Agricultural Technology Commercialization from Government Research Institutions to Agribusiness in Taiwan

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ABSTRACT

Taiwan, with more than hundred years of R&D efforts in agricultural science and technology, has relative higher citation index than other domains. There are 16 governmental research institutes affiliated to the Council of Agriculture (COA) that are ensuring continuous R&D innovation. Previously in traditional agriculture in Taiwan, technologies were free for farmers, but they are knowledge-based agriculture. Nowadays, how to commercialize the agricultural technologies into agribusiness plays an important role in the industrial chain. This topic will mention the systematic process in Taiwan, including technology management, technology transfer platform, training, agribusiness incubation, agricultural Biotechnology Parks and the establishment of Agricultural Technology Research Institute (ATRI). It is not only the paradigm-shift from an industrial value-added model but also emphasizes on the social impact in Taiwan's agricultural industry transformation.

Keywords: Technology commercialization, agricultural technology transfer, agribusiness, ATRI, agricultural biotechnology parks

INTRODUCTION

The role of agriculture in Taiwan have multiple functions, generally include; food nutrition, food security, energy supply, commodity supply, water conservation, air purification, climate adjustment, landscape decoration and even social stability. The research and development (R&D) of agricultural technologies are primarily performed and financed by the government, there are 16 governmental research institutes affiliated to the Council of Agriculture (COA) that are ensuring continuous R&D innovation. In the past, the government focused on solving field problems for farmers. It oriented R&D’s direction and most of the results were treated as public property. State-owned research institutes were given the responsibilities to guide and assist farmers as well as solving their problems. In that ambiance, farmers, even government, were careless bout the R&D’s intellectual property, though there were some technology license from governmental research institutes, they were usually gratuitous licensing.
The environment has changed in a recent couple of decades. Free Trade Agreement (FTA) between countries gives impacts not only towards the industrial goods but also the agricultural goods. Taiwan is a small island that relies on international trade, as the competitiveness getting more tempests, the agriculture also faces the influence. Agriculture in Taiwan is also confronted by the limitation of land use, shortage and aging of farmers, lack of economic scale on small farming scale, and shorts of incentives for expansion and development of agribusiness. To face the challenge, Agriculture in Taiwan has to extend from production-oriented to a new value chain of agriculture, improving the innovative value-added and multi-discipline integration, especially the capacity of international marketing and sales promotion. The transition of agricultural R&D is not only the technology breakthrough but also about how to commercialize and develop agribusiness in a systematic process.

REGULATION FOR TECHNOLOGY TRANSFER IN TAIWAN

Since the R&D of agricultural technologies are primarily performed and financed by the government through governmental institutes, the intellectual property rights (IPR) of the R&D achievements belong to the government. The government has established the legal environment and system for agricultural technology management. All R&D achievements that were transferred or commercialized from the public sector to the private sector must follow the laws and regulations. In addition, the agricultural policy will lead to the agricultural trends in Taiwan.

Government Laws and Regulations

When people commercialize the technology from the public sector in Taiwan, they have to follow the legal system as follows:

- **Fundamental Science and Technology Act 1999**;
- **Government Scientific and Technological Research and Development Results Ownership and Utilization Regulations 2000**; and
- **Regulations for Scientific and Technological Research and Development Results Ownership and Utilization by the Council of Agriculture 2001**

Besides, depending on the IPR type of R&D achievement, they also have to follow other rules, such as **Patent Act, Trademark Act, The Plant Variety and Plant Seed Act** in Taiwan. Although the regulations seem complex and numerous, the ownership and utilization of government supported agricultural R&D achievements can simply follow the principles as seen below:

- Equity, openness and license fee required;
- Domestic licensing as first priority;
- Licensing abroad on condition; and
- Preferential license fee and royalty for farmers and farmer's associations
Under the guidance, all the agricultural technology transfer cases from the public sector have to be submitted and evaluated by the Agricultural Intellectual Property Rights Committee (AIPRC). There are also a gratuitous extension of some new technologies to the farmers by training courses, consultation and demonstration.

