billion in 2006, and increased to NT\$ 510.4 billion by 2015, representing an annual growth rate of 6.2%, totaling 66.2% growth over the past decade. However, since the global financial crisis of 2009, annual growth rates have all been below average, except for 2010.



Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 1 National Annual R&D Expenditure and the Change of Growth Rates, 2006-2015

The business sector is the main source of the nation's R&D activity funding, which is similar to the situation in other major industrial countries worldwide and demonstrates the expansion of R&D capacity in private sectors. In 2015, business sector contributions accounted for 77.9% of total national R&D expenditure, whereas government sector contributions accounted for 21.1%, and contributions from higher education, private non-profit, and abroad together accounted for a mere 1% of total national R&D expenditure (Figure 2).



Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 2 Sources of National R&D Expenditure

The allocation of national R&D expenditure is categorized into different research phases, where most spending occurs at the technology development stage. In 2015, technology development spending reached NT\$ 348.1 billion, accounting for 68.2% of the total expenditure; applied research spending reached NT\$ 118 billion, accounting for 23.1%; and basic research spending was NT\$ 44.3 billion, accounting for 8.7%. Although national expenditure for different phases of research have all increased, the growth in technology development spending is the most significant, causing the percentage for basic research and applied research to decrease (Table 1).



Table 1 R&D Expenditure by Types of R&D, 2011-2015

Unit: 100 million NT\$

Year	Basic research		Applied research		Experimental development		Total	
	Amount	Percentage	Amount	Percentage	Amount	Percentage	Amount	Percentage
2011	402	9.7%	982	23.7%	2,760	66.6%	4,144	100.0%
2012	407	9.4%	1,016	23.4%	2,912	67.2%	4,335	100.0%
2013	420	9.2%	1,062	23.2%	3,094	67.6%	4,576	100.0%
2014	434	9.0%	1,110	23.0%	3,291	68.1%	4,835	100.0%
2015	443	8.7%	1,180	23.1%	3,481	68.2%	5,104	100.0%

Source: *Indicators of Science and Technology*. MOST, 2016.

Taiwan's R&D expenditure over the past few years has accounted for a high gross domestic product (GDP) ratio, exceeding the average ratio of other Organization for Economic Co-Operation and Development (OECD) member countries. The R&D intensity in Taiwan for 2015 was 3.06%, which, albeit lower than that of Israel (4.25%), Japan (3.49%), South Korea (4.23%), and Sweden (3.26%), is higher than that of mainland China (2.07%), Germany (2.87%), and the US (2.79%).

Although Table 2 shows that R&D expenditure as a percentage of GDP was not particularly significant for Germany and the US, the two countries' scientific research results were widely recognized around the world, demonstrating that the amount of R&D funding input is only one of the factors affecting a nation's scientific research performance. The importance of budget implementation efficiency and a well-designed oversight and evaluation system must also be emphasized.

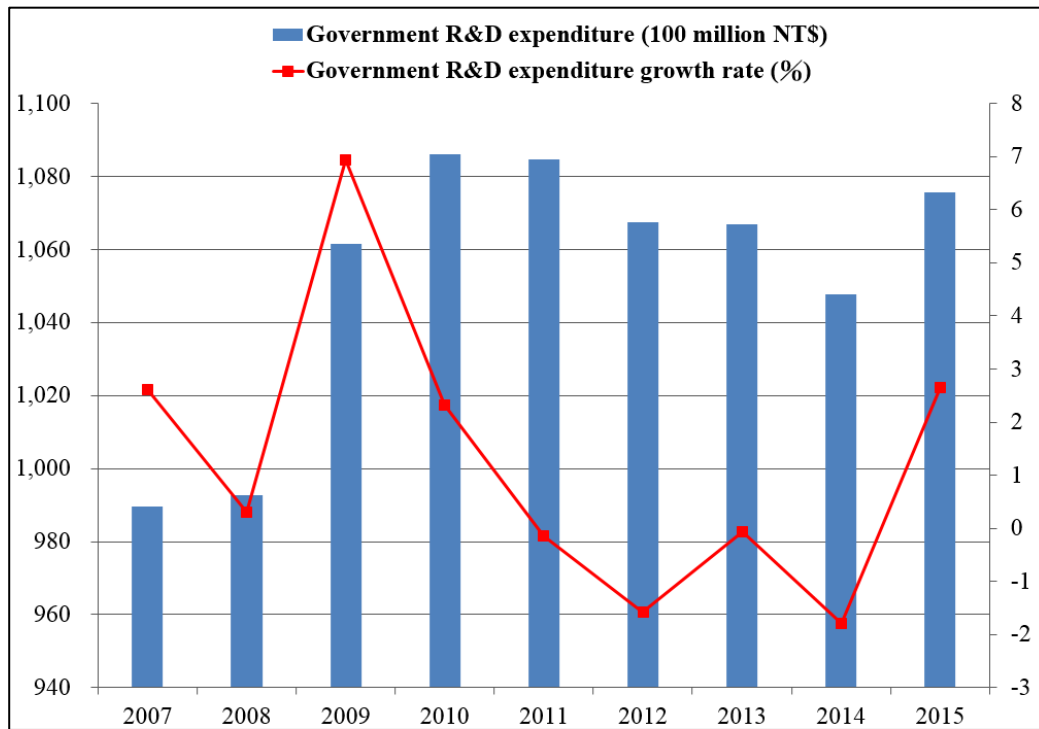
Table 2 Annual R&D Expenditure as a Percentage of GDP for Various Countries, 2010-2015

Unit: %

Year	Taiwan	Mainland China	Germany	Israel	Japan	South Korea	Sweden	US	OECD Average
2010	2.80	1.71	2.71	3.94	3.25	3.47	3.22	2.74	2.30
2011	2.90	1.78	2.80	4.02	3.38	3.74	3.25	2.77	2.33
2012	2.95	1.91	2.87	4.16	3.34	4.03	3.28	2.71	2.34
2013	3.00	1.99	2.82	4.15	3.48	4.15	3.31	2.74	2.37
2014	3.00	2.02	2.89	4.27	3.59	4.29	3.15	2.76	2.39
2015	3.06	2.07	2.87	4.25	3.49	4.23	3.26	2.79	2.40

Source: *Main Science and Technology Indicators*. OECD, 2016/2.

Many areas of Taiwan government expenditure have become more conservative because of financial pressure, which has in turn slowed the growth of R&D expenditure, resulting in a drop in funding in recent years. For four consecutive years, from 2011 to 2014, Taiwan's government funding has seen negative growth (Figure 3). However, in 2015, government R&D funding reached NT\$ 107.6 billion, showing an increase of 2.7% compared to the previous year. The trend in decreased government R&D expenditure is not exclusive to Taiwan; according to the *OECD Science, Technology and Industry Outlook 2014*, the global financial crisis and recession increased the uncertainty of the overall economic environment and curtailed the will and motive of governments and industries in many countries to invest in innovative R&D activities.



Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 3 Annual R&D Expenditure of the Central Government and the Change of Growth Rates, 2007-2015

The Taiwan central government planned a budget of NT\$ 106,238,262,000 for technology R&D for 2015, of which NT\$ 100,025,454,000 was the actual implemented figure, reaching a budget implementation efficiency rate of 94.2%. Aside from the DCS and EPA, the budget implementation efficiency of most other government agencies reached 90% (Table 3).

**Table 3 Technology R&D Budget Statistics of Government Agencies
for 2015**

Unit: NT\$ 1,000

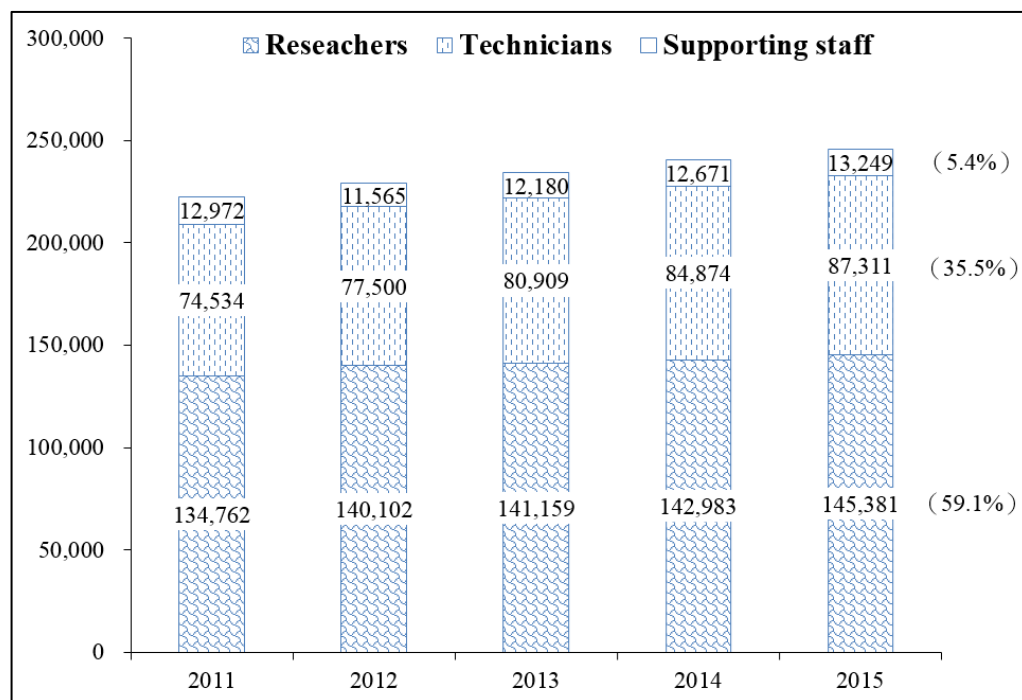
Competent authority	Budget	Implementation
AS	11,184,804	11,135,469
BOST	38,161	35,222
DCS	297,977	264,764
GEC	22,583	22,409
MOI	660,879	653,271
MND	103,438	101,316
MOF	308,586	308,586
MOE	1,598,210	1,590,861
MOJ	155,038	152,119
MOEA	29,837,603	29,152,018
MOTC	1,093,927	1,089,345
MOC	608,705	567,875
MOL	181,731	172,514
MOST	50,546,646	45,459,376
MOHW	4,193,176	3,993,426
DGPA	67,747	66,441
EPA	84,925	63,230
NPM	20,482	19,997
NDC	461,630	449,451
AEC	846,537	833,252
COA	3,742,153	3,711,385
PCC	6,648	6,538
CIP	159,700	159,700
HAC	10,890	10,890
CSPTC	6,086	5,999
Total	106,238,262	100,025,454

Source: *Book of Technology R&D Performance by the Central Government 2015*.
MOST, 2016.

In 2015, Taiwan's total R&D personnel totaled 245,941 people, showing an increase of 2.3% compared to the previous year. Between the years 2011 and 2015, the average annual growth rate



was approximately 3.1%. In 2015, research personnel accounted for the highest percentage (59.1%) of the total R&D personnel at 145,381 people, whereas technical personnel totaled 87,311 people (35.5%) and supporting personnel totaled 13,249 people (5.4%) as shown in Figure 4.



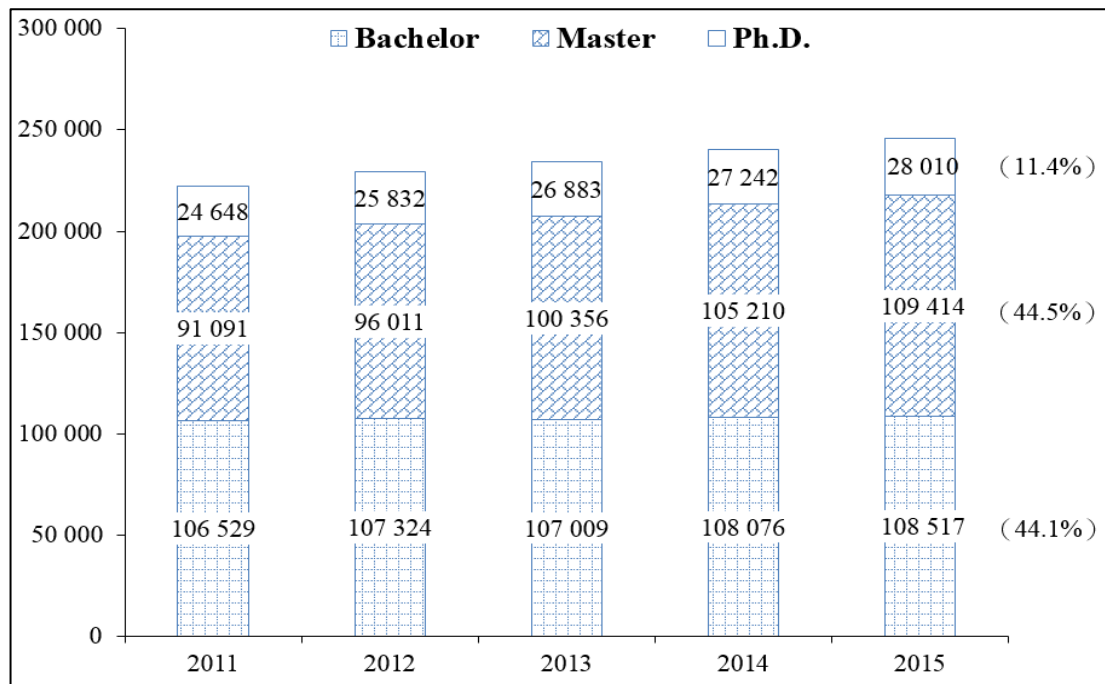
Note: Full-time equivalent (FTE) = person-years

Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 4 R&D Personnel (FTE) by Occupation, 2011-2015

Regarding R&D personnel's qualification, it has been found that most have acquired diplomas from graduate institutes (master or doctoral degrees). For 2015, 44.5% of the overall R&D personnel had acquired a master's degree, which in comparison to 2011, was a 3.5% increase of 18,000 people. Moreover, 28,010 people, accounting for 11.4% of the overall R&D personnel, had a doctoral degree, which was an increase of 3,362 people from 2011 (0.3%). The statistics show that Taiwan's national innovation

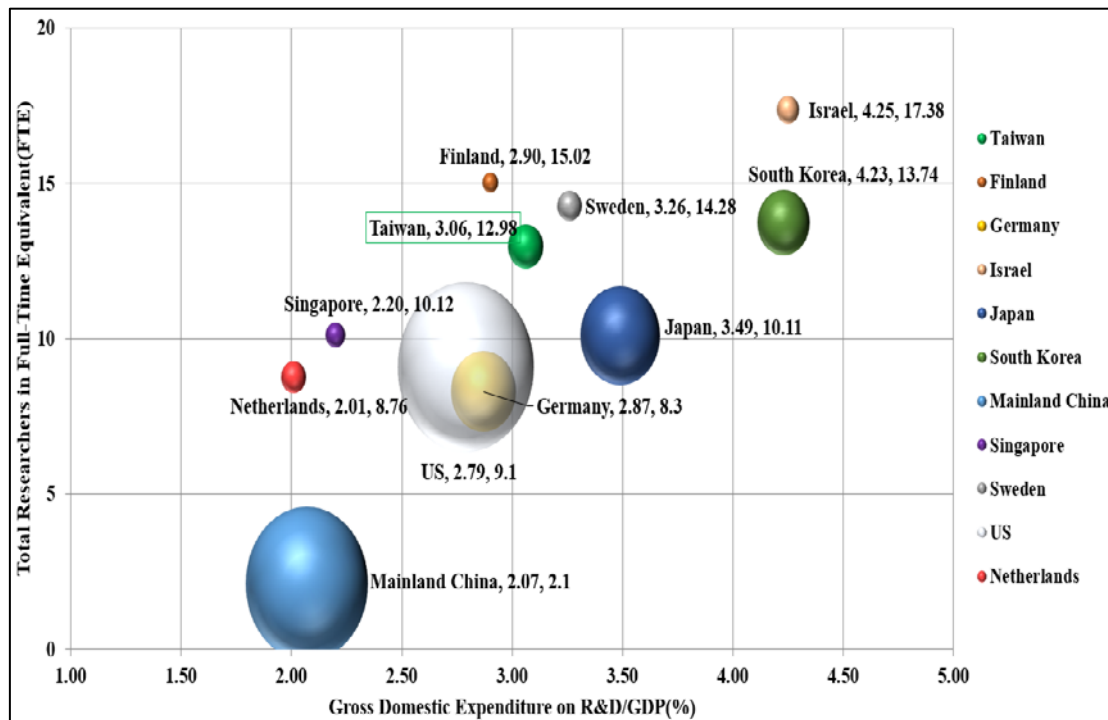
system has a strong qualified research force with research personnel holding graduate diplomas or above accounting for over 55%. In comparison with other countries, Taiwan is reasonably abundant in its number of R&D personnel, which may be a result of the expansion of higher education (Figure 5 and 6).



Note: Full-Time Equivalent (FTE) – person years.

Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 5 R&D Personnel (FTE) by Qualification, 2011-2015



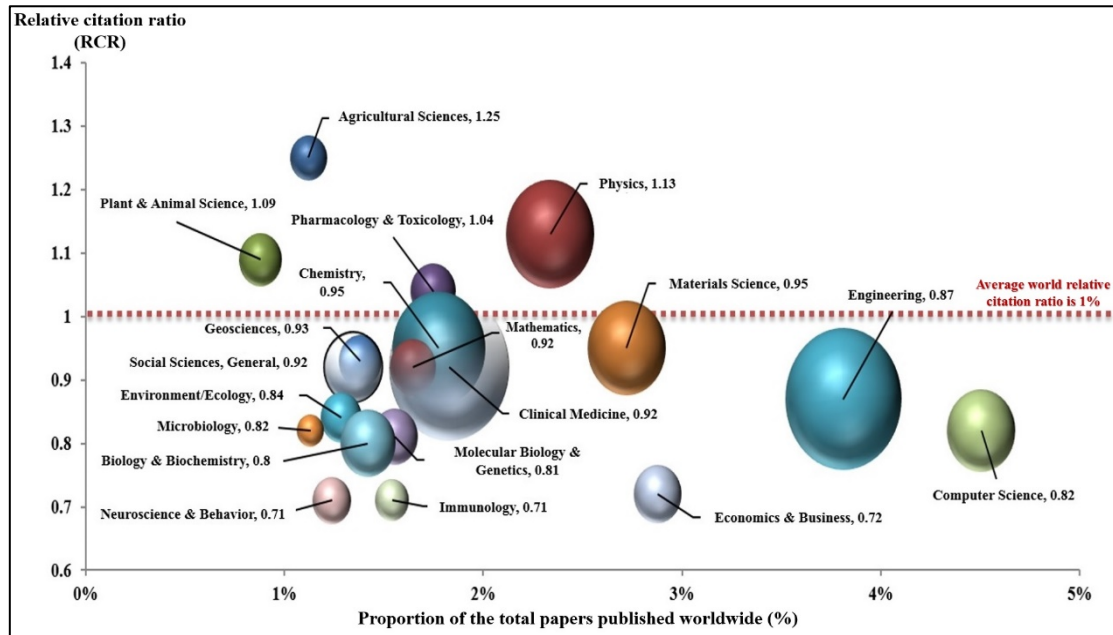
Note: FTE = person-years.

Year of information: national R&D expenditure as a percentage of GDP and national total R&D budget are for 2015 for all countries except Singapore, which are for 2014. Data of FTE for all countries are for 2015, except Israel, Singapore, and the US. Israel is for 2012, and Singapore and the US are for 2014.

Source: *Main Science and Technology Indicators*. OECD, 2016/2.

Figure 6 R&D Expenditure and Personnel of Major Countries, 2015

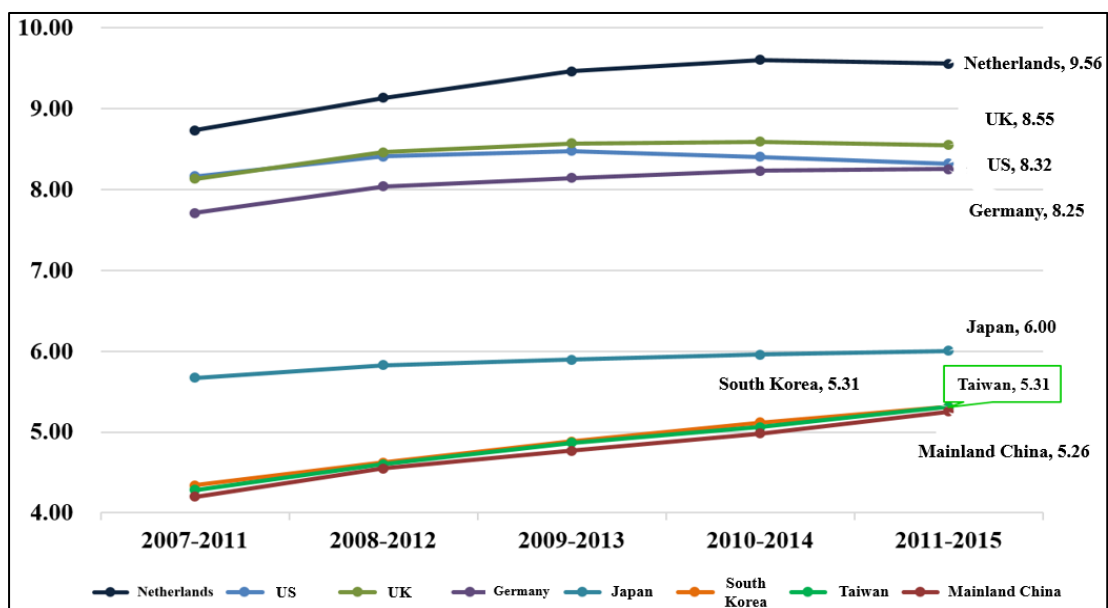
As mentioned, Taiwan is reasonably pro-active in R&D innovation activities, and R&D-related input has contributed to Taiwan's academic research output. In terms of the performance of Taiwanese research papers, more emphasis is now placed on the influence that these papers exert on the world, rather than only the number of papers published, as in the past. Taiwanese papers in agriculture, physics, and plant biology and animal sciences enjoy a higher relative citation ratio (RCR) than papers in other fields (average world RCR, 1%; Figure 7). Deeper analysis of the average citation number of Taiwanese Science Citation Index (SCI) papers reveals that the RCR of Taiwanese scientific papers has gradually increased and, despite a significant lag remaining behind the US and the UK, Taiwan is gradually catching up to South Korea and Japan (Figure 8).



Note: The size of the bubbles represents the total number of papers published in different research fields. The X axis represents the proportion of research papers in each field in different countries of the total papers published worldwide. The Y axis represents the relative citation ratio (RCR); if a country's RCR is 1%, it is the same as the world average.

Source: InCites. Thomson Reuters, 2016.

Figure 7 Performance of Academic Publication in Different Domains, 2010-2015

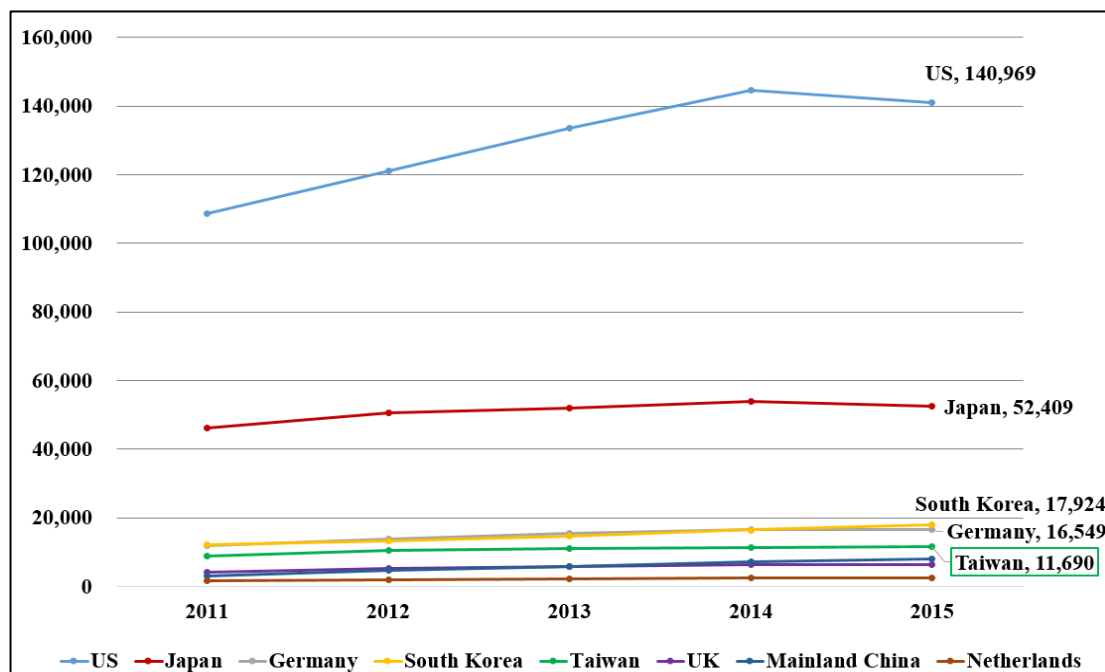


Source: Web of Science. Thomson Reuters, 2016.

Figure 8 Number of Citations per SCI Paper



Over the past few years, Taiwan has relatively consistently ranked fifth in the number of patents granted, according to the United States Patent and Trademark Office (USPTO). It must be stressed that although the number of patents granted may be used to measure the achievements and output of a nation's innovative R&D activities, it cannot reflect the quality and value of the patents.



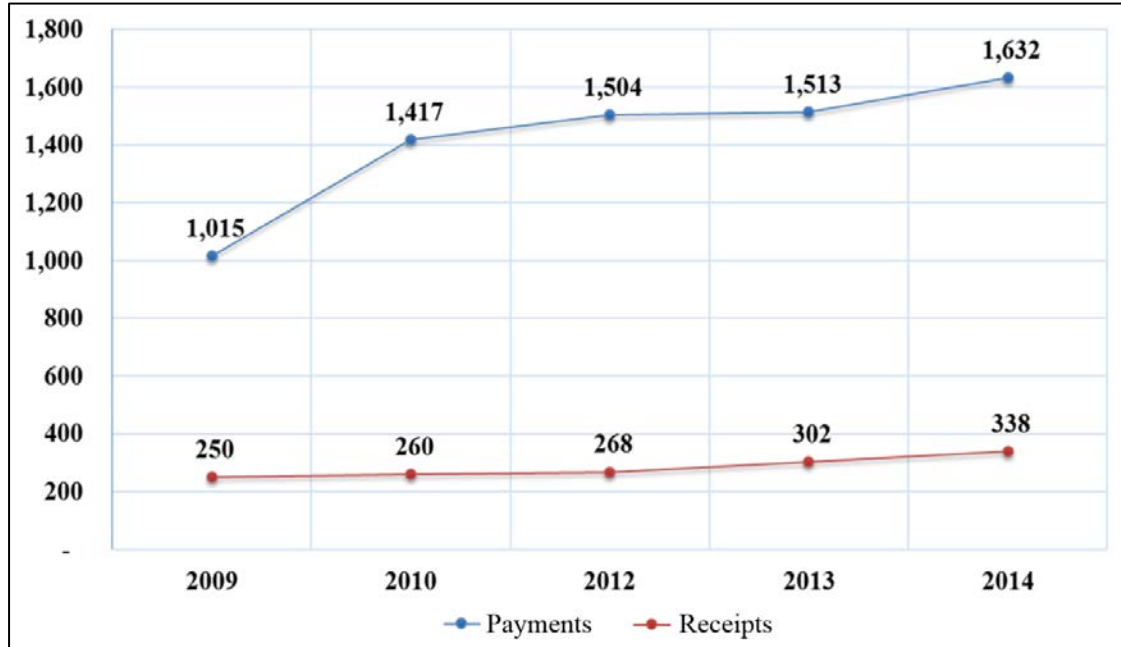
Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 9 Number of US Granted Utility Patents, 2011-2015

Figure 10 shows the technology balance of payments, which has often been used to evaluate a nation's control and autonomy in key technologies and technology progression. This is the amount of money involved in purchasing foreign technology or selling technology to foreign countries through technology cooperation and technology licensing, including patent transaction, patent licensing, trade of specialized technology, trademarks, technical services, and commissioning foreign enterprises to conduct R&D activities. Of the total technology trade, Taiwan's technology

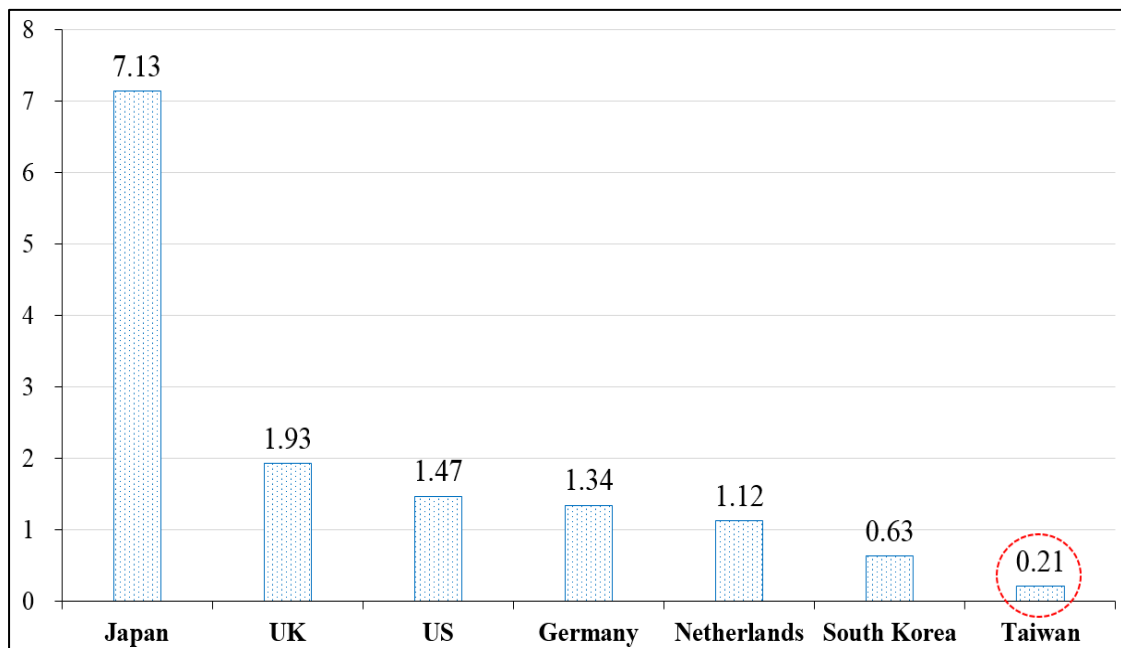


export volume has increased every year; however, the overall technology balance of payments remains lower than that of other major countries (Figure 11).



Source: *Indicators of Science and Technology*. MOST, 2016.

Figure 10 Taiwan's Technology Balance of Payments, 2009-2014



Note: Data of all countries are for 2015, except Taiwan is for 2014.

Source: *Main Science and Technology Indicators*. OECD, 2016/2.

Figure 11 Comparison of Technology Balance of Payments between Taiwan and Other Major Countries



According to *The Global Competitiveness Report 2015–2016* of the World Economic Forum (WEF), Taiwan’s rank risen from 15th to 14th out of all 138 rated countries (and 4th in the Asia-Pacific), behind Singapore (2nd), Japan (8th), and Hong Kong (9th), and leading ahead of Malaysia (25th), South Korea (26th), and mainland China (28th) (Table 4).

Regarding “innovation and sophistication factors,” Taiwan ranked 11th for “innovation.” The NDC analysis revealed that, although the government’s procurement policies have benefitted the advancement of technology and have improved in enterprise R&D expenditure, the rankings have dropped for Taiwanese enterprises’ innovation capabilities and industry-academia R&D cooperation. This shows that despite the government continuing to promote academic–enterprise R&D cooperation and innovative entrepreneurship policies, there remains much room for improvement. Regarding “business sophistication,” Taiwan ranked 22nd for 2016, which was a drop of one rank compared to the previous year. Taiwan’s local suppliers have increased in number and there has been an improvement in enterprises adopting more sophisticated marketing strategies. However, rankings have dropped for the quality of local suppliers and the level of enterprise participation in the industry value chain (Table 5).

Conversely, according to the International Institute for Management Development (IMD) *World Competitiveness Yearbook 2016*, Taiwan’s overall competitiveness dropped from 11th in 2015 to 14th in 2016. Of the four major competitiveness factors, only the ranking for “government efficiency” remained the

same (9th), whereas the rankings for the other three factors all dropped; “economic performance” dropped four ranks to 15th, “business efficiency” dropped two ranks to 16th, and “infrastructure” dropped one rank to 19th (Table 6).

