Analysis of Taiwan' s Industrial Technology Research Institute Development Model and Its Implications for Industrial Think Tank Development (Post-print)

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Date: 2017-11-05T00:00:00+00:00

Abstract

[Purpose/Significance] This study examines Taiwan' s Industrial Technology Research Institute, a key industrial think tank, analyzing its management system and operational mechanisms to provide references for nations (regions) building industrial think tanks, accelerating industrial technology innovation, and achieving industrial transformation and upgrading. [Method/Process] Using a case study methodology, data were collected through literature review and website investigation to conduct an in-depth analysis of Taiwan' s Industrial Technology Research Institute. [Result/Conclusion] In providing technical and intelligence support for Taiwan' s industrial economic development, the Industrial Technology Research Institute of Taiwan has developed an efficient construction model. Its clear goal orientation, comprehensive institutional framework, flexible corporate-style management, and diversified channels for disseminating research outcomes offer valuable lessons for nations (regions) establishing industrial think tanks.

Full Text

Analysis of ITRI's Construction Model and Its Implications for Industrial Think Tank Development

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Abstract

This paper examines the management system and operational mechanisms of Taiwan' s Industrial Technology Research Institute (ITRI) to provide references for countries and regions seeking to build industrial think tanks that can accelerate industrial technological innovation and facilitate industrial transformation and upgrading. Using a case study approach, we collected data through literature review and website investigation to conduct an in-depth analysis of ITRI. The findings reveal that ITRI has developed a highly efficient construction model in its process of providing technical and intelligence support for Taiwan' s industrial economic development. Its clear strategic positioning, comprehensive institutional framework, flexible enterprise-style management, and diverse channels for disseminating research outcomes offer valuable lessons for industrial think tank construction.

Keywords: industrial think tank; ITRI; construction model; enterprise-style management

Classification Numbers: C932.8; G321.2

Industrial think tanks represent a specific category of think tanks aimed at enhancing decision-makers' planning capabilities and guiding industrial development directions. They conduct innovative research and strategic analysis from the perspective of industrial economic development and reform, provide policy recommendations and strategic insights for industrial development, foster emerging high-tech industries, and serve socioeconomic development. At the Policy Advisory Work Conference held in February 2017, Li Wei, Director of the Development Research Center of the State Council, identified revitalizing the real economy as one of nine key priorities for think tank research. He emphasized that under the dual pressures of low-cost competition from late-developing countries and re-manufacturing initiatives from developed nations, enhancing enterprise innovation capabilities, achieving industrial upgrading and transformation, and building strategic industrial clusters are critical to maintaining international competitiveness. As a key industrial think tank driving Taiwan' s economic development, ITRI has, over more than 40 years of practice and exploration, innovated its institutional framework, clarified its objectives, and evolved from a technology importer and follower to a technology innovator and participant in industrial policy formulation. It has successfully created renowned semiconductor industrial clusters and dozens of industrial alliances, significantly advancing Taiwan' s industrial R&D capabilities and transformation. Its experience offers important insights for building industrial think tanks and maintaining industrial competitiveness.

1. Overview of the Industrial Technology Research Institute

Established in 1973, ITRI operates under the mission of "conducting R&D to drive industrial development, create economic value, and enhance social welfare." It is a non-profit research institute established through legislative procedures and represents a significant institutional innovation in Taiwan' s science and technology system. Over the past four decades, ITRI has closely followed international industrial trends and local development needs while aligning with government policies. Amid social transformation and changing global economic environments, ITRI has continuously adjusted its development strategies and positioning to fulfill its mission of promoting technological innovation and supporting industrial development, all while maintaining its fundamental identity as an applied research institution. This adaptive approach has profoundly influenced Taiwan' s industrial transformation and its ascent to the global economic stage. Based on ITRI' s positioning and primary development strategies, its evolution can be divided into four distinct phases .

The table illustrates ITRI' s development trajectory from the 1980s as a mission-oriented applied technology R&D institution, through its second growth period in the 21st century as a participant and executor of industrial policies, to its current role as a global innovation network member. Throughout its 40-year history, ITRI has evolved from a technology importer and follower to a technology innovator and policy participant, developing operational mechanisms that align with market economic principles. Its identity as a think tank has gradually gained recognition, culminating in its inclusion in the University of Pennsylvania' s Global Go To Think Tank Index in 2015. While existing scholarship has examined technology research institutes in developed countries, focusing primarily on their development, innovation models, and roles in technology transfer, few studies have addressed their emerging function as industrial think tanks or conducted comprehensive analyses of their management systems and operational mechanisms. As China stands at a critical juncture of science and technology system reform, industrial transformation, and think tank construction, a systematic study of ITRI' s institutional mechanisms—given its similar development background and representative status—holds significant importance for promoting national innovation system development, industrial think tank construction, and industrial upgrading.

