

Part I. Overview of Industrial Technology in Taiwan

Chapter 1

Current Status and Outlook of Industrial R&D and Innovation Activities in Taiwan

Peter Drucker (1993) pointed out that for the post-industrial societies, economic growth will rely more on knowledge factor rather than traditional production factors, such as capital, land, and labors. The essence of Research-Development and Innovation (RDI) has been identified as the key driver for national competitiveness. For countries that pursue the objective of knowledge-based economy, the RDI factor often rank high in policy makers' priority list. Consequently, for Taiwan to become an innovation-driven and knowledge-based economy, it is essential for policy to stress upon cultivation of core competences via RDI investment for better exploitation of science and technologies, business opportunities, and ultimately to improve economic welfare for citizens.

Under such context, it is necessary to examine the current RDI status from the perspective of input, process, and output in order to identify Taiwan's strengths and weaknesses. Policy makers then can make better decision based on this information. In this article we briefly summarize the relationships between past RDI activities and obstacles currently faced by Taiwanese industries. We further discuss the connection between RDI performance and the international competitiveness of Taiwan from the perspectives of the International Institute for Management Development (IMD) and the World Economic Forum (WEF). We also check if there is anything to be coped with in order to enhancing national competitiveness except RDI factor. Finally, policy implications are provided based on these main themes.

1. Strengths and Weaknesses of RDI Activities in Taiwan

This section examines Science-Technology and Innovation (STI) indexes from input, process, and output perspective to identify the strengths and weaknesses in RDI activities. This information can serve the purpose for raising policy awareness for eliminating disadvantages and sustaining advantages. The abstract strengths and weaknesses of the RDI are presented below with each index in summarized form.

Table 1-1-1 Strengths and Weaknesses of Taiwan's RDI Activities

Category	Strengths	Weaknesses
Input	<ul style="list-style-type: none"> • R&D density is higher than the OECD average at the national level. • The rate of R&D capital spending is accelerating both at national or business sector levels. • The density of R&D human capital is higher than the OECD average at the national level. • The growth rate of R&D human capital is above average at both the national or business sector levels 	<ul style="list-style-type: none"> • R&D density is lower than the OECD average at the business sector level. • The percentage of R&D expenditure performed by business sector is lower than 70%, which is the norm for most of the advanced economies, and the proportion performed by the public sector remains high. • The R&D expenditure is extremely unevenly distributed, especially leaning to high-tech manufacturing industry and is very low in service sector. • The density of R&D human capital is lower than the OECD average at business sector level. • Employment of doctoral graduates tends to concentrate in the public sector.
Process	<ul style="list-style-type: none"> • Judged by the higher education Expenditure on R&D (HERD) financed by industry, the linkage between the higher education and business sectors is getting better. • Judged by patent inter-citation rate, there exists an active relationship between the research institutes and business sector, and the relationship between the universities and business sector is also active. • The scientific linkage of technology is getting better based on the number of inter-citation during the past two years. 	<ul style="list-style-type: none"> • The linkage between the higher education and business sectors remains below OECD average based on the HERD financed by industry. • Judged by foreign R&D funding, the linkage between domestic and overseas RDI activities remains very low. • Judged by inter-citation of patents, the relationship between research institutes and the universities is inactive, and so is the relationship between individual inventors and other innovation performers. • The scientific linkage of technology remains below global average in terms of citation during the past two years.
Output	<ul style="list-style-type: none"> • Papers publications in terms of SCI and EI indices are good in volume and rate of growth. • Taiwan currently ranks No. 4 in USPTO, No. 5 in JPO and No.3 in SIPO in terms of the total number of patents granted. • In the utility patent category, Taiwan currently ranks No. 4 in USPTO in terms of its patent strength. 	<ul style="list-style-type: none"> • The impact of papers in science and engineering is lower than the world average in terms of average citation number. • The impact of total patents in Taiwan is below the world average in terms of current impact index. • Taiwan is doing poorly in EPO in terms of patent performance.

Source: Tier, September 2008.

2. Taiwanese RDI Focuses and Industry Situation

This section discusses the relationships between Taiwanese RDI focuses and current industry situation. The analysis aims to provide stakeholders a quick note for policy reference.