Table 4 The Ranking of Overall Competitiveness by WEF, 2007-2016

Countries	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	Rank Change as of 2016
Taiwan	14	15	14	12	13	13	13	12	17	14	+1
Singapore	2	2	2	2	2	2	3	3	5	7	0
Japan	8	6	6	9	10	9	6	8	9	8	-2
Hong Kong	9	7	7	7	9	11	11	11	11	12	-2
Malaysia	25	18	20	24	25	21	26	24	21	21	-7
South Korea	26	26	26	25	19	24	22	19	13	11	0
Mainland China	28	28	28	29	29	26	27	29	30	34	0

Source: *The Global Competitiveness Report 2015-2016*. WEF, 2016.

Table 5 National Ranking of Subindexes and Pillars in Global Competitiveness Report for Taiwan by WEF, 2007-2016

Indicators	Year											Rank Change as of 2016
	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007		
Global Competitiveness Index	14	15	14	12	13	13	13	12	17	14	+1	
1. Basic requirements	14	14	14	16	17	15	19	18	20	19	0	
(1)Institutions	30	27	27	26	26	31	35	38	40	37	-3	
(2)Infrastructure	13	12	11	14	17	20	16	16	19	20	-1	
(3)Macroeconomic environment	14	13	23	32	28	22	20	25	18	26	-1	
(4)Health and primary education	15	14	13	11	15	11	11	15	20	6	-1	
2.Efficiency enhancers	16	15	16	15	12	16	16	17	18	17	-1	
(1)Higher education and training	17	14	12	11	9	10	11	13	13	4	-3	
(2)Goods market efficiency	15	13	11	7	8	11	15	14	14	17	-2	
(3)Labor market efficiency	25	22	32	33	22	33	34	24	21	22	-3	
(4)Financial market development	15	17	18	17	19	24	35	54	58	58	+2	
(5)Technological readiness	30	28	30	30	24	24	20	18	15	15	-2	



Indicators	Year										Rank Change as of 2016
	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	
(6)Market size	20	20	17	17	17	16	17	17	16	16	0
3.Innovation and sophistication factors	17	16	13	9	14	10	7	8	8	10	-1
(1)Business sophistication	22	21	17	15	13	13	13	13	12	14	-1
(2)Innovation	11	11	10	8	14	9	7	6	7	9	0

Note: As of 2006, the WEF has officially replaced “Growth Competitiveness Index” with “Global Competitiveness Index”. The two indexes evaluate different factors which make the two hard to compare.

Source: *The Global Competitiveness Report 2015-2016*. WEF, 2016.

**Table 6 National Ranking in World Competitiveness Yearbook for
Taiwan by IMD, 2012-2016**

	2012	2013	2014	2015	2016	Rank Change as of 2016
Overall ranking	7	11	13	11	14	-3
Economic performance	13	16	14	11	15	-4
Government efficiency	5	8	12	9	9	0
Business efficiency	4	10	17	14	16	-2
Infrastructure	12	16	17	18	19	-1

Source: *World Competitiveness Yearbook*. IMD, 2016.

(2) Achievements in Technology Development

The government’s technology policies are aimed at facilitating industrial economic development, ensuring sustainable national development, and improving people’s well-being. The following sections reflect upon Taiwan’s technology development achievements from four perspectives: 1. Facilitating industrial development by enhancing national technology strength, clarifying the contributions of technology R&D to economic development; 2.

Enhancing people's well-being and sense of happiness through application of innovative technology, clarifying the benefits innovative technology has created for social development; 3. Improving cultivation and retention of talent through innovative talent policy, clarifying the effects that technology policies exert on talent cultivation and attraction; 4. Further improving the scientific research environment by promoting systematic reform, clarifying the achievements made in the scientific research ecosystem through technology system reform.

A. Facilitating industrial development by enhancing national technology strength

(a) Expanding the industrialization of research output and increasing industry competitiveness

The government integrated research institutions, led all sectors and industries, improved technology autonomy, facilitated industries' innovative technology R&D, and pushed for business R&D investment and created NT\$ 80 billion in added output value per year.

(b) Establishing a comprehensive industry value chain and improving the industry's added value

The government promoted industrial logistic integration service systems, guided industry operators to establish competitive cross-border supply chain and logistics services, and assisted Taiwanese businesspeople with global layout.



- (c) Establishing science parks and optimizing the environment for emerging industries' development

The government established the Hsinchu Biomedical Science Park, which targets advanced medical devices and new drug R&D as its core industries, and subsequently established the Biomedical Technology and Product R&D Center and Biomedical Science Park Incubation Center.

- B. Enhancing people's well-being and sense of happiness through application of innovative technology

- (a) Integrating disaster prevention and weather forecast systems and ensuring the safety of people's lives and property

The government built a multi-functioning disaster prevention information broadcast environment that integrates information from all perspectives and improves efficiency.

- (b) Enhancing earthquake monitoring abilities to enable earlier emergency response

The government established a new earthquake monitoring system that sends out immediate seismic activity reports to enable people to respond earlier, before damaging seismic waves hit. On May 12, 2016, a magnitude 5.8 earthquake struck northern Taiwan, and the Central Weather Bureau sent out its very first Presidential Earthquake Alert text message.

- (c) Executing the Health Cloud Project and establishing a high-quality healthcare service system



The government established a virtual cloud platform for hospitals that aimed to close the urban–rural medical digital gap, assist with remote areas, highlands, and outlying islands, and improve district health centers’ medical services as well as overall medical quality.

- (d) Supporting medical research for critical illnesses, investing in research, and developing treatment drugs for major illnesses

Through the National Research Program for Biopharmaceuticals, animal model research and validation for many anti-cancer drugs has been completed, with results proving suppression of tumor growth. Additional clinical trials will be conducted.

C. Improving cultivation and retention of talent through innovative talent policy

- (a) Adjusting talent policy to attract international talent

The government established Executive Yuan's Board of Population and Talent Policy, continued to promote the Integrated Program to Cultivate, Retain, and Attract Talent, and pro-actively organized related events to cultivate, retain, and attract talent.

- (b) Cooperating with industries in actual practices and operations and cultivating talent

The government promoted the Information Talent Cultivation Program, cooperated with industries in opening courses for industry–academia cooperation, cultivated seed



teachers, and improved the employment of information software talent. The Intelligent Electronics Talent Cultivation Program was also promoted, and a thematic internship platform was established with industries to provide students with professional research and study opportunities and environment.

(c) Establishing a digital platform and adopting innovative teaching methods

The government promoted the New Generation Digital Learning Project, established and opened Massive Open Online Courses (MOOCs) in the fields of human cultures, natural sciences, applied sciences, medical studies, social sciences, history, and geography, as well as improving the quality of courses and facilitating new education teaching methods.

(d) Promoting the cultivation of advanced technology talent and increasing talent competitiveness

The government promoted the Talent Fostering Program for Advanced Industry Equipment and Training Program on Innovation and Entrepreneurship of Biotechnology, facilitate industry–academia cooperation, enhanced innovative entrepreneurship knowledge and capability, provided education resources for major advanced technology fields, enhanced the capability of teachers, and cultivated talent for industry upgrade.



D. Further improving the scientific research environment by promoting systematic reform

(a) Relaxing regulations and creating a friendlier research and study environment

The government led all universities and colleges in Taiwan to adopt a flexible compensation system, amended the National University Endowment Fund Establishment Act to increase the scope of self-help fundraising, and relaxed restrictions on the use of endowment funds.

(b) Promoting the application of big data and enhancing government efficiency in implementing policies

The government capitalized on the academic and research sectors' creativity and capacity, conducted deep analysis of data in the government sector to aid the government in implementing policies, and strengthened the research basis for big data application and talent cultivation.

(c) Promoting industry-academia cooperation and strengthening industry's technology potential

The government promoted the Industrial Value Creation Program for Academia and Using Legal Entities to Link Industry and Academia Collaboration Project, encouraged academia to link with industries and research community, and pushed R&D results toward commodification and industrialization in the pursuit of maximum synergy in an industry-academia-research cooperation model.



(3) Review and Reflection

Taiwan's S&T policies have already brought about fruitful results; however, to pursue greater impact of S&T policies, the government should review and reflect upon issues such as S&T policy achievements, capital application and allocation, R&D environment, and the effect that policies have exerted on industrial economy and on people's well-being. These reflections should then be used as a basis of reference for future policy planning. The following sections provide a deeper discussion from four major perspectives.

A. Economic development

- (a) The technology research budget should be more focused on helping industrial development.

Balanced S&T budget allocation has been overemphasized, resulting in a loss of focus and the government's R&D budget allocation being too widely dispersed. In addition, many industries' development plans are inconsistent because of changes in personnel.

- (b) The link between R&D budget growth and industries' capability and autonomy on key technologies is weak.

Although the R&D budget as a percentage of GDP has increased each year, and the technology trade deficit has gradually decreased, the technology balance of payments remains lower than other major countries. This shows that the



link between R&D expenditure and industries' capability to control key technologies must be strengthened further.

- (c) S&T policies should place more focus on the challenges and opportunities presented by emerging technologies.

Rather than simply assisting industries in strengthening existing technologies, the government should place more focus on the challenges and opportunities presented by emerging technologies such as the digital economy, applications of IoT, green energy, the circular economy, and biotechnology.

B. Social development

- (a) The performance of technology applications in safeguarding food safety should be improved.

Food safety has become a pressing issue in recent years, severely damaging people's confidence in the government's ability to ensure food safety, as well as worsening Taiwan's image as a "food-lovers' paradise." In addition to fixing existing shortcomings in the system and regulations, the government should also make better use of technology tools to improve the efficiency in ensuring food safety to truly guarantee people's health and well-being.

- (b) To respond to a rapidly changing social environment, medical technology applications should be adopted and strengthened to enhance people's health.



As society rapidly changes and develops, healthcare systems face many new challenges. Emerging transmittable diseases, non-transmissible diseases, mental health, and child healthcare are all examples of new emerging problems that affect people's health. The following points are issues that the government should place more focus on in the future to ensure people's health. First, the government should seize the opportunities now offered by the digital era and develop policies related to e-mental health. Second, the threat of emerging diseases increases by the day; diverse information systems should be introduced to monitor and provide early warnings for transmittable diseases. Third, intelligent and automated clinic medical operation system should be introduced to continuously monitor indices and resolve any irregularities to improve medical efficiency and quality. Fourth, as methods of bioinformatic and disease testing are evolving rapidly, more focus should be placed on the development of precision medicine in the future.

- (c) The scope of application for disaster prevention technology should continue to be expanded.

Taiwan is one of the countries at high risk of facing natural disasters. It is crucial to address issues such as the following: enhancing watershed early warning technology and safety management mechanisms to improve watershed disaster resilience; forming responsive measures to rainfall impact caused by climate change and developing intelligent technology to enhance national disaster resilience and thus

create a sustainable and secure urban environment; and leveraging IoT and big data technology to establish an intelligent disaster prevention environment.

- (d) Green technology should be developed to realize the goal of becoming a low-carbon society.

Taiwan is a country short of natural resources and therefore has a higher urgency than neighboring countries to develop green technology and build a low-carbon society. The government's S&T policies should focus on enhancing the efficiency of renewable energy and developing low-carbon power-generating technology, thus building an environment of sustainable development. A circular economy should also be developed, stressing the importance of waste reduction, recycling, and reusable resources to create additional forms of value and efficiency.

- (e) National information security capabilities should continue to be improved.

Recently, internet data security threats have rapidly increased, requiring the government to implement different levels and types of information protection measures. In the past, the government's information security focus has mainly been placed on the establishment of information system security and internet protection mechanisms; however, the current main task lies in effectively preventing information leakage and ensuring the security of mobile devices and telecommunication networks.



C. Talent cultivation and attraction

(a) Technology talent cultivation mechanism must be transformed.

Taiwan's existing technology talent cultivation mechanism must undergo systematic and functional transformation to correspond to new technology development trends and cultivate talent in diverse fields, rather than being limited to traditional education regime.

(b) Lack of education and teachers in professional and interdisciplinary fields must be addressed.

Education and research in the universities have always operated individually in the past and the application of academic resources has been limited. Teachers and education in professional or interdisciplinary fields need to be improved.

(c) Links with international talent must be strengthened.

In recent years, Taiwan has been a net exporter of top talent to countries such as Singapore, Hong Kong, mainland China, and South Korea, resulting in serious brain drain. Taiwan should strengthen its links with international talent by taking advantage of top talent allocated worldwide as a channel to cooperate with the global community, promote international cooperation, and assist with the cultivation of talent with international perspective and experience. Universities and companies should be encouraged to pro-actively approach other countries, employ policy instruments such as national integrated research projects or cross-border technology



cooperation to establish foreign research institutes or companies, and establish links through Taiwanese talent deployed abroad.

- (d) International talent attraction and retention policies must be improved.

Taiwan does not provide good incentives such as attractive compensation to top talent. Moreover, many restrictions are imposed on foreign talent, making it even more difficult to attract top talent to Taiwan. In the past, Taiwan has focused on “task-based” or “single-function” migrant worker policies to attract foreign professionals. Because of these conservative policies, insufficient focus has been placed on long-term development of diverse and integrated talent attraction.

D. Ecosystem for S&T Development

- (a) A technology foresight and R&D budget allocation mechanism remains to be established.

The linkage between technology foresight and R&D budget allocation remains to be established. With the external environment always changing, it is one of the most critical tasks of the government to invest its limited budget into key areas to address the various challenges of sustaining national development.

- (b) The international R&D cooperation network must be continuously improved.



Taiwan's current international R&D cooperation lacks a systematic integration. Although many international cooperation projects are currently ongoing, in which many universities have signed agreements or MOUs with foreign universities, a systematic R&D cooperation network remains lacking.

In terms of government efforts, authorities such as the MOEA, MOST, MOE, and MOFA have established responsible unit in promoting international R&D cooperation. Project funding measures have also been provided, such as Technology Development Program (TDP), international cooperation research project, and bilateral S&T cooperation program, to assist with enterprise and research institutions' international R&D cooperation. However, some problems persist, such as the lack of a horizontal linking platform and mechanism, insufficient coordination and integration between agencies and programs, and inefficient use of resources.

- (c) The performance assessment of major S&T projects must be improved.

For current S&T R&D projects, Taiwan currently lacks a mechanism designed specifically to assess the performance of R&D features. Taiwan has only limited resources, and it is crucial to the nation's technology development and competitiveness that the government establishes policies that guide the use of resources in S&T research to assist with national sustainable development. Implementing S&T projects



that ensure full realization of government policies is also necessary.

- (d) Performance evaluation systems for research projects must be improved.

Performance evaluation systems and related indicators for current research projects must be reviewed and relaxed. The uniqueness of various fields of study and the differences between them must also be taken into consideration when conducting evaluations.

- (e) Industry–academia cooperation must continue to be strengthened.

Government agencies' allocation of R&D resources is distributed across various universities and juridical persons, resulting in unsuccessful linkage of the results from different R&D value chain stages. Furthermore, problems such as differences in understanding and insufficient linkage between industry and academia also exist.

4. Future Prospects

The future holds many advantages and opportunities; however, there are also many challenges ahead. Taiwan has a highly efficient and flexible ICT industry value chain, and more industry innovation must be facilitated in the future to create momentum for industry and the economy. Taiwan has very strong technology research potential and fruitful results have already been achieved; in the future, more focus will



be placed on environmental pollution, climate change, and disaster prevention, and research results will be applied to create a better living environment. Taiwan also has excellent talent and a continuously improving education and research environment; in the future, talent cultivation, attraction, and retention mechanisms will be enhanced to maintain national competitiveness. Business sectors and the government are also fully aware of the importance of scientific R&D; in the future, the basic environment of technology research and innovation will be further improved, and resources will be integrated with private sector so that the nation's innovation system may operate more smoothly.

In economic terms, in the digital economy era, Taiwan must learn to control and manage the global innovative economic development model arising from the internet, and transform achievements in R&D into forward momentum for industrial innovation. Taiwan will establish a data flow platform to facilitate the rapid application of abundant corporate and consumer information, which in turn will benefit the development of a diverse and inter-disciplinary innovation application. Furthermore, industrial clusters will be built and innovative economic development will be encouraged through the establishment of a regional innovation system and continuous regulation review.

In social development terms, the government will first take advantage of agricultural technology, make the farming environment friendlier, and improve food safety. Second, it will build a comprehensive disease prevention information network and integrate medical care services to improve people's health. Third, it will improve the disaster resilience of rivers, slope lands, and natural resources to create a sustainable living environment. Fourth, it will enhance the

power generating and storage capabilities of reusable energy sources and expand their application. Fifth, it will introduce green innovative technology and develop a green economy. In ICT terms, the government will continue to strengthen core technologies, meet international standards of information security governance (ISG), and assist with the visibility and publicity of related talent and small and medium enterprises (SMEs) on the international stage.

In terms of talent cultivation and attraction, talent policy will comprise four major points. The first point is cultivating talent with both professional expertise and digital abilities to meet the challenges and opportunities of the digital economic era. The second point is strengthening talent cultivation mechanisms for industry practitioners, and guiding young people's participation in the industry and to meet companies' talent demands. The third point is improving the talent cultivation mechanism for R&D doctorates and closing the gap between education/research and employment demand. The fourth point is creating a friendly living and working environment to attract international top talent, which will in turn consolidate economic development and industrial transformation.

Finally, in terms of enhancing the innovation ecosystem for scientific research. First, the diverse dialogue between government and society must be expanded, and a consensus must be reached among various sectors on supporting national S&T policy development, thus making S&T development to respond to social demand and turning S&T projects into actual practices. Second, a favorable legal environment must be created for industrial application of R&D results and enhance the interaction between society and actual technology research



achievements. Third, support must be provided for academic development to be diversified and liberalized, and the link between academic research and social demands must be strengthened. Fourth, diverse evaluation and promotion systems for higher education must be promoted to guide both industry and academia to focus on the innovative R&D demanded by society and industries, and thus creating a benign cycle in the innovation ecosystem.

Chapter 3 Goals and Vision

The goals and vision of the National Science and Technology Development Plan (2017-2020) are as follows:

Goal 1. Revive Economic Dynamics through Innovation

This goal is in response to the arrival of the digital economy era. Business services which integrate big data and then provide/share large amounts of industry information represent a major global trend for industry development. If Taiwan wants to revive economic dynamics through innovation, it must learn from current economic models of global innovation that have been driven by digital networks, effectively transform the fruits of domestic R&D into foundations for industry innovation, and establish a comprehensive platform for data exchange. Doing so will ensure that large amounts of industry information and consumer information can be shared and used rapidly, which can help develop cross-disciplinary and diverse innovative applications. This will create a nurturing environment for industrial innovation by integrating all economic regions in Taiwan. At the same time, regulatory systems and the industrial environment must be adjusted in order to stimulate growth for the innovation economy.

Goal 2. Develop Robust Smart Living Technologies and Industries

The goals related to agriculture are aimed at using smart technology in agricultural production, creating an agricultural environment that is both safe and competitive, and ensuring that crops



are safe for Taiwanese consumption. The goals related to medical technology are aimed at enhancing the emergency medical system for children and employing digital technology to boost the mental and physical health of citizens, including establishing a robust information network to prevent disease, and a mechanism for integrated medical services that will enhance the health and well-being of all people in Taiwan. The goals regarding disaster prevention are aimed at boosting robustness of valleys, mountainous regions, and natural resources to disasters. They will create safe and sustainable urban areas; enhance the earthquake-resistance of core infrastructure; develop smart technology to help prevent disasters; and use emerging smart technologies to create a smart, safe workplace on all levels. The goals regarding green energy technology are aimed at boosting renewable energy so that it accounts for 20% of all electricity produced in Taiwan by 2025. This will include expanding smart meter, establishing integrated pilot sites, and developing key technology and services for industries, which will save energy and reduce carbon emissions. These goals also seek to introduce innovative green technologies during product design and production phases; invigorate the green economy; develop decommissioning technology to shut down nuclear plants; and help Taiwan create a green, nuclear-free homeland. The goals related to environmental quality are aimed at laying a solid foundation to develop IoT, deploying IoT sensors to monitor environmental quality, and effectively maintaining the quality of the environment while simultaneously driving the growth of domestic IoT industries. The goals related to cyber security are aimed at paving the way for the development of core technology in

Taiwan, adopting global standards for ISG, helping individual talent, as well as small and medium-size enterprises, obtain renown on the international stage, and boosting the international impact of Taiwan's cyber security technology.

Goal 3. Foster and Recruit Talent with Diverse Career Paths

The Executive Yuan aims to encourage all ministries and government agencies to combine the energies of local industry, academia, and research community to promote the major 5+2 Industrial Innovation Plans (which covers biomedicine, green energy technology, smart machinery, national defense, and the Asia Silicon Valley, as well as new agriculture and the circular economy). The digital economy forms the foundation for the 5+2 industries, so there is a great demand for the quality and quantity of S&T talents. There are four major strategic plans: (1) Foster Interdisciplinary Talent in the Digital Economy; (2) Reinforce Technical Expert Training Mechanisms for Industries; (3) Diversify Career Paths to Invigorate the Cultivation of High-Caliber Scientific Research Professionals; and (4) Recruit and Retain International Top Talent. These four plans aim to respond to the challenges and opportunities of the digital economy by developing cross-disciplinary talents who combine expertise in a specific field along with the digital skills required for success in the digital economy. These plans aim to enhance training mechanisms for industry technicians, encourage youth to develop their career in industry, create talent to satisfy industry demands, and upgrade the skills of employed workers. They will also improve



training mechanisms for doctor of philosophy (Ph.D.) holders working in R&D industries in order to reduce the gap between education/research and employment demand. They will bolster measures to recruit world-class talent, creating an environment that makes life and work easier for international talent, thereby attracting more global talent and forming a stronger connection with the world. All of this will be accomplished with a view to laying a foundation to support Taiwan's transition to an innovation economy and boosting industry competitiveness.

Goal 4. Enhance the Innovation Ecosystem for Scientific Research

This goal aims to build a national consensus on S&T policy through legal amendments and dialogue with various stakeholders. It also aims to adopt legislation and complementary measures required for R&D knowledge transfer and innovative models for collaboration between academia and industry; creating a friendly legal environment for commercializing R&D results; and enhancing the interaction between academic knowledge/scientific research and society and the economy. In addition, the government must create research infrastructure that meets international standards, support diverse and free academic research, and foster a deeper connection between academic research and societal needs. It must also promote diversity within the accreditation of higher education and within the rules of faculty promotion evaluation in the universities. Furthermore, the government must guide innovative R&D within academia and

industry that is directed at meeting societal needs and industry demand, and use both talented professionals and R&D as the driving force behind industrial innovation, creating a positive and progressive cycle for the innovation ecosystem.



Chapter 4 Strategies and Important Measures

Goal 1. Revive Economic Dynamics through Innovation

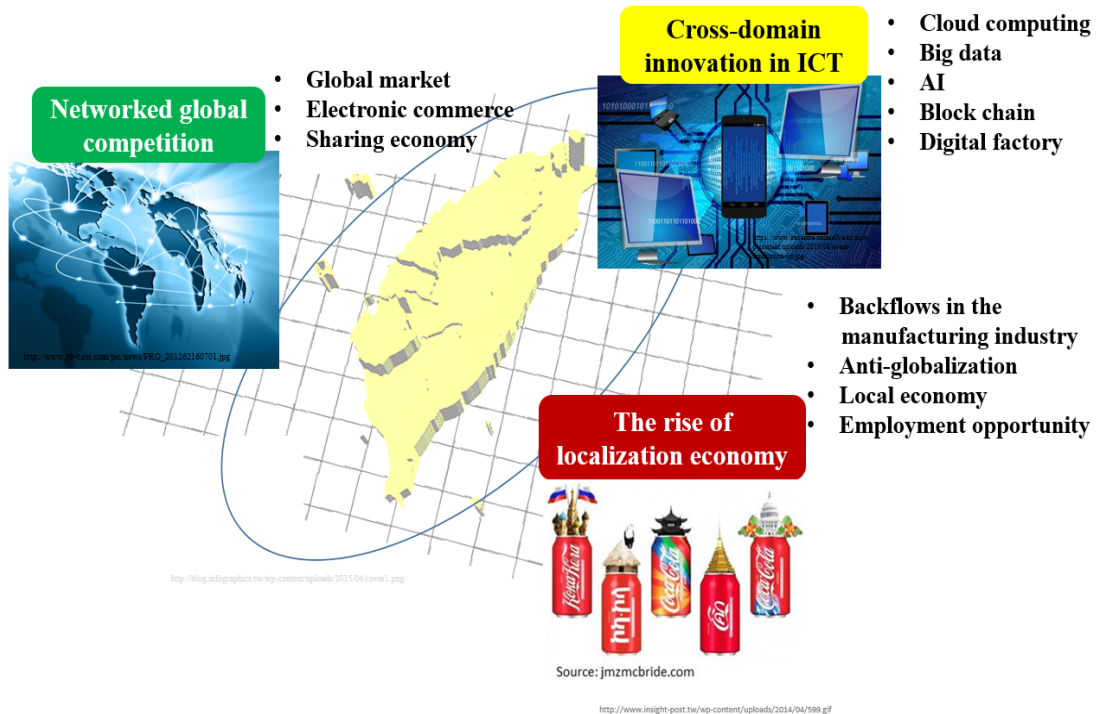


Figure 12 Overall Illustration of Goal 1

With the coming of the digital economy era, the cross-domain integration and application of big data has increasingly become the crucial part of current & emerging industries. In addition, with the rapid developments of mobile and digital information technology, major digital reforms will also occur. To reconstruct economic momentum through innovation in Taiwan, we must grasp the current developmental trends of global innovative economies resulting from digital networks, for effective transformation of Taiwan's technology R&D results into energy for innovative industrial developments. In addition, well-organized data circulation platforms should be established to facilitate the swift sharing and use of substantial industrial and consumer information, for the benefit of developing diversified, varied, and cross-

domain innovative applications and services. Furthermore, we can facilitate the development of an innovative economy by integrating the industrial innovative ecology cultivated in each regional economic system in Taiwan while making adjustments in regulatory systems and industrial environments. With the constant progress of digital economy, all domains are confronted with changes in terms of technology integration, business model innovation, and industry chains. In view of this, the urgent issues in industrial developments currently lie in how to fortify the momentum of Taiwan's economic growth by promoting innovative growth in industries on the basis of innovative thinking. The current situation and trend analysis of each dimension of this goal is as follows:

(1) Current Situation Review and Trend Analysis

A. The key to make transformations in industrial innovation lies in how to create substantial benefits in digital economy by developing commercial application models based on big data technology.

(a) Regarding big data applications, corporations in Taiwan require commercial, innovative, and cross-domain talent: The government should promote open data to allow industries the opportunity to participate in service innovation and realization.

To respond to the digital economy era and the accompanying digitalized society, cross-domain integration and application of big data to initiate commercial services for sharing and using substantial industry information are expected to become the core of industrial application in the



near future. However, in terms of big data applications and developments, corporations in Taiwan are still hindered by many obstacles at present, including the following:

- Corporations have difficulties in framing the key issues required for big data solutions: Corporations are unable to evaluate detailed input–output because they are unclear on the values and problems can be caused or solved by such data.
- The diversity and instantaneity of big data are insufficient in commercial applications: At present, in big data analyses, corporations have fewer links with external data; in terms of quantity and diversity, their accumulated data cannot be comparable to those of international enterprises. Data value should be discovered through cross-industry cooperation. However, corporations in Taiwan are confronted with regulatory restrictions in the development of cross-industry data integration. This is the main challenge in innovative applications and developments.
- Cross-domain big data talent for commercial innovation is lacking: In the current supply chains of big data talent in Taiwan, the amount of such talent is clearly insufficient, ranging from algorithm engineers and data programmers to data scientists. Hence, there are gaps in both the planning and execution of innovative data services in Taiwanese corporations.

- Swift evolution in the development of international open data: With support from industry, academia, and research institutions, the government has been promoting open data in recent years, and ranked No. 1 in the Global Open Data Index in 2015. The most critical issue for now is how to stay ahead of others and cope with the gradually increasing quantities of open data sets as well as the trends for diversified categories and swift evolution of international open data developments.

(b) Taiwan requires soft and hard power integration to assist corporations in making transformations in software applications and the digital entertainment value chain. In addition, motion-sensing technology should serve as a pioneer in innovative technology applications.

In recent years, due to the relevant evolution of mobile communications technology, breakthrough developments have also occurred in transmission technology, display technology, and sensing techniques. Taiwan also has advantages in hardware R&D and manufacture, which are reflected in various new devices (e.g., head-mounted display virtual reality (VR) equipment, smart bands and watches). Taiwan must now urgently provide assistance for corporations in making transformations, input of software applications, and the digital entertainment value chain, through soft and hard power integration. Motion-sensing technology is an apt example of an innovative technology application derived from technology developments.



Motion-sensing technology is a type of human-oriented technology application that combines content, software and hardware, mechatronics, and cloud and big data. Various sensory effects can be achieved through motion-sensing simulation, augmented reality (AR) and VR, and wearable devices. This is a highly innovative industry of cross-domain integration. Numerous commercial applications of specific domains can be developed further, in addition to entertainment purposes.

- (c) The development of digital environments depends on rapid, steady, and flexible network environments. Governments and private sectors should work together to pour resources into next-generation communications technology R&D.

Mobile and digital information technology advances rapidly, resulting in digital reforms in human life and corporate developments. With the constant progress of digital economy, industries including smart machinery, Asian Silicon Valley, biomedicine, green energy technology, new agriculture, and circular economy are also confronted with changes in technology integration, business model innovation, and industry chains. The urgent issues in industrial developments currently lie in how to support the development of innovative industries by means of the digital economy.

To realize instant transmission of substantial information through big data and the cloud, the development of digital environments heavily depends on rapid, steady, and flexible

network environments. Therefore, governments and private sectors should work together to pour resources into the R&D of next-generation communications technology, including Beyond 4G (B4G), 5G, and low-power wide-area network (LPWAN). In addition, site demonstrations should be held in combination with application services to develop a new industry ecosystem under the development of the digital economy.

(d) For enhancing competitive advantages, the service industry in Taiwan requires cross-industry cooperation and cross-border development of commercial value, while the government must ensure innovation in service and marketing mechanisms by introducing smart applications to the IoT.

- Developing a smart consumer ecosystem in the digital economy: Service industry intellectualization is flourishing with the progress of the digital economy, thanks to the application of IoT services. This helps to subvert the traditional systems of supply and demand and consumer value. According to the market estimations of the global IoT made by Gartner's Industrial Economics and Knowledge Center, 80% of the commercial opportunities in the IoT will derive from application services until 2020. According to the observations of Frost & Sullivan, applications in retailing and travel account for the greatest growth; applications in retailing primarily provide an optimized consumer experience as well as strategic layouts for omni-channel retailing. SMEs account for the majority



of the service industry in Taiwan. Without cross-industry cooperation, they will face difficulties in winning sustainable competitive edges in domestic and international markets. Therefore, they are continuously and actively seeking cooperative partners. More than 70% of such enterprises report that it is difficult to find trustworthy partners with credible experiences. Less than 10% of such enterprises have joined any cross-industry R&D alliance.

- Creating an ecosystem of cross-border E-commerce in the ASEAN: In recent years, the growth of ASEAN markets has gradually garnered increasing attention. It is estimated that a 25% growth will occur annually in the potential development of E-commerce shopping. Geographically, Taiwan is close to ASEAN countries and is also similar in the aspects of consumer culture and market scale. In addition, compared with the US, mainland China, Japan, and Europe, Taiwan is also closer to the ASEAN countries in terms of E-commerce technology, regulatory environment, and developmental experience. Thus, by fully leveraging such advantages, Taiwan can build a cooperative partnership with the ASEAN to develop E-commerce industries collaboratively. In terms of the trading domain of business to business (B2B) in Taiwanese corporations, demand for substantial improvements is ongoing regarding the use of big data trading analyses as well as the proportion of cross-border E-commerce in expansion and distribution in international markets. However, SMEs account for the

majority of corporations in Taiwan, which means that many gaps remain in their application of digital technology. The government should provide continuous guidance for corporations to understand and capitalize on the trend of digital trading developments by using online and offline diversified expansion and distribution tools to contribute to successful worldwide marketing.

(e) The application of and innovation in mobile payment are prerequisite environments for the contextual development of the digital economy. Digitized payment environments should be optimized continuously.

- Taiwan currently has robust and well-organized laws and regulations related to mobile payment. As of the end of December 2016, the mobile payment situation in domestic financial institutions was as follows: 21 institutions offered trusted service manager (TSM) mobile credit payment; 13 institutions offered host card emulation (HCE) mobile credit payment; 16 institutions offered mobile ATM cards; 15 institutions offered QR code mobile payment; 7 institutions offered mobile point of sale (mPOS) services; and 2 institutions offered mobile X cards. Total transaction amounts reached approximately NT\$ 2.36 billion.
- The domestic environment of mobile payment has been enriched and rapidly applied in various ways: As of the end of December 2016, 50,573 contactless ATM card readers had been used for mobile payments in Taiwan. Furthermore,



app-based mobile payment has been made available through the e-Bill National Payment Network, in addition to the service of interfacing mobile channels with financial institutions via the application programming interface (API).