**National Agricultural Policy**

Agricultural Science and Technology (S&T) policy should integrate “National agricultural policy” and “National S&T policy”, and go through multiple S&T projects, but the characteristics of S&T projects are generally time-consuming and uncertain on its results. The environment changes from time to time and, agricultural S&T Policy needs to be reviewed and modified periodically in response to the changes in agricultural and S&T environments. Agriculture is not just an economic industry, it also creates such non-economic external effects as a contribution to both physical and mental health, helps in social stability, and increase in green national income. Such effects have a value far beyond the GDP calculated traditionally. The mechanism of agricultural S&T policy making, marked as 0, is from S&T committee to the research area evaluation committee to do the research area evaluation and planning, and then the task force will perform each project. There is also the S & T Development Planning Group as the think tank to provide expert opinions for research evaluation and planning. Under the series action plans launched by the Executive Yuan of Taiwan for six emerging industries in 2009 including the Hi-end Agriculture, COA performs The Quality Agriculture Program. The program comprises of tree planting, reborn coastal areas, and rural reconstruction to help revive the agricultural sector and promote agro-tourism.

![Agricultural S & T Policy Making Mechanism in Taiwan](image)

**AGRICULTURAL TECHNOLOGY COMMERCIALIZATION**
Agricultural technology commercialized from the public sector to agribusiness is not only the technology transfer but the entire system following the governmental policy to define the strategies, to create the business opportunities and infrastructure by the systematic process to help agribusiness development and raise the probability of success.

**Thinking on Agriculture’s New Value Chain**

The strategic thinking for agriculture in Taiwan is to expand from production-oriented agriculture to an agriculture with a new value chain. As 0, the value will add by each value chain steps. In order to accomplish agriculture with new value chain, there are some strategies:

- **Industrial value adding:** It includes the combination of innovative value-adding and cross-domain integration to create the synergy of the value. On the other hand, establishing Taiwan’s international agriculture brands to ensure the recognition of Taiwan agriculture is worldwide.

- **Revitalizing resources:** Combining human, land & water resources for agriculture and upgrades of services. This refers to the fallow lands in Taiwan, some are caused by resource allocation and some are by political regulation.

- **Establishing agricultural technology research institute to accelerate technology development and industrialization.**

![Interdisciplinary Cooperation Value](image)

**The value chain in agriculture**

**Systematic Process**

Refer to 0, the systematic process is aimed to help agriculture technology commercialization in Taiwan basically with six function support for agribusiness. The help could be in a sequence or simultaneously. In addition, the government also holds some campaigns like Grand Awards of Innovation in Scientific and Technological Agribusiness (GAISTA) to encourage agricultural enterprises strive for further growth and share the successful experiences to other enterprises comprehensively.
Systematic process for agricultural technology commercialization in Taiwan

**R&D**

The agricultural R&D framework of the public sector in Taiwan includes Academia Sinica, Universities and 16 COA affiliated research institutes. Refer to 0 for the agricultural R&D framework, the basic research mostly under the responsibilities of universities while the national research institute - Academia Sinica, the COA affiliated research institutes, including 7 research institutes and nine district research and extension stations, are in charge of the applied research technology and operation. The application of R&D achievements is enforced by the agribusiness community and its related associations, cooperatives and farmers. It rarely happened that it comes directly from Academia Sinica but from the 16 COA affiliated research institutes. Sometimes it comes directly from the universities.

**Governmental agriculture R&D framework in Taiwan**
As this was mentioned in the regulation section, all the technologies from the public sector that transferred to the private sector have to be approved by the Agricultural Intellectual Property Rights Committee (AIPRC), refer to 0, all the technology transfer case from COA affiliated research institutes have to submit to AIPRC. In cases where R&D results from the Non-COA affiliated research institutes, only the research project which was financed by COA have to submit to AIPRC. AIPRC evaluate and make decisions, or deal with the particular subject about IPR registration and technology transfer.

**Workflow for technology transfer from the public sector**

Furthermore, COA also promotes the “Industry-Academia Cooperation of Agricultural Science and Technology Program” in 1998 and the “Agricultural Technology Development Program” for the agricultural industry in 2007. The goal of these programs is to commercialize the agricultural R&D results. Refer to 0, in the “Industry-Academia Cooperation” model; the private sector can be a company, foundation, corporation aggregate, farmers’ association or industry association. The private sector join the program with their fund to modify the R&D results for pre-production, in other words, for their commercial use. Though the IPR belongs to the public sector, the private sector can acquire a non-exclusive license when they fund at least 10% of each program and get an exclusive license when they fund more than 30% of each Industry-Academia Cooperation program.