2.1.1 Independent Corporate Legal Entity Status

During the 1960s and 1970s, Taiwan' s labor-intensive economy faced declining international market conditions, prompting the government to advocate for technological innovation and prioritize industrial upgrading. To this end, the government overcame numerous obstacles to legislate the "Industrial Technology Research Institute Establishment Act," merging the United Industrial Research Institute, United Mining Research Institute, and Metal Industries Research Institute to establish a government-funded, non-profit public research institution

in the Hsinchu Science Park. This legislation granted ITRI independent corporate legal status, enabling autonomous operation free from political interference while supporting government policy objectives of upgrading traditional industries and pioneering emerging ones. As an independently operated corporate entity, ITRI effectively avoids becoming an inefficient government agency while simultaneously serving as a crucial implementer of government industrial policies. It conducts R&D but differs from pure academic institutions by focusing primarily on applied technology research. While it spawns new industries, it does not become a profit-making enterprise, representing a major innovation in Taiwan' s science and technology institutional reform.

2.1.2 Organizational Structure

ITRI' s organizational structure has evolved with changing internal and external environments and strategic repositioning at different stages, culminating in a mature, flexible management framework [Figure 1: see original paper]. Currently, ITRI operates under corporate-style management, with a board of directors composed of opinion leaders from government, industry, academia, and research sectors guiding strategic decision-making. A supervisory board oversees the board and administrative departments. Regular guidance on R&D activities is provided by the Forward-looking Technology Guidance Committee (comprising domestic and international technical experts) and the Industrial Advisory Committee (comprising industry leaders). Under the board, a three-tier administrative and R&D system consists of the institute headquarters, research institutes (or centers), and research groups. The president, who serves as CEO and reports to the board, oversees all R&D, service, and administrative units, as well as the Innovation Industrial Technology Transfer Co., Ltd. Units share resources and maintain smooth information flow channels while enjoying considerable autonomy in management.

ITRI' s core business comprises three main components: technology R&D divisions, product innovation centers, and industrial service and value derivation divisions. The technology R&D divisions and product innovation centers constitute ITRI' s research units. The former represents ITRI' s strategic R&D areas and Taiwan' s industrial development directions, selected based on international technology trends and local needs as permanent organizations. Product innovation centers conduct cross-disciplinary research directly oriented toward industry, generating transferable technologies or support services to enhance productivity and identify new business opportunities. Some centers are established based on short- to medium-term needs of Taiwan' s authorities and industry, transitioning or dissolving upon completion, while others with persistent needs become permanent organizations, such as the Measurement Technology Development Center. The industrial service and value derivation divisions serve as service units, providing customized technical services, talent development, international cooperation, and legal assistance to ITRI, government, industry, and overseas institutions through collaboration with research units.

Notably, the Industrial Economics and Knowledge Center (IEK) and the Knowledge Economy and Competitiveness Research Center are categorized differently in various sources. While ITRI's technology policy researchers and senior project managers classify them as service units, ITRI' s 2016 report lists them as research units. Given that ITRI' s research units primarily conduct scientific and technological research while these two centers focus on auxiliary economic and intelligence research, we have categorized them in the third division, though their research nature should not be overlooked. IEK, in particular, serves as ITRI' s primary think tank, with two main tasks: strengthening industrial trend research to provide professional consulting services that create value and enhance efficiency for clients, and driving the development of Taiwan' s knowledge-based service industry while fostering consensus between government and industry. Its development goal is to become a key hub for industrial trends and policy research in the Asia-Pacific region.

Furthermore, while ITRI operates independently and makes autonomous decisions, both government and industry exert influence through various means to ensure alignment with development needs. The government primarily influences through funding allocations, board and supervisory board participation, project guidance, and rule-making. Industry influence occurs through project collaboration, financial donations, and participation in the Industrial Advisory Committee and board of directors.

2.2.1 Market-Oriented Research Project Selection Mechanism

ITRI undergoes strategic transformations approximately every 10-15 years, with research topics selected according to current development strategies. ITRI' s research portfolio includes medium- to long-term research, cross-disciplinary research, and short-term research. Short-term research primarily serves enterprises, with topics determined by client commissions, ensuring market relevance. Medium- to long-term and cross-disciplinary research aims to enhance Taiwan' s overall science, technology, and industrial levels, emphasizing forward-looking perspectives and representing the focus of this analysis.

Given that Taiwan' s industries primarily target international markets, ITRI must consider the global competitiveness of its R&D outcomes when selecting topics. This requires analyzing future market trends and the probability of success for new product market development, while also assessing whether existing technologies can be upgraded to international standards.

Medium- to long-term and cross-disciplinary research projects originate from two sources. First, commissioned projects from the government enable ITRI to track policy directions and ensure effective implementation of R&D outcomes. Leveraging its strong research capabilities and efficient, flexible operational mechanisms, ITRI undertakes over half of all government technology development projects annually. Second, self-initiated projects begin when the Planning Committee, based on government industrial technology policies, inter-

national trends, and actual industry needs, and incorporating recommendations from the Forward-looking Technology Guidance Committee and Industrial Advisory Committee, establishes technology development directions and research plans. A project leader is appointed to conduct prior art searches, project planning, and related exchanges. Each research institute or center then elaborates on the specific technical elements requiring consideration in the development of particular technology fields according to government policies and industrial technology development strategies before applying for technology development projects. Once proposed, projects undergo internal discussion and debate within the institute or center, with ITRI' s internal planning committee participating in project selection. Selected projects then receive detailed planning, including patent reviews, feasibility analyses, indicator systems, R&D formats, and development strategies. Resource requirements and assessments of future industrial impact are discussed with external organizations. Representatives from Taiwan' s Ministry of Economic Affairs and the planning committee negotiate to determine the R&D category, which includes advanced innovative technologies, key component technologies, and basic R&D technologies. Finally, the ITRI chairman approves the technology orientation and project funding, enabling project execution [13-14].

IEK' s current research projects primarily focus on global and Taiwan production and sales analysis, industrial development status and market trend forecasting, product and technology application trends, leading manufacturer strategies, competitive landscape analysis, regional and emerging market research, real-time industry issue analysis, and key component development [15]. Additionally, as a primary implementing unit of the Ministry of Economic Affairs' Industrial Technology Intelligence Service (ITIS) program, IEK conducts in-depth research on industries, products, technologies, and manufacturers across five major domains: machinery and metals, biomedicine, electronics and information, chemicals and livelihood, and emerging energy. IEK' s research outcomes serve as important reference materials for other ITRI institutes and centers in formulating their R&D plans.

2.2.2 Full-Resource Research Outcome Formation Mechanism

Leveraging its accumulated resources and reputation, ITRI has established itself as an efficient, rigorous research platform. Once a research project is approved, ITRI mobilizes required resources through this platform, including hardware resources, software resources, and strategic management intelligence resources. Hardware resources encompass facilities, equipment, and logistical support. ITRI provides space through its integrated research building, offering project teams access to facilities, equipment, administrative services, comprehensive living services, and engineering maintenance, enabling researchers to focus entirely on their work without distractions.

Software resources primarily include endowment support, talent from domestic and international academic institutions and enterprises, and technological

resources. ITRI maintains an open research system with flexible management and resource-sharing mechanisms, facilitating research collaboration not only among internal institutes and centers but also with other research institutions and enterprises. Frequent personnel exchanges occur among organizations, and existing research outcomes and technological resources can support new studies. Additionally, ITRI' s proximity to the Hsinchu Science Park, National Chiao Tung University, and National Tsing Hua University fosters close, trusted alliances with academia and industry. Universities serve as talent hubs, the science park as the optimal venue for applying research outcomes and identifying needs, and ITRI as the bridge connecting them. Combined with ITRI' s role as a policy implementer, this creates a well-functioning government-industry-academia-research innovation network where talents from all sectors interact closely to support R&D projects. ITRI' s long-established cooperative relationships with top overseas research institutions and manufacturers also attract talent and provide guidance from leading-edge technology experts.

Strategic management intelligence resources include enterprise-style management guidance, market and technology information, patent retrieval systems, patent intelligence, patent management guidance, and outcome distribution guarantees. ITRI assists project teams through open laboratories that leverage its extensive resource base and practical experience to provide various guidance and consulting services within a well-established management framework. In patent management, ITRI is renowned for its forward-looking intellectual property asset deployment