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# An Analysis of Bio Economy in Taiwan =Challenges, Opportunities and Future Perspectives=

Yaeko Mitsumori
*Institute for International Initiatives, The University of Osaka, Osaka, Japan*

## 1. Introduction

Taiwan is renowned for the Taiwan Semiconductor Manufacturing Co. (TSMC) and its chips. However, the government also puts an emphasis on biotechnology and bioindustry.

The Taiwanese government aims to position the country as the leading hub for biotechnology and biomedical industry research and development in the Asia-Pacific region. It intends to create 20 new medicines, launch 80 2 high-value medical devices into the market, and raise the biomedicine industry to a trillion NT dollar (approximately $32 billion) sector within a few years.
The Taiwanese government has undertaken various initiatives, established biomedicine clusters, and formulated policies to achieve this objective.
Taiwan has 128 listed biotech and medical care companies, with a total value of $39 billion. The Taiwanese government, under the Ministry of Economic Affairs, established the Biotechnology and Pharmaceutical Industries Promotion Office (BPIPO) as a one-stop service window for Taiwan's biomedical industry. The BPIPO provides financial support, investment promotion and stock listing, R&D collaboration, technology transfer, commercialization, and marketing strategic alliances for biomedical companies in Taiwan.
This article will first provide an overview of the current status of the biotechnology and biomedical industries in Taiwan, before analyzing the factors contributing to their rapid developments and predicting the future of the Taiwanese biotechnology and biomedical industries. The article consists of eight chapters, with the Chapter 1 is the introduction; the Chapter 2 is a prior arts analysis; the Chapter 3 is a historical background of Taiwan; the Chapter 4 is an overview of the current economy in Taiwan; the Chapter 5 is an analysis of Taiwan's biotech policy; the Chapter 6 is an analysis of the Taiwanese biotech and biomedical industries; the Chapter 7 is a discussion; and the Chapter 8 is the conclusion. This study's results may be beneficial for policymakers and industry leaders not only in Taiwan but also around the world.

## 2. Prior Arts Analysis

2.1 Biotechnology related policy analysis
A couple of papers analyzed biotechnology national innovation system (NISs) and research, technology, development and innovation policies (RTDI) and regional innovation system (RIS) .
The dynamics of national innovation systems (NISs) are a source of considerable academic and policy interest, especially in efforts to address the new competitive challenges that these systems involve. In this regard, Mark Dodgson et al., used the ITC model to examine the case of Taiwan, which is embarking on a new phase in its approach to building its national innovative capacity through the creation of infrastructure for the biotechnology industry. The authors analyzed the dynamics underlying the country's NIS by examining the process and mechanisms by which new biotechnology innovation networks are established, contrasting their development with that of existing networks. Taiwan has enjoyed considerable success in implementing ITC, with the Taiwanese government being instrumental in the formation of networks with collaborating firms. Dodgson et al. recommended that the government extensively involve itself in the development of the biotechnology sector [1].
Chao-chen Chung et al. inquired into the roles of government in policies on research,

*Corresponding author: aaa@example.ac.jp

technology development, and innovation (RTDI) from the perspective of the National Sectoral Technological Innovation System (NSTIS) of Taiwan. The authors developed an analytical framework, which was applied to Taiwanese pharmaceutical biotechnology policies as empirical cases. On the basis of these exemplars, they found that the consistency and appropriateness of RTDI policies are shaped by four factors: policy, horizontal coordination, vertical coordination, and the involvement of external stakeholders [2].

Regional innovation systems (RISs) have become a key priority for policymakers in many advanced countries and regions. These systems have also been shown to be relevant and applicable to newly industrialized countries and developing economies. Yu-Shan Su and Feng Shag Wu, explored recent developments in three biotechnology RISs in Taiwan: the Nankang RIS for new drug development, the Hsinchu RIS for medical electronics, and the Southern Taiwan RIS for medical devices. The authors also probed into cross-RIS interactions [3].

The biotechnology industry has seen dramatic development, with this sector currently being Taiwan's second most profitable industry following the field of ITC. The country's biotechnology companies have been flourishing given the substantial funding that they receive from the Taiwanese government. Nevertheless, a scrutiny of the world market indicates that the Taiwanese biotechnology industry remains of minimal value. Against this backdrop, Jui Kuei Chen and I-shuo Chen, reviewed a considerable volume of studies on total quality management and categorized criteria for measuring industry value. They subsequently conducted in-depth interviews with relevant background experts to extract and verify the most suitable measurement criteria. The contribution of this study lies in its construction of a TQM measurement model for the Taiwanese biotechnology industry [4].