- Various mobile payment modes continue to be developed in global markets, for example, a mode in which primary account numbers (PANs) can be deposited in secure elements on mobile phones via TSM service platforms. An HCE mode is also available, in which the activities of secure elements are emulated on the cloud via host computers. In recent years, the “token” technique has been developed, in which PANs are replaced by codes and deposited on mobile phones.
- (f) To help the public grow accustomed to the digital economy, the government should continue guiding startups and SMEs to collaborate in cross-domain fusions and applications of big data and ICT. Thus, innovative commercial applications will be realized, while consumer value flourishes.

Because of the progress in relevant big data gathering and analysis techniques, the concrete realization of data economy has gradually advanced in application aspects such as smart machinery and new agriculture, through IoT concepts. However, most of the countries that have devoted substantial resources to such aspects have prioritized guiding the cross-domain (cross-border) fusions and applications of various

software and hardware technologies and ICT, based on commercial applications and consumer value.

However, most corporations in Taiwan are situated at specific links in supply chains, in which the involved upstream and downstream vendors have uncomplicated data in cooperative relationships and commercial behavior. Therefore, Taiwan should exert more effort in facilitating public awareness of the digital economy, with the key points being how to combine upstream, midstream, and downstream vendors vertically and equivalent vendors horizontally to collaborate in new, data-based business models; such innovative business models are aimed at shaping the main theme for satisfying customer lifetime value. User feedback can thus be obtained continuously by promoting application service solutions.

B. Industrial applications of scientific research achievements should be implemented as soon as possible to facilitate innovative industrial developments.

(a) Activating R&D momentum in governmental or departmental juridical persons and research institutions by spreading diversified results, enhancing talent capabilities, and strengthening international exchanges and cooperation.

R&D juridical persons, who provide assistance for industrial developments, have been weakening somewhat in many aspects in recent years and are therefore confronted with numerous difficulties and challenges. The current situation



and problems for scientific research juridical persons in regards to forms of scientific research, as well as the three aspects of performance, talent, and international exchanges, are listed and explored as follows:

- Forms of scientific research and performance
 - The ministries or departments of each juridical person have different natures and tasks. For example, the juridical persons governed by the MOEA emphasize industry, whereas the juridical persons governed by the MOST emphasize academia. However, horizontal communication mechanisms remain insufficient between different ministries or departments and juridical persons. Hence, proactive academic research cannot be effectively integrated with industrial practice. In addition, the insufficiency of cross-institution or interdisciplinary research plans leads to a weaker grasp of the trend of innovative technology R&D, as well as inferior activation of the R&D energy between different juridical persons.
 - Research achievements lack systematic and integrated developments. For example, intellectual property rights belong to specific executive units, without any centralized management. Consequently, integrated effectiveness is difficult to achieve, resulting in limited positive implications on industrial developments.
 - The measurement mechanism for juridical persons' performance, as evaluated by the existing competent



authorities, is focused primarily on short-term annual indicators, such as patent applications or number of certificates granted, numbers of journal articles, proportion of self-financing, and amount of profits. Consequently, short-term effectiveness is pursued through cooperation among juridical persons, industries, and academia, instead of long-term planning and technology cultivation. This situation leads to poorer examination of long-term effectiveness and inferior long-term developments.

- Scientific research talent
 - Achieving ideal conditions for attracting top talent is difficult when subject to traditional organizational charters and salary levels.
 - As for middle-level cadres, an M-shaped trend occurs in the structure of talent because of company spin offs.
- International exchanges and cooperation
 - At present, fortified improvements remain necessary for international cooperation activities in innovation technology.
 - Connections should be forged with international professional talent as well as cooperation with foreign enterprises.



- Tasks such as information exchanges of digital economy should be undertaken collaboratively with embassies and compatriot communities.

(b) Strengthening the links between industries and academia through TDP subsidy mechanisms to facilitate 5+2 industrial innovation developments.

- Current situation

To assist industries in enhancing their short-, mid-, and long-term technology R&D capacities and using the research results of academic studies effectively, all units (e.g., MOST, COA, Department of Industrial Technology (DOIT) of the MOEA, Industrial Development Bureau (IDB) of the MOEA, Bureau of Energy (BOE) of the MOEA, Small and Medium Enterprise Administration (SMEA) of the MOEA, and Department of Commerce of the MOEA) should make comprehensive appraisals based on perspectives such as industry tendency, governmental policies, livelihood demands, and respective responsibilities. In addition, under the principle of using resources effectively, R&D subsidy mechanisms related to industries and academia should be promoted, and the government should arrange and encourage bilateral cooperation. The major technology R&D projects in industry and academia in existing ministries or departments mainly include the following:

- Major Alliances between Academia and Industry of the MOST: Enterprises are encouraged to form alliances to engage in proactive technology R&D with academia, based on the model in which academia provides solutions for the problems raised by industries.
- The A+ Industrial Innovative R&D Program of the MOEA: Enterprises are encouraged to engage in long-term R&D of high-level advanced technology or leading techniques. Proprietors are encouraged to engage in vertical, horizontal, and interdisciplinary cooperation and integration, to develop a complete industry ecosystem. International conglomerates should be attracted to Taiwan to establish R&D centers and realize joint R&D of key modules and components with Taiwanese proprietors.
- The Industrial Value Creation Program for Academia of the MOEA: Based on R&D results in academia, commodification developments should be introduced jointly with R&D capacity in enterprises or juridical persons. Ultimately, the goal of this program is to drive new ventures. Through multilateral cooperation, it aims to spread academic R&D results to industries by means of technology industrialization, to create greater industrial value and social benefits.
- The Taiwan Industry Innovation Platform Program (TIIP) of the MOEA: Research funding are provided to



- encourage enterprises to engage in innovative R&D through both bottom-up and top-down R&D programs.
- The Small Business Innovation Research Program (SBIR) of the MOEA: SMEs are funded to develop innovative techniques and services, while R&D results are put into practice, and applied extensively and commercialized to meet market and customer demands, thereby aiding the sustainable operation and growth of domestic SMEs.
 - The Service Industry Innovation Research Program (SIIR) program of the MOEA: Proprietors in the service industry are guided to engage in innovative exploitation tasks for new service products, new business models, new marketing models, or new commercial applications of technology to enhance their added value and create competitive advantages.
 - The Industrial Energy Technology Program of the MOEA: Enterprises are encouraged to engage in innovative applications and relevant services, such as new energy and renewable energy, energy saving and carbon reduction, and system integration, to enhance industry value added.
 - The Agricultural Technology Development Program of COA (academia, research communities, and industries): Upstream, midstream, and downstream R&D systems are integrated to use agricultural R&D resources effectively, thereby overcoming difficulties in industrial developments by infusing innovative momentum and



facilitating industrial independent innovation and sustainable development.

- Issue discussion

- In response to the 5+2 Industrial Innovation Policy, many adjustments are still required for R&D themes: According to the overall observations of the R&D theme of current industry–academia programs, most focus primarily on biomedicine, smart machinery, ICT, IoT, and renewable energy. Less emphasis is placed on circular economy industries and national defense industries, which cannot correspond to new industrial policies. Therefore, relevant supportive measures must be determined to enable cross-domain integration of academic technology and achievements and meet the demand for industrial commodification. Thus, we can respond to and assist relevant new ventures in advancing along the right paths.

- Several industries have weak R&D capacity and should therefore be actively encouraged to leverage academic resources to enhance R&D effectiveness: In the past, because of the prosperous development of the ICT Industry, Taiwan has attracted considerable R&D talent and resources. However, the emergence of IoT technology has facilitated the upgrading of vertical industries. Therefore, it is crucial to promote new waves of industry–academia cooperation while ensuring in-depth planning aimed at meeting the goals of 5+2 industrial innovation.



- Industry–academia collaboration mechanisms and effectiveness require reinforcement: The proposals and execution of TDP show that resources have not been fully exploited at various stages. Superior industry–academia matching mechanisms and relevant supportive measures must be identified to engage in cross-domain integration of academic technology and meet the demand for industrial commodification.

C. To maintain sustainable growth energy in industries, regional innovation systems should be fortified.

(a) Science parks should serve as regional innovation hubs, connecting local industries, academia, and research communities, to facilitate innovative transformation.

Because of globalization, talent and resources are widely distributed. Thus, there is keen competition among more than 400 science parks worldwide. Unlike the previous role of merely focusing on R&D, science parks have gradually transformed into facilitators for speeding up knowledge conversion and creation of cross-organizational innovation networks. They are also critical sites for activating regional economies and forging links in innovative ecosystems. The resources required far exceed the parks' capacities, which should be resolved through the integration of regional innovation resources. Thus, not only will the parks of new generation form the basis for production and manufacture, but

the parks will also shoulder the important responsibility of serving as regional innovation hubs.

Taiwan's science parks have always been crucial bases for R&D and production in high-tech industries. For many years, they have also been benchmarks for the development of science parks internationally. According to the indicators of State of Cluster Development in the *Global Competitiveness Report* from the WEF, Taiwan's science parks have continuously ranked in the top 5 in the world since 2010. This is a critical factor in attracting investment from domestic and foreign vendors. However, during the past 5 years, there has been a slowing tendency in revenue growth. The recovery of the global economy was particularly weak in 2015, which hindered the kinetic growth in sales in terminal consumer electronics products. However, each park still actively engaged in R&D and innovation. Hence, revenue remained at the level of NT\$ 2.3 trillion, while a balance has gradually been achieved in R&D energy between Southern Taiwan and Northern Taiwan.

Numerous types of critical industrial clusters, such as integrated circuit (IC), photoelectronics, precision machinery, ICT, and biotechnology, have been formed in Taiwanese science parks. Not only are they attractive to industry leaders as a part of their strategies, but they also provide sturdy foundations for industrial development. In the light of future industrial development needs in Taiwan, innovation and technology will replace the previous original equipment



manufacturer (OEM) and manufacture patterns. The industrial resources accumulated in the existing parks will further serve as crucial bases for developing the industrial innovation and R&D promoted actively by the government (including biomedicine, green energy technology, Asian Silicon Valley, smart machinery, national defense, circular economy, and new agriculture). With the overall development of peripheral supply chains facilitated by emerging industries, local industrial clusters are also more closely linked to the promotion of innovative transformation for international market output.

To forge active links among the innovation energy from industries, academia, and research communities, and leverage kinetic transformation energy to improve industrial competitiveness, science parks can serve as pioneering hubs for regional innovation. By using industrial clusters with innovative energy and the plentiful resources of peripheral academic and research capacity, they can be actively combined with their surrounding areas through urban planning, thus forming development bases for emerging industries. In addition to activating regional economies, the parks emphasize formation of industrial clusters and the cross-domain integration of heterogeneous industries. This will help guide existing industries in upgrading and transforming themselves. Clusters of innovative industries will also be cultivated thereby to strengthen the innovative and economic energy in overall industry in Taiwan.

(b) Fortifying the regional innovation system through the establishment of a regional platform for cooperation between governments and industries

- Current situation

Under global competition, regional industries will be the driving force for Taiwan's economic development because a nation's innovative capacity cannot be improved merely by depending on the designs and guidance of central governmental systems. Instead, the innovation capacity for having robust establishments in each region is much more crucial. According to regional innovation systems, regional organization systems can be formed by multitasking and relevant innovative units within a certain territorial scope with open borders (e.g., systems constructed by central government, local government, enterprises, research institutes, and higher education institutions). Such innovative units can result in new achievements through interactive learning and knowledge exchanges, and can create the benefits of a knowledge-based economy. However, forming regional innovation systems and achieving national competitiveness depends on whether such innovative units can have mutual connections and cooperate effectively. Industrial clusters congregate because of regional demands. The industries within such a congregated cluster can learn from one another, which benefits innovation. Industrial clusters are also beneficial to the congregation of specialists, as well as the reinforcement



of professional knowledge exchanges, diffusion, and sharing. Regional industrial developments and innovation can be promoted further by means of information circulation, technology transfer, technology diffusion, and innovation.

The establishment of six municipalities has changed the structure of administrative power in Taiwan. Regional stakeholders' needs and characteristics should be taken into account by the central government when making regional industry policies. From the perspective of innovative roles in regional innovation systems, whether the innovation promotion units of central and local governments can cooperate is, to a large extent, critical in regional industrial developments and promotion. However, based on regional industry cooperation between the central government and local governments in the past, the following challenges need to be overcome: 1) Because central and local governments have inconsistent goals in regional industrial developments, reasonable layouts cannot be realized for regional capacities; 2) Local governments anticipate participation in the enactment of industry policies, despite channels and platforms being insufficient between governments, which hinders the communication of both parties' opinions and needs; 3) The central government provides insufficient support to regional industry cooperation and local governments are not enthusiastic about it. Hence, in terms of regional industry developments,



both parties cannot reach a consensus, and they lack the necessary resources; 4) Regional industry policies lack well-organized local implementation systems and institutions. In the past, industry development policies have been enacted by the central government. However, in terms of policy creation, linear local implementation systems and management organizations led by local governments are lacking. 5) Cross-governmental meetings of industrial policy have convened infrequently, and most meetings have been held in the capital. Therefore, the current pattern can be viewed as a broken link in regional innovative units, which will adversely affect regional industry developments and the entire regional innovation system.

- Issue discussion

The establishment of six municipalities has had a major impact on regional industries but local governments continue to play insignificant roles in terms of the enactment of regional industry policies. Disagreements in industrial policy enactment between the central and local governments often result from gaps in their understanding of such policies. The governments also lack the channels that connect industry policies and communication, which tends to result in gaps in understanding. The failure to form a consensus in industries leads to inadequate use of resources. Consequently, regional industries have poorer innovative capacities, and Taiwan's overall competitiveness and synergy weakens.



Vision and plans for the future are laid out through proactive foresight activities concerning regional industry policies. A well-organized proactive governance system should be established by means of future governance for short-term and long-term plans for the future with proactive activities concerning regional industry policies. Proactive policy systems should be strengthened to closely connect the central government and local industries, authorities, academia, and research fields. For enhancing proactive, legitimate, and continuous regional industry policies, a consensus should be reached through realization of plural participation.

(c) Cultivating greater R&D capacity in industrial innovation through the establishment of industrial innovation R&D platforms

- Current situation

For many years, to maintain local industrial cluster developments, the MOEA, with the R&D capacity in its juridical persons, has applied its main policy tools through the establishment of regional industry innovation research parks and centers, and by providing guidance for industrial clusters. Several local innovation bases have now been created (e.g., Southern Taiwan Innovation & Research Park, CHIAYI Industry Innovation and Research Center, Kaohsiung Software Technology Park, Central Taiwan Innovation Research Park, and Eastern Taiwan Industrial

Technology Service Center), all of which are aimed at serving as local innovation R&D platforms. In addition, with measures such as industrial assistance, an industrial arcade can be connected to speed up local industry upgrading and transformation. Although these regional industry innovation research parks and centers are a good beginning for future development, they still require stronger connections with local regional innovation systems. Particularly in consideration of the industrial development policy of the new central government — industrial innovation should be based on developmental basis of specific regions, the main regional innovation systems should be adjusted and optimized simultaneously, to achieve the dual goals of developing innovative industries and promoting balance in regional developments.

To carry out the government's industrial innovation and R&D policy based on the concept of "in connection with the future, in connection with the world, and in connection with localities", the MOEA adjusts the developmental directions and operation models for regional industry innovation research parks and centers to strengthen the connection of R&D resources from regional industries, academia, and research communities, with the aim of connecting an industrial arcade to form a sturdier industrial innovation system and speed up industry upgrading and transformation.



While promoting regional industrial R&D innovation platforms in Taiwan, the MOEA will optimize such regional industrial R&D innovation platforms by promoting technical R&D collaboration among industries, academia, and research institutions, thereby implementing and reinforcing the integration of R&D resources in each region. Local industries can be improved to meet international standards with innovative technology via R&D. Thus, governments can realize the pledges—deep cultivation of industrial competitiveness, promotion of industrial clusters, creation of industrial advantages, and innovative industrial growth.

In the future, the MOEA will connect and strengthen the existing infrastructures in relevant ministries and departments, based on instructions to fortify regional innovation systems and maintain the growth energy of industrial clusters. Various resources in MOST science parks, MOEA industrial parks, and innovation research parks and centers in each region should be integrated to create industrial clusters with regional features when carrying out Industrial Innovation Research and Development Plans. This can provide and maintain the innovative growth energy for Taiwan's industrial clusters, with the aim of assisting industries with transformations and industrial technology innovation, and gaining competitive advantages for sustainable development.

- Issue discussion

In terms of the future development of regional industry innovation research parks and centers, the MOEA should consider local resources and planning for industrial innovation R&D, local governments' input and focal points for industrial development, along with reform of TDP mechanisms, such as major juridical persons playing the leading role in regional R&D. By doing so, industrial innovation R&D platforms applicable to the development of major regions will be constructed. In addition, the R&D results from industries, academia, and research fields should be integrated effectively to speed up the promotion of industrialization.

Although regional industry innovation research parks and centers across Taiwan should be the focus for facilitating the innovative momentum of regional industrial innovation, many cross-ministry and cross-department issues hereby involved must also be discussed. In the future, the MOEA will act as the coordinator among all ministries and departments. In addition, such promotions should be in line with the main developmental themes of each local government by approaching regional industry needs combined with the R&D capacity from local universities. Thus, the energy of industrial innovation and R&D can be provided to local industries more effectively.

- (d) Revamping agricultural operation patterns and developing industrial clusters through the promotion of agricultural technology



Agriculture is an increasingly important industrial category which will undeniably attract attention. Taiwan boasts numerous industrial advantages, such as favorable geographical environment, abundant technological capacity, and industrial transformation. Accordingly, Taiwan has been a major player in global markets for many years. However, in terms of agricultural developments, the focus no longer lies entirely on the output of primary produce, because of changes in the external environment (e.g., global climate change, rapid development of agricultural technology, accessibility and convenience of international transportation, borderless markets). Despite enjoying some industrial advantages, because Taiwan's industrial structures remain focused on primary farmers, agriculture production and marketing groups, and SMEs, comprehensive functions are still unable to be implemented in aspects such as product certificate acquisition, expansion of sales networks, and industrialized management, in the face of competition from international agricultural enterprises. In the future, Taiwan must promote agricultural technology and industrialization. Agricultural enterprises should be integrated by means of industrial cluster patterns, while comprehensive services should be provided, (e.g., quarantining, epidemic prevention, import/export clearance, warehousing, and logistics). Taiwan should establish a value chain of agricultural technology across production, value added, and sales, to create new economic momentum by

further increasing the value of agricultural produce from farming, fishery, and livestock industries.

D. Facilitating domestic innovative start-ups, much friendlier innovative venture environments and developmental mechanisms must be provided.

(a) Links with the R&D energy from academia and research fields can help to construct venture-friendly environments beneficial to new generation industries.

In recent years, Taiwan has promoted the Youth Entrepreneurship Program and the HeadStart Taiwan Project. In addition, relevant policies, such as the Innovation and Startups Taskforce, have also been implemented to provide assistance for youth entrepreneurship. No effort has been spared in perfecting the overall environment for the development of entrepreneurial clusters (ecosystems). Critical elements of the Innovation and Startups Taskforce are as follows:

- International Entrepreneur Initiative Taiwan (IEIT): IEIT is a single-portal website for entrepreneurial services, on which governmental and civil entrepreneurial resources are collected to provide information such as funding, consultation, marketing resources, and entrepreneurial activities and courses. Since its revision in March 2015 until September 22, 2016, the cumulative page views have exceeded 3.7 million, with average monthly cumulative page views of 160 thousands.



- **Taiwan Start-up Hub:** The hub was under trial operation since June 2015, and was then formally launched on August 21, 2015. As of August 2016, approximately 1,002 cases of entrepreneurial consultation services have been provided (of which 274 cases were transferred to governmental entrepreneurial planning offices or private offices) and 242 events have been held, with 10,499 participants. It actively connects 89 civil entrepreneurial communities and working spaces.
- **Mobile Entrepreneurship Taiwan 368 Service:** The tour has held 308 local spontaneous entrepreneurship-themed events in 95 townships in 22 counties/cities nationwide, from August 2015 to August 2016, with approximately 11,660 participants. Of these events, 41 were held in remote areas, 84 were cross-ministry/cross-departmental cooperative activities, and 62 were campus cooperative activities. A total of 74 entrepreneurial communities have been formed nationwide.
- **Social Enterprises Hub:** The cluster has been operational since its launch on May 29, 2015. At the first stage, 10 social enterprise teams were resident. During the period of operation, the teams were not required to pay any maintenance fees. In May 2016, Buildings B and C were completely renovated. At the second stage, 33 civil enterprises were resident. As of the end of August 2016, more than 430 events concerning social issues and

entrepreneurship have been held. These events had approximately 15,000 participants.

- Taiwan Rapid Innovation Prototyping League for Entrepreneurs (TRIPLE): TRIPLE was activated on March 30, 2015. As of the end of August 2016, a total of 385 members (of which 21% are large enterprises, 73% are SMEs, and 6% are R&D juridical persons and incubation centers) have joined. Approximately 275 consultation cases of innovation sources have been undertaken, and 196 TRIPLE applications have been filed, among which there were 37 successful matches, 86 cases concluded and 73 cases due to be matched. All prototypes were adopted and realized by system integration (SI) / original design manufacturing (ODM) corporations in private sectors.
- Taiwan Air Force Innovation Base (TAF Innovation Base): Since April 2016, the Service Office has completed 76 site surveys and guided tours and helped organize 349 events with more than 24,500 participants.
- Business Angel Plan (NDF): This project was launched at the end of 2013. As of September 22, 2016, it has undertaken 257 cases, winning subsidies up to NT\$ 824 million.
- Taiwan Silicon Valley Technology Fund Investment Program: This fund aims to promote links among talent, technology, and funding in Taiwan and Silicon Valley. From May 2015 to the end of August 2016, two applications



(Vivo and WI harper) were qualified to win venture capital. The total funds raised under this plan have reached US\$ 275 million.

- Taiwan Innovation and Entrepreneurship Center (TIEC): So far 55 teams from new ventures have been selected to travel to the US. Among them, 18 teams have been placed in the Silicon Valley accelerator; a total of 29 teams have raised over US\$ 46.6 million in funding.
- Taiwan Startup Stadium (TSS): This project has helped nine teams successfully apply for overseas accelerators, establishing cooperative relationships with 16 international accelerators and forging links with resources such as international venture capital and large enterprises. Many startups have been assisted in successful fund-raising.
- Assisting the Asia Silicon Valley Development Plan: By “building an international cooperative partnership” and “guiding investment and technology cooperation” projects were planned to build an entrepreneurial acceleration ecosystem, in line with the Asia Silicon Valley Development Plan, embodying the Silicon Valley spirit, strengthening links with Asia, fulfilling the policies of innovative startup ecosystem, and promoting the implementation of specific measures related to “providing innovation sites”.

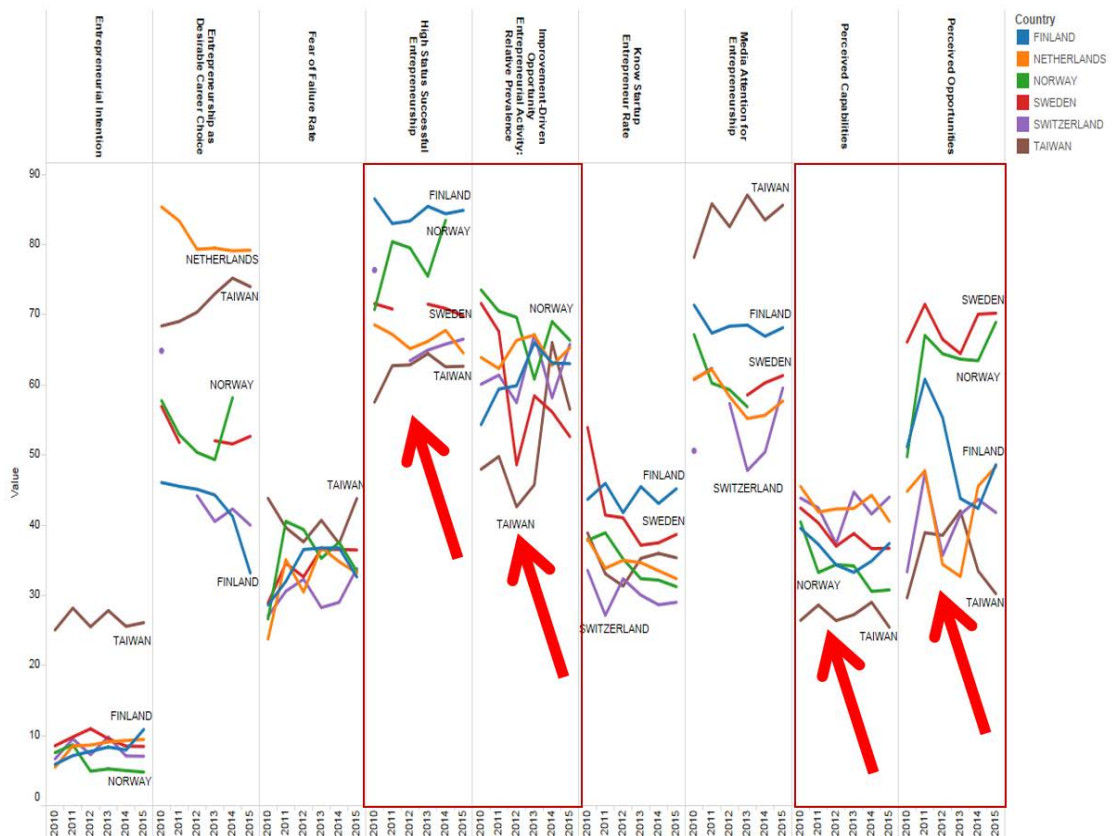
Because of these critical elements, public and private sectors have cultivated entrepreneurial clusters (ecosystems)

with local characteristics (e.g., in Northern Taiwan: Taiwan Start-up Hub in conjunction with National Taipei University of Technology (NTUT) and the Taipei City Government, Appworks, and National Chiao Tung University Innovation Incubation Center, among others; in Central Taiwan: Star-Catching Start-Up of Taichung City Hall, Feng Chia University, Ideax Company, and Han Yang Start Up Incubation Center; in Southern Taiwan: Digital Art Kaohsiung United Office).

Taiwan has a high capacity of technological innovation in new-generation industrial sectors, and has considerable innovation energy in academic and research departments. However, according to a cross-country survey comparison conducted by Global Entrepreneurship Monitor (GEM) (Fig. 13), Taiwan's opportunity-pull entrepreneurs still have insufficient abilities in identifying entrepreneurial opportunities and relevant knowledge. Although the Taiwanese government has promoted many projects to help young entrepreneurs in the past, the key to progress now lies in bringing together innovative energy. In addition, local startup ecosystems must be strengthened to effectively promote disruptive entrepreneurship in the development of new-generation industries and create an entrepreneurship that benefits them. Furthermore, although Taiwan's SMEs have been booming for many years, most are facing the challenges of passing down experience and unable to cope with the pressure caused by emerging technologies. There is an urgent



need to introduce transformation with technologies that can integrate business experience inheritance and is suitable for the new trend of industrial development, thus ensuring that the development of Taiwan's SMEs is sustainable.



Source: GEM Database (2016)

Figure 13 International Comparison of Opportunity–Pull Entrepreneurship Capacity

In the future, Taiwan can link the R&D capacity from academia and research fields to construct an innovative entrepreneurial environment with abundant resources and construct local new-generation industrial demo sites, effectively promoting a new generation of industrial development and passing down experience. The power of



entrepreneurship can help promote the realization of Taiwan's industrial policies and innovation activities.

- (b) Innovative experimental demo mechanisms should be introduced, and the test results can serve as feedback for the competent authorities and as references for regulation adjustments. Hence, laws and regulations related to innovative entrepreneurship can remain relevant.

Taiwan set up the Innovation and Startups Taskforce based on the Regulatory Adaptation Platforms and the Youth Entrepreneurship Program. This allowed a focus on analyzing the issues in regulations related to innovative entrepreneurship and breaking regulatory restrictions for further relaxation. Specific results include the following: In 2013, amendments to the public offering of shares in a company's shareholding guidelines to cancel the stipulation concerning the NT\$ 10 stock denomination; in 2015, amendments to the Company Act to increase special sections concerning closed corporations; in April 2015, opening of equity-based crowdfunding nature to private sectors; in December 2015, Executive Yuan's promotion of the establishment of the first domestic Social Enterprise Revolving Funds to provide social enterprises with small amounts of investment in early development; in May 2016, enabling of social enterprises to apply for investment; in 2015, the commencement of the Entrepreneurial Visa, speeding up the introduction of international persons and teams to Taiwan for creating new businesses. However, in recent years, Taiwanese youth have



continued to encounter many regulatory barriers to innovation and entrepreneurship, in addition to the issues regarding the relaxation of laws and regulations affecting society as a whole. The reason is likely that Taiwan adopts restrictive legislation, unlike the elastic legislation of Europe and the US. Will this make innovation ideas impossible? Will innovation ideas or creative businesses be questioned in terms of legal compliance? Is it necessary to re-examine the purpose of the existing regulations governing the market mechanism? Who can be asked for assistance when entrepreneurs need the competent authority of the trade regulation to relax regulations? Which mechanism can serve as a regulator? It is necessary to continue reforming the regulation systems regarding innovation and entrepreneurship to answer these questions. Industrial needs should be responded to rapidly and existing non-essential control measures should be reviewed, while introducing flexible legislation in response to emerging industries and business models. Thus, Taiwan's industrial transformation can be accelerated and overall competitiveness can be enhanced, with regulations serving to support rather than hinder innovation and entrepreneurship.

- (c) The risks of entrepreneurship and early investment will also increase because of information asymmetry. Trends of innovative entrepreneurship should be deciphered using big data technology, linking early investment resources domestically and overseas so that innovative enterprises can find business opportunities to obtain funds.

In terms of industrial innovation and entrepreneurship development, network economy will be increasingly important in the future, such as e-commerce service innovation, deeper applications of the IoT, popularization of digital finance, social media, the development of digital games, and the integration and application of big data. This not only gives rise to many emerging industries (e.g., sharing economy, unmanned aerial vehicles, smart homes), but also connects cross-border developments with traditional industries (e.g., financial technology, circular economy, emerging agriculture, telehealth). In view of the current worldwide trends in laws and regulations, the UK launched a Regulatory Sandbox mechanism in 2016–2017 to maintain its leading role as the center of European finance and technology, based on consideration of future developments in financial innovation and to reduce the limitations imposed by current regulations. This mechanism was aimed at establishing a safe and secure space separate from the existing system, so that relevant risks can be controlled. Under these conditions, it is possible to test innovative products or business models along with new venture applications based on financial and technological innovation. Singapore, Australia, and other countries also have similar plans. In addition, Japan launched the Japan Industrial Competitiveness Enhancement Act in 2014 to strengthen industrial competitiveness in the country with regulation reform measures to encourage industries to conduct new business activities (e.g., System to Remove the Gray



Zone Areas, System of Special Arrangements for Corporate Field Tests). In view of the evidence-based regulatory adjustment mechanisms introduced by the aforementioned countries, there is an urgent need for adjustment in terms of innovative activities and inherent regulation systems. Therefore, when governments enforce current regulatory policies, new developmental trends seem to lie in how to incorporate the empirical spirit into regulatory adjustments to serve as critical concrete measures for governments to support innovative entrepreneurship policies.

In an innovative startup ecosystem, funding plays a crucial role in maintaining normal operation, as well as representing the market value of innovation and entrepreneurship. Although Taiwan's new ventures have abundant creative energy, they often face difficulties in creating value in the market. The main reasons are as follows:

- New venture lack market analysis capabilities, and thus are unable to identify favorable opportunities.
- Entrepreneurs lack comprehensive information of the trends and funds in domestic and international markets.
- Entrepreneurs lack the ability to combine innovative products or technologies with business models.
- Traditionally, investors in new venture have been faced with information asymmetry; generally, entrepreneurs have lacked information and links regarding investors, and



investors have incurred many costs in searching for new potential businesses.

Therefore, to ensure a robust environment of innovation and entrepreneurship, the key points and critical conditions for cultivating Taiwan's development of innovation and entrepreneurship lie in how to promote market transparency and information efficiency, eliminating the venture and investment risks caused by information asymmetry. Thus, the capacity of SMEs to identify commercial opportunities and innovation and entrepreneurship can be enhanced.

(2) Strategies

Strategy 1. Create Development Models of Digital Economy for Industrial Innovation

A. Strategic Objectives

- ① Create a cross-domain environment of data integration and application that gives consideration to both personal privacy and industrial development, construct a cross-industry and data-oriented innovative intelligence service ecosystem, effectively combine information from public and private sectors, and create value of data economy.
- ② Construct an environment for the development of motion-sensing technology for cultivating technical energy in software and hardware integration by means of business to customer (B2C) driven B2B, application-driven industries,



and exports driven by domestic demand, in order to construct an innovation industry ecological chain and develop cross-domain industry applications, in which consumer experience and development opportunities are the priorities that lead to business opportunities and investments.

- ③ Arrange and prepare the application of network construction, complete and fortify 5G, the IoT, and other advanced technology applications, and spectrum planning. Improve basic environments by creating a suitable demo site and platform with a scale of applications, combined with local demands and innovation application test mechanisms.
- ④ Develop a mobile consumer business services ecosystem by means of IoT technology and based on the life style demands, to position Taiwan as the benchmark for smart business services applications in the Asia-Pacific region. Build a cross-border ecosystem with e-commerce channels in the ASEAN, set up global trade insights and indicators, enhance cross-industry (cross-border) international marketing effectiveness, create a complete cross-industry (cross-border) e-commerce ecosystem, and develop a new blue ocean strategy for exports.
- ⑤ Encourage financial institutions to develop mobile payment business and create a friendly regulatory environment, based on the premise that risks are controllable and consumer rights are guaranteed, to promote the development of domestic industries related to mobile payment.



- ⑥ Accelerate the transformation of SMEs with digital technologies, build innovative industry clusters in a digitally connected economy with hardware and software integration, shape a full-time smart life service environment, and create a mutual innovation relationship between products/services and consumer experience.

B. Important Measures

Measure 1. Innovate data services for activating cross-domain data applications:

- ① Construct cross-domain data exchange standards and service platforms.
- ② Facilitate cross-domain data innovation service networks.
- ③ Promote talent training using cross-domain practice data.
- ④ Forge information service industry supply chains.
- ⑤ Develop applications for industrial data in specific fields.

Measure 2. Develop motion-sensing technology for merging cross-field content:

- ① Create a brand-new industrial cluster for motion-sensing technology.
- ② Use industrial R&D subsidies.
- ③ Create experience opportunities.
- ④ Hold international events to promote applications.



⑤Support industries in overseas marketing.

⑥Create a sound industry environment.

Measure 3. Innovate network development for building a complete cross-network environment:

①Create an inventory of Taiwan's development of 5G + IoT network industry energy.

②Intensify R&D mechanisms of the TDP.

③Construct experimental networks to connect next-generation industrial network communication chains.

④Introduce living application trials and innovative diffusion.

Measure 4. Innovate commercial development strategies for creating a cross-industry/cross-border ecosystem:

①Develop a smart consumer ecosystem in the digital economy.

②Build a cross-border ecosystem for ASEAN e-commerce.

③Facilitate business service innovation with technology.

④Set up global trade insights and indicators.

⑤Provide customized digital marketing services.

Measure 5. Expand applications and innovation in mobile payment:

①Create a friendly payment and regulatory environment.



- ② Accelerate the integration of electronic payment and equipment.
- ③ Promote electronic payment services in public sectors and medical institutions.
- ④ Coordinate with international mobile payment proprietors to encourage cooperation with Taiwan.
- ⑤ Use policy tools and relevant supporting measures to popularize mobile payment.

Measure 6. Innovate business models for building a network of digital connections:

- ① Help industry clusters to transform with digital technology.
- ② Promote the value innovation mechanism of hardware and software integration.
- ③ Shape a full-time smart life service environment.
- ④ Implement innovative services and applications by means of real business data.
- ⑤ Select and support top-notch and high-growth enterprises.

Strategy 2. Strengthen the Translation of Scientific Achievements into Industrial Innovation and Development

A. Strategic Objectives



- ① Activate the R&D momentum in the juridical persons affiliated with ministries or departments and in the administrative juridical persons:
- Become demonstrators of R&D effectiveness by promoting R&D results for practical application in life and industry through solid internal R&D capabilities and external interactive networks that are supplemented by the resources of R&D organization TDP. Hence, people will gain a deeper understanding of the R&D results created by juridical persons.
 - Become industrial technology leaders: by using advantages such as abundant high-level talent and advanced equipment. Hence, juridical persons can take the lead in industry to develop forward-looking and market-oriented technology, guiding the development of industrial technology.
 - Become international cooperation promoters through connections among international markets, technology, capital, and talent. Hence, juridical persons can enhance the international perspective of scientific and technological R&D, and establish contact networks with foreign scholars or entrepreneurs, thereby increasing the opportunities to contact and cooperate with foreign enterprises. Thus, international cooperation and development is effectively promoted.



- ② Strengthen the TDP subsidy mechanism in industries and academia, for facilitating 5+2 industrial innovation developments.
- Help manufacturers transform or drive new business by forging links with R&D capacity in academia.
 - Support the government in promoting technology development for 5+2 industrial innovation.
 - Encourage innovation and entrepreneurship to promote the development of emerging industries.
 - Focus on 5+2 industrial innovation developments through cooperation between the central government and local SBIR.

B. Important Measures

Measure 1. Boost the R&D capacity of juridical persons under ministries and government agencies:

- ① Diversify scientific research modes and performance evaluation indicators.
- ② Enhance the quality of scientific research talent and strengthen international exchanges and cooperation.

Measure 2. Improve the funding mechanism of industry-academia technology development projects to facilitate 5+2 industrial innovation:



- ① Use the incentives of the TDP subsidies mechanism to strengthen the links between industries and academia.
- ② Organize policy-oriented R&D projects aimed at 5+2 industrial innovation.
- ③ Promote the industrialization of research results and foster new ventures.

Strategy 3. Build a Robust Regional Innovation System to Sustain the Growth Dynamics of Industrial Clusters

A. Strategic Objectives

- ① Expand the introduction of diversified industries to guide industrial upgrading and innovative transformation and leverage science parks' function as regional innovation hubs for kick starting economic and industrial growth.
- ② Establish a strong regional industrial policy development system for strengthening cooperation between the central and local governments; promote regional economic developments through regional innovation systems and accelerate the formation of a mechanism linking central and local industrial policies through industrial innovation policies. These strategies include clear analyses of the innovative demands and energy in regional industries, for improving the integrity of these policies. The regional intergovernmental cooperation mechanism should be



reinforced to reflect the policy value. In addition, the communication of and publicity for industrial innovation policies should be strengthened to gain public support and ensure administrative feasibility.

- ③ Identify the orientation of each regional industry innovation research park or center and perform functional integration for juridical persons; link regional R&D resources with local university resources; build a suitable industrial innovation R&D platform for supporting the development of innovative industries.
- ④ Forge links with academic research capacity to promote agricultural technology and create an innovation value chain in the agricultural technology industry, thereby expanding market opportunities; accelerate international convergence to promote Taiwan's agricultural exports.

B. Important Measures

Measure 1. Strengthen the innovation capacity of science parks and energize regional innovation and development:

- ① Expand the introduction of diversified industries, and accelerate the incubation of new ventures.
- ② Shape the demo sites of emerging industries and promote international links.



- ③ Connect peripheral industrial resources and strengthen the promotion of exchanges among industries, academia, and research communities.

Measure 2. Build a robust regional innovation system by establishing an intergovernmental regional industrial cooperation platform:

- ① Establish an intergovernmental platform for regional industrial communication and cooperation.
- ② Shape a common intergovernmental goal for effective use of national resources.
- ③ Use proactive governance to strengthen the links among governmental policies.

Measure 3. Construct an industrial innovation R&D platform to bolster R&D capacity for industrial innovation:

- ① Focus on and enhance R&D innovation energy in regional industry innovation research parks or centers.
- ② Integrate regional innovation systems through regional industry innovation research parks or centers.
- ③ Strengthen the industrialization effectiveness of regional innovation systems to enhance the growth momentum of industrial clusters.

Measure 4. Advance the use of technology in agriculture to transform agricultural management models and foster industry clusters:

- ① Strengthen the import and export functions of agricultural biotechnology parks and promote industrial exports.
- ② Strengthen the integration of industry and academia and construct value chains for improving competitive advantages.
- ③ Create brands for industrial clusters and build global marketing and market channels.
- ④ Strengthen personnel training to fortify the foundation of industrial export.

Strategy 4. Create a Friendly Environment and Development Mechanism for Innovation and Start-Ups

A. Strategic Objectives

- ① Forge links with the R&D capacity from academia and research fields to create local innovative startup ecosystems, in which new-generation industrial developments can be effectively promoted, while traditional industries can be facilitated in responding to new technology trends and experience inheritance.
- ② Construct an innovative entrepreneurship environment of ideas, experiments, entrepreneurship, and investment with fully prepared consultation resources, thereby attracting early funding and improving the government's innovation procurement and relevant resources, for helping new venture



teams; constructing new-generation local industrial demo sites for enhancing the success rate of innovation and entrepreneurship.

- ③ Assist new ventures incubated in each local innovative startup ecosystem to forge marketing links with international markets; attract international new ventures and talent to each local innovative entrepreneurial ecosystem.
- ④ Establish a mechanism that can operate systematically and respond in a timely manner to encourage and support the development of emerging industrial patterns with the flexible approach of guiding innovative incentives. Eliminate control measures that hinder economic development and improve the environment of entrepreneurial laws and regulations to create flexible entrepreneurial demo or trial sites, thereby establishing a friendly entrepreneurial base in Asia and attracting international entrepreneurs to select Taiwan as the first choice for an entrepreneurial base.
- ⑤ Construct an innovative entrepreneurship environment of market, entrepreneurship, and investment, with information transparency and counseling resources, to improve new ventures' identification of market opportunities and capacity to commercialize creativity, thereby attracting early funding and relevant resources, enhancing the success rate of innovation and entrepreneurship, and increasing job opportunities.

- ⑥ Shape a regional innovative startup ecosystem by forging links with transnational accelerators, new venture investment units, and entrepreneurial counseling agencies; introduce domestic and foreign funds that can be successfully invested into Taiwan's high-quality new ventures, and guide international entrepreneurial teams and talent to capitalize on Taiwan's industrial advantages.

B. Important Measures

Measure 1. Build a friendly environment for new-generation startups:

- ① Combine new forms of research centers linking industries, academia, and research communities, to accelerate innovation and entrepreneurship.
- ② Create a regional empirical ecosystem to promote entrepreneurship development.
- ③ Promote business succession and ensure convergence of technology innovation with technology development actions.
- ④ Expand and forge links with international markets, and attract international entrepreneurial talent and capital.

Measure 2. Optimize regulatory systems for startups and build a flexible empirical mechanism for industrial innovation application services:



① Establish adjustment mechanisms for entrepreneurial regulations.

② Promote flexible empirical mechanisms in industries.

Measure 3. Link information technologies with funding resources to energize innovation:

① Apply big data technology to decipher the trends of innovative entrepreneurship and research and analyze development opportunities for enterprises.

② Forge links with early investment resources at home and abroad to support enterprises' innovation value.

③ Assist new ventures in obtaining funds through credit guarantee databases and platforms.

Goal 2. Develop Robust Smart Living Technologies and Industries



Figure 14 Overall Illustration of Goal 2

Smart technology represents a major trend in future technology and possesses a broad range of applications. Therefore, Goal 2 aims to build a smart living for all citizens by addressing issues of their mental and physical health as well as that of the social environment, while supporting industries related to smart technology. In order to realize the objective of “consolidating smart living technology and industry,” the strategic planning will cover all aspects that are closely related to industry and the lives of citizens, including the following six key areas



as agricultural production, medical technology, disaster prevention, green energy technology, environmental quality, and information security. It is hoped that these will ensure national health and the quality of agricultural products so that citizens can live in an environment that is safe, clean, comfortable, natural, and sustainable. Furthermore, as ICT keeps developing, it is also important to mitigate the threats and disturbances to information security, so that all citizens may enjoy a high quality of life. Each of the six areas is discussed below, along with an analysis of respective trends.

(1) Current Situation Review and Trend Analysis

A. In response to the diversified demands for agricultural products and the emphasis on food safety, there is a need to employ new technology to boost agricultural competitiveness.

(a) The climate and pestilence have a huge impact on agricultural production, making it essential to enhance the management of plant and animal health.

The number of instances of disease in animals and plants is rising annually all over the world, resulting in constant controversies over the safety and quality of agricultural products. As more and more emphasis is placed on the quality and safety of agricultural products, the structure of agricultural production should be adjusted to the changing consumer consciousness. Factors such as abandoned and fallow fields, the excessive use of chemical fertilizers, climate change, and the impact of extreme weather have all brought uncertainty and

limits to agricultural production in Taiwan. Under the circumstances, there is an urgent need to introduce new varieties of plant and breeds, use emerging technologies in the management of plant and animal health, boost guidance to industry, push domestic industries to expand globally, and guarantee the quality and quantity of Taiwan's agricultural products in order to ensure food safety and a healthy environment. One example of how to do this is to replace antibiotics with vaccines, which can boost the safety of locally produced food. For the moment, however, more resources need to be committed to expanding R&D in order to strengthen the market-environment links and meet global standards. There is also a need to boost R&D for microbial fertilizers and protective agents, instruct farmers on correct usage, amend related laws, expand the scope of industries, and improve the quality of farmlands. The quality and safety of food can only be ensured through the actions above.

- (b) Food safety incidents affect the rights and interests of consumers, making bolstering the management of food safety necessary.

With the rapid development of emerging economies, the liberalization of agricultural trade, the advancement of technology, and the improvement of transportation, global trade of fresh and processed food is constantly growing. As living standards rise in Taiwan, consumers have become more conscious of environmental protection. The shock of recent food safety incidents further lead consumers to emphasize food



safety and quality at every stage of its production, whether it be farming, processing, or retail. However, with global expansion of disease in animals and plants over recent years, there have been more and more disputes regarding the quality and safety of food, which have also created obstacles for the growth of agricultural trade. Domestic food incidents have resulted in economic losses and consumer mistrust. With high concerns regarding safety during production, processing, and retail, consumers increasingly demand the government to take more responsibility to protect the rights of customers and guarantee food safety. The core theme for promoting new agriculture is the establishment of a safety system for agricultural products, with a focus on increasing food supply and ensuring food safety. The prime objective of this policy is to safeguard the health of consumers. It is only through a comprehensive management system for food safety that domestic agricultural products can break into international markets and boost Taiwan's international competitiveness.

- (c) There is a growing shortage of food supply and labor, rendering smart technology for agricultural production a must.

It is estimated that the global population will reach between 7.5 and 10 billion by 2050, meaning that demand for food will be increasing in folds. Taiwan is a net food importer, and with only 0.035 hectares per person of arable land, domestic production is insufficient to support overall demand for food. At the same time, with the increasing severity of extreme weather brought about by climate change, food

shortages and rising food costs are inevitable. In addition, an aging farming population and low birth rates cause a growing labor shortage in the agricultural sector, thereby hitting agricultural productivity. The costs of agricultural production are relatively high in Taiwan due to the limited availability of land, which makes it difficult for local farmers to compete globally. Therefore, when drawing up plans to boost agricultural productivity, there must be greater focus on structural adjustments to industry and developing innovative technologies.

B. There should be an active push for precision medicine as a response to new global trends in personalized medicine and biopharmaceutical industries.

Precision medicine, or ‘personalized medicine’ as it is also known, includes preventive screening at the front end and targeted treatment at the back end. It represents a new trend in biomedicine industries and individual health. Those in the global biopharmaceutical profession are actively following this trend, which is considered key in raising the effectiveness of medical care.

During his 2015 State of the Union address, US President Barack Obama pledged an investment of US\$215 million in the Precision Medicine Initiative. In this initiative, US\$130 million would be devoted to establishing a medical database of one million people, including medical records, gene data, lifestyle habits and other indicators; US\$70 million would be devoted to



searching for cancer-causing genes and developing new cancer-fighting drugs; US\$10 million would be spent on establishing regulations; and US\$5 million would be invested in research for protecting privacy and personal information. The US government also hoped that this initiative could serve as a clarion call to collect greater amounts of genetic information of patients worldwide for analysis. Such analysis, combined with the development of new drugs, can help in finding appropriate treatment methods for individual patients.

By launching this new initiative on a national scale, the US is leading global biopharmaceutical research into a new era of personalized medicine. Taiwan already possesses the conditions to develop precision medicine: a most comprehensive database of national health insurance in the world, high-quality medical professionals and excellent achievements, and solid ICT industries. Therefore, promoting technology for precision medicine can help Taiwan connect with the wider world, but even more importantly, such technology can help establish an important foundation for the future development of medicine and healthcare in Taiwan. Precision medicine is also expected to be an important driver for the development of domestic biomedicine industries.

Public health in Taiwan is facing many challenges such as demographic changes brought about by an aging population and low birth rates; the spread of communicable diseases and problems with food safety that have come about through globalization; rapid developments in medical S&T; climate

change; and environmental pollution. As a result, the demand for high-quality medical care has been growing. The issues above and their concomitant impacts on individual health are also challenging the effectiveness of medical care system. We should therefore pursue more forward-looking research with smarter and more precise methods to achieve the following goals: developing preventive strategies, to resolve medical issues, promoting the importance of early prevention and health enhancement, forming a smart medical environment and monitoring system to provide citizens with quick updates on the latest health information, and moving towards personalization and autonomous health management so as to more effectively protect the health of citizens. A thorough analysis has shown that Taiwan must resolve the following issues for developing precision medicine:

- (a) To improve the functioning of big data databases is a prerequisite for developing precision medicine.

Big data analytics forms the foundation for developing precision medicine. It is therefore very important to set up health-related big data databases. While Taiwan has a comprehensive database of national health insurance, hospitals and clinics nevertheless have established their own separate systems according to their operational needs. Hence while a rich amount of information is collected, the systems are not integrated through smart technology. This means that it is difficult to fully understand data flow, gain a complete picture of medical information, conduct knowledge management and



information sharing, and then analyze the data to generate accurate response measures. Therefore, innovative ICT and IoT technologies should be used to establish a smart medical environment with an integrated platform for medical information. Such a platform would incorporate databases of biological information, medical records, long-term care records, health records, and information on food as well as disease prevention. The effective collection of large datasets for clinical and health information and the fortification of infrastructure for precision medicine will be of major assistance to biopharmaceutical research in Taiwan as it moves toward precision medicine.

- (b) With noninfectious chronic disease (NCD) becoming the leading causes of death in Taiwan and death from malignant tumors remaining high, it is important to improve the quality of medical treatment and ensure patient safety.

Taiwan is set to become a super-aged society by 2025. A society with an aging population and low birthrates not only faces typical challenges associated with aging such as physical debilitation, sarcopenia, dementia, and disability, but also encounters dangers posed by NCD, such as cancer, cardiovascular disease, chronic kidney disease, respiratory disease, metabolic disease and autoimmune disease, which are catalyzed and intensified by environmental pollution, pesticide traces in food, and unhealthy lifestyles, and are sure to create an enormous burden for Taiwan. The feature of diseases has slowly changed as well, with eight of the top ten

main causes of death in Taiwan being NCD. According to an analysis of causes of death, NCD account for eight out of ten, or a full 79.3% of deaths. Of these deaths, malignant tumors account for 29% and cardiovascular disease for 22.9%, marking an increase of 1.9% and 2.1% respectively from the previous decade. As technology develops, there is an endless stream of new medical tools that can assist in diagnosis and treatment, including protons, neutrons, and heavy particle treatments. Such tools have become key surgical options as part of radiation therapy for cancer treatment. Countries all over the world have been setting up high-tech treatment facilities for particle treatment. Medical institutions in Taiwan have been actively following suit. This necessitates the establishment of quality standards for medical equipment and facilities, criteria and mechanisms for inspections, a communication platform between the government and medical service providers, and safety assessments for radiation during particle treatment as well as techniques monitoring the effectiveness of treatment, so that patient safety is assured and the quality of medical care enhanced. It is therefore important to think about how Taiwan confronts the impacts of emerging medical technologies on the medical environment and management, as well as how the biological databases for cancer research and intelligent medical systems may help resolve problems facing health and medical care.



(c) Compared with OECD countries, the level of health care for children in Taiwan remains to be raised, and boosting the quality of medical care for children is essential.

Taiwan's mortality rates of children of all age groups suggest that Taiwan is in a position tantamount to those in the bottom third of OECD countries, meaning that Taiwan lags most OECD countries when it comes to the level of child health. Despite this, there has been a growing short of pediatric medical staff over recent years, with only one-third of pediatric specialists remaining in hospitals, while the rest transferring to physician clinics for work. This means hospitals are understaffed and that there are heavy workloads for those who remain working there. Children's hospitals that specialize in intensive illness and difficult-to-treat diseases will be unable to save sick children in a timely manner, let alone creating innovative technology and advancing medical treatment for children. It is absolutely essential to step up the prevention of disease, detect disease early through screening, improve the pediatric network and ensure the stable growth of medical staff, encourage innovation and professionalism, improve treatment for severe and difficult-to-treat diseases, and investigate the causes of accidental deaths.

(d) The threat of emerging diseases and zoonoses are on the rise, posing a significant challenge for the network of communicable disease prevention.

Globalization and climate change not only cause major changes to the ecosystem, but also have a direct impact on human health. Emerging diseases and zoonoses pose rising threats, spreading quickly throughout the world via the advances in transportation that foster and are fostered by globalization. These threats challenge our network of communicable disease prevention, making it important to enhance the prevention, detection, and response capabilities in dealing with communicable diseases, establish monitoring and early warning mechanisms through international cooperation, and develop capabilities to rapidly screen pathogens as well as to produce vaccines domestically.

- (e) There are more and more food types thanks to the development of science and technology, making food safety issue increasingly complex.

In order to strengthen food safety management systems, databases from the following ministries should be integrated: MOEA, MOF, COA, MOL, EPA, and MOHW. This will help develop the capabilities of collecting and analyzing risk information and source control, implement management of agricultural products from farm to table involving production, processing, and traceability, raise the efficiency of management, and improve monitoring at each phase of food production, so that an environment for the safe consumption of food can be established. A food safety system should be constructed in order to prioritize chemicals or additives according to the degree of their potential harm, and then



recognize and assess their harm to health, thereby reducing the risk of food safety for all citizens.

C. The frequent occurrence of compound disasters indicates an urgent need to use emerging technologies to construct a safe and disaster resilient environment.

(a) Climate change has brought an increase in extreme precipitation and flooding. The capacity of comprehensive urban and river basin management and disaster-resistance must be improved.

- Floods create unique difficulties because flooding can cover a wide range of aspects and last for a relatively long time.
- Climate change has brought an increased risk of extreme precipitation and flooding.
- The capability of monitoring meteorological disasters needs to be enhanced, including monitoring facilities as well as analysis techniques.
- Compound disasters occur frequently and technological capabilities for hybrid warning systems must be improved.
- Risk potential assessments and surveys for disaster-susceptible areas should be constantly reviewed and updated.
- Land development on the outskirts of urban areas has increased the amount of run-offs. There is a lack of sufficient facilities in urban areas, making the protective



capabilities to decrease annually and increasing the risk of flood.

- Land subsidence and receding coastlines reduce the effectiveness of water control and flood prevention in coastal areas.
- Integrating large datasets on disaster prevention and actively transmitting early warnings can allow citizens to rapidly receive accurate information.
- Disaster governance should adopt an all-hazards approach, and evaluation techniques should be developed to establish long-term follow-up mechanism.

(b) Disasters in sloped areas affect the safety of citizens, and steps must be taken to lower the impacts.

- There are no sufficient tools to measure the scales of natural slopes, quantify disaster potential with high resolution, and assess the impacts. Resolution must also be boosted for space assessment models of the direct and indirect disaster impacts.
- High-resolution forecast and warning models, as well as assessment tools are insufficient.
- No big data platforms and databases on disaster prevention have been established yet, and assessment tools for various scales are difficult to develop.
- The application of such technologies as sustainable engineering, land and environmental monitoring, and



remote sensing in disaster prevention is still to be strengthened.

- Current drainage systems and buffer zones in urban areas are almost saturated. Their space and capacities for expansion are also limited.
- Citizens lack disaster-related information or only receive such information passively. It is difficult for them to actively obtain such information in order to make a personal judgement on the loss caused by the disaster, grasp the risks and plan an escape in a timely manner.
- Smart technology of disaster reduction in sloped areas awaits development.
- There is insufficient knowledge about reducing the damages triggered by soil and rocks.

(c) Facing potential threats from earthquakes, there is an urgent need to enhance capabilities for earthquake resistance.

- Public and private buildings in urban areas as well as important infrastructures must be made more earthquake-resistant.
- There is a dearth of information for analyzing the disaster potential of earthquakes so as to draw up a large-scale evacuation plan.
- The seismic capacity of critical infrastructure is clearly insufficient, creating an urgent need to collaborate with the



academia to develop technologies and strategies for disaster reduction.

- Taiwan suffers from near-fault earthquakes. Technology must be developed to better withstand near-fault earthquakes and reduce the damage.
- Earthquake blind zones are to be reduced and the service for rapid report during earthquakes to be improved.

(d) Smart technology for disaster prevention should be developed in order to timely grasp the situation rapidly and lessen the impacts.

- Sensing technology for disaster-prevention is to be enhanced.
- The application of big data by the civil society, businesses, and social media is to be integrated.
- The accessibility of information on disaster reduction is to be improved for users.

(e) Smart technology should be used to ensure workplace safety, boost business competitiveness, and improve workers' health.

- A cloud-based service platform for the general safety of workers must be developed to integrate various inspection systems, lower the threshold for businesses to introduce mobile communications technology, and boost the overall competitiveness of domestic businesses.
- In accordance to national policy objectives, industrial safety management is to be actively developed through



employing mobile smart technology to inspect and monitor workplace safety, thereby enhancing the level of occupational safety industries in Taiwan.

- Automated information systems for industrial safety management should be promoted to reduce the economic cost of industrial safety management.
- Users are to be instructed on industrial safety to raise the awareness of industrial safety.
- Information should be integrated through cloud services, thereby reducing social expenditures for industrial safety management.
- Users should be provided with a free platform to exchange industrial safety knowledge and experience.
- Online video tutorials should be routinely provided through cloud services, increasing users' knowledge about dangers when it comes to industrial safety.
- R&D talents in environmental safety are to be cultivated, job opportunities created, and industry development promoted.

D. Green technology should be actively developed to create a low-carbon and sustainable society.

(a) Looming energy shortages make it essential to intensify the development of renewable energy.

- Photovoltaics: currently the commercialized products have a lifespan of 20 to 25 years and an efficiency level of

approximately 16 to 17.5%. R&D in solar power technology should be enhanced to raise its efficiency in generating electricity.

- Wind power: obtaining ideal land sites usually encounters such difficulties as acquiring the land, and protests from local groups as well as environmentalists, whereas the setting up of offshore wind energy requires addressing key issues of docks, shipping lines, fishing rights, constructing ships, domestically produced electric generators, as well as earthquakes, typhoons and other extreme weather conditions.
- Biomass energy:
 - To increase the supply of sources: Growth in Taiwan's biomass power generation has been limited due to the following factors: a lack of biomass resources, instability in the supply chain, and fuel costs. Biomass materials (such as waste products, leftover agroforestry resources, rice straw, animal waste, polluted water and soil) should be promoted so as to establish an industry chain and improve the collection of biomass materials and the production of energy.
 - Industrialized biomass technology must be developed to boost efficient energy use: waste products have low energy efficiency (approximately 19%) when producing electricity. Pellet fuel, marsh gas, cracked oil, and syngas produced by gasification all hold potential for



industrialization, which could boost the energy efficiency of biomass.

- Geothermal power: With the exception of the 50kW binary cycle plant at the Qingshui Geothermal Field and the small-scale corrosion-resistant geothermal plant in Beitou, there are no commercial operational geothermal plants in Taiwan. There is a need to boost technology for controlling geothermal resources and developing greater corrosion-resistance.
- Energy storage technology: As global costs of energy storage are high and little mainstream or mature technology is reliable, and low-cost technology for energy storage should be actively developed.
- Marine energy: Investment in commercial power generators suitable for the domestic environment is to be made on the basis of Taiwan's unique geographical conditions.
- Hydrogen energy and fuel cells: The development of key technology used in fuel cells has not been able to commercialize because of the economic scale, rendering the costs to remain high. In addition, the government must do more to educate state-owned and privately owned firms and even the public, so that citizens can have a better understanding of hydrogen energy and fuel cells.
- Carbon Capture and Storage (CCS): There has been a pilot test on capturing carbon dioxide and reusing it to raise



algae. Acts are to be made and communication with the general public to be enhanced for a test on CCS at a larger scale.

- (b) Electricity provided through renewable energy is unstable. Finding a way to improve its reliability is a key challenge.

Setting up renewable energy facilities on a large scale increases the electricity supply, but its instability could also affect the reliability of power supply. For instance, the southern part of Taiwan has more potential for photovoltaics, but when electricity is overly concentrated in a small number of feed lines, it can cause abnormal voltage in the feed lines or the return power to exceed the voltage capacity of the main transformer, disturbing the stability of the system. The capacities of wind and photovoltaics is being affected by the weather, as short and rapid turbulence can affect system frequencies, requiring the energy storage or quick responding generation facilities to increase or decrease load to maintain balance. Seasonal variations also affect the configuration of power supply. For example, photovoltaics is beneficial for maintaining the power supply during peak summer hours, but if the power generation exceeds the voltage load, it will obviously impact the dispatch of baseload generators.

The large-scale incorporation of such unstable forms of green energy as wind and photovoltaics into the power grid will create reliability problems. Such problems are to be addressed



at both the supply-side and demand-side of the power system efficiently and cost-effectively.

On the supply-side, the insufficient capability of increasing and decreasing load and dispatch in Taiwan's current electric power systems makes it not able to quickly adapt to the rapid variations in power caused by the use of renewable energy sources. It is therefore necessary to introduce energy storage systems and enhance the basic infrastructure for transmission and distribution. On the demand-side, the inability to clearly know how much power is being used by users in real time renders the power system not being able to effectively dispatch and manage power when facing risks of instability. It is therefore necessary to deploy smart grid and employ demand response measures.

- (c) Energy-saving technology and facilities must be developed in order to make energy-saving more effective.

Domestic energy prices have remained low for a long period of time. Together with a long payback period for investments in energy-saving facilities, these two factors have affected the success of energy-saving in Taiwan. In residential, commercial, and industrial sectors, the high cost of initial investment on high-efficiency facilities results in a lengthy payback period on the investment, indicating that there are insufficient economic incentives. Mandatory regulations and appropriate subsidies are needed to promote high-efficiency facilities. In addition, residential, commercial, and industrial

sectors share a common characteristic that there are many small and medium-sized power users. These users do not have the personnel or experience to embrace energy-saving on their own, while providing each of them with guidance on energy-saving would be prohibitively expensive. The costs for system integration and services for small and medium-sized power users are high, and hence in the future these costs are to be lowered through software and ICT. Energy-saving demonstrator models, energy-efficient architectural designs, a green building certification, among other regulations and market mechanisms, can all help popularize energy conservation in the residential, commercial, and industrial sectors.

Energy-saving solutions in the industrial sector are difficult to develop because electricity consumption in the sector involves factory designs and production secrets, there is great diversity in manufacturing processes, and full investment into energy-saving R&D is very expensive. Under the circumstances, energy saving in factory operation should be the focus in the short-term. Over the long-term, the development of professional energy-saving services and guidance for applying technology on the basis of industrial demands and features may be achieved through offering Energy Service Companies (ESCOs) credit guarantees, low-interest loan and other finance and taxation measures.

In addition, with global standards for the safety and energy consumption of automobiles becoming ever stricter,



electronics and electrical engineering sectors have the opportunities to enter emerging industries. Facing the marketplace competition for next-generation vehicles, domestic automotive industries should actively develop key systems and components for automobiles and meet global standards when it comes to energy-saving, modularization, and securitization.

- (d) The development of the circular economy should be accelerated due to the greater scarcity of resources.

For a long time, global economy has been based on large-scale resource consumption, seriously damaging the natural environment and aggravating the lack of resources. In response, there is a growing global trend towards green innovation and the idea of circular economy, with the aims being the elimination of waste, the more efficient use of resources, value creation and the reduction of impacts on the environmental.

Taiwan has a low level of energy self-sufficiency, a scarcity of water resources, and a limited environmental carrying capacity. Therefore, the circular economy should be based on waste reduction and recycling, as well as energy-using products (EuP) and the development and application of technologies in clean production. This will create more value and new kinds of benefits for both the industry chain and the new circular economy.

- (e) Nuclear decommissioning technology must be enhanced in order to realize a nuclear-free homeland.

Countries with nuclear energy all have independent regulation agencies or organizations to undertake active, rigorous and prudent measures to inspect nuclear facilities in order to ensure safety. In response to the policy of a “nuclear-free homeland,” it is important to enhance technologies of nuclear decommissioning and safely handling the radioactive waste so that the nuclear-free agenda can be actively advanced.

The First, Second and Third Power Plants currently have a total of six power generators, but will begin reaching the end of their legal operating period starting in 2018. The decommissioning process for nuclear power plants involves inspections for radiation at the plant site, the decontamination and dismantling of facilities and components, the demolition of the plant building, the restoration of the site and the reuse of its land, the removal and disposal of radioactive waste, the management of used nuclear fuel, and the installation of safety monitoring systems at the back end, all of which require the long-term investment and support of government, industry and academia in Taiwan.

In the face of challenges associated with decommissioning the nuclear power plants and competition in the global market, the government should guide domestic industries to effectively integrate the required technology through research on decommissioning nuclear plants planning as well as the introduction of key technologies for removing and dismantling the reactor and internal components and decontaminating the systems. In establishing an industry chain



and robust technological capabilities for decommissioning, the safe decommissioning of nuclear plants with independent technologies can be assured.

In addition, as Taiwan develops technology for disposing radioactive waste, there is inevitably the problem of NIMBY when it comes to storage installations. For instance, if the waste in question is high-level radioactive waste, there is a lack of deep underground repository for data survey and experiment. When it comes to low-level radioactive waste, there are concerns about land use, the select of storage locations is prolonged. Broader thinking on the issue is required to deal with the difficulties of obtaining land. This includes new research ideas of the storage, transportation, and disposal of used nuclear fuel; centralized storage for high- and low-level radioactive waste; and assessing the feasibility of a comprehensive plan to dispose both. A rigorous and objective scientific assessment that is public, transparent, and involves the participation of citizens is needed to channel communication between the public, NGOs, and local governments, so that the disposal of radioactive waste, an incredibly important issue of public safety, can have a comprehensive solution.

- E. Sensing technology represents a rising trend, and should be used to enhance the control of environmental quality and smart governance.

- (a) R&D of sensors should be actively pursued, setting up a foundation for the development of an environmental IoT.

The IoT uses the Internet to incorporate widely dispersed sensors and information devices into an integrated system, facilitating deeper, and wider analysis, application, and value added of information, as well as accurate decision-making, action, and future planning. Advanced countries all see IoT technology as an important direction for future development, with concrete applications including smart transportation, smart factory, smart medicine, smart housing, smart environment, and smart city. The International Data Corporation (IDC) predicts that the market value of the global IoT will reach US\$7.1 trillion by 2020, and that the compound annual growth rate for IoT facilities between the years 2013 and 2020 will reach 17.5%.

The IoT represents emerging industries of the future. Taiwan holds a relative advantage in that it has a mature level of ICT. While this renders the costs for hardware to decreasing annually and is beneficial for the making of various IoT applications, Taiwan still lags behind developed nations when it comes to environmental monitoring applications required by the IoT. Both Taiwan's level of technology for environmental sensor components and the ability to develop sensors being applied to various fields are insufficient. This situation makes it difficult to construct a foundation upon which a large number of sensors could be deployed, and may limit the growth of environmental IoT in Taiwan.



The Executive Yuan has approved the Environmental IoT Deployment and Enforcement Plan (2017-2020). This plan will enhance the grasp of information of environmental quality, services, and pollution management.

- (b) In order to protect the environment, ICT technology should be used to expedite the deployment of environmental IoT.

Taiwan's advantage in developing the IoT lies in its well-established foundation and high-quality industry chain. In addition to the excellent production and response capabilities of those terminal equipment manufacturers, technologies of components and devices in the areas of radio-frequency identification (RFID) and IC design are also mature thanks to Taiwan's edge in R&D. As a result, in the field of wireless sensor network (WSN) there is a relatively integrated upstream and midstream business in Taiwan, although in the downstream sector there are fewer system integration firms. Additionally, the success of IoT lies in its practical application to problem solving as well as benefit and value creation. In this regard, there is an urgent need in environmental protection to boost the capacity of the remote monitoring of pollution and environmental quality, a need that merits the applications of IoT. Therefore, if the government can rapidly employ resources to guide the private sector to integrate the development of environmental sensors and the IoT in law enforcement, it will not only create momentum for innovation and spur the development of IoT in Taiwan, but will also help

resolve environmental problems and improve the quality of the environment.

The EPA currently maintains and operates a robust system of air quality monitoring network. Through regular quality assurance and quality control (QAQC), it not only ensures the reliability of data, but also makes it available for public consult in real time, and hence is a national system of air quality monitoring network with a high degree of public trust. However, the high costs and the size of such stations makes the network unable to be deployed at a large scale. If the innovative energies of domestic industries can be harnessed and incorporated with emerging technologies such as sensing and ICT, to set up an environmental IoT, while those monitoring stations run by the local governments and large state-owned enterprises can be integrated to form an overlapping network for monitoring air quality with monitoring facilities of various and complementary features, the public will be able to access more and latest air quality information in their surrounding with ease.

(c) In dealing with complex environmental crimes, law enforcement with smart technology is to be developed.

By deploying an environmental IoT, environment monitoring techniques can be used to collect high-resolution data of environmental quality in both time and space. After comparing data from automatic monitoring of environmental pollutants emissions, monitoring, approval and declaration



information of all sorts, appeals reception, and pollution reports by online media are collected and compared, big data analyses can be conducted to identify hot spots and peak times of pollution, so that inspectors can be dispatched immediately. This will not only shorten the duration of the polluting activities, but will also reduce the negative impacts on the environment.

In addition, conventional environmental law enforcement focuses heavily on sampling and testing at the end of the drains and meeting the inspection quotas. There is also no unified system in place for archived data from related systems to be cross-checked and compared and for inspectors to grapple with the situation and then accurately strike at the source of pollution. As a result, there are firms that rely on luck and use various tricks to avoid getting caught, making illegal emissions not uncommon. Faced with the complex environmental crimes today, technologies and strategies for environmental law enforcement must become more acute and effective through smart inspections. Digitalization, technological advancement (with cloud technology), and big data analysis can be connected with the environmental IoT to integrate the resources of environmental law enforcement so as to accurately and effectively find out pollutions, recover the illegal profits, halt serious polluting activities, and combat environmental crimes.

F. Foresight technologies must be actively developed to deal with rising threats to information security.

(a) Key technologies for information security must be upgraded to fight against increasingly complex cyber-attacks.

- The current situation

The digital economy is founded by the internet, broadband networks, mobile applications, information technology services, and hardware. The expansion of the digital economy has been the prime driving force behind economic growth, and has been simultaneously transforming the society. With the rapid development of the internet, mobile devices, and financial technology all over the world, the digital economy has already revolutionized conventional physical modes of the economy, offering a broad range of applications at each aspect of life. This includes disruptive innovations that have transformed traditional modes of the economy, as well as the gradual application of the internet and smart technology to every aspect of life: food, clothing, housing, transportation, education and entertainment. The digital economy has brought numerous challenges and opportunities in its wake.

Threats to information security have been rising rapidly over recent years. With the emergence of mobile devices, the IoT, and cloud services, hackers have been developing increasingly sophisticated methods of attack, while their goals have also shifted from sabotage to extracting benefits. Conventional defense facilities and anti-virus software have a difficult time blocking such attacks. There has been an endless stream of economic



crimes and personal information leaks all over the globe, bringing heavy losses and serious implications for national security industrial development, business operations, and personal privacy.

Taiwan's investment in R&D for information security has been limited, making it difficult to cultivate technology in the medium and long-term, and to develop integrated technology for information security. Most small businesses in the information security industry also lack R&D capabilities and are not technologically competitive. According to a survey conducted by the Taiwan Institute of Economic Research (TIER) in 2013, there were 146 information security companies in Taiwan, of which 64% have 50 employees or less. In the domestic market, self-developed products amount to NT\$ 3.95 billion, while those imported stand at NT\$ 14.7 billion.

In order to reach the national goal of autonomous innovation of information security technology, the innovative capacity of domestic academia and research community can be guided to invest in key technologies and patents, thus fostering the translation and application of R&D results to the industry. Comprehensive technical solutions for next generation information security technology are to be developed and technical standards and the applications of emerging information security technology to be studied to meet the demands of the domestic industries, as well as to command critical cloud,



virtual and mobile technologies while meeting international standards, thereby driving growth and competitiveness in the domestic information security industries.

Threats to internet security have risen sharply over recent years. With the emergence of mobile devices, the IoT, and cloud services, hackers have been developing increasingly sophisticated methods of attack, which have a wide range of impacts. An analysis of the current situation is as follows:

- Key technologies for information security are largely in the hands of advanced countries, and breakthroughs are difficult to make.
- Advanced countries have invested aggressively in R&D for information security technology as well as industries in the field of information security identification and authentication, maintaining a technical advantage while increasing the gap between themselves and the latecomers.
- It is difficult to evaluate and inspect the effectiveness of information security, rendering potential benefits often ignored, and the resources committed to information security insufficient.
- The government's division of labor in information security lacks clarity. There is room to improve both legislative and organizational factors associated with information security.



- The government has been promoting ISG, but the effectiveness of such efforts has room for growth.
- The government is to speed up the promotion of productivity 4.0 in order to guide industry development and innovative applications. It should simultaneously upgrade basic infrastructure to create a safe environment for development.
- New forms of attacks on information security have surfaced with the advent of the IoT and mobile payment, making almost anything the potential target of cyber attacks. This even has repercussions in the physical world.
- The government and industries have committed huge resources to the internet, cloud computing, big data, IoT, and other areas. However, the lack of clear policy guidance and development plans means a missing strategy for key technology.

- Trend analysis

Privacy protection and information security represent latest global trends. To this end, the White House announced on February 9, 2016 its Cybersecurity National Action Plan (CNAP), which included short-term measures and long-term strategies to enhance cyber security awareness and protections, protect privacy, and maintain public safety and economic and national security. The plan authorized the US government to take better control of



digital security. It also establishes a Federal Privacy Council to ensure the Federal Government has more robust guidelines for protecting privacy, so that the pursuit of developing technology, innovation, and big data can also guard against changing cyber threats while effectively and sustainably protect the privacy of citizens.

On July 12, 2016, the European Commission announced its adoption of the EU-US Privacy Shield, which replaced the International Safe Harbor Privacy Principles having been in place since July 2000. (The Principles were invalidated by the Court of Justice of the European Union (CJEU) in October 2015 because the disclosure of the National Security Agency surveillance scandal in 2013 indicated insufficient privacy protection of the Principles). The EU-US Privacy Shield established norms and protection for information exchange between the US and EU, and provided EU citizens with extra privacy protection when their information is transferred to the US.

The OECD amended its Privacy Guidelines in July 2013 to serve as a reference for member states to promote privacy protection. The new guidelines focused on two major themes: (1) the practical implementation of privacy protection through an approach grounded in risk management, and (2) the need for greater efforts to address the global dimension of privacy through improved interoperability.



Over recent years, global cyber attacks and leaked personal information have caused incalculable losses and raised concerns over invasions of privacy. In response, advanced countries have committed greater resources to information security and privacy protection than they did in the past. The US has the largest information security industry, but even so, it still encounters many information security incidents. For example, the personal information of over 80 million people held by health insurer Anthem was breached, while Apple's iCloud has also been hacked, resulting in a leak of intimate photos of various celebrities and a violation of user privacy. The Defense Advanced Research Projects Agency (DARPA) has developed new technology to protect privacy, hoping to enable safe and predictable sharing of data in which privacy is preserved.

Israel is a good example for its innovative development of information security technology, as there are over 200 hi-tech companies covering a range of areas such as information security, finance, and mobile innovation, of which information security is Israel's strongest suit. With the support of the Israeli government's bold and open policies for nurturing innovation, numerous information security companies can rapidly respond to new demand in the international market, and are constantly releasing all sorts of successful technology to protect information, with Check Point and Verint being the most striking examples.

Taiwan has had modest success in producing innovative technology that protects privacy and information security. AirSig, which is known for its air signature mobile authentication, has attracted the interest of Foxconn, which became an official shareholder. iDGate, which specializes in ID authentication systems and financial information security, is currently working with many banks both domestically and overseas. In the future, in response to issues of privacy protection and information security in smart commerce and the use of information security technology to maintain a high quality of life for citizens, practical models and solutions are to be developed through mastering key autonomous technologies in cloud, VR, and mobile devices.

(b) Facing the imperative of transformation, the information security industries should attribute resources to ameliorate the environment for developing information security in Taiwan.

- Current situation and trend analysis

With the constant evolution of ICT and big data cloud technology, cyber attacks have been evolving rapidly as well, meaning that it is difficult for conventional defense facilities and anti-virus software to block such attacks. There are relentless economic crimes and major leaks of personal information globally. These attacks target not only business, government, and national security secrets, but also threaten key infrastructures and physical safety. As



global cyber threats to information security intensify, European countries, the US, Japan, South Korea, and other advanced countries all continue to invest major resources in protecting information security and cultivating professional talent.

Information security industries in Taiwan are facing a transitional phase brought about by IoT. With respect to the deployment of the emerging information security field, industry, government, and academia can pool resources into research, put Taiwan's ICT to good use, cultivate professional talents, and improve the domestic environment for developing information security, so that a suitable environment is prepared for the industries to go global. The current situation is discussed below along with an analysis of the trends:

- Domestic information security industries are relatively small in scale and firms do not have sufficient funds, making it difficult for them to cultivate or attract professional talents.
- Domestic businesses do not place enough importance on information security, making it difficult to generate market demands.
- With respect to the application of emerging technologies, there is a lack of information security technology integration, making it difficult to expand the emerging field of information security.



- Taiwan's R&D investments in information security are limited and there is a lack of large-scale realm for testing. It is not easy to lay roots for the medium and long-term development of the technology.
- Domestic legislation on information security is not robust enough. It is difficult for related agencies to enforce the laws.

(2) Strategies

Strategy 1. Develop New Technologies for Safer Agricultural Products

A. Strategic Objectives

- ① Create a robust environment and a secure food supply by promoting systems and technology to manage plant and animal health, introducing new varieties/species and new technology to reduce agricultural losses and waste produced by diseases in plants and animals, maintaining both the quality and quantity of agricultural goods, and boosting productivity in agricultural, fishing, and livestock industries.
- ② Ensure food safety for consumers through the establishment of safe agricultural zones in order to stabilize food supply and develop organic farming, and the full implementation of a safety management system for agricultural products in order to stabilize the food supply and raise the quality of agricultural products.



- ③ Move towards a new era in agriculture that is efficient, safe, and low-risk by developing key technologies for smart agriculture, employing forward-thinking and integrated technology to boost agricultural productivity and create a high-quality agricultural environment.

B. Important Measures

Measure 1. Strengthen animal/plant health management to ensure environmental security and agricultural products safety:

- ① Develop competitive technology for managing plant and animal health to bolster cross-disciplinary and integrated R&D.
- ② Create a competitive environment for the management of plant and animal health, enhance guidance to industries, and expand industrial clusters.
- ③ Promote the internationalization of industries of plant and animal health management, engage in international collaborative efforts, and meet international standards.

Measure 2. Establish agricultural product safety management to protect consumer interests and rights:

- ① Promote the Large Granary Plan, establish food safety management, and boost Taiwan's food self-sufficiency.

- ② Implement source control, build a system for safe agricultural production, increase the frequency of product inspections, and create a trust-worthy labeling system for agricultural products.
- ③ Promote R&D in environmentally-friendly farming techniques, make agricultural production safe and having low impacts on the environment, and encourage the sustainable use of the environment.

Measure 3. Develop smart agricultural production and digital services to establish a new product marketing and communication model:

- ① Promote the development and application of smart technology in agricultural production through alliances of smart agricultural industries.
- ② Use integrated ICT technologies to build agricultural knowledge and service support systems.
- ③ Employ interactive, user-friendly technology to create a new model for communication between producers and consumers.

Strategy 2. Introduce Precision Medicine Technologies to Improve the Health of the General Public

A. Strategic Objectives

- ① Integrate medical databases to bolster the foundation for precision medicine.



- ② Develop the management of precision medicine and emerging medical technologies, enhance related regulations and technology to speed up R&D in innovative medical products.
- ③ Use smart technology and big data analysis to improve emergency and critical care pediatrics and resolve shortages of pediatric medical staff.
- ④ Use big data to conduct risk assessment of communicable diseases and create value-adding applications, develop techniques for the rapid detection of pathogens, bolster vaccine R&D, and enhance capabilities for the emergency production of vaccines.
- ⑤ Build a database through cloud technologies for food sources as well as a comprehensive detection and warning system for foodborne pathogens, promote R&D in food inspection, and enhance risk assessment and management to ensure food safety for all citizens.

B. Important Measures

Measure 1. Build an integrated database containing biological, health care, and health-related information to boost value-adding applications:

- ① Collect biological and clinical information on cancer and other common diseases in order to establish a big data database.
- ② Use smart technology to raise the quality of medical care, develop smart hospitals, provide quick access to clinical archives, and establish model hospitals and medical teams.
- ③ Employ ICT and IoT technology to establish platforms for cloud holistic health management services and preventive healthcare, raising the abilities of citizens to manage their own health.
- ④ Develop information systems for integrated and human-centered medical care (including treatment and long-term care systems) and establish channels for them to interconnect.

Measure 2. Develop precision medicine and new medical technologies for the general public and introduce relevant legislation:

- ① Analyze and plan the application of precision medicine in the treatment of illnesses in Taiwan to maximize the health and welfare of citizens.
- ② Collaborate with medical centers to introduce learning health systems (LHS) and implement the application of precision medicine technology in clinical decisions and outcome research.
- ③ Form industrial alliances of precision medicine, conduct technology investment and asset management, bring in



business talents to manage projects, develop innovative products, and provide integrated services.

- ④ Enhance regulations and technology to meet the challenges of emerging medical S&T.
- ⑤ Connect to the world.

Measure 3. Develop innovative technologies to refine pediatric care services:

- ① Use the life course approach as a framework to collect health information of people from birth to early childhood, elementary school, junior high school, and even adulthood, and connect big data of both birth and medical records.
- ② Use new technology to enhance the effectiveness of medical treatment for children.
- ③ Establish a nationwide long-term evaluation system of the effectiveness of hepatitis B vaccines for infants and collect empirical data.
- ④ Evaluate the medical effectiveness and cost-effectiveness of medical care for children.

Measure 4. Build a risk assessment network for primary and emerging infectious diseases and expand the capacity of vaccine development and emergency production:

- ① Use big data and cloud technology for early detection and precaution of epidemics.



- ② Research and develop new diagnostic tools such as rapid testing agents in pathogens to assist in the decision-making of preventing epidemics.
- ③ Improve the capabilities of vaccine development and emergency production.

Measure 5. Use technologies to improve food safety mechanisms:

- ① Use smart technology to build an early warning system.
- ② Enhance systems for pathogen detection and prevention.
- ③ Innovate the R&D of food inspection technology.
- ④ Evaluate food safety brought about by emerging technologies.

Strategy 3. Enhance Disaster-Prevention Technologies to Mitigate Disaster Impact

A. Strategic Objectives

- ① Improve warning systems and safety management mechanisms in valley regions so that the ability to withstand all forms of disasters can be enhanced. In response to extreme precipitation brought by climate change, use smart technology to bolster the resilience of national land and create a safe and sustainable urban environment.



- ② Boost the resilience and sustainability of sloped land and natural resources, and develop smart technology to create a safe and healthy living space.
- ③ Strengthen the R&D capacity in earthquake engineering, develop a cost-effective seismic assessment of buildings and enhance related retrofit technology to construct “tumbler cities.” Promote collaboration between academia and industry to build earthquake-resistant core infrastructures and boost the capability of risk management, thereby creating a win-win situation for public safety and sustainable business operations.
- ④ Create an environment conducive to smart technology in disaster prevention and related applications.
- ⑤ Use ICT, IoT, smart wearable devices, and various sensing devices to build a monitoring system for workplace safety, thereby creating a comprehensively smart and safe workplace.
- ⑥ Reduce earthquake blind zones and provide earthquake rapid report services.

B. Important Measures

Measure 1. Develop technologies that enhance the comprehensive management and disaster resilience of metropolitan areas and river basins:



- ① Enhance the technological capacity of flood hazard prevention in urban areas in order to respond to the impacts of climate change, short-term climate variation, and short duration torrential downpour events.
- ② Enhance technology for comprehensive flood-control in river basins (including coastlines) to build flood-resistant living areas close to water.

Measure 2. Enhance the sustainability and disaster resilience of slope lands and natural resources:

- ① Boost the disaster resistant capacity of sloped lands in non-urban planning divisions, and efficiently manage shifting soil in river basins.
- ② In response to extreme weather and megaseisms, improve the earthquake-resistant capacity of sloped lands surrounding urban planning divisions in order to protect the lives and property of citizens.
- ③ Set up a land monitoring system and a big data database of disaster prevention to provide information on the dynamic state of national lands and sustainable management of natural resources.
- ④ Establish a smart disaster-prevention network for sloped lands to provide both citizens and the incident commending system with real time information for decision-making.



Measure 3. Enrich the anti-seismic capability and disaster resilience of key facilities:

- ① Develop technology and strategy to boost the earthquake resistant capacity of core infrastructures, lowering the risk of damage.
- ② Develop technology to withstand near-fault earthquakes, thereby reducing their impacts.
- ③ Improve the ability to analyse abnormalities in monitoring data of high-risk seismogenic layers.

Measure 4. Develop smart disaster-prevention technologies:

- ① Enhance the monitoring capacity of sensors used for disaster prevention.
- ② Boost the capability of processing and analysing big data related to disaster prevention.
- ③ Improve citizens' access to information of disaster prevention.

Measure 5. Engage in R&D of smart safety sensor and surveillance technologies for workplaces:

- ① Develop monitoring technology to ward off accidents in workplace and ensure workplace safety.
- ② Improve the accuracy of workplace safety monitoring data and real-time analytical technology.

- ③ Enhance the mechanism of distributing risk information in workplace.

Strategy 4. Develop Green Technologies to Create a Low-Carbon and Sustainable Society

A. Strategic Objectives

- ① Develop green technology to increase the supply of renewable energy
- Photovoltaics: Develop power cells and conversion modules with efficiency reaching international standards, and expand photovoltaic facilities to reach a 20 GW capacity by 2025.
 - Wind power: Promote offshore wind energy stations to produce 3,000 MW by 2025, and onshore wind power stations 1,200 MW by 2025.
 - Biomass power: Boost the capacity of biomass facilities to produce 813 MW by 2025.
 - Geothermal power: Develop geothermal energy to be the baseload power supply, promote the Tatun Volcano Area as a geothermal pilot site with a capacity of 200 MW by 2025.
 - As hydrogen and fuel cells can be part of the power storage mechanisms, plan in the long term to establish hydrogen supply facilities to reduce the costs of transporting fuel.



- Carbon capture, storage and utilization (CCSU): establish a large-scale local industry chain for CCSU by 2025.
 - Energy storage technology: verify in the short term the feasibility and economic benefits of building storage devices for renewable energy on a large-scale, and the measure should be given priority in remote and offshore areas.
 - Make renewable energy account for 20% of total energy in Taiwan by 2025.
- ② Build smart grid to boost the reliability of electricity and the supply of green power
- Expand the setting of smart meters to the extent that at least 3 million such meters are installed so that user interaction and the value-adding application of the electric network can be promoted.
 - Strengthen the response to demand and other demand-side managing mechanisms, and increase the flexibility of power dispatch in order to maintain a reasonable level of reserve capacity and reduce the risks associated with dispatch.
 - Establish integrated pilot sites, verify the benefits of smart grid, and help manufacturers test products and create tangible results to expand the industrial scale.



- ③Develop key technology and integrated systems and services to save energy and reduce carbon in the residential, industrial, and transportation sectors
- Screen equipments consuming large amounts of electricity, and utilize low temperature waste heat recovery and refrigeration systems to establish a robust manufacturing supply chain that includes materials, components, controls, and integrated systems, so as to lower production costs for high-efficiency equipment and establish an equipment and components industry with international competitiveness.
 - Use technologies of ICT and software to push for large-scale energy-saving among small and medium users while create an energy-saving service industry.
 - Optimise energy-saving in buildings and the use of existing sites of distributed renewable energy through system integration, thereby making popularisation of energy-efficient buildings and nearly net-zero energy buildings.
 - Become a high-quality global supply center for key components and systems in smart energy-efficient automobiles, understand market demand for next generation vehicles, and push for whole cars and key system modules produced in Taiwan to enter the global supply chain, thereby rendering a third-wave of autonomous transformation in automobile industry.
- ④Promote green innovation and enhance the development and application of resource circulation and green technology



- Introduce green innovation technology to product design and manufacturing.
 - Boost resource productivity to stimulate the green economy.
- ⑤ Develop decommissioning technology for nuclear plants and march towards a green and sustainable society
- Use S&T to enhance regulatory measures for decommissioning nuclear plants, fully implement a national regulatory strategy for radioactive waste regulation, and establish safety techniques of international standards to ensure societal security.
 - Introduce cutting-edge technology, strengthen the regulatory system, improve managing institutions and forge social consensus to address urgent issues of nuclear power plant decommissioning and radioactive wastes that require more governmental investment of S&T resources.
 - Develop autonomous technology for decommissioning nuclear facilities domestically to enter the global market for nuclear power plant decommissioning.
 - Enhance the technology of the release, amount reduction, stabilisation, and packaging of low-level radioactive waste, and develop technology of used nuclear fuel storage and disposal to meet the goals of “reducing the waste safely” and “long-term stability,” thereby effectively reducing the risk of endangering the environment.

- Integrate the specialized domains of geology, seismology, geochemistry, geotechnics, and nuclear engineering, work towards research breakthroughs in technology of deep layer geological repositories, and develop autonomous technology for disposal on the basis of Taiwan's context, thereby building a solid foundation for professional quality, safety-first, and sustainable management.

B. Important Measures

Measure 1. Develop green technologies to increase renewable energy supplies:

- ① Enhance renewable energy technologies in areas such as photovoltaics, wind power, geothermal energy, biomass, and large-scale energy storage.
- ② Develop clean and low-carbon emission technologies for generating electricity, such as CCSU, hydrogen power infrastructure, and high-efficiency fuel cells.

Measure 2. Deploy smart grids to increase power supply reliability and green energy supply:

- ① Strengthen the infrastructures of power transmitting and distributing to facilitate the integration of renewable energy into the power grid.
- ② Improve demand-side management to increase the flexibility of power grid dispatch.



- ③ Assist the development of domestic industries with pilot projects.

Measure 3. Develop energy-efficient carbon-reduction technologies and integrated systems and services for real estate, industrial, and transportation activities:

- ① Develop system integration technology for low carbon emission residential and commercial buildings.
- ② Develop key materials, components, and systems in industrial energy-saving technology.
- ③ Develop core module technology for energy-saving smart automobiles.

Measure 4. Promote green innovation and reinforce the development and application of resource recycling and green technologies:

- ① Make green innovation a part of each phase of the product life cycle, reducing the impacts on the environment.
- ② Promote industrial symbiosis, and develop circular technology for industrial materials to improve the efficiency of energy and resource use.

Measure 5. Develop technologies for nuclear waste disposal and nuclear power plant decommissioning to strive toward a green and sustainable society:

- ① Ensure public safety by refining the regulatory system for radioactive waste, improving openness and transparency, and strengthening the mechanism of public participation.
- ② Learn from countries with experience in decommissioning nuclear power plants, and develop a comprehensive plan and managing techniques for large nuclear facility decommissioning.
- ③ Develop rigorous techniques of radiation assessment as regards the large amounts of waste after the decommissioning of nuclear plants so as to ensure the safety of waste reuse and to effectively reduce the costs.
- ④ Upgrade technologies used for the release, amount reduction, and stabilization of low- and micro-radioactive waste to ensure long-term safety and stability.
- ⑤ Explore technology for the storage and disposal of high-level radioactive waste.
- ⑥ Establish laboratories of disposal technology verification and other related hardware and software facilities for demonstration, thereby promoting research on public communication and education.

Strategy 5. Use Smart Sensing Technologies to Maintain Environmental Quality

A. Strategic Objectives



- ① Close the technological gap in trace concentration detection and complete the development of sensors monitoring air and water quality at major sites so as to provide the option for deploying the IoT in environmental monitoring.
- ② Integrate IoT technology in environment in an cross-domain and cross-professional manner, deploy the IoT in sensors monitoring air and water quality, develop related maintenance technology, and complete the construction of the IoT in sensors monitoring the quality of air and irrigated water in major urban and industrial areas.
- ③ Use information flow and big data analytics related to the environment to enhance environmental information services, and build a next-generation smart operating system of environmental law enforcement, so as to enhance the accuracy and efficiency of law enforcement, extensively reduce pollution, and protect environmental quality.
- ④ Open up the data for cross-domain and value-adding smart applications by taking the IoT in environmental monitoring as the basis for open data promotion, the integration of cross-domain information, hence enhancing the development of innovative and smart applications, with raised value and benefits.

B. Important Measures

Measure 1. Intensify the R&D of sensing technologies to

**consolidate a foundation for the development
of the IoT in environmental protection:**

- ① Develop more effective and durable components used in monitoring sensors for air and water quality.
- ② Develop sensor products suitable for measuring air and water quality in different fields of application.

**Measure 2. Integrate cross-cutting technologies to deploy
a network of IoT applications for
environmental monitoring:**

- ① Develop operating systems for the deployment, maintenance, and quality inspection of air quality sensors and IoT sensors.
- ② Deploy the IoT in water quality monitoring, and develop a maintenance system.

**Measure 3. Develop environmental data application and
analytical technologies to better transmit
environmental information and integrate
smart features into enforcement networks:**

- ① Develop smart service systems to collect, inspect, manage, and analyze big data from the network of air and water quality monitoring.
- ② Connect information collected from the IoT in environmental monitoring, develop a warning cloud system to catch sources of pollution in hot spots, and work to perfect the smart operating system for environmental law enforcement.



Strategy 6. Use Information Security Technologies to Assure the General Public a High Standard of Living

A. Strategic Objectives

- ① Guide the innovation capacity of universities and research community to invest in key cyber security technology and patent deployment, participate in the making of international standards for ISG, actively take part in international organizations and associations in cyber security research, and enhance the autonomy of the innovation of emerging cyber security technology.
- ② Develop integrated technology for cyber security applications to drive industry growth and create new business opportunities; cultivate talents in cyber security and optimise both services and products to create opportunities of internationalization for domestic industries; supporting companies to march to the international stage to expand their influence of cyber security technology; push for domestic small and medium-sized companies to become international superstars in cyber security; improve the domestic environment for the development of cyber security, create a robust industrial environment to construct an ecosystem with a positive cycle for the promotion, R&D, and export of the cyber security industries.

B. Important Measures

Measure 1. Develop new information security technologies:

- ① Understand the latest global trends in cyber security, and boost the autonomy of the innovation of cyber security technology.
- ② Earn international certification in ISG to enhance the maturity of technology.
- ③ Innovate the deployment of technology to establish a protection mechanism for key intellectual property rights and to raise the competitiveness of emerging cyber security technology.

Measure 2. Develop information security technologies and services:

- ① Develop integration technology for core cyber security technology and its emerging applications.
- ② Promote services for cyber security application to support the upgrade of cyber security industries.