(1) Capital Investment in High-tech Manufacturing Industries Unable to Yield Returns in the Short-term

Over 70% of total R&D investment in Taiwan happens in high-tech manufacture industries, and is highly concentrated in Information Technology (IT) and electronic industries. However, these industries require increasing heavy investment to sustain their competitiveness. Our investigation shows that over 30% of these industries' added-value currently comes from capital investment comparing to 10~20% in the 90's. The investment contributes to GDP as part of economic growth, but is deducted from national income. The result is an illusion of prosperity with stagnant growth in wage.

(2) Slow Growth and Poor Productivity in Service Sector

The R&D spending of the service sector accounts for slightly over 7% of total R&D spending in Taiwan, yet the service sector accounts for over 70% of GDP. The disproportional distribution of R&D investment has produced some unfavorable consequences. The growth of added-value in the service sector has been slow, with Compound Annual Growth Rate (CAGR) from 2003 to 2007 for being just 4.26%. Comparing to 8.61% in the manufacturing sector and 5.23% in GDP growth rate over the same period, it can be said that the service sector did not perform as it is expected. In addition, both growth rate of labor productivity (12.63%) and capital productivity (-8.33%) of service sector are considerably lower than those of the industry sector (45.62% and 20.00% respectively).

(3) Long Way to go from OEM to OBM

The result of "The Second Taiwan Innovation Survey" shows that a majority of firms have been engaging in technological innovation activities rather than in marketing and product innovation activities. Furthermore, number of process improvement patents still far exceeds novelty invention patents originated from Taiwanese industries. It means that greater efforts were put into technology-related process and efficiency improvement rather than marketing or product innovation with original creativity. These phenomena indicate that majority of Taiwanese enterprises are still operating under the OEM model. Despite a few successful stories in branding, such as Acer, Asus and recent HTC, most of Taiwanese enterprises are still undergoing a tough journey to transform from OEM to ODM and ultimately to OBM model.

(4) Some New Economic Phenomena Undermine Industrial Linkage Effects and Domestic Added-value

As the Moore's law succeeded in predicting the rate of chip size reduction, the speed of innovation in technology-related industries is extremely fast, resulting in price disruption. To cope with continuing price cut, efforts to improve efficiency and to reduce costs are inevitable. Hence, global supply chain with labor division is evolved. Modularization of production process is the core concept to make division of labor work efficient. On the negative terms, modularization decreases firm's appropriability and increases transaction costs. Nonetheless, Taiwanese firms embraced modularization concept, and transferred modularized parts manufacturing to China as soon as the concept was adopted. The division of labor between Taiwan and China forms the basis of so called triangle trade and accelerates re-export phenomenon. According to the statistics, the volume of triangle trade and re-export accounts for more than 7% of GDP in 2007. Although the trade volume may make economic figures look dazzling but in fact, it contributed little to domestic added-value, job creation and industrial linkage effects.

3. Relationship Between RDI and International Competitiveness

As suggested by IMD and WEF, although certain extent of international labor division can lead to better re-allocation of resources, continuous investment in RDI should remain important to enhance Taiwan's competitiveness. Besides, overall national competitiveness cannot rely solely on RDI, there are numerous socio-economic dimensions should be considered altogether. The IMD and WEF global competitiveness reports highlight the areas that Taiwan can pay more attention.

(1) RDI Positively Impacts National Competitiveness

According to IMD and WEF's investigations, Taiwan has achieved impressive global competitiveness rankings. The 2008 IMD World Competitiveness Yearbook reported that Taiwan ranked 13th in overall competitiveness, and ranked 5th and 4th respectively in Technological Infrastructure and Scientific Infrastructure indices. Similarly, according to the 2007~2008 WEF's Global Competitiveness Report, Taiwan ranked 14th in overall competitiveness and 10th in innovation and sophistication factors. Under the innovation and sophistication factors category, Taiwan ranked 9th and 14th respectively in innovation and business sophistication sub-indexes. It can be claimed that the RDI performance contributes significantly to overall Taiwan's economic competitiveness.

(2) Certain Issues Besides RDI Also Significantly Influence Competitiveness

a. Limited International Trade and Inability to Attract Foreign Direct Investments (FDI)

The measures for which Taiwan endured the largest declines during 2008 include

international trade and foreign investment. International trade is strongly influenced by global economic recession and also constrained by inherent political issue with China. However, the situation has been getting better since 2008 presidential election and government taking friendlier policy towards China. With respect to FDI, Taiwan performed poorly in terms of stock market and flow of inward investment. Despite substandard performance in attracting international investment, Taiwan has seen significant rise in inward FDI flow, from US\$ 1.6 billion in 2005 to US\$ 7.5 billion in 2006 (*better list the amount in 2008, up to September, at least), but this still account for only small percentage of GDP (2%).

b. Avoiding Excessive "Sinicization" of Taiwanese Economy

Notably, cross-strait political tensions have not prevented Taiwanese firms from investing heavily in China. The cross-strait investments now exceed US\$ 100 billions. Four Taiwanese-owned firms rank among China's top 10 biggest exporters. 10% of the Taiwanese labor force now works in China. Over 70% of Taiwanese foreign investments currently go to the Mainland as Taiwan and China become increasingly entwined economically. Trade between Taiwan and China has grown 12% reaching more than US\$ 12 billions in 2007. It thus created a growing trade surplus and made China the primary export market for Taiwan. Although used-to-be-hostile tension between Taiwan and China has been eased to a certain degree, Taiwan should seek to maintain stable relation with China while continuing to protect national security, and avoiding excessive "Sinicization" of Taiwanese economy. Strategies to avoid excessive "Sinicization" of the Taiwanese economy could include efforts to increase geographic diversity of overseas Taiwanese employment, diversifying Taiwan's export markets and investment.

c. Education, Talent and Labor Issues

Taiwan ranks 19th in the sub-index for education in the 2008 IMD Competitiveness Report. Although Taiwan scores highly (6th) in the category of the number of people to reach tertiary level education, it has achieved only a mediocre ranking (19th) in the effectiveness with which the education system meets the needs of a competitive economy. Likewise, Taiwan ranks just 28th in terms of the language skills of graduates meet the needs of enterprises, and ranks 35th in terms of inbound student mobility according to the foreign tertiary-level students per 1,000 inhabitants. Furthermore, analysis of the Taiwan's labor market reveals that Taiwan has a below average ranking (37th in 2007) for the percentage of its population in the labor force (46.66% in 2007) and moreover, labor force growth has declined slightly in recent years.

4. Conclusions

Based on the WEF Report, Taiwan is currently positioned at the transitional phase between efficiency-driven and innovation-driven economy. Hence RDI will be an important

driver for Taiwanese economic growth in the future. Consequently, the key issues facing Taiwan are: how to strengthen RDI and how the government should intervene. This article intends to address the critical issues that Taiwan's industry is now encountering and its outlook in the future.

After examining the strengths and weaknesses of Taiwanese RDI, the government should strive to foster existing strengths and intervene to improve upon weaknesses. First, the government should attempt to reverse the market downturn and to stimulate service sector to invest more in RDI. Second, the government should attempt to design mechanisms for activating cooperation and linkages among various innovation players both domestically and overseas. Finally, the government should improve the quality and impact of RDI outputs and refer to foreign experiences in setting standards and goals to increase the effectiveness of all RDI outputs.

Owing to the modularization and division of labor, industrial RDI focused more on improvement of efficiency in manufacturing process. It naturally led to volume production, but not in added-value creation. The government should consider guiding the industrial players to form an integrated innovative network in order to cultivate on irreplaceability and originality rather on rapid duplication and efficiency improvement. Furthermore, insufficient RDI investment in the service sector has resulted in low productivity and slow growth. It certainly requires government intervention. System defects exist in the service sector, such as tax incentive scheme discriminates against service innovation, and the state must identify these problem and try to correct them.

Although Taiwan has received positive evaluations from international organizations such as IMD and WEF, there are still a lot of areas that Taiwan should work on to improve RDI capabilities. Nevertheless, this clearly indicates that strong policy emphasis on RDI investment has produced the desired outcomes. Furthermore, recent industrial innovation policies focused on "International Innovation Outreach and Linkage", "Industrial Cluster and Local Innovative Growth", and "Dual Core of Industrial Innovation", all of which are relevant and should provide remedies to the grim situation that Taiwan currently faces. Therefore, it can be expected that Taiwan is accelerating its steps toward the right direction into the innovation-driven economy.