### 2.2 An analysis on biotechnology related business analysis

Biotechnology related business has been flourishing in Taiwan. A couple research papers analyzed biotechnology related business.

Jean Francois Tremblay stated that Taiwan has registered considerable achievements since it began promoting biotechnology a few decades ago, and several Taiwanese biotechnology firms have drug candidates undergoing late-stage clinical trials in the US and other countries. The author reported that in 1980, no Taiwanese biotechnology company was listed on the stock exchange, but today more than 100 companies are listed and have a combined value of US$25 billion. He identified the following highly successful biotechnology firms: ScinoPharm, a contract manufacturer of active pharmaceutical ingredients; TaiGen Biotechnology, which has several drug candidates in late phases of testing in the US and China, is the largest customer of ScinoPharm; and PharmaEngine, another prominent company that has outlicensed products for more than $200 million in the European and Asian markets. Tremblay, however, also pointed out that a number of Taiwanese biotechnology firms have recently stalled because of the Taiwanese government's overly strict regulations on labor and environmental protection. Quoting TaiMed's CEO James Change, Tremblay wrote that the business culture in Taiwan discourages companies from paying salaries as high as those in the US and that regulations in Taiwan restrict the ability of corporations to offer stock options [5].

Taiwan is positioning itself as a leading hub for advanced medical research and product development, but challenges persist due to low investments in public health. The presence of many international companies that have chosen to invest in R&D facilities in Taiwan is a testament to its broad appeal to members of industry and academia. Currently, more than 100 Taiwanese biotechnology and biopharmaceutical firms with a combined value of over US$25 billion are listed on international stock exchange markets. Many of them are emerging biopharmaceutical companies.

Neil Armstrong indicated that the Taiwanese advancement in innovative healthcare can be attributed to a comprehensive biotechnology cluster, robust IT infrastructure, broad National Health Insurance (NHI) coverage, and reliable and transparent regulations for clinical trials.

The author also stated that the Taiwanese government has implemented significant changes to tax codes, providing tax breaks and offsets to encourage investment in the sector. Quoting William Tsai, head of public affairs and communication for the Taiwanese division of Sanofi, Armstrong declared that Taiwan's

investment in healthcare as a percentage of the GDP is low at 6% compared with those of neighboring South Korea (8%) and Japan (11%). "Most challenges in healthcare systems are attributed to financial constraints, and healthcare expenditure should be (considered) an investment, not a cost" (Tsai, as cited by Armstrong) [6].

2-3 An analysis of biologics usage pattern and an analysis of Bio Bank in Taiwan

One paper analyzed usage pattern of biologics in Tawan while another paper analyzed Biobank in Taiwan.

Chee Ruey Hsieh and Ya-Min Liu found that spending on biologics in Taiwan is highly concentrated in a small number of products and that their use is targeted toward a few patients. These patterns have resulted in exorbitant costs from biologics adoption. The authors also discovered that the determinants of biologics use include not only clinical factors but also economic issues, such as the sizes and forms of ownership of hospitals. The following conclusions were drawn: First, it is important to evaluate the gains derived from biologics treatment in terms of health outcomes against increases in health expenditure. A careful but expeditious analysis of costs versus benefits of new individual biologics before their introduction represents a promising approach to enhancing the value of public spending. Second, given that the probability of receiving biologics treatment varies depending on hospital size and ownership, the findings imply that access to costly biologics is uneven among patients with universal coverage for prescription drugs [7].

Yen-Chen Anne Feng et al., described an impressive biomedical resource in Taiwan called the Taiwan Biobank (TWB), which is an ongoing prospective study of more than 150,000 individuals aged 20 to 70 years. A comprehensive list of phenotypes was collected for each consenting participant at recruitment, and follow-up visits involving structured interviews and physical measurements were conducted. Biomarkers and genetic data were generated from blood and urine samples. Feng et al. presented an overview of the quality of TWB's genetic data, population structures, and familial relationships, which encompass individuals of predominantly Han Chinese ancestry. These data highlight the important attributes and genetic findings of the TWB, along with the genetic makeup of the Han Chinese population. This resource enables large-scale genomic research [8].

## 3. Historical Background in Taiwan

The Republic of China (ROC) was founded in 1912 in China. At that time, Taiwan was under Japanese colonial rule as a result of the 1895 Treaty of Shimonoseki, by which the Qing ceded Taiwan to Japan. The ROC government began exercising jurisdiction over Taiwan in 1945 after Japan surrendered at the end of World War II. The ROC government relocated to Taiwan in 1949 while fighting a civil war with the Chinese Communist Party. Since then, the ROC has continued to exercise effective jurisdiction over the main island of Taiwan and a number of outlying islands, leaving Taiwan and China each under the rule of a different government. The authorities in Beijing have never exercised sovereignty over Taiwan or other islands administered by the ROC [9].

Table 1. Taiwan at Glance [10]

| | |
|---|---|
| Official Name | Taiwan |
| Area | 36,197 square kilometers |
| Population | 23.3 million |
| Ethnicity | Over 95 % Han people, 2.5% Indigenous Malayo-Polynes 2.5%new immigrants |
| Government | Multiparty democracy |
| Capital | Taipei City |
| National currency | New Taiwan dollar (NT$) |
| Languages | Mandarin, Holo, Hakka, |
| Major religions | Buddhism, Taoism, I-Kuan Tao, Chinese folk religions |

Source: Taiwan Ministry of Foreign Affairs, Republic of China

## 4. The Current Economy in Taiwan

4.1 Taiwan Economic Outlook

Taiwan holds an important position in the global economy. According to the World Trade Organization (WTO), Taiwan was the 16th largest exporter and the 21st largest merchandise importer in 2023. It was also one of the largest holders of foreign exchange reserves as of December 2023. According to the International Monetary Fund (IMF), Taiwan's gross domestic product per capita reached US$32,440 in 2023. In terms of nominal GDP, Taiwan ranks close to Poland and Switzerland, while its GDP per capita expressed as

purchasing power parity is similar to that of Denmark and the Netherlands [11].

4.2 Taiwan as global leader in ITC biz

Taiwan is a global leader in semiconductor manufacturing, with Taiwan Semiconductor Manufacturing Company (TSMC) dominating the advanced chip industry. The Taiwan economy is heavily reliant on high-tech exports, particularly semiconductors, electronics, and precision machinery. Taiwan's strong industrial base, efficient infrastructure, and skilled workforce have made the country an indispensable player in global supply chains [12].

4.3 Recent economic development of Taiwan

Taiwan's gross domestic product (GDP) grew 4.30% in 2024, a three-year high, after the country reported the better-than-expected economic growth in the fourth quarter, according to Directorate General of Budget Accounting and Statistics (DGBAS). An advance estimate report compiled by the DGBAS showed Taiwan's GDP growth in 2024 topped the previous estimate of 4.27 % made in November to reach 4.30 %, the highest level since 2021 when the country's economy grew 6.72 % [13].

Singapore-based DBS Bank in Jan. 2025 forecasted that Taiwan's GDP would grow 3% in 2025, up from a previous estimate in October of 2.6 %, due to an uptick in global demand for emerging technologies.

DBS also said that while inflationary pressures in Taiwan are expected to ease this year, its central bank monetary policy will likely turn neutral and leave interest rates unchanged [14].

## 5. Taiwan Biotech Industry: Policy Development

Taiwan's biotechnology industry emerged in the 1980s, mirroring global trend recognizing the strategic importance of this sector. The Taiwanese government prioritized building a strong foundation. However, this policy faced several challenges including limited funding for early-stage research and development, a shortage of experienced researchers and novel drug discovery and complexities of navigating regulatory frameworks. Then the government needed a stronger foundation in preclinical areas such as chemistry manufacturing and controls pharmacokinetics and toxicology testing as well as the expertise to navigate these processes to address this challenge [15].

To response these problems, the Ministry of Economic Affairs, the Department of Health, the National Science Council and Academia Sinica jointly launched "the Biopharmaceutical National Science and Technology Program" in 2000, and the Genomics Medicine National Science and Technology Program in 2002 [16].

In 2011, the National Research Program for Biopharmaceutical Development (NRPB) was established to bridge the gaps between research and commercialization [17].

In the same year (in 2011), the Taiwan Supra Integration and Incubation Center (Si2C) was established to further bridge the gap between research and commercialization [18].

In 2023, inspired by Stanford University's successful SPARK program, the NSTC established "SPARK Taiwan" to advance talent development in Taiwan [19].

Participants of the "SPARK Taiwan" program, who are called "SPARKees" gain crucial knowledge in translation scientific discoveries into marketable products.

## 6. Current Status of Taiwan Biotechnology Industry

6.1 Taiwan govt. to create 20 new drugs by 2025

The Taiwan government aiming to position the country as the leading hub for biotechnology/biomedicine research and development in the Asia-Pacific region. By 2025, the Taiwan government aims to create 20 new medicines, and introduce 80 high value medical devices to the market, and elevate the biomedicine industry into "a trillion -NT dollar (about $32 billion) industry" [20].

In order to achieve these targets, the Taiwan government has taken various initiatives including established biomedicine clusters and implemented several policies to achieve this goal [21].