Goal 3. Foster and Recruit Talent with Diverse Career Paths

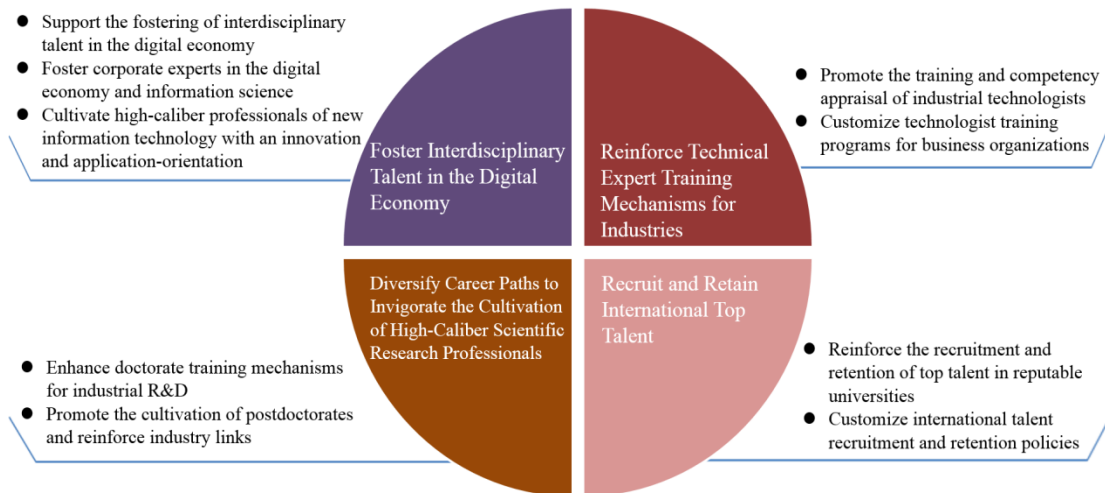


Figure 15 Overall Illustration of Goal 3

To speed up Taiwan’s industrial upgrading and transformation and to deepen cross-sectoral integration and development, the Executive Yuan encourages ministries/departments to promote 5+2 industrial innovation by combining the capacity of local industries, academia, and research institutions, using the digital economy as the base for industrial development. This policy addresses the urgent need for sufficient high-quality technology talent. Through strategic planning for the four goals of cultivating cross-domain talent for the digital economy, strengthening the mechanisms for training industrial technology personnel, revitalizing diverse career options for reviving the cultivation of high-level scientific research personnel, and recruiting and retaining international top talent, we aim to cultivate cross-domain talent with both professional and digital capacities, in response to the challenges and business opportunities presented by trends in the digital economy. Through strengthening the mechanisms for training industrial technology personnel, young people are encouraged to enter into industry, thus creating the talent necessary for industries and

strengthening the capacities of incumbent staff. By strengthening the mechanisms for cultivating R&D level industrial doctoral talent, we can shorten the gap between education/research and employment demand. By strengthening the measures for recruiting international top talent, we can create a welcoming life and work environment, thus achieving the goal of attracting international talent to support economic development and innovative transformation, and enhance industrial competitiveness. A review of the current situation and analysis of trends in each dimension of this goal are presented as follows:

(1) Current Situation Review and Trend Analysis

- A. The digital economy has become a trend of the global economy, and cross-domain talent in the digital economy has become the crucial foundation for industrial transformation and development.
 - (a) In response to future digitalization and intelligence development, students should cultivate their cross-domain digital capabilities through education systems.

WEF published *The Future of Jobs* in January 2016, indicating that the fourth industrial revolution (dominated by digitization, automation, AI, material revolution, and biotechnology) will subvert the global economy, resulting in human streamlining and talent failure; approximately 5 millions job opportunities will disappear within the coming 5 years. Governments must prepare early to help workers improve their skills and learn new skills, starting with investment in education and adult learning programs.



In the global economy, the trend is moving toward the development of a digital economy driven by AI combined with data, and the digital skills required of people are different. All citizens, general workers, or ICT professionals must enhance their digital skills constantly. In *The Future of Work: Jobs and Skills in 2030* (2015) survey, the UK Commission for Employment and Skills (UKCES) indicates that the trend of the next 10 years will have a strong emphasis on skills such as unique insights, social competencies, self-regulated adaptability, cross-cultural competitiveness, computer-like thinking, new media literacy, interdisciplinary research, design thinking, cognitive load management, and network collaboration. The last six are relevant skills necessary for the development of a digital economy. However, Taiwan is now facing problems concerning talent supply shortage because the education system cannot match the pace of social and economic changes. The government faces major challenges in how to endeavor to enhance the capacities of the digital economy and socialization, in response to employment opportunities presented by the digital economy.

In view of the increasing importance of digital innovation and its application to economic development, major countries have actively strengthened national strategies regarding networks or the digital economy in recent years. For example, the US proposed the Smart America Challenge; the European Union (EU) launched A Digital Single Market Strategy for Europe; Japan adopted the Declaration to be the

World's Most Advanced IT Nation; and mainland China enacted the “Internet Plus” Action Plan. To support the development of the digital economy, many countries, including Germany, the United Kingdom, and Japan, are actively promoting relevant personnel training policies to expand the cultivation of talent in ICT as well as online entrepreneurship.

At present, Taiwan's domestic industrial policies are actively tilting toward the development of digitalization and intelligence. The Executive Yuan encourages ministries/departments to cooperate with industries, academia, and research communities to develop 5+2 industries (biomedicine, green energy technology, smart machinery, national defense, Asian Silicon Valley, new agriculture, and circular economy). Among these, smart machinery and the Asian Silicon Valley are closely related to the digital economy. The key capabilities required for smart machinery and programs related to the Asian Silicon Valley (including IoT/Smart Application Project) include man-machine collaboration, machine vision and sensing technology, IoT applications, AI, and big data analysis. In addition, after the implementation of the Digital Finance 3.0 Strategy by the FSC, all banks are in urgent need of talent in terms of digital information, user interface / user experience (UI/UX) design, experiential marketing, big data analysis, and community marketing.



Although Taiwan has been cultivating digital talent for many years, many severe problems have been encountered in face of the digital economy transformation, such as a shortage of new-type professionals in industry. This reflects the gap between education and industrial development not having been effectively addressed, Problem-solving capabilities should be cultivated through education; people should know how to solve problems by applying what they have learned. Rather than capabilities only in information science, capabilities in cross-domain thinking integration and logical identification are even more critical. Regarding problem-solving, problems are not limited to classroom exams; numerous pragmatic solutions should be considered, in terms of life, environment, business, and social issues. As for exploring the problems faced by Taiwan in terms of cross-border talent cultivation in the digital economy, the main problems are as follows:

- Insufficient cross-sector coordination in the linkage between industries and academia: Governmental departments fail to predict rapid changes in future work patterns and employment skills and respond by organizing instantly and systematically. The regular and long-term study *The Future of Work: Jobs and Skills in 2030*, conducted by UKCES to assess the next 10–15 years, can serve as a reference standard for personnel training in front-end education sectors to reduce schooling (training) gaps. In response to the development of digital economic



personnel, Taiwan has primarily adopted the Financial Technology Personnel Training measures from the report — *Functional Benchmarks and Vocational Training for the Development of Productivity 4.0*, proposed by the MOL at the end of 2015, as well as the *FinTech Development Strategy White Paper*, issued by the FSC in May 2016. In the case of Taiwan, there is still room for improvement in terms of linkage between functional promotion in ministries/departments and the development of national talent resources.

- Cooperation between industries and academia requires strengthening: Rapid transformations occur in industries, and sometimes they even occur before the education system starts to adapt, in terms of personnel training. As an example in financial technology, in response to the Bank 3.0 challenge, the financial industry activates a number of financial transformation programs and implement their own practice-oriented talent cultivation. In addition, the Taiwan Productivity 4.0 Initiative has many more focuses on practice at demo sites. Taiwanese universities and colleges may encounter problems such as insufficient practical facilities or practice sites.
- Most of the cultivation of digital and software capacities still lies in information-related departments: Because of the development of the digital economy, the demand for software talent is greatly increasing, and various fields need talent that is able to use digital tools and programming



language communication skills to solve problems. However, because of a lack of software talent, particularly students in non-information-related departments, a major shortage persists in talent cultivation in terms of digital applications and software capacity. In addition, computational thinking capability is helpful in problem solving, and learning program design is an effective method to cultivate computational thinking. Programming education must be promoted and encouraged to take root.

- (b) Hardware production has long been the focus in Taiwan's industrial structure. When facing the transformation and development of the digital economy, Taiwan must make adjustments and supplementations in terms of industrial business thinking and new types of professionals.

The digital economy refers to economic activities based on digital computing technology. In 1993, the US President Bill Clinton promoted the National Information Infrastructure Plan, network construction, the development of information equipment, and digital information content construction help facilitate global digital information. Thus far, the activities in e-commerce, digital application services, and digital manufacturing, which have been developed using computer/intelligent handheld devices, IoT, and cloud computing, have profoundly affected people's daily life. In 2016, the OECD indicated that the digital economy has become an indispensable part of life. For example, in current production activities, 5%–10% of efficiency can be improved



through networking, and approximately 9% of Internet users in developed countries have used online financial services. In the future, the infiltration of the digital economy will increase, becoming a major part of life. The OECD speculates that there will be 14 billion devices in the families of its member states connected to the web by 2022, providing many more digital services. Much more new jobs will appear; approximately 65% of new job opportunities in the future have not been defined yet.

On the world's leading venture capital fund-raising platform — AngelList, 16,000 new ventures are recruiting talent online, providing a total of 548,000 job offerings. In recent years, most newly-established enterprises provide business services such as mobile services, cloud services, e-commerce, and online education. This shows that digital economy activities have been the main market for new ventures and will be the main trend of the global economy in the future.

Taiwan is now trying to implement innovation-driven economic development models instead of previous efficiency-driven models. Taiwan must also accelerate the development of a digital economy. However, if Taiwan intends to play a key role in trends of the digital economy, the following problems remain:

- Taiwan's business thinking and organizational structure require transformation: Hardware production has long been



the focus in Taiwan's industrial structure. Although most companies recognize that entering the digital economy and developing products based on software and hardware integration are critical issues, the existing corporate culture and organizational structure requires adjustments. The main driving force of change is how highly senior management values digitalized operations and how these are introduced into a business.

- Taiwan still lacks the professional talent necessary for the development of the digital economy: Professional talent in Taiwan primarily comprises engineers related to the support of hardware production activities in product R&D, process improvement, quality management, and equipment maintenance. Although the demand for software engineers continues to grow, the supply cannot meet the demand for rapid development of the digital economy.

(c) To develop a digital economy, Taiwan must cultivate high-level talent in innovative application-oriented emerging information technology.

In recent years, computers have been able to engage in rapid and extensive data processing as well as in-depth learning. With moderate self-correction capabilities, AI can challenge human intelligence in many critical areas, with major milestones including IBM Deep Blue's defeating Kasparov, IBM Watson defeating TV quiz champion, and the recent Google AlphaGo beating a Go master. With the advent

of big data age and the rapid development of information computing capacity, the importance of AI and in-depth machine learning will increase daily. Therefore, all of industry and academia worldwide is invested heavily in the R&D of AI technology and applications, with the aim of obtaining a leading competitive position in all walks of life. For Taiwan's information industry, of which hardware OEM traditionally accounts for the majority, this trend is a warning. However, it is also an opportunity to provide business transformation and industrial upgrading. In conclusion, the problems faced by Taiwan, in terms of high-level cross-border talent cultivation in the digital economy, are as follows:

- Taiwanese nationals are highly willing to embrace new technology and new applications; however, most traditional industries are more hesitant in the introduction of new technologies and tend to adopt a wait-and-see approach. Capital investment often cannot be in multiple places at once, which causes industries to gradually lag behind foreign manufacturers and lose competitiveness. In addition, existing laws and regulations are inflexible to the changes in the environment produced by emerging information technology, and therefore industries have relatively low demand for emerging information technology talent.
- While international competition in the digital economy is fierce and this area still needs to be researched and developed. At present, the world remains at the stage of exploring the mainstream direction, in which innovation



and differences are required for establishing competitive niches.

B. In line with the trend of innovative industrial development, Taiwan should strengthen mechanisms for training science and technology personnel for industries.

(a) Industrial incumbent practitioners need to improve their skills, while cultivation of professional personnel should be linked with industrial key functions.

- Industrial incumbent practitioners must improve their skills.

In Taiwan's industrial structure, long-term emphasis has been placed on hardware manufacturing activities with mature technology. The development of 5+2 industries/areas requires relevant capabilities and thinking about high-value products, industry intelligence, digital economy, and circular economy, and industrial incumbent practitioners must be helped to improve skills according to trends.

- The cultivation and application of professional talents remains inadequate.

The government has been promoting various personnel training measures through industry-academia cooperation to strengthen students' practical experience in learning the industry skills required. However, the existing measures are still not sufficient to meet industries' real needs for new talent with practice capacities. In particular,

in key industry positions, much more young people must be attracted to make investments and develop practical capability.

- (b) Taiwan's enterprises are less inclined to provide on-the-job training. A gap remains between the various existing industry-academia classes and the expectations of industries.

Because of economic and trade competition, the integration and strengthening of a regional economy produced by globalization, and the trend of international industrial development, Taiwan is facing many challenges in industrial development. The president has presented plans regarding R&D for the top five Industrial Innovation Research and Development Plans, namely green energy technology, Asian Silicon Valley, biomedicine, smart machinery, and national defense, to create industrial innovation ecosystems and promote the upgrading and transformation of industries in Taiwan. Among them, the Executive Yuan has approved Smart Machinery Development Program to promote Taiwan as a global R&D and manufacturing center for smart machinery and high-end equipment components. Smart machinery is created through the combination of precision machinery and smart technology, such as robots, IoT, and big data, to construct and realize an ecological system of smart machinery. Technology must be strengthened to integrate the capacity from local industries, academia, and research communities and cultivate sufficient and high-quality technology talent.



Taiwan's enterprises are less inclined to provide on-the-job training. With the rapid changes in industrial technology in recent years, existing practitioners have an increasing need to enhance their professional knowledge and skills. As for the educational training for skill enhancement, in-service workers mainly participate in the channels provided by their companies. Therefore, an effective method to enhance practitioners' professional knowledge and skills is to encourage Taiwan's enterprises to hold vocational training to improve in-service talent. However, according to the *Report on the Vocational Training Survey* produced by the MOL in 2014, only 27.7% of the enterprises in Taiwan offered professional training, which was lower than the rate of 71% in Singapore (2012), 71% in France (2010), 61% in Germany, 60% in the United Kingdom, and 47% in Italy (2010).

In addition, although various existing industry–academia cooperation classes held by current technology-specific schools and colleges have proven effective, and the linkage between schools and industries has been established, industrial expectations remain unmet in the following matters:

- There is no mechanism for exchanges between schools and industries, and the need for manpower in industries cannot be fulfilled immediately.
- Cooperating organizations have not been fully involved in student selection and course design.



- Students should be enrolled in outside internship and basic skills training, and should be provided with career counseling by their schools.
- The graduate employment rate remains to be improved.

C. Cultivation of high-level personnel is crucial to the capacity and industrial development of a country's national innovation systems. The gap between research and employment demand must be actively improved and diverse career options need to be provided.

(a) In the doctoral employment market, the phenomena of oversupply and gaps between research and employment demand are often seen, which is unfavorable for people who intend to participate in doctoral programs.

The quality of high-level talent cultivation directly affects the capacity in a country's national innovation systems. A high-quality high-level talent pool provides decisive advantages in solving social development problems and leading industrial and technological innovation. In view of this, all countries worldwide have different ideas regarding how to link doctoral talent cultivation with industry. For example, the EU has proposed innovative R&D projects to invite EU enterprises to take the initiative in proposing demands of high-level talent and required expertise, and ask them to cultivate Ph.D. through cooperation with academic units (e.g., universities, research community). Doctoral candidates are the main subjects of this program and are



required to spend more than half of their time on in-depth research on corporate work and studies. All of their salary and training expenses are supported by the EU. Through participation in the program, enterprises gain the opportunity to recruit excellent cross-border talent and benefit directly from the academic R&D capacity. The academic units can establish long-term cooperative relationships with enterprises and channel their academic research results to them directly. For the EU market, the overall development of the EU economy can be driven by the promotion of regional movement of transnational high-level talent (including doctoral candidates, academic units, and corporate resources).

By contrast, Taiwan's higher education systems have been popularized and expanded while industrial structures have changed. The doctoral employment market is shrinking, but the total doctoral cultivation is difficult to reduce because of the demands of university students, which results in the problem of oversupply of doctors in the job market. At the same time, doctoral training in universities tends to focus on single academic expertise that has too little linkage with social trends, resulting in gaps between research and employment demand. All of these factors collaterally affect people with academic potential, rendering them less willing to participate in doctoral programs. This causes adverse effects on the cultivation of high-level talent in Taiwan.

In summary, the current high-level talent cultivation in Taiwan has the following problems:

- In terms of talent cultivation patterns, positive actions should be taken in response to the structural change of the academic market.
- Positive improvements must be made to bridge the gap between education/research and employment demand.
- High-level talent should be guided and provided with diverse career options.
- The enrolment quota of doctoral candidates should be reduced annually in accordance with the market.

(b) Taiwan's senior R&D manpower is congregated mostly in academia and government; academic R&D findings cannot be effectively spread to industries. Therefore, diverse career options must be provided.

In terms of Taiwan's R&D manpower, although the proportion of talent with doctoral and master's degrees has gradually increased each year, this phenomenon does not reflect the situation in Taiwan's industries and employment markets. Table 7 shows that people with two degrees accounted for 46% of Taiwan's R&D manpower in 2004, whereas they accounted for 56% in 2015. This shows that the vast majority of doctoral and master's research manpower remained in academia and government, despite R&D manpower having increased substantially. The situation of doctor-level manpower is the most obvious. Table 8 shows that, in terms of Taiwan's senior R&D manpower in 2015, the R&D manpower staying in governmental departments and



academia accounted for 80.77% of all the doctoral R&D manpower. By comparison, doctoral R&D manpower accounted for only 18.13% of the manpower in industry. Because talent is critical for the diffusion and transfer of knowledge, dissemination of knowledge from academia cannot be effectively achieved if high-level R&D talent is overly congregated in academia and government, which will ultimately lead to the problem in linkage between upstream R&D results and downstream industries.

In general, the current cultivation of postdoctoral talent encounters the following problems:

- Failure to synchronize high-level manpower supply with job market demand.
- High-level R&D manpower is congregated in academia and governmental departments.

Table 7 Taiwan's R&D Manpower Composition, 2004-2015

Unit: persons

Year	R&D Manpower A	Doctor B	Percentage (B/A)	Master C	Percentage (C/A)	Bachelor D	Percentage (D/A)	Other E	Percentage (E/A)
2004	187,001	23,796	12.73%	63,096	33.74%	54,978	29.40%	45,131	24%
2005	195,721	24,907	12.73%	69,087	35.30%	57,854	29.56%	43,871	22%
2006	212,483	26,879	12.65%	76,628	36.06%	65,124	30.65%	43,851	21%
2007	228,987	29,081	12.70%	82,968	36.23%	70,830	30.93%	46,108	20%
2008	241,366	31,397	13.01%	90,483	37.49%	74,342	30.80%	45,144	19%
2009	256,543	33,701	13.14%	98,650	38.45%	79,599	31.03%	44,592	17%
2010	273,447	35,762	13.08%	107,693	39.38%	85,760	31.36%	44,232	16%
2011	288,726	38,099	13.20%	115,776	40.10%	91,765	31.78%	43,086	15%
2012	296,724	39,727	13.39%	120,422	40.58%	94,205	31.75%	42,370	14%

Year	R&D Manpower A	Doctor B	Percentage (B/A)	Master C	Percentage (C/A)	Bachelor D	Percentage (D/A)	Other E	Percentage (E/A)
2013	301,001	40,922	13.60%	124,665	41.42%	94,811	31.50%	40,603	13%
2014	307,933	41,396	13.44%	130,047	42.23%	97,024	31.51%	39,466	13%
2015	313,463	42,174	13.45%	134,241	42.83%	98,523	31.43%	38,525	12%

Source: *Indicators of Science and Technology*. MOST, 2016.

**Table 8 Sectoral Distribution of Taiwan's Doctoral R&D Manpower
in 2015**

Department Category	Number of Persons	Number of Doctors	Proportion of the Number of Taiwan's Doctors
Nationwide	313,463	42,174	100%
Business Sector	220,212	7,647	18.13%
Governmental Sector	35,978	6,821	16.17%
Higher Education Sector	55,776	27,245	64.6%
Private Nonprofit Sector	1,497	461	1.09%

Source: *Indicators of Science and Technology*. MOST, 2016.

**Table 9 Recruitment of Postdoctoral Research Personnel Funded by
the MOST**

Year	2012	2013	2014	2015	2016
Number of Applicants	3,062	3,243	3,334	3,066	3,082
Number of Persons Funded	2,195	2,226	2,225	2,251	2,412
Pass Rate	71.69%	68.64%	66.74%	73.42%	78.26%

Source: Academic Statistics Database, MOST, 2017.



D. The government should exert effort in talent recruitment and retention. Taiwan still lacks relevant measures for attracting foreign talent.

(a) Policy systems and the talent retention/application environment should be improved.

- Shortage of new and international talent

An assessment of the Flexible Salary Scheme, implemented by universities/colleges in the academic years of 2010 to 2014, shows that the key of promotion was retaining incumbent special talent by providing flexible salary rates. Newly-employed talent accounted for only 4.7% of the total number of people who received salaries based on flexible salary rates. As for talent categories, most were domestic talent (in the academic year of 2014, international talent accounted for only 6.6% of all the people receiving salary issuance). The program still requires substantial improvement to achieve goals such as the introduction of international higher education talent, ensuring newly-engaged special talent at home and abroad, and the recruitment of higher education management talent.

- Each school's performance indicators and flexible salary systems must be strengthened.

In the academic year of 2014, the talent receiving flexible salary subsidies was 9,849 people, accounting for 19.7% of the total number (50,000) of full-time teaching and research staff nationwide. However, the performance



indicators of flexible salary are not based on the distinctive features or future development needs of each school. In addition, to ensure fairness, most indicators were point-collection quantitative indicators. Each school's performance indicators of flexible salary must be strengthened.

- Ministries/departments have different plans and schools have difficulties in integration.

Flexible Salary Scheme are approved and funded by the MOE and the MOST. There are two funding sources, which not only increases the costs of application but also create duplicated subsidies.

- It is difficult for international talent to access pensions and their children have difficulties in going to the schools that suit them.

Because of retirement regulations, treatment of international talent is poorer than that of native teachers in Taiwan's pension scheme. Hence, international talent is difficult to recruit and retain. In addition, children's education arrangement is a critical factor to attract international talent, and language learning and general course plan must meet their needs.

- (b) Relevant laws and regulations must be relaxed, enhanced, and synchronized internationally.



Currently, industries, public sectors, academia, and research institutions are all trying to optimize policies and systems and create friendly retention and employment environments in order to recruit international talent. Owing to the 2011 amendments to the Fundamental Science and Technology Act, public research institutions enjoy more autonomy and freedom in management and talent recruitment. However, research and innovation developments are limited by the framework of laws and regulations in which management and prevention of malpractice are emphasized. For example, many limitations remain in relevant laws and regulations such as Immigration Act, the Civil Servant Work Act, the Employment Service Act, and the Regulations Governing the Relations between the People of the Taiwan Area and the People of the Mainland China Area. For this reason, Taiwan has difficulty recruiting high-quality international talent in a timely, flexible, and efficient manner. For catching up and possibly even surpassing other countries, there is an urgent need for the pace of legislation to be relaxed.

According to the results of a survey conducted by the MOEA on talent demand, Taiwan's industries urgently need to recruit high-level talent. Manufacturing industries require scientific and technological management personnel as well as high-level technology R&D personnel, service industries require transnational management personnel, and all of them have a common need for talent that can develop overseas markets. To solve the gradually worsening problems of

business head-hunting and meet Taiwan's urgent need for international talent, the Executive Yuan has set up the Talent Competiveness Strategy Promotion Group. Cross-departmental panels will be established for the four dimensions of overseas network layout, reinforcement of global talent recruitment, enhancement of the conditions for competitive talent, and establishment of a friendly talent retention environment. Specific concrete measures will be proposed by these panels.

In terms of academia and research fields, relevant laws and regulations (e.g., Civil Servant Work Act) prevent any possibility of joint-hiring of any crucial domestic or foreign scholars between two schools (e.g., 50% of the salary paid by each of two schools). However, the joint-hiring system is beneficial to cross-school talent exchanges as well as the recruitment of crucial foreign scholars to the ranks of Taiwan's higher education and scientific research, for the purpose of expanding international perspectives. Therefore, it is increasingly imperative to perform joint-hiring for both domestic and foreign teaching and research institutions. However, because the source of pay is limited to the system for civil servants' salaries, flexible sharing and planning of working conditions cannot be achieved. Consequently, there is a need for a breakthrough under the existing ordinance.

Furthermore, in response to fierce international competition in research talent hunting, the research and teaching fields have in recent years been calling on the



government to separate civil service, education and research and to increase the flexibility on salary for teachers, in order to increase the competitiveness of international talent recruitment. There are restrictions in existing Government Procurement Act concerning donations, commissioned procurement plans, and bid rendering, as well as preventing scientific research personnel from working part-time because of the limitations of civil service law and interest conflicts caused by technical transfers. All of these problems are not conducive to Taiwan's scientific development, and they must be effectively resolved.

(2) Strategies

Strategy 1. Foster Interdisciplinary Talent in the Digital Economy

A. Strategic Objectives

- ① Promote the development of digital economic talent and cultivate cross-domain talent with both professional and digital capabilities. Let students deepen their thinking and basic software abilities.
- ② Cultivate talent in Taiwan's enterprises to build comprehensive thinking regarding operating in the digital economy, as well as operative capacity, in response to the challenges and business opportunities presented by trends of the digital economy. Assist enterprises to develop the



professionals necessary for the digital economy, introduce information science mechanisms, and enhance the value of products and services.

- ③ Cultivate abundant high-quality research talent in data analysis, machine learning, and AI to promote many new ventures based on these areas as the core technology. Apply emerging technology, such as information analysis and AI, to Taiwan's traditional industries to enhance industrial competitiveness.

B. Important Measures

Measure 1. Support the fostering of interdisciplinary talent in the digital economy:

- ① Predict the trends of future tasks and skills in the digital economy.
- ② Promote a cultivation mechanism by linking academia, research community, and industries to enhance cross-domain talent employment.
- ③ Promote program design education in universities and cultivate the cross-domain talent of both professional and digital capabilities.

Measure 2. Foster corporate experts in the digital economy and information science:



- ① Encourage universities/colleges to hold in-service education programs related to the digital economy and information science to strengthen the linkage between schools and local industries.
- ② Promote on-the-job training for professional talent for the digital economy.

Measure 3. Cultivate high-caliber professionals of new information technology with an innovation and application-orientation:

- ① Cultivate and recruit high-level talent in AI and machine learning to enhance the quality and quantity of Taiwan's core talent in emerging information technology.
- ② Promote innovative emerging technology and its application in R&D projects to strengthen Taiwan's competitiveness in AI and machine learning.

Strategy 2. Reinforce Technical Expert Training Mechanisms for Industries

A. Strategic Objectives

- ① Focus on the policy directions and talent needs in 5+2 industries and help Taiwan's industries strengthen the capacities of incumbent personnel. Combine the capacity in industries and academia to establish a cyclical model of teaching, training, appraisal, and appointment, based on the core of ability appraisal. Thus, young people can be

encouraged to exert effort in advanced tasks in industry and supplement industries with the necessary talent.

- ② Encourage universities of technology and colleges of technology to establish mechanisms for talent training. Enterprises and schools should jointly organize hands-on courses and on-site practice to assemble the tailored personnel necessary for industries, so that students can be immediately employed upon graduating from school. Provide assistance for local enterprises in the establishment of training systems to help enterprises construct exclusively customized personnel training mechanisms based on operational development strategies and required capabilities, curriculum development, and cultivation of internal teachers. These aims strengthen the upgrading and transformation of industrial smart machinery. Through counseling and incentives to facilitate human capital driven by business investment, enterprise groups should be rewarded for enhancing innovative actions with human capital to achieve the purpose of benchmarking.

B. Important Measures

Measure 1. Promote the training and competency appraisal of industrial technologists:

- ① Support 5+2 industrial S&T innovation and application for the training of personnel in industrial practices.



- ② Promote the identification of talent capability in 5+2 related industries, encourage young people to engage with high-quality jobs, and build a talent cultivation model with the cycle of teaching, training, appraisal, and appointment. Facilitate the linkage between schools, training institutions, and employing enterprises, based on the identification of professional talent capability. In line with the policy measures implemented by each ministry/department, promote young people to become the key talent required by 5+2 related industries.

Measure 2. Customize technologist training programs for business organizations:

- ① Encourage universities/colleges of technology to run industrial academies and guide schools to establish a mechanism for cooperating with industries in talent cultivation.
- ② Assist enterprises in establishing talent quality-management system and drive enterprises to invest in human capital through the National Talent Development Awards scheme.
- ③ Engage in cross-sectoral cooperation with links to personnel training services.
- ④ Provide enterprises with assistance measures related to customized personnel training, in accordance with the enterprise size, and improve the incentives for training for scientific and technological personnel.

Strategy 3. Diversify Career Paths to Invigorate the Cultivation of High-Caliber Scientific Research Professionals

A. Strategic Objectives

- ① Integrate resources from the government, universities, and industries for establishing a model in which the doctoral talent cultivation process is closely connected with industries. Hence, the gaps between education/research and employment demand can be bridged. Strengthen new and innovative resources from universities to encourage doctoral students to transform research results into entrepreneurial resources, contributing to future developments. Integrate educational resources from domestic universities and international research institutions to establish systematic co-cultivation models for Taiwan's doctoral talent and international research institutions. Cultivate Taiwan's academic elite to achieve international first-class standards and lead the development of Taiwan.
- ② Cultivate the high-level human resources necessary for national development and encourage enterprises to participate in personnel training.

B. Important Measures

Measure 1. Enhance doctorate training mechanisms for industrial R&D:



- ① Promote new forms of trial programs linking industry, academia, and research community.
- ② Fortify the innovative entrepreneurship environment in universities/colleges.
- ③ Control the total quantity of doctoral programs and increase the diversification of career options for doctoral talent.

Measure 2. Promote the cultivation of postdoctorates and reinforce industry links:

- ① Identify the situation of doctoral graduates in the workplace.
- ② Cultivate the high-level human resources necessary for national development by means of diverse funding measures and policies.
- ③ Promote innovative industry–academia cooperation, increase the interaction between industries and academia, and encourage enterprises to participate in personnel training.

Strategy 4. Recruit and Retain International Top Talent

A. Strategic Objectives

- ① Strengthen the recruitment and retention of top talent in reputable universities, and facilitate the divergence of civil service, teaching, and research sectors.
- ② Focus on the development of key industries in Taiwan to strengthen the measures for talent recruitment. With cross-

government resources, the aim is to recruit overseas high-value talent to supply the talent necessary for the development of Taiwan's key industries. Create a friendly life and work environment for attracting international talent and achieving the goal of forging international links.

B. Important Measures

Measure 1. Reinforce the recruitment and retention of top talent in reputable universities:

- ① Strengthen the incentives for international talent in each dimension and environment.
- ② Provide talent with an environment with sufficient support of research, life and international links.
- ③ Extend competitive funds to the Flexible Salary Scheme.
- ④ Improve the schooling environment provided for the children of international talent.

Measure 2. Customize international talent recruitment and retention policies:

- ① Relax and amend relevant laws and regulations.
- ② Implement a joint-hiring system in international academic communities.
- ③ Provide suggestions for reforming the divergence between civil service and teaching/research sectors.



- ④ Strengthen the matching and consultation services for foreign talent employment.

Goal 4. Enhance the Innovation Ecosystem for Scientific Research

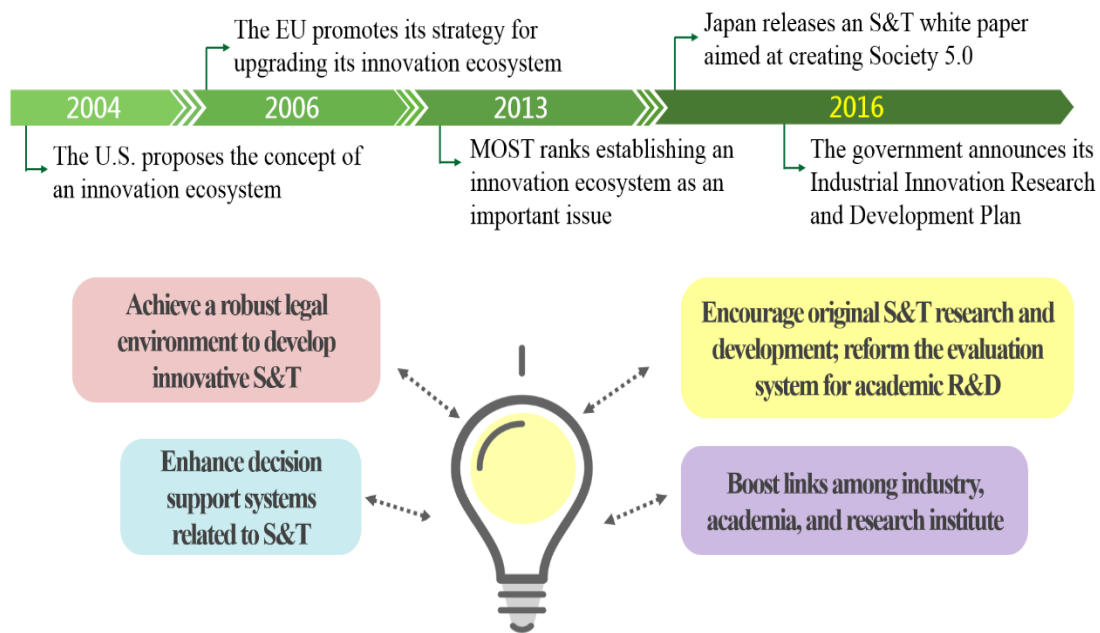


Figure 16 Overall Illustration of Goal 4

The concept of an innovation ecosystem was first proposed by the US Council on Competitiveness in 2004. The idea was that individuals, groups, and the environment exist in a cyclical relationship, with each needing and relying on the others. Two years later, the EU started promoting strategies for its own European innovation ecosystem. Its primary objectives are to plan out major blueprints for actions, raise the value of scientific research application, help resolve problems at the national and social level, and spur innovation in Europe. In 2013, MOST hosted the Science and Technology Development Advisory Conference; a Strategy for Creating an Innovation Ecosystem was proposed as a major item on the agenda. The strategy provides support for industries as they engage in innovative activities. Such support encompasses a variety of different levels, ranging from resources, professional talent, organization, and mechanisms. In a cabinet meeting in 2016, the Government of Japanese formulated S&T objectives which covered a



broad range of topics such as the internet, big data, and AI among others. It also set out the goal of establishing Society 5.0, which is designed to fulfill needs of individuals. That same year, the Taiwan's government emphasized the importance of building close, collaborative partnerships among industry, government, and academia to collectively promote the Industrial Innovation Research and Development Plan with focus on innovation, employment, and distribution. With respect to Goal 4 of the Plan, the focus is on the following four major dimensions in order to enhance the S&T innovation ecosystem: (1)decision support systems; (2)laws and regulations; (3)evaluation of R&D results; and (4)industry-academia-research cooperation. Each of these dimensions will be discussed respectively below, with emphasis on the analysis of current situation and trends.

(1) Current Situation Review and Trend Analysis

A. The establishment of robust decision support systems takes center stage in the constant refinement of the policy-making and planning processes for S&T policy.

(a) S&T policy requires long-term vision and forward-thinking plans.

Technology Foresight is aimed at responding to the future societal and economic needs through the consensus-building and diversified engagement approaches. Accordingly, technology foresight is regarded by many advanced countries as a critical component of S&T policy-making processes. Take Japan and South Korea as illustrative examples, Technology Foresight in Japan is aimed at societal needs in

thirty years. In addition to directly navigating the formation of S&T program frameworks, and orienting the development of emerging technologies, Japan's government takes some measures such as distributing policy booklets and comics to disseminate the topics addressed in Technology Foresight, thereby exerting Foresight's impact on achieving a societal consensus on it. Likewise, South Korean government formalized the Technology Foresight in the S&T policy-making processes through amending its Framework Act on Science and Technology in 1991, becoming the first nation to granting Technology Foresight legally binding status with clear specifications regarding the procedures and a competent authority. South Korea conducts a survey on Technology Foresight every five years in order to explore the major trends in the coming 25 years and informing the S&T programs planning accordingly. It navigates the formulation of S&T policy, and serves as a basis for allocating budget resources and implementing S&T programs. The cases of Japan and South Korea clearly demonstrate the critical benefits that Technology Foresight brings to S&T policies and programs.

Given the emphasis of S&T development by Taiwan's government, the Executive Yuan reorganized the Science and Technology Advisory Group (STAG) into the newly launched BOST to serve as a cabinet-level platform for S&T policy-making and for interagency coordination. Science and Technology Advisory Board Meetings of the Executive Yuan was launched in 1980 to solicit the opinions from domestic



and overseas talent from industry and academia to reach the consensus-based policy recommendation for S&T policy. STAG convened the 25th Science and Technology Advisory Board Meetings of the Executive Yuan in 2005 and conduct the “Research of 2015 Taiwan Industry Development and Technology Integration Project”, which prospectively mapping the key industrialized technologies in 2015. Likewise, in 2009 and 2012, the STAG conducted industry foresight research for 2020 and 2025, respectively, recognizing technology foresight as an important means to enhance national innovation systems. Since its restructuring in 2012, BOST has held major strategic meetings to discuss pressing industry demands as well as international contingencies. To date, it has already held 13 strategy meetings to address the critical S&T issues.

Horizontal communication, integration, and cooperation between government departments in Taiwan must be bolstered in order to create a closer connection between technology foresight and S&T policy. Furthermore, through experience in technology foresight and by attracting professional talent, there can be a clear direction for long-term development plans at the national and lower levels of government, which will also help to create a more robust foundation for the sustainable development of S&T in Taiwan. In addition, the diffusion of technology foresight can help Taiwan arrive at a social consensus for the directions in which S&T should develop, and thereby encourage the concentration of resources into

S&T projects that enhance Taiwan's competitive advantage and help it respond to major socio-economic issues.

- (b) The constant improvement management mechanisms for S&T programs assures the alignment of S&T programs' outcome with societal needs.

MOST and other departments implementing S&T programs made an effort to equip Taiwan's government robust mechanisms for qualitatively and quantitatively assessing the S&T programs throughout their planning, implementation, and assessment processes. However, when compared with the decision-making systems for S&T in advanced countries, there is still striking differences between advanced nations and Taiwan in the following dimensions: alignment of societal needs with S&T program formation, and comprehensiveness of outcome-based management and evaluation mechanisms such as the ex-ante, mid-term, and ex-post evaluation informing the program improvement and resources allocation. First, there is a lack of empirical evidence to substantiate the relevance between proposed S&T programs and their corresponding major S&T policy goals reflecting the societal needs. Secondly, in terms of program management and evaluation mechanisms for S&T programs designed to implement the major S&T policy with essential socio-economic goals established, large costs incurred, and interagency collaboration required, most advanced countries prospectively and retrospectively measure the impact of S&T programs utilizing the evaluation methods such as benefits



assessment or technology assessment (social impact assessment) conducted by ad hoc profession agency to inform S&T policy-making regarding resources allocation. These difference signify that the policy-making system for Taiwan's S&T policy remains to be further improved when compared with advanced nations. Thirdly, Taiwan's ministry and agencies do not have sufficient professional capacities (staff and expertises) and evaluation guidelines regarding the S&T program evaluation; therefore, the ministries carrying out the evaluated S&T programs do not afford to fulfill the required qualifications required by the sophisticated S&T program evaluation practices concerning relevance, efficiency, and effectiveness to align the S&T programs with the societal needs. The primary problems to be address are as follows:

- Inadequacy of systematic assessment and identification of pressing topics and societal needs: Various ministries and agencies in Taiwan are already equipped with policy-making mechanisms to formulate major S&T policy responding to socio-economic needs and inform the planning of inter-disciplinary and trans-disciplinary S&T programs to facilitate cooperation among academia, government, and industry. Yet such major policies still require a means to conduct systematic assessment and well-defined measurable objectives; and sophisticated evidence-based evaluation to improve impact of the major S&T policy reflecting the societal needs. Furthermore, the program alignment framework between major S&T

policies and related programs are required to navigate the ex-ante and ex-post evaluation and budget review practices.

- The adequacy of the planning and review of major S&T programs relies on comprehensive prospectively and retrospectively assessing the impact of S&T programs, and sophisticated management mechanisms. Meanwhile, Taiwan's MOST are supposed to improve the evaluation guideline and capacities to assure the evidence-based evaluation of S&T programs. Furthermore, in the planning phase of major S&T programs, the governance mechanisms must be enhanced in order to conduct evidence-based impact assessments, R&D risk management, technology assessment, and social impact assessments. This evidence-based approach can also inform the prioritization of the budget, and program improvement thereby minimizing the negative impact and maximizing the beneficial impact. In addition, during the implementation phase, the professional decision-support agency with qualified program managers should be established to proactively conduct the technological and financial risks assessment, inform the budget allocation, and make strategic adjustments under the highly volatile circumstances of high-risk R&D.
- In terms of governance mechanisms in support of S&T policy-making, some advanced countries set up a cabinet-level decision-support agency in charge of management and coordination of S&T programs to carry out the monitoring, and evaluation of the S&T programs. At the ministry and



agency level, other countries set up the funding agencies (such as National Science Foundation (NSF), DARPA, and National Institute of Standards and Technology (NIST) in the US) in charge of program planning, project selection and investment portfolio risk management. Pertinent to the specific attributes of S&T program, funding agencies usually take different approaches to managing their investment portfolio. To carry the mission, the funding agencies appoint program managers proficient in R&D program management to manage R&D projects with varying degree of power to conclude the program selection and management.

- In addition, Taiwan's current mechanisms regarding the evidence-based evaluation of the relevance, efficiency, and effectiveness of S&T programs in Taiwan remains to be improved. The outcome/impact indicators currently employed is not as sophisticated as those of advanced countries; therefore, it is difficult to employ the outcome evaluation to align the S&T programs with societal needs. The inadequacy of Taiwan's evidence-based program evaluation results from the absence of sophisticated guidelines and methods of S&T program evaluation and the insufficiency of the evaluation capacities of Taiwan's ministries and agencies to fulfill the requirement concerning the top-down implementation of the planning, indicator-based monitoring, and evaluation of S&T programs. In addition, the dialogue and coordination



between the cabinet-level and ministry-level evaluation or funding agency should be strengthened.

- Out of countries boosting their capabilities for evaluating S&T programs, the UK, Switzerland, Japan, Finland, Denmark, Norway, and mainland China have all established evaluation criteria, guidelines, and frameworks; the US, Switzerland, Australia, Belgium, Norway, Denmark, Finland, and Spain have been amending and integrating S&T indicators; the US, Japan, and South Korea have created a foundation for S&T policy information; and the US is devoted to creating evaluations and benefit assessments for particular groups.

B. The legal environment must be constantly reviewed and amended in order to promote technological innovation.

(a) S&T is constantly evolving, and relevant laws and regulations must keep pace with new developments.

- Facing a constantly changing and highly competitive environment for scientific research, the Fundamental Science and Technology Act and related regulations should be routinely reviewed in order to identify problems in practice that have arisen after their promulgation, and to adapt the legal norms to guide the decision-making systems for S&T policy.



- Since its promulgation in 1999, the Fundamental Science and Technology Act has been discussed at meetings of the National Science and Technology Conference, with a view to reviewing laws and regulations and generating response measures based on domestic and international developments. In order to improve the legal system for S&T development in Taiwan, the Act was amended three times between 2003 and 2011, followed by the amendments to related secondary legislation accordingly.

Table 10 Amendments to the Fundamental Science and Technology Act

Previous National Science and Technology Conferences	Previous Amendments to the Fundamental Science and Technology Act
The Sixth National Science and Technology Conference	2003 (Amendments made to Articles 6, 12, 13, and 17)
The Seventh National Science and Technology Conference	2005 (Amendments made to Articles 5, 6, and 13)
The Eighth National Science and Technology Conference	2011 (Amendments made to Articles 3, 5, 6, 13, 14, and 17)
The Ninth National Science and Technology Conference	Continued discussions on legal guidelines adaptation

- Over recent years, amendments to the Fundamental Science and Technology Act have focused on application of R&D results and loosening legal restrictions on industry-academia cooperation. For example, R&D results and the intellectual property rights thereby derived from R&D projects are exempt from restrictions in the



National Property Act (Article 6, paragraphs 1 and 2). The Executive Yuan and other governmental departments have also made adaptations to their respective regulations on the ownership and application of R&D results. Another new addition to the law is that when government-commissioned organizations and public research institutes make procurements for purposes of S&T research and development, they will not be subject to regulations in the Government Procurement Act (Article 6, paragraph 4). This change was also amended in Regulations Governing Procurements for Scientific and Technological Research and Development. In addition, the following articles will no longer apply when research personnel in public schools or public research institutions need to use technology as investment capital or hold concurrent jobs for the purpose of scientific research: Article 34 of the Act of Governing the Appointment of Educators; Article 13, paragraph 1 of the Civil Servant Work Act, which limits total shares held by any civil servant in a business to ten percent; and Article 13, paragraph 2, and Article 14 of the Civil Servant Work Act, which does not allow researchers to hold another position concurrently. In addition, Regulations on Moonlighting, Technology Transfer and Acquisition of Stock Shares for S&T Researchers has also been amended.

- The following issues are all important considerations of the Fundamental Science and Technology Act: the balanced development of basic and applied research,



developing an abundant supply of research talent and ensuring stable scientific research capacities in Taiwan, and having S&T research that responds to societal needs. It is essential to routinely review the Fundamental Science and Technology Act and other laws or regulations related to scientific activities in order to keep up with international trends in scientific research and the government's direction for domestic S&T development. Even more important is to use the opportunity for open dialogue with related stakeholders when reviewing and amending the laws above, as this will help to arrive at a national consensus on S&T development in Taiwan.

- The importance of quick, flexible mechanisms for changing laws and regulations when it comes to open innovation within S&T:
 - Developments in S&T can create negative results which were unforeseen by current legislation and therefore they cannot be prevented by the law. That said, excessive fears about the negative ramifications of S&T can also hamper emerging developments.
 - Using innovative applications of S&T to drive emerging industries involves management guidelines that may be scattered throughout different laws and vary among departments. Taking two examples from the sharing economy, Uber and Homejoy, there is need for greater legal clarity about issues such as specialized licenses,

industrial relations, and so on. Industrial innovation is often driven by S&T. Given the fact that S&T application often goes beyond current knowledge, it is important to be forward-thinking when making legal adjustments, so as to preserve the greatest flexibility for new S&T applications, and push the law to go hand in hand with the rapid transformations of science, technology, the economy, and society (e.g. how conventional laws on attributing responsibility for traffic accidents must be adapted to the advent of driverless cars). Yet it is also important to make sure that taking the steps above does not create unwillingness to invest or innovate due to the lack of legal clarity. Finding a proper balance between these issues will be truly difficult.

- (b) Legislation must be constantly revamped and adapted to allow for smoother cooperation among industry, academia, and research community.

The Bayh-Dole Act in the US was referenced when creating Taiwan's Fundamental Science and Technology Act. The Act aims to free up R&D results, allowing the rich supplies of knowledge, scientific research, and R&D results within academia to be put to use through technology transfer and collaboration with industry. Previous versions of National Science and Technology Development Plans (please refer to Table 11) shows a consistent trend towards industrializing academic knowledge and scientific research, and encouraging closer collaboration among government, industry, and



academia. MOST and other governmental departments have been experimenting with different mechanisms for collaboration between industry and academia and for joint programs to deepen and proliferate technological R&D.

**Table 11 National Science and Technology Development Plans:
Topics Relevant to Industry-Academia Cooperation**

National Science and Technology Development Plan (2013-2016)	Goal 1: To Raise Taiwan's Academic and Research Status. Strategy 3: Regulations on Industrial-Academic Collaboration and Conflict of Interest
National Science and Technology Development Plan (2009-2012)	Strategy 3: Putting the Legal and Regulatory System on a Sound Footing, Integrating Sci-Tech Resources Subtopic 1: Putting the Legal and Regulatory System on a Sound Footing, Promoting the Synergistic Utilization of R&D Results by Industry, Academia, and Research Organizations
National Science and Technology Development Plan (2005-2008)	Strategy 3: Boosting Academic Research Standards, Developing Distinctive Academic Fields Key Measure 2: Boosting Industry-Academic Relationships, Pursuing Excellence and Innovation
National Science and Technology Development Plan (2001-2004)	Strategy 3: Strengthening Academic Research, Pursuing Academic Excellence Key Measure 2: Knowledge Innovation will Serve as a Driving Force of Economic Development

Enhancement of collaboration between industry and academia was an important part in the National Science and

Technology Development Plan (2013-2016) drawn up in the Ninth National Science and Technology Conference. Potential difficulties and practical problems (with regard to laws and regulations) faced when commercializing the products of academic research were reviewed. These discussions aim to encourage new venture to grow out of academic R&D. Changes to law and regulations include:

- Amendments to the Statute for Industrial Innovation about deferring tax and income tax payments for inventor of technology who receive shares from an academic research institute based on the value of the technology: In June 2015, MOST announced an amended version of MOST Scientific and Technological Research and Development Results Ownership and Utilization Regulations. The amendments were intended to enhance the industrialization of results from academic R&D and to encourage establishing new venture. Amendments included the provision that patent rights may be shared between the academic research institute and the producer. Domestic R&D inventors who receive shares valued at the price of the technology come under deferred tax and income tax regulations. However, as these regulations are only applicable to institutes receiving funding from MOST, the effectiveness of these regulations has been limited. In the future, MOST will consult with the MOEA, MOF, and other departments to explore additional measures, thereby increasing the incentives for academic research institutes to pursue technology transfer.



- Restrictions were loosened on public school instructors and researchers, so that they may serve directors of the board of new ventures if they do not concurrently hold an administrative position at their school: In order to expand benefits for researchers who join and assist new ventures, the Executive Yuan and the Examination Yuan amended the Regulations on Moonlighting, Technology Transfer and Acquisition of Stock Shares for S&T Researchers in 2016. Instructors and researchers at public schools may serve as directors of the board of a start-up company if they do not concurrently hold an administrative position at the school. The Executive Yuan will also explore the feasibility of further relaxation of the restrictions.

There are currently discussions on making further amendments to the Fundamental Science and Technology Act in order to keep in step with the government's objectives to promote innovative R&D within industry, expedite the application of R&D results, and relax restrictions on researchers concurrently holding an additional position. At the same time, there are continued discussions with MOEA about amendment to the Statute for Industrial Innovation regarding deferred taxation of domestic technology producers who have not acquired full ownership rights of R&D results, but are given shares in exchange for their contribution. Previous amendments were directed at encouraging involvement of outstanding research and researchers to actively join new venture, so that innovative research from academia could



speed up changes in industrial innovation, help domestic S&T industries upgrade, and break down barriers for outstanding talent from the S&T world, thereby creating more active exchange between industries and academic research communities.

In response to the diverse forms of cooperation between industry and academia, and to encourage closer and more substantial collaboration between industry and academia on scientific research projects, amendments will be made to Regulations Governing Procurements for Scientific and Technological Research and Development, which was adopted in accordance with Article 6, paragraph 4 of the Fundamental Science and Technology Act. Amendments will make the procurement system for S&T research and development more flexible, helping the system adapt to changing times. This will correspond to different demands and different forms of collaboration between industry and academia, letting industries actively draw on the research capabilities of academic and research institutes, and transforming those capabilities into momentum for upgrading domestic S&T industries. Adjustments to the procurement system will not only involve the Fundamental Science and Technology Act, but also the authority, rights, and obligations of various government departments. For example, one such piece of legislation which will be involved is the Government Procurement Act, which comes under the authority of the PCC. Therefore, the future will see continued cooperation between



government departments and further legal adjustments, which will help create a high-quality environment for sustainable development of S&T in Taiwan.

In addition to an appropriate relaxation of related laws to boost cooperation between academia and industry, proper guidelines must be simultaneously established to avoid conflicts of interest. In order to provide a firm legal basis for regulations regarding ownership of R&D results and the avoidance of conflicts of interest, the government added regulations pertaining to conflicts of interest and information disclosure to Article 6 of the Fundamental Science and Technology Act. Based on their authority, the Executive Yuan and other departments have also made changes to their own regulations in this respect. In 2012, MOST set out clear guidelines for conflicts of interest and information disclosure in the MOST Scientific and Technological Research and Development Results Ownership and Utilization Regulations, urging all schools to create internal guidelines for information disclosure and the avoidance of conflicts of interest as they as regards R&D results.

- C. In order to boost international competitiveness within the academic realm, improvements to research facilities and the academic environment must be continued.
 - (a) Research diversity should be encouraged in order to create better base for driving of S&T innovation.

Since long time ago, with the aim of developing S&T and boosting national academic competitiveness, policy-makers around the world have put much emphasis the importance promoting and encouraging of free exploration in basic and applied research, and thus creating better base for driving of domestic innovation. Since the outcome of scientific research is inherently unpredictable, the themes of such kind of projects are mostly based on proposals suggested by the bottom-up approach form researchers and are focus on the basic, then than applied research. While the nature of free exploration is characterized by their uncertainty and head for longer investment, many governments and departments of higher education over the world still choose to support of such kind of research since they may have wider and deeper impacts on the society. As compared to other countries, the ratio of investment for basic research to the R&D expenditure in Taiwan is lower than the ratio of Japan, South Korea, and Singapore. The R&D expenditure of industries is mostly for developing technology, and hence the support of funding of basic and applied research from government is necessary. While the government boosted funding for basic and applied research in 2014, and the ratio to the total R&D expenditure is modestly increased when compared to the one of technological development. However, many countries around the world to increase funding for basic and applied research, in order to ensure that innovation can be sustained for longer term in Taiwan. In addition, the government needs to ensure the development of research, and



reward outstanding research results, so that long term innovation capacity can be continued. Meanwhile, Ph.D. students with innovative capabilities are graduated from universities every year, possessing true potential for cross-disciplinary research ability, are recently encounter the limited availability of positions for full-time jobs in universities and research institutions in Taiwan. Only a few of Ph.D. graduates can become the new blood of academia research. In the short-term, these Ph.D. holders with innovative potential will face challenges in career path confined. In the long-term, aging researcher may become an emerging issue, which is unfavorable for the innovative, sustainable development of academic research in Taiwan.

In addition to ensuring the free development of academic research, another major goal of national S&T policy is to guide academic research towards finding solutions for key national issues or societal challenges. Under the current institution, most themes of research projects have been selected and decided by the government and professional scholars; it is therefore difficult to fully reflect the various concerns and needs of diverse groups within the society. In addition, the Fundamental Science and Technology Act clearly stipulates that national S&T development plan must take national development, societal needs, and balanced regional development into considerations. To fulfill such objections, there will be more demand on specialized S&T programs involving greater cross-domain, cross-departmental, and cross-

bonding collaboration. The government should encourage the co-design of research themes by inviting more widespread participation of diverse social groups in order to ensure the linkage of academic research to social benefits.

Science education should boost the interest of citizens on science, and provide opportunities for lifelong learning through multiple forms of activities in popular science. Such activities can help students and the general public understand, interested in, and participate in science, and can be cultivated in skills such as exposition, inference, debate and judgment. This will help them to utilize their knowledge and application of scientific approach to resolve problems of everyday life, and enhance their capabilities to objectively analyze and discuss S&T issues in public domain. It is the responsibility of the government to provide sufficient scientific resources to satisfy the rights of the public to enjoy science. Yet at the same time, popular science activities still rely heavily on government funding; the market mechanism for popular science in terms of bridge of upstream and downstream operations and circulation is still immature. There is relatively low ratio of input from social and industrial investment in popular science, and large gaps exists between urban and rural areas. Government leadership is thus required for a reasonable distribution of limited resources. The government should integrate the resources and ability from the academic stakeholders, local governments either at the county and city level, as well as those of private organizations, individual communities, and



industries, in order to work together in promoting popular science. In addition, the government must also step up efforts in promoting popular science activities on S&T issues that are highly relevant to the public interest in order to boost citizens' interest and participation, as well as their capabilities in a discuss S&T issues on a deeper and broader way.

(b) Research infrastructure should be enhanced in order to ensure providing a competitive environment for scientific research.

Research infrastructure in the state of the art is an important foundation for supporting of advanced research. It is also an important indicator for evaluating of a nation's research capabilities. In the past, many large-scale international collaborative projects of Taiwan were based on continuously investment on the construction of major international research infrastructure, thereby many world-class, cutting-edge research were developed. However, the scale and capital cost for building of research infrastructures required for advanced research are growing, and must take multinational and interdisciplinary research agenda into consideration. It is thus important to continue leveraging resources from international research platforms and keep in pace of international science, technology and innovations in order to ensure a competitive and sustainable R&D environment for Taiwan. In addition, in order to respond to S&T innovation needs in the future and to widen the pioneer research fields, more frontier research facilities must be purchased, built, expanded or upgraded. This will be beneficial for making breakthroughs and upgrading

S&T in Taiwan. Furthermore, by the highly developed ICT development status, e-research infrastructure with the core of ICT technologies should be appropriately deployed, so that remote resources and can be easily accessed and shared, and huge amount of data can be handle more efficiently. This will result in the enhancement of the service efficiency of research infrastructure and generation of more innovative services.

- (c) International collaboration on R&D has become a core strategy for S&T policy in most countries, and R&D capacities and capabilities must be expanded through global collaborative projects in frontier scientific research.

In recent years, globalization of R&D has become a major policy of nations intending to boost the upgrade S&T capabilities. The ability to connect and interact among R&D networks has become the main driving force for globalization of R&D. From the perspective of OECD, it highlights the close links and collaboration in global R&D will help in the dissemination of knowledge, and thus bringing applications with value added. It is clear that global collaboration in R&D has become a core strategy for countries wishing to boost R&D capabilities and enhance national competitiveness. For example, many leading countries have recognized the importance of globalization of R&D, and have released white papers announcing national policies for global collaboration in innovation in recent years. The construction of global R&D networks is the cornerstone in these white papers, and the main objectives include: R&D deployment in key regional areas,



collaborating deepening in core strategy items, and developing and exchanging international talents, thereby actively creating an environment for multinational research and strengthening international connections for R&D activities. Currently, within the overall framework for international collaboration on S&T, Taiwan has establishing close interaction networks with other countries through the S&T Divisions, Taipei Economic and Cultural offices abroad. These networks help not only to promote greater exchange and collaboration in S&T between Taiwan and the international communities, but promote in collaborating with international partners on many items through the signing of various bilateral and multilateral agreements, including contacting scientific scholars living abroad, recruiting of S&T talent for domestic needs, such as Ph.D. and postdoctoral researchers, international exchange of S&T personal, conferring international awards, and attracting international organizations to co-fund a multinational research center.

For example, Taiwan has signed a cooperative agreement with the Directorate-General for Communications Networks, Content and Technology under the EU in 2003, which allows research teams from Taiwan to participate in collaborative research projects under EU frameworks. In 2014, Taiwan established the National Contact Point (NCP) in advance with the EU's Horizon 2020 Program. The NCP creates greater opportunities for participation in wider scientific research networks through a series of actions, including designing

more system horizontal linking strategic planning, and integration for different ministers and organizations to promote an overall strategy development. While the international competition become more intense as a result of globalization, Taiwan has to be a more active participant in global collaborative programs on frontier S&T research in order to enhance on competitive advantage and key position in the R&D value chain.

As to the R&D developed in key regional areas, the rapid growth of trade within the Asia-Pacific has turned the region into a major area for R&D network building by multinational corporations, establishing integrated networks for R&D collaboration, and multinational corporations to increase innovative R&D activities is therefore spurred in this region. With the benefits that Taiwan has geographic proximity in Asia-Pacific region and become an important hub in the region, it provides a solid foundation for collaboration in the region due to past cooperative initiatives on S&T with other Southeast Asian countries. For instance, the Southeast Asia International Joint-Research and Training Program has helped domestic academic and research bodies establish a network and platform for collaboration inside the region. Based on this foundation, Taiwan should continue to keep its advantage in S&T, lead the development of research in the region, and boost collaborative partnerships with the nations in the Asia-Pacific region in order to resolve common challenges in the region and create new opportunities.



In summary, Taiwan should continue to make full use of its advantages in innovative R&D. Based on the current foundation, the resources for international collaboration in R&D should be kept integrated continuously, by both horizontal and vertical communication, therefore international collaboration of R&D under an integrated framework can be achieved. In addition, Taiwan should actively follow global trends in R&D, to collaborate and interact with advanced countries to discuss S&T research and strategies with those countries, and to actively participate in R&D networks in the Asia-Pacific region.

- (d) In accordance with the diversity of societal needs, evaluation mechanisms for R&D results must also be accelerated reformed.

Universities and research institutes possess rich R&D capabilities, and also play important roles in innovation-related R&D activities. However, the institution of S&T is heavily influenced by factors such as the direction of national policy, academic review systems, and research subsidies. In the past, for the aim to raise the international renown and global rankings of universities. The criteria for judging the performance of scientific research relied heavily on publication in global periodicals listed in SCI and Social Science Citation Index (SSCI). The consequence was that the systems for evaluating and promoting professors placed excessive importance on their academic publications and the professors devoted their careers towards publishing more than

anything else, making it difficult for them to truly find their niches and fully demonstrate their expertise. The MOE has loosened restrictions on universities which specialize in applied subjects that allowing technical reports, artistic work, or proof of athletic performance in lieu of a written work for review. Yet even so, over the past five years, professors who earned promotions through written academic works still accounted for over 90% of promotions. This clearly shows that diversified systems for promoting professors are not universal adopted. Article 21 of the University Act reads, ‘Universities shall establish a review system for professors which evaluates their achievements in teaching, research, counseling, and services.’ A review guidelines used by universities in evaluating academic research shows that publication performance in SCI and SSCI journals still constitute a major component of evaluation. It is still the key factor in whether researchers can receive promotion, awards, or funding. Such a system does not recognize or appreciate value other than pure academic research. The mechanisms still lack enough flexibility, diversity, and pluralism. In order to have a broad range of specializations within higher education and encourage professors to enter diverse fields in teaching and applied the technologies, the MOE in 2013 promoted its Pilot Program for Pluralistic Faculty Promotion within Universities and Colleges. The Pilot Program takes into account the diverse development for different schools, the specializations of professors, and the diverse cultivation of



students. It seeks to establish diversified evaluation models and standards for different academic domains. Promotion of the Pilot Program should be continued in the future, and the linkage of outcome expanded so that the effectiveness provided by professors with regard to teaching, research, counseling, and service and of the unique characteristics for different universities should be built. In order to construct databases and evaluation criteria for different academic domains.

According to the MOST Scientific and Technological Research and Development Results Ownership and Utilization Regulations, R&D results include both domestic and overseas patent rights, trademarks, trade secrets, circuit layout rights, copyrights, and other intellectual property rights. However, when reviewing evaluation criteria for research project proposals, publication performance in SCI and SSCI journals of prospective principal investigator (PI) still play a very important role. The quality and quantity of a professor's publications over the past five years still the focus for examiner to review. The differences in the type of project, discipline or the academic field differentiation are not taken into consideration. Instead, there is a one-size-fits-all evaluation standard, which makes it difficult for projects to respond to other objective, such as national development, societal needs, and industrial upgrades. In order to correct the tendency towards emphasizing publishing articles, MOST stopped using the Research Performance Index (RPI) as the

sole criteria for measuring research achievements in 2012, and started to adopt diversified indicators to reflect the academic achievements of researchers. However, when it comes to evaluating R&D results of research projects, the items required in current review systems are still too standardized and rigid. They also fail to take into account the differences exist between different academic disciplines. In addition, after a research project has finished, findings are only shared in reports which are posted online. Many of these reports possess high degree of reference value for policy making, and some even contain major discovery results that are relevant to the public interest. However, public agencies and department are too busy to actively explore the related reports, and then them as a reference for drafting policy proposals. Therefore, there is a need to design a path for delivery of the results of research projects to proper destination.

D. Industry-academia-research cooperation should be bolstered in order to efficiently integrate R&D capabilities.

(a) The results of scientific research hold potential for industrialization, which should be actively developed. It is imperative for juridical persons to exploit their advantages in creating high-value R&D results.

Government departments have been investing resources in innovative R&D at juridical persons and universities for a long time in order to stimulate industry growth. However, the dispersal of resources makes it difficult to efficiently create



synergy. In addition, while universities have been working hard to cultivate the talent required for national development, certain issues, such as low salaries and gap between education and employment demand, have not been properly addressed. It is clear that the efforts of the academic world have not translated to the economic benefit.

Universities support innovative talent, possess an abundance of resources dedicated to research, and have mechanisms to ensure stable development. If the resources of juridical persons could be efficiently integrated with those of universities, then combined into mechanism of industry-academia cooperation, along with access to outstanding research and teaching talent, and finally linked up with the resources of regional industries, it could help drive industrial development. By having all departments working together to bring the capabilities of research institutes into university campuses, setting up research teams headed by professors, and establishing new forms of R&D centers, Taiwan's overall capabilities in R&D could be greatly enhanced.

(b) Innovative academic research should be connected with social development and industry demand, thereby lessening the gap between research and employment demand and maintaining industry competitiveness.

As international trade becomes increasingly competitive, a key policy of countries has been boosting innovation as a means to raise their competitiveness globally. Global



innovation policy has gone through a paradigm shift; there is a major trend towards creating an innovation ecosystem founded on an interactive research network among industry, government, and academia. The government has been announcing many major policies, such as the “Three Arrows” to Create Momentum for an Innovation Economy; Building Communication Platforms for Policy-Making; and Creating an Environment to Support Young Entrepreneurs. These policies are directed at strengthening cooperation among industry, academia, and research community, so that the innovative capabilities of academic research can connect with social development and industry demand, which will help industries maintain their competitive advantage. The role of the government will also shift from monitoring to providing comprehensive support systems for innovation.

In retrospect past 20 years shows that industry-academia-research cooperation has been an increasingly important issue. This has been the case especially since the government promulgated and implemented the Fundamental Science and Technology Act back in 1999. The Act specifically states that research institutes or businesses may hold complete ownership or have authorized use of intellectual property rights and research results derived from projects that were commissioned by the government or received government subsidies or investment. This has triggered more active collaboration between industry and academia. However, there is still room to make the industrialization of R&D results more effective. All



parties believe that it is very important for the mechanisms for collaboration between industry and academia to transform and evolve. One of the principal reasons for this is that the academic world has an inadequate understanding of business demands, which creates a gap between industry and academia. Another reason is that professors tend towards academically-inclined research and lack direct incentives to connect with industry, thereby creating a gap between research and employment demand. In addition, there is no robust channel for communication, so industries find it difficult to seek out suitable academic partners. The absence of a connection between industry and academia is serious and creates numerous difficulties for developing and promoting a comprehensive innovation ecosystem.

In creating momentum for innovative growth, the government strongly emphasises that academic research has a social responsibility. The basic capabilities of academic research will be put to active use, first in promoting Scientific Research 4.5, and then towards Scientific Research 5.0 for the year 2020. It is hoped that basic research will create momentum for business innovation, and fulfill expectations for improving the domestic economy, citizen welfare, and social security, as well as improving how the topics of research projects are selected, and enhancing the mechanisms for applications, review, and evaluation for such projects. Therefore, it is important to adjust current models and mechanisms for industry-academia-research cooperation so that they

accommodate social needs and industry demand. This will let R&D results from the academic and research worlds spur innovative upgrades within industry and drive economic growth. At the same time, this will boost the quality of academic research, and help to reach the final goal of having integrated resources to pursue innovative S&T.

Action should be taken to develop a mechanism for demand-led cooperation among industry, academia, and research community in order to realize their innovative potential for producing high-quality research, effectively transform the research capabilities within academia into a stable and durable foundation to support domestic innovation, and drive industrial innovation. Such a mechanism will guide industry, academia, and research community into making joint investments to develop technology which benefits regional development, industry demand, and social welfare. It will also free up the value and benefits created by academic R&D, and turn R&D capabilities and tech startups into support for continuous innovation and upgrades within industry. This will create a virtuous circle for a diversified innovation ecosystem.

(2) Strategies

Strategy 1. Enhance Decision-Making Support Systems for S&T Policy

A. Strategic Objectives

- ① Use a systematic approach to follow changing trends, encourage broad participation, and expand channels of



communication in order to reach a consensus for the development of S&T.

- ② Enhance mechanisms to assess the benefits and management of major S&T programs, and evaluate the effectiveness of such programs; audit, define, and assess the measurable objectives of major policies, and ensure that review, resource allocation, planning, and execution for major and general S&T programs are connected to social needs.

B. Important Measures

Measure 1. Improve Policy Planning for S&T Development with Technology Foresight:

- ① Use technology foresight to create a vision for the development of S&T in Taiwan in the medium and long-term, focusing on the promotion of core issues.
- ② Promote strategic plans for key areas.

Measure 2. Reinforce the ties among policy demands, resource allocation, and project effectiveness through a management mechanism for key policy-oriented S&T programs:

- ① Take an audit of major domestic demands and issues, establish a connection between policy objectives and programs, and support evidence-based research topics.



- ② Revamp planning and review mechanisms for key policy S&T programs, using industry and social benefits as benchmarks when assessing effectiveness, and provide feedback on resource allocation for scientific research.

Strategy 2. Perfect the regulatory system for promotion of technological innovation and development

A. Strategic Objectives

- ① Push for amendments to the Fundamental Science and Technology Act and complementary legislation, and enhance the legal environment in order to make it conducive to pursuing innovative scientific research.
- ② Promote laws and complementary measures required for R&D knowledge transfer and the creation of innovative models of exchange between industry and academia, and create a legal environment favorable for commercializing R&D results.

B. Important Measures

Measure 1. Complete the legal regulations and supporting measures for S&T development:

- ① Push for amendments to the Fundamental Science and Technology Act and complementary measures.
- ② Plan mechanisms to adjust legislation for emerging S&T.



Measure 2. Adapt the regulatory system to fortify the ties among industries, academia, and research institutes:

- ① Enhance the legal environment for the creation of value-adding R&D and professional exchange among industry, academia, and research community.
- ② Promote comprehensive guidelines needed for risk-control mechanisms connected to the use of R&D results.

Strategy 3. Encourage Originality in S&T Research and Development and Reform Evaluation Systems for Academic R&D Outcomes

A. Strategic Objectives

- ① Provide long-term support for the diverse and free development of academia, bolster the connection between academic research and social needs, and popularize and expand scientific education for the general public.
- ② Establish high-quality research infrastructure and expedite the process for enhancing innovative R&D for key technology in Taiwan.
- ③ Create a world-class research environment, enhance R&D activities to meet global standards and connect with the world, and become a hub in the international network for collaborative research.

- ④ Promote a system for the promotion for professors attached to career development, thereby ensuring a diverse range of specializations among faculty; use a diverse array of evaluation mechanisms, so that innovative research has a greater impact within academia, on the industrial economy, and on social welfare.

B. Important Measures

Measure 1. Boost diversity in research and development:

- ① Encourage diverse forms of scientific research in order to enrich research capabilities.
- ② Encourage research projects aimed at responding to social needs.
- ③ Promote scientific education for the general public, encouraging citizens to understand and pay attention to scientific developments.

Measure 2. Reinforce research infrastructure and encourage resource sharing:

- ① Take Taiwan's best S&T strategies and participate in platforms at global research facilities in order to maintain a competitive environment for scientific research.
- ② Make continual improvements to the construction, maintenance, and integration of research facilities and resources, as well as their shared use among industry,



academia, and research community; employ ICT to upgrade efficacy of services and promote innovative services at such facilities.

Measure 3. Facilitate a transnational research environment and a network of R&D cooperation:

- ① Actively participate in international collaborative projects for forward-looking research, enriching research capabilities.
- ② Link up with scientific research networks in Asia and expand Taiwan's influence in the areas where it boasts an advantage.

Measure 4. Build a diversified assessment mechanism for academic R&D outcomes:

- ① Promote diversified systems for the evaluation and promotion of professors in higher education, and establish support systems for scientific research.
- ② Improve the academic review system and encourage excellence and innovation within academic research.

Strategy 4. Strengthen Ties in Industry–Academia–Research Cooperation

A. Strategic Objectives

- ① Integrate the capabilities of universities and juridical persons, establish new forms of innovative research centers that connect universities and industries, focus on industrial

innovation R&D, link up resources of local industries, create a regional network, boost innovative R&D capabilities, and develop new venture.

- ② Produce innovative networks for collaboration and exchange by guiding industry, academia, and research community to conduct innovative research that focuses on social development and is led by industry demand, turn R&D capabilities and professional talent into the driving force behind industry innovation, and create a virtuous circle for the innovation ecosystem.

B. Important Measures

Measure 1. Enhance cooperation mechanisms among universities, colleges, and juridical persons supported by ministries and government agencies to invigorate value creation for scientific research achievements:

- ① Combine the capabilities of universities and junior colleges with those of juridical persons, create new forms for collaboration among industry, academia, and research community, and actively recruit talent from juridical persons to join universities.
- ② Concentrate on innovative R&D in industries, with a particular focus on high-value innovation and the start-ups produced by such R&D in order to promote industry growth.



- ③ Expedite the movement of scientific researchers and the circulation of intellectual property in order to create momentum for value-adding innovation within industry.
- ④ Establish global links on campuses as well as mechanisms for entrepreneurial guidance, and play the roles of angel investor, venture capital, and accelerator.

Measure 2. Promote mechanisms for demand-oriented collaboration among industry, academia, and research community:

- ① Promote mechanisms for diverse forms of collaboration and unique R&D alliances between industry and academia, increase incentives, and boost the dispersion of value-adding results.
- ② Guide the commercialization of innovative ideas and enhance the development of global entrepreneurial talent.

Chapter 5 Strategies and Division of Labor for Important Measures

The plan contains 4 goals, 18 strategies, and 57 important measures, due to be jointly implemented by 17 ministries/departments/agencies, AS, BOST, DCS, NDF, and local governments, and the implementation plans are prepared by the competent authorities responsible for the individual measure respectively. Each of the competent authorities shall submit annual implementation report every year, and the MOST shall be responsible for monitoring and evaluation. Experts and scholars shall be invited to evaluate mid-term and final results. In the cases that progress is not satisfactory or there is some obstacles to be tackled, the MOST can convene inter-department meetings for coordination when necessary. The annual results will be submitted and reported to the Executive Yuan for approval.



Goal 1. Revive Economic Dynamics through Innovation

Strategies	Important Measures	Organizer	Co-organizer
1. Create Development Models of Digital Economy for Industrial Innovation	1. Innovate data services for activating cross-domain data applications	MOEA	
	2. Develop motion-sensing technology for merging cross-field content	MOEA	
	3. Innovate network development for building a complete cross-network environment	MOEA	
	4. Innovate commercial development strategies for creating a cross-industry/cross-border ecosystem	MOEA	
	5. Expand applications and innovation in mobile payment	FSC	
	6. Innovate business models for building a network of digital connections	MOEA	
2. Strengthen the Translation of Scientific Achievements into Industrial Innovation and Development	1. Boost the R&D capacity of juridical persons under ministries and government agencies	MOEA, MOST	MND, MOHW, COA
	2. Improve the funding mechanism of industry-academia technology development projects to facilitate 5+2 industrial innovation	MOEA	MOST, COA

Strategies	Important Measures	Organizer	Co-organizer
3. Build a Robust Regional Innovation System to Sustain the Growth Dynamics of Industrial Clusters	1. Strengthen the innovation capacity of science parks and energize regional innovation and development	MOST	MOEA, COA
	2. Build a robust regional innovation system by establishing an intergovernmental regional industrial cooperation platform	MOEA	Local Government
	3. Construct an industrial innovation R&D platform to bolster R&D capacity for industrial innovation	MOEA	MOST
	4. Advance the use of technology in agriculture to transform agricultural management models and foster industry clusters	COA	MOST, MOEA
4. Create a Friendly Environment and Development Mechanism for Innovation and Start-Ups	1. Build a friendly environment for new-generation startups	MOEA	NDC, MOE, MOST, MOL, MOC, COA, PCC
	2. Optimize regulatory systems for startups and build a flexible empirical mechanism for industrial innovation application services	MOEA, NDC	MOTC, COA
	3. Link information technologies with funding resources to energize innovation	MOEA	NDC, NDF



Goal 2. Develop Robust Smart Living Technologies and Industries

Strategies	Important Measures	Organizer	Co-organizer
1. Develop New Technologies for Safer Agricultural Products	1. Strengthen animal/plant health management to ensure environmental security and agricultural products safety	COA	MOST
	2. Establish agricultural product safety management to protect consumer interests and rights	COA	
	3. Develop smart agricultural production and digital services to establish a new product marketing and communication model	COA	MOST
2. Introduce Precision Medicine Technologies to Improve the Health of the General Public	1. Build an integrated database containing biological, health care, and health-related information to boost value-adding applications	MOHW	MOST, MOL
	2. Develop precision medicine and new medical technologies for the general public and introduce relevant legislation	MOHW	MOST, AEC
	3. Develop innovative technologies to refine pediatric care services	MOHW	MOST
	4. Build a risk assessment network for primary and emerging infectious diseases and expand the capacity of vaccine development and emergency production	MOHW	MOST
	5. Use technologies to improve food safety mechanisms	MOHW	AEC, MOST

Strategies	Important Measures	Organizer	Co-organizer
3. Enhance Disaster-Prevention Technologies to Mitigate Disaster Impact	1. Develop technologies that enhance the comprehensive management and disaster resilience of metropolitan areas and river basins	MOEA	MOTC, MOI, COA, MOST
	2. Enhance the sustainability and disaster resilience of slope lands and natural resources	COA	MOTC, MOI, MOEA, MOST
	3. Enrich the anti-seismic capability and disaster resilience of key facilities	MOST	MOTC, COA, MOEA, MOI, MOHW
	4. Develop smart disaster-prevention technologies	MOST	MOTC, COA, MOEA, MOI, NCC, AEC
	5. Engage in R&D of smart safety sensor and surveillance technologies for workplaces	MOL	MOST, MOTC, MOEA
4. Develop Green Technologies to Create a Low-Carbon and Sustainable Society	1. Develop green technologies to increase renewable energy supplies	MOEA	MOST, EPA, COA, AEC
	2. Deploy smart grids to increase power supply reliability and green energy supply	MOEA	MOST, AEC
	3. Develop energy-efficient carbon-reduction technologies and integrated systems and services for real estate, industrial, and transportation activities	MOEA	MOI, AEC
	4. Promote green innovation and reinforce the development and application of resource recycling and green technologies	MOEA	AEC



Strategies	Important Measures	Organizer	Co-organizer
	5. Develop technologies for nuclear waste disposal and nuclear power plant decommissioning to strive toward a green and sustainable society	AEC	MOST, MOEA, NDC
5. Use Smart Sensing Technologies to Maintain Environmental Quality	1. Intensify the R&D of sensing technologies to consolidate a foundation for the development of the IoT in environmental protection	EPA	MOEA
	2. Integrate cross-cutting technologies to deploy a network of IoT applications for environmental monitoring	EPA	MOEA, MOST, COA
	3. Develop environmental data application and analytical technologies to better transmit environmental information and integrate smart features into enforcement networks	EPA	
6. Use Information Security Technologies to Assure the General Public a High Standard of Living	1. Develop new information security technologies	MOST	MOEA, DCS
	2. Develop information security technologies and services	MOEA	MOST, MND, DCS

Goal 3. Foster and Recruit Talent with Diverse Career Paths

Strategies	Important Measures	Organizer	Co-organizer
1. Foster Interdisciplinary Talent in the Digital Economy	1. Support the fostering of interdisciplinary talent in the digital economy	MOE	MOEA, MOL, MOST
	2. Foster corporate experts in the digital economy and information science	MOEA	MOE
	3. Cultivate high-caliber professionals of new information technology with an innovation and application-orientation	MOST	MOE
2. Reinforce Technical Expert Training Mechanisms for Industries	1. Promote the training and competency appraisal of industrial technologists	MOEA	MOL, MOST, MOE
	2. Customize technologist training programs for business organizations	MOL	MOEA, MOST, MOE
3. Diversify Career Paths to Invigorate the Cultivation of High-Caliber Scientific Research Professionals	1. Enhance doctorate training mechanisms for industrial R&D	MOE	MOST
	2. Promote the cultivation of postdoctorates and reinforce industry links	MOST	MOE, MOEA, COA, MOHW, MOL
4. Recruit and Retain International Top Talent	1. Reinforce the recruitment and retention of top talent in reputable universities	MOE	MOST
	2. Customize international talent recruitment and retention policies	AS	NDC, MOEA, MOI, MOL, MOE, MOHW, MOST



Goal 4. Enhance the Innovation Ecosystem for Scientific Research

Strategies	Measures	Organizer	Co-organizer
1. Enhance Decision-Making Support Systems for S&T Policy	1. Improve Policy Planning for S&T Development with Technology Foresight	MOST	MOEA, MOHW, COA, BOST
	2. Reinforce the ties among policy demands, resource allocation, and project effectiveness through a management mechanism for key policy-oriented S&T programs	MOST	BOST
2. Perfect the regulatory system for promotion of technological innovation and development	1. Complete the legal regulations and supporting measures for S&T development	MOST	MOEA, COA, MOHW, AS
	2. Adapt the regulatory system to fortify the ties among industries, academia, and research institutes	MOST	MOE, MOEA, MOF, AS
3. Encourage Originality in S&T Research and Development and Reform Evaluation Systems for Academic R&D Outcomes	1. Boost diversity in research and development	MOST	AS, MOE, BOST
	2. Reinforce research infrastructure and encourage resource sharing	MOST	AS, COA, MOHW, BOST
	3. Facilitate a transnational research environment and a network of R&D cooperation	MOST	AS, MOE

Strategies	Measures	Organizer	Co-organizer
	4. Build a diversified assessment mechanism for academic R&D outcomes	MOE, MOST	AS
4. Strengthen Ties in Industry–Academia–Research Cooperation	1. Enhance cooperation mechanisms among universities, colleges, and juridical persons supported by ministries and government agencies to invigorate value creation for scientific research achievements	MOE	MOST, MOEA
	2. Promote mechanisms for demand-oriented collaboration among industry, academia, and research community	MOST	MOE, MOEA, COA, MOHW



Chapter 6 Science and Technology Development Goals of Government Departments and Agencies

The scientific and technological development goals of government departments and agencies from 2017 to 2020 are summarized as follows, and the details are described in the appendix.

Academia Sinica

To deepen basic academic research, promote inter-disciplinary cooperation, strengthen applied science research concerning livelihood and well-being; to shape a good research environment, enrich the research resources, cultivate outstanding academic leaders; to guide, reward domestic academic R&D, for enhancing capacity and international competitiveness of our academic research; to actively promote international cooperation and exchanges, to participate and promote international R&D cooperation programs, in order to learn from international experience and demonstrate the achievements of our country's scientific research; to diffuse academic research results and findings, to conduct science education and promote the transfer of technology to actively contribute to the society and enhance everyone's wellbeing.

Ministry of the Interior

To promote green building construction, green building materials, intelligent buildings and other innovative applications of S&T, R&D of innovative and advanced construction industries, and building information technology, to construct sustainable, energy saving, healthy, safe and comfortable living environments; to improve the spatial planning system, to enhance the capacity of prevention and reduction of compound disasters,

to enhance the quality and quantity of land data with real-time updates, to ensure the sustainable spatial development; to improve criminal site investigation and improve forensic technology, to enhance forensic capabilities for physical evidences, to provide professional criminal justice services, and to create a safe and secure environment; to improve the information technology capabilities of the police for crime control and prevention; by introducing cloud computing and big data analysis technology, for cloud video retrieval and cloud service dispatch; to promote online application for fast entry at immigration control; to improve the management of foreigners, to strengthen the identity check mechanism, and to improve the efficiency of anti-terrorism intelligence inspection and notification.

Ministry of National Defense

To integrate R&D technology capacity and resources of S&T from the industries, academia and research institutions in the country, to foresee the trends of future technology and make strategies for advanced technology R&D, to establish long-term technological development mechanisms, with an aim of enhancing key technologies necessary for basic technology and system R&D; in line with the government's Industrial Innovation Policies, to transform defense technology capacity into the development of technology for military and civilian use, and create industrial benefits.

Ministry of Finance

To establish a cloud platform for customs service based on customs port trade single window, and to speed up cargo clearance efficiency with sophisticated customs inspection technology resulting from cross-agency process re-engineering; in terms of food traceability, to connect



information at every stage of food production process through cross-agency information exchange and big data analysis, for establishing the database matrix of food traceability trails, with the aim to achieve the important goal for supporting food safety and safeguarding health for the people.

Ministry of Education

To build capacity in humanities, S&T, cultivate forward-looking, and cross-cutting talents; to revive the cultivation of advanced scientific talent with various career paths; to encourage top universities to recruit and retain top talent; to enhance cooperation among industry, academia, and research community, so as to activate the value creation path for the R&D results of S&T; to establish multiple evaluation mechanisms for academic R&D performance, with diversified teacher promotion tracks in the universities; to promote education about sustainable environmental by deepening students' learning of energy saving, carbon emission reduction and disaster prevention; to promote digital learning, and construct a fair, open, high-quality self-learning education environment; to cultivate cross-domain talents for digital economy.

Ministry of Justice

In terms of judicial enforcement and human rights: to improve the databases of judicial investigation and enforcement, to promote resource-sharing for cross-cutting collaborative services; to enhance information security defense capabilities, and update the capacity and capability of legal technology services; to strengthen the supervision of the guard and control in prisons, and improve prison management with technology; to digitize paperwork and documents for establishing paperless & efficient

judicial administration; to develop electronic monitoring technology platforms for guarding, controlling, tracking, investigation and management; to develop technology for implementation and security protection in inquiry sessions, to enhance the capacities of judicial enforcement and protection.

In terms of forensic science and crime detection and prevention technology: to establish technology for "correct, professional, high-quality, safe, efficient, advanced, service-based" criminal investigation and forensic examination; to construct forensic examination and test laboratories and teams compliant with international standards, to promote the certification systems by establishing standard operating procedures for forensic science, in order to maintain the quality of accreditation; cultivate excellent talent and establish advanced research teams in forensic science; to enrich crime detection and prevention databases of all kinds of investigation, detection, scrutiny, drugs, people, and criminal investigation, to enhance overall efficiency of case handling.

In terms of forensic toxicology and identity check: To improve the quality of post-mortem and forensic examination for judicial purposes; to strengthen the integration and applications of forensic examination resources by establishing forensic examination databases; to improve identification instruments and R&D methods, in order to deepen and widen the capacity of forensic toxicology; to enhance the credibility of forensic tests with the establishment of modern and advanced forensic toxicology certification and reference laboratories; to establish databases of drugs with a variety of ingredient analysis methods and lethality analysis; to enhance the accuracy of serum evidence and DNA tests; to establish the genotype frequency databases of different ethnicity of Taiwan.



Ministry of Economic Affairs

To increase value of Taiwan's industry with innovative R&D: To increase promoting TDP for juridical persons, industries, and academia; to enhance international cooperation on innovative R&D; to constantly develop industry-based technology, thereby enhancing the capacities of key industries; to take the lead in creating innovation patterns for industries with innovative governance.

To guide the industries to conduct innovative transformation with new development models: Continue to enhance the output value and added value of key industries; to enhance the value of the service industry with new technology and internationalization; to encourage development of technology and features in traditional industries; to promote the development of cluster innovation and entrepreneurship for small and medium enterprises.

To improve the facilities and infrastructure for the development of intellectual property and standard verification: To strengthen the basic environment for patent retrieval and the cultivation of intellectual property talents; to implement the Intellectual Property Strategy Program, so as to promote high-quality R&D and patent strategy; to improve essential elements of industrial competitiveness, so as to enhance the added value of products; to promote international cooperation in setting common standards and engage in exchanges of information on industrial standards.

Deepen the industrial and social development of sustainable energy/resources: To promote energy conservation and enhance energy efficiency; to actively develop carbon-free renewable energy by fulfilling renewable energy development potential; to continue developing the

technologies for disaster prevention and mitigation for security of environment; to comprehensively cope with energy/resources and environmental issues, so as to secure the foundation for sustainable development.

Ministry of Transportation and Communications

To construct the decision support systems for energy conservation and carbon emission reduction policies in transport sectors, and to plan governance blueprint for transport sector in response to climate change; to construct Taiwan-wide intelligent transport system, in order to provide safe, high-quality, smooth and energy-saving low-carbon sustainable transport environment; to research and develop the disaster prevention technology for harbors, bridges and mountain roads, in order to enhance the transport efficiency of ports and roads; to enhance the safety of navigation and port operation efficiency and quality with R&D of green port technology; to enhance the safety of maritime navigation, enhance the competitiveness of marine industry and aviation safety of Taiwan with R&D on the improvement of international sea and air transport; to promote delicate & intelligent meteorological information application services in line with key industrial innovation policies; to enhance our capability in early warnings of natural disasters such as earthquake and tsunami, to expand the application of earthquake information in disaster prevention, land and academic research; to improve harbor monitoring facilities and forecasting technology, so as to enhance maritime disaster prevention; to actively plan frequency spectrum with the global development of 5G and IoT in order to promote innovative development of national ICT industries; in line with "Digital Nation and Innovative Economic Development Plan (2017-2025)", to achieve the target of 90% coverage at 1Gbps by 2020.



Ministry of Health and Welfare

To create a healthy and happy society; to ensure a safe living environment; to perform major disease prevention and control for our nationals; to give sustainable, high-quality medical services; to build quality caretaking service systems; to improve social welfare systems; to improve infrastructure; to develop biomedicine and health care industry; to develop relevant technology and caretaking systems in response to the trends of aging and low birth rates; to develop a people-centered integrated medical care system with technology.

Ministry of Culture

To reinvent cultural governance by constructing support systems for the freedom of arts/expression; to link and reproduce the history/memory of land and people; to deepen community development by revitalizing local culture, to enhance cultural connotation to boost the cultural economy; to unfold a new chapter of culture.

Ministry of Labor

In terms of research on safety and health in workplace: To improve the basic rights and interests of workers and their safety and health.

In terms of research on cultivation of quality IoT talents and the safety and health service industry in workplace: to focus on forward-looking basic research and personnel training, the development of intelligent technology products through the cooperation among industry, academia, and research community, in order to connect the Silicon Valley, and promote innovation in Taiwan with transformation and upgrading of industries from information technology (IT) to IoT.

In terms of research on the application and intelligence of big data in labor economy: To achieve social innovation in the dimensions of life, production, and ecology, to ensure availability of talent in academia-industry collaboration for a good technology entrepreneurship environment to develop and integrate key emerging industries.

Ministry of Science and Technology

To plan the development of national S&T policies with effective use of science and technology R&D resources; to pursue academic excellence by creating a R&D friendly environment, and constantly enhancing R&D capacity and capability for S&T; to support the key technologies for emerging industries by means of academic innovation, so as to bring about innovation industries; to build a sound and solid R&D environment by sharing common research facilities and disaster prevention/rescue resources; to consolidate regional industrial innovation clusters with science park development.

National Development Council

In terms of promoting industrial transformation and upgrade via IoT, and to drive economic growth through innovation and entrepreneurship, and actively involve in the development of the next generation industries: To promote industrial upgrade and transformation, and strengthen the linkage with international innovation clusters such as Silicon Valley; to improve the ecosystem of entrepreneurship, and deepen international links of innovation and entrepreneurship.

On taking advantage of big data in cloud and IoT to reinvent governmental service patterns in data-orientation, and to create a globally leading digital government: To create convenient and secure digital



services; to develop digital economy; to widen the transparency of governmental information.

Directorate-General of Personnel Administration, Executive Yuan

Cultivate multidisciplinary S&T management talents and negotiation talent in order to enhance the competitiveness of the country.

Environmental Protection Administration, Executive Yuan

To construct the national air quality sensing IoT; to accomplish the water quality sensing IoT in potentially polluted regions of agricultural land; to improve the new generation intelligent operation systems for environmental law enforcement; to establish intelligent environment sensing data centers and integrated platforms for common application services.

National Palace Museum

To promote publicization of the Museum, and to establish the Museum as a model in the application of ICT; to promote culture rights with technology by providing digital access to cultural relics collections; to promote forward-looking technology education in humanities by creating a new museum exhibition model with new media; to enhance cultural relics preservation technology, and promote the digitalization of cultural relics and digital added value.

Atomic Energy Council, Executive Yuan

To improve safety control technology of atomic energy for enhancing safety in using atomic energy; to encourage cross-domain innovative R&D of atomic energy technology, to research and develop key technology of new energy industry.

Council of Agriculture, Executive Yuan

To develop industrial characteristics and create new advantages; to strengthen the adaptability to climate change, for sustaining ecological environment; to build diversified capacity for happy life in rural areas, so as to promote a humane and friendly society; to enhance food security, strengthen the traceability management of agricultural products, for ensuring food safety; to strengthen industrial advantages, and make strategies for global market.

Council of Indigenous Peoples

To plan and construct wireless broadband environment in national ethnic minority areas, to enhance the wireless broadband coverage in our country as a whole and the original tribes, for the introduction of wireless broadband application services, as well as the implementation of governmental care for the aborigines, thereby reducing the gaps between cities and aboriginal towns, for the development of an equal and active online society.

Board of Science and Technology, Executive Yuan

To make overall strategy of key technology industries for the government, as well as administrative advice; to be in charge of division of labor and coordination between departments/agencies of the government, so as to effectively enhance administrative efficiency in the government on S&T; to coordinate and promote major scientific and technological projects and programs, and strengthen the competitiveness of technology industries of the country.



Civil Service Protection and Training Commission

To develop the applications of S&T for civil service trainings, in order to enhance the effectiveness of civil service training.

Directorate-General of Budget, Accounting and Statistics, Executive Yuan

To integrate information flows for in-depth use; to perform resource sharing to maximize economic benefits; to strengthen internal control for enhancing administrative efficiency.

Department of Information Management, Executive Yuan

To use and analyze the big data accumulated in the relevant business information systems within Executive Yuan and its departments and agencies at all levels, to enhance the speed, quality and performance of policy-making, crisis management and; to use and analyze data of external networks, news, public opinion, opinion poll, political and social development, so as to ensure the Executive Yuan's actions meet public demands and societal needs.

Department of Cyber Security, Executive Yuan

To enhance self-protection capacity and capability and to protect our country's digital security.

Aviation Safety Council

To improve the quality and efficiency of the investigation of aviation accidents, to strengthen tracking of the improvements and recommendations; to enhance technical capacity of aviation accident investigation; to conduct researches projects that have significant impact



on flight safety, and to promote exchange of safety information; to deepen the cooperation and exchanges between our country's and international aviation accident investigation institutions.

National Communications Commission

To carry out the legislation and law revision on digital convergence; to carry out the analysis and inspection of the communication broadcasting market in the country; to strengthen the self-discipline mechanism of telecom business, to enforce consumer protection; to conduct 5G technology development trend analysis; to enhance the efficiency of frequency spectrum utilization; to enhance the competitiveness of communication/broadcasting industries.

To ensure that digital convergence/IoT products or services meet the requirements of security with the construction of security management platforms for communication network; to strengthen the information security protection capabilities of key infrastructure in communication businesses with risk assessment to help proprietors' products or business management comply with information security requirements.



Chapter 7 Planning for Central Government's Distribution of Funding and Resources for Science and Technology

Our country's S&T policies come from different sources, including important meetings (such as the National Science and Technology Conference, Meetings of the Board of Science and Technology of the Executive Yuan, Meetings of Strategy Review Board of the Executive Yuan), the Executive Yuan's key initiatives (such as the “Three Arrows” to Create Momentum for an Innovation Economy, Building Communication Platforms for Policy-Making, Creating an Environment to Support Young Entrepreneurs), ministries' S&T action plans (regarding the development of technology and industrialization) and so on. In "the 10th National Science and Technology Conference", the focus was on four key issues about the development of science and technology in our country. In this issue of "National Science and Technology Development Plan", the overall objectives and strategies for the development of S&T in our country from 2017 to 2020 were set forth as a policy initiative, based on the conclusions of the conference. As one of the sources of our country's S&T policy, it will be implemented by ministries and departments of the government and resources will be allocated by those ministries/departments in light of policy objectives and promotion measures.

As for the allocation of government budget requirement for S&T development of the country, the administrations will propose the funding in the form of plans, which were made on the basis of the major policy initiatives of the Executive Yuan, the departmental policies and the conclusions of important meetings. The BOST and MOST will review the plans and send a draft plan to the Executive Yuan for approval. After it is

approved, the ministries and departments will then make budget and send it to the Legislative Yuan for review and approval. In the year of 2017, after being reviewed and approved by the Legislative Yuan, the amount of the government's overall S&T budget (excluding occasional adaptation of the National Science and Technology Development Fund) is NT\$ 102.8 billion. As for the budget required for the development of S&T in 2018~2020, based on average annual GDP growth rate of 2.37% set by NDC¹, the estimated amount will be NT\$ 105.2 billion in 2018, NT\$ 107.7 billion in 2019, and NT\$ 110.3 billion in 2020 respectively.

¹ According to the "Four-Year National Development Plan (2017-2020) and Plan for National Development in 2017", the benchmark value is based on the benchmark programs according to international forecasting agencies such as International Monetary Fund (IMF) on global economic growth rates and other international economic variables, as well as the estimation value of the variables in domestic policies such as governmental and public sector investments, estimated by DGBAS.



Chapter 8 Implementation and Effectiveness Monitoring

The plan is divided into two parts: overall national S&T development and the S&T development in different S&T fields and government agencies. The implementation and effectiveness monitoring are explained as follows:

1. The overall national S&T development: It contains 4 goals, 18 strategies, and 57 important measures, due to be jointly implemented by 17 ministries/departments/agencies, AS, BOST, DCS, NDF, and local governments, and the implementation plans are prepared by the competent authorities in charge of each measure, with actions being undertaken year by year. Each of the competent authorities shall submit annual implementation report every year, and the MOST shall be responsible for monitoring and evaluation. Experts shall be invited to carry out evaluation on mid-term and final results. Depending on the achievement of the targets, the MOST shall convene inter-ministerial meetings for coordination when necessary. The annual results will be submitted and reported to the Executive Yuan for approval. According to Article 9 of "Fundamental Science and Technology Act", the government should put forward vision and strategy for the development of S&T every two years. Therefore, the plan will be duly modified in two years' time in response to changes in circumstances.
2. In terms of the goals and strategies of S&T fields and government agencies, as well as the resource planning in 2017~2020, the agencies shall propose their funding requirement in the form of S&T development plans, which will first be approved by the Executive Yuan through the Implementation Directions for Preliminary

Planning Process of National Science and Technology Programs, and then be implemented after the budget is approved by the Legislative Yuan. As for evaluation of program implementation results, the Executive Yuan will conduct evaluation of the programs on its own tracking list, and the MOST will be in charge of the other programs.

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