The other model, in which the members of the private sector have their R&D output already; the private sector can be company, foundation or farmers’ association. The private sector can apply for the agricultural technology development program, in this model; private sector has to fund more than 50% of each program so that they can keep the IPRs. COA funds the innovative private sector partially to help them in commercializing their R&D outputs.
Programs for improving agribusiness R&D capacity

Financial Affairs

There are at least five financial-help for agribusiness in Taiwan. Those can help the agricultural enterprise reduce the cost of funds, funding from the capital market and lighten the burden of tax.

- Preferential loan
The preferential loan is for a company who moves into the Agricultural Technology Park, 0 shows the briefs of the loan, it is not only about reducing the cost of the fund but also on who can get long term payment periods.

<table>
<thead>
<tr>
<th>Items</th>
<th>Introduction</th>
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<tbody>
<tr>
<td>Accommodator</td>
<td>Agribusiness who move into the Agricultural Technology Park</td>
</tr>
<tr>
<td>Use for loan</td>
<td>To build or buy the facilities and for working capital</td>
</tr>
<tr>
<td>Interest rate</td>
<td>1.5%</td>
</tr>
<tr>
<td>Credit limit</td>
<td>USD 2.5 million (NTD 80 million)</td>
</tr>
<tr>
<td>Payback period</td>
<td>Each tenant agribusiness may apply for a 15-year loan from Agricultural Bank of Taiwan</td>
</tr>
</tbody>
</table>
Hastening enterprise to be listed company
For funding from the capital market, technology agribusiness complies with a standard of capital which shall apply for Taiwan Stock Exchange (TWSE) or Gre Tai Securities Market (GTSM) trading of its stock, but not limited by required periods of establishment and profitability. After being evaluated by COA and the non-profit financial organizations, COA would adopt the issuance of assessment opinion to TWSE or GTSM which is innovative agribusiness with a potential and foresighted market. TWSE or GTSM will, upon receipt of the letter of reply with assessment opinion from COA, issue the opinion to the applicant. Technology Agribusiness shall apply for TWSE or GTSM trading of its stock. By the process, the application for TSWE or GTSM trading of stocks could shortened by 1 to 2 years.

Reduction of expenditures for corporate research as investment
It’s evaluated by application from the agricultural enterprise; COA will review the foresight, risk and innovation of corporate research and then shall issue the opinion to the National Taxation Bureau for reduction of expenditures for corporate research as an investment. It could promote agribusiness to increase the investments of research and strengthen the ability of successful development of technologies and products.

Preferential loan for agribusiness innovative research
The preferential loan is for the company who would like to invest in research for their agribusiness, the applicant can be a company or farmer’s association. It can reduce the cost of funds.

Venture capital intermediary platform for agribusiness
Though the executions of projects, the platform encourages venture capital (VC) to visit, interview and evaluate the agribusiness as a potential investment target. It also exchanges the information and sharing of experience between VC’s and companies.

Human Resource
COA continuously holds two types of talent training programs, including “Technology Management” and “Agribusiness Management”. The courses are integration of resources from university, government and industry and positioning as cross-disciplinary training. Trainees who finish the course will get the credit hour of Master’s degree. In addition, there are also other courses such as the practice course for international exhibition, international marketing in order to help agribusiness in learning the specific purpose.

Technology management course
This is for the researchers in COA and managers in agricultural enterprises. The course include IPR Management, Technology Package and Transfer, Finance, Innovation and Entrepreneurship. There are more than 400 trainees who have completed the course. It also organizes an association to integrate resources from different disciplines.
Agribusiness management course
This is primarily for managers in agricultural enterprise, the course includes production, marketing/sale, human resource, R&D management, finance/account and information management. There are more than 120 trainees who completed the course, the graduated students applied for advanced studies.

Production

COA initiates the environment and invest the infrastructure for agribusiness development in Taiwan, including the establishment of agricultural innovation incubation centers and the Agricultural Biotechnology Industry Cluster.

Agricultural innovation incubation centers
In order to commercialize the R&D achievements, COA promotes the affiliated research institutes to set up the innovation incubation center (IIC), refer to 0, the first COA affiliated IIC established in Livestock Research Institute in 2005, then followed by the Agricultural Research Institute, and Fisheries Research Institute and Forestry Research Institute. There is also an IIC in Agricultural Technology Research Institute (ATRI), the IIC in COA affiliated research institutes that focuses on technology incubation and IIC in ATRI is more comprehensive in business incubation. Moreover, COA promotes theses five incubation centers integrate into the Agricultural Innovation Incubation Center (AIIC). The AIIC can help the start-up of agricultural enterprise from early-stage to post-stage incubation.
Agricultural biotechnology industry cluster

The mission of establishing an agricultural biotechnology industry cluster is to transform traditional agriculture into agri-bio industry. It is not only the planning and investing on agricultural biotechnology parks but it is also about companies with other incentives such as the preferential loan which is mentioned at the financial affairs section.

There are two agriculture biotechnology parks in Taiwan, referred to as 0, Taiwan Orchid Plantation helps to transform the orchid industry by integrating national resources into the domestic industry and by adopting strategies to promote professionalism and globalization. It also holds an International Orchid Exhibition in March every year.

The Pingtung Agricultural Biotechnology Park (PABP) is located in almost at the southernmost of Taiwan. PABP created six major clusters, including Natural Products for Health & Cosmetics, Agro-Bio Products, Biotechnical Service, Energy-saving & Ecological Agro-Production System, Animal Health and Feeds and Aquaculture. There are more than 100 agricultural enterprises which is involved in the operation of the six clusters in the park.

### Briefs of agriculture biotechnology parks

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<tr>
<th></th>
<th>Pingtung Agricultural Biotechnology Park (PABP)</th>
<th>Taiwan Orchid Plantation</th>
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<tbody>
<tr>
<td><strong>Area of Park (Hectares)</strong></td>
<td>233</td>
<td>175</td>
</tr>
<tr>
<td><strong>Budget of Capital Construction (USD Million)</strong></td>
<td>261</td>
<td>59</td>
</tr>
<tr>
<td><strong>Park Residents (Enterprises)</strong></td>
<td>55</td>
<td>51</td>
</tr>
<tr>
<td><strong>Investment of Enterprises (USD Million)</strong></td>
<td>178</td>
<td>196</td>
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**Marketing**

COA holds and attends agricultural technology exhibition for marketing. 0 shows the exhibitions that join with Agriculture Pavilion every year. COA acquires more than 750 M² in the exhibition. There are many one-on-one partnership in the Taipei int’l Invention and Tecnomart to make technology transfer match. In BIO Taiwan, in addition to the exhibitors showing their updated technologies, there are also many promotion activities during the exhibition to attract the public and other potential technology users. COA also joins the world’s largest BIO exhibition in North America companies with other Taiwan’s official department every year.
Briefs of agricultural technology exhibition in Taiwan

<table>
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<tr>
<th>Exhibition</th>
<th>Taipei int’l Invention and Technomart</th>
<th>BIO Taiwan</th>
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<tr>
<td>Properties</td>
<td>1. R &amp; D Result Exhibition</td>
<td>1.R &amp; D Result Exhibition</td>
</tr>
<tr>
<td></td>
<td>2. Technology Transfer Match</td>
<td>2. Agribusiness promotion</td>
</tr>
<tr>
<td>No. of Technology</td>
<td>50+</td>
<td>50+</td>
</tr>
<tr>
<td>Exhibitor</td>
<td>1. Public Research Institutes</td>
<td>1. Public Research Institutes</td>
</tr>
<tr>
<td></td>
<td>2. Universities</td>
<td>2. Universities</td>
</tr>
<tr>
<td></td>
<td>3. Private Research Institutes</td>
<td>3. Private Research Institutes</td>
</tr>
<tr>
<td></td>
<td>3. Agribusiness</td>
<td></td>
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</table>

COA has joined many agricultural product-oriented exhibition in the world. In addition, it also supports agribusiness to join the agricultural technology-oriented international exhibition. Such as the VIV China, VIV Asia (Thailand), Pet Fair Asia (China), Agri World (Japan), SIMA SAEAN (Thailand), VIETSTOK EXPO & FORUM (Vietnam). COA supports these exhibitions by Taiwan Pavilion to help Taiwan’s agricultural enterprises enhance the performance of promotions in the exhibitions. There are more than 60 companies that join the Taiwan Pavilion.

**Information**

COA initials a digital platform for agricultural technology R&D achievements, the Operating Office for Agricultural Technology Industry was established in 2008, it built the “Agri TI” platform to manage all the R&D results belong to COA, refer to 0, AgriTI link COA, ITRI, technology supplier and the business.

**Function of AgriTI**

- Enforce and propose suggestions
- Suggest the Promotional policies
- Establish the information system
- Establish the management system
- License research innovation
- Consulting
- Training
- Match-making
- Consulting
- Service-providing
- Industrial technology supplying
Following the operating office, COA also promotes a web-based agricultural technology exchange information system-Taiwan Agricultural TechnoMart (TATM, http://tatm.coa.gov.tw). People can find the information about agricultural transferable technologies, industry-academia cooperation, popular agricultural inventions, licensing announcement and agricultural technology licensing activities on the website. TATM will also issue the agricultural technology news and send the e-DM to their members for free to let the agricultural technology information spread comprehensively.

**Establishment of Agricultural Technology Research Institute**

In order to accelerate technology development and industrialization, Agricultural Technology Research Institute (ATRI) was established in 2014 with three basic missions:

- Commercialize & industrialize agricultural research results;
- Provide assistance to private sectors in strengthening competitiveness and promoting international markets; and
- Work with academia, research institutes and members of the private sector to develop innovative technologies for commercial production.

Though ATRI is initially endowed by COA, it is a non-government and non-profit organization. It shows the role of ATRI as the intermediary between agricultural research system and the agricultural industry in Taiwan. By execution of COA’s projects, technology commercialization, investment facilitation, industrialization of science and technology and international marketing are the major work of ATRI, especially, by its Industrial Development Center. There are three laboratories, two centers and one administration department. The three laboratories include animal technology, aquatic technology and plant technology, but the laboratories are not engaged in basic research. They concentrate on the technology application research and development to accelerate agricultural technology from lab to industrial use. Agricultural policy research center is one of the two centers which will be the think tank of agricultural department of the government, it can provide suggestions or be the reference on the planning or decision of agricultural policies.
Role of Agricultural Technology Research Institute

Industrial Development Center (IDC) plays a strenuous part in the role of ATRI. It shows the complex function and works in IDC. Ideally, IDC provides the industry development strategies and R&D/IP planning as the orientation of R&D. When R&D comes with outcomes, IDC provides the consultant and service of patent application, technology appraisal and legal consultation. As in the middle part of 0, IDC combines the new business promotion, industrial innovation, incubation center and technology transfer and licensing to commercialize the R&D achievements. Moreover, marking, international linkages, promotion, exhibition, talent training and the information system are also undertaken by IDC.

One of the agricultural technology commercialization models is to evaluate and facilitate a new agribusiness, but it generally needs the combination and integration of technologies, sometimes the technologies come out from different research organizations. IDC plays the role to integrate the combinations of technologies and evaluating whether the application of technologies with business opportunities is feasible or not. Then, IDC will try to develop a business plan for the integrated technology combinations including: market analysis, legal and regulation analysis, IPR analysis, technology feasibility analysis, business-model and productivity analysis with financial evaluation. The business plan also has a due diligence (DD) made by an outside expertise. After business plans pass the DD, IDC will announce the business plan, inviting the potential investors and visiting them for further discussion after the announcement.
R&D expenditure in agriculture is less than 3.7% of the annual budget of COA, but many achievements have been obtained. This section mentions about the performance of R&D, financial affairs, Production and the example of the Rapid Bio-assay for Pesticides Residue (RBPR) Technology commercialization from government research institutions to agribusiness.

0 shows the changes of agricultural technology license in the recent decade, the revenue of technology license more than 85 times since 2002, the ration of technology licensing revenue divide technology research input also from under 10% to more than twice. Besides, the number of technology transfers starts from under 10 items increases to more than 140 items.
Performance of COA technology transfer

On the financial affairs for agricultural enterprises, there are many outcomes as 0. These affairs help agribusiness in Taiwan reduce the cost of capital, burden of tax and funding more comprehensively.

Outcomes of COA financial affairs in the last decade

<table>
<thead>
<tr>
<th>Preferential loan</th>
<th>Reduction of Expenditures for Corporate Research as Investments</th>
<th>Hastening enterprise to be listed company</th>
<th>Venture capital intermediary platform for Agribusiness</th>
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<tr>
<td>391 approved, USD 62.3 Million (since 2004)</td>
<td>3 cases (since 2011)</td>
<td>OTC:1 Pre OTC: 8 IPO: 2 Pre-Listed: 4 (since 2014)</td>
<td>Matching 4 agribusiness with VC, USD 20 million (since 2015)</td>
</tr>
</tbody>
</table>

Source: Statistic data from AgriTI.

In Pingtung Agricultural Biotechnology Park (PABP), Companies in the six clusters increase time by time, as is showed in 0, there are 102 agribusinesses that moved into PABP of which the capital invested more than US$290 million there, and creating more than 6,000 employed population.
Agribusiness in PABP

The Taiwan Agricultural Research Institute (TARI) is one of the 16 COA affiliated research institutes. TARI uses specific house fly to produce Acetylcholine-esterases (AChE) and its bio-assay. The bio-assay can test the anticholinergic materials which is usually used in pesticides, and can get the results quickly. This helps the bio-assay to be utilized as a rapid test for pesticides residue. TARI named the technology as Bio-assay for Pesticides Residue (RBPR). RBPR technology was developed in TARI more than 50 years ago. But it is not the official certificated pesticide residue test method, in fact, only China and Panama have certificated this method as a quick test method. Though TARI has helped to build and trained talents for more than 300 RBPR stations, this method was promoted as self-management for the private sector. Although there were more than 700,000 time tests in Taiwan, it still supported by TARI.

IDC of ATRI cooperated with TARI, in developing a business plan of the RBPR technology combinations. The business plan includes the following:

- Industry trends and market analysis
  - Law and regulation of pesticides in Taiwan
  - Analysis of the pesticide industry
  - Scale of market forecast
  - Development and competitiveness analysis
  - Market analysis for applications
  - Strategy recommendation
- IPR analysis
  - Patent mining
  - Patent analysis
• Patent visualization analysis
• Portfolio analysis
• Recommendation

• Feasibility analysis on technologies
  • Technology trends and status
  • Roadmap
  • Status of IPR protection
  • Competitiveness analysis of technology
  • Specifications of technology
  • Bone chart of technology and product

• Feasibility analysis on commercialization of technology
  • Productivity analysis
  • Time table for production

• SWOT analysis
• Key Success Factor analysis
• Financial analysis
  • Capital investments
  • Sales forecast
  • Cost of production
  • Operation expense
  • Working capital
  • Financial statements forecast
  • Financial indication of investments

IDC is not only developing the business plan but is also looking for potential investors. IDC visits some potential investors, presenting the business plan to show the value of the technology combinations. Refer to 0, after the process by the regulation, one company in Taiwan acquired the exclusive license under terms and conditions of US$275,000 license fees and 3% running royalty of net sales. It’s a turn-key technology transfer case, creating US$1 million capital investment initially. Some talents from TARI spun-off to the new business division, and the licensee company move into the agricultural innovation incubation center in TARI. The RBPR case demos the win-win strategy in commercialization of agricultural technologies. TARI is not only beneficial from the licensing and royalty revenue but is also a relief from maintaining the support of RBPR stations. Talents in TARI can concentrate on their research duties. For technology commercialization, the licensee company promotes and sells the RBPR products in Taiwan, and China already. Furthermore, the company is now trying to promote the product into other southeast countries. Technology penetration spread from Taiwan to other countries.
CONCLUSION

Through the systematic process, the commercialization of agricultural technology keeps rolling and rolling in Taiwan. The quantity of technology transfer from COA to agribusiness has changed tremendously over the past decade. Government in Taiwan has built the capacity of agricultural technologies and is willing to harvest the value of these technologies. Although there is a need to establish regulations which are favorable for industry development, and for technology extension to outside of Taiwan, agriculture in Taiwan trends should move from knowledge-based to smart agriculture. Agriculture is flourishing through technology commercialization, and it is hoped that it can move the industry forward to the next stage.

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