6.2 The current status of Taiwan biotech market

Taiwan's Biotech Industry has been growing steadily. The revenues of Taiwan's Biotech Industry increased from 3,590 mil. $NTD in 2012 to 7,009 mil. $NTD in 2022.

When the biotech industry is divided into five categories -- Applied biotechnology, Pharmaceutical, Medical Devices, Healthcare and Digital Health – the Healthcare category

occupied the largest share among the four categories recently years.
The revenues from Healthcare category in 2023 was mil. 2268 mil. $NTD. The Digital Health was added to the data in 2020. In 2022 revenues from digital health was 502 mil. $NTD.

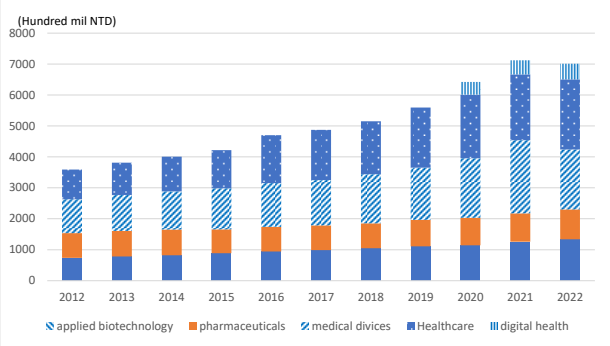


Fig. 1 Revenues of Biotechnology Industry by category (2012-2022)

Source: Biopharmacy, Key Innovative Industries in Taiwan, Ministry of Economic Affairs, Taiwan Government

6.3 Listed biotech firms
In 2021, Taiwan had 128 listed biotech and medical care companies, with a total value of $38.94 billion in revenue.
Among them, 75 have been registered on an emerging market, while 20 have been registered on the Go Incubation Board for Startup and Acceleration Firms (GISA) stock market. Through diverse capital market fundraising channels for operating and R&D funds, the value of Taiwan's public capital market continues to grow. In 2022, 172 companies were certified as biotech companies, with 453 new drugs approved, of which 72 have been launched in either domestic or international markets [22].

## 7. Discussion: Taiwan vs. Japan Comparison study

While Japan was suffering under the so-called "lost decades," between the 1990s and 2020s, Taiwan's economy rapidly expanded, led by, primarily, the semiconductor industry. Currently, the Taiwanese chip industry holds more than 60% of the share in the world market. Meanwhile, several bio venture companies in Taiwan achieved significant success during the same period, with a number of new drugs developed by Taiwanese pharmaceutical companies approved by regulatory offices in the US and/or European countries.

To date, seven Taiwanese bio venture companies have successfully conducted an IPO in the Taiwanese stock markets, accumulating more 100 billion JPY market capitalization.
The top three Taiwanese bio venture companies today are PharmaEssentia, Onesess Biotech, and Bora Pharmaceuticals [22].
Most of these Taiwanese biotechnology start-up firms were founded by Taiwanese nationals who studied and worked temporarily in the USA, before returning to Taiwan and founding their own biotechnology venture firms. It is evident that these startup company founders gained entrepreneurial skills in the U.S. [22].
Fully utilizing this new entrepreneurial spirit, they also took advantage of the many supporting programs offered by the Taiwanese government as well as an abundance of governmental and private funding.
The situation in Japan is different: In Japan, there are numerous listed bio venture companies; however, many of them are suffering from low stock prices and thus have low market values. As such, they might be able to learn from these successful Taiwanese bio-venture companies [23].

## 8. Conclusion

As mentioned above, Taiwan's biotechnology industry emerged in the 1980s, mirroring the global trend that recognized the strategic importance of this sector. Seeing this, the Taiwanese government prioritized the construction of a strong foundation for its bioindustry.
Today, some bio venture firms or start-up firms have achieved significant success in Taiwan.
As mentioned before Taiwan had 128 listed biotech and medical care companies with a total value of $39 billion USD. As of today, 172 companies have been certified as biotechnology or biomedical companies, and 453 items have been approved, of which 72 products have been approved for marketing both domestically and internationally. However, the biotechnology and biomedical industries in Taiwan still face some challenges.
Since the Taiwanese biotech market remains relatively small, capital available for investment in biotech also remains small.
Taiwan must, therefore, strive for further advancements in various ways:
-The government should set up a sovereign fund for the biotechnology and biomedical industries.

-Tax benefits should be given to not only domestic companies but also foreign companies.
-Taiwanese biotech firms should increase their connections with international biotechnology companies.

Through these policy implementation, Taiwan's bioindustry may have greater opportunities to grow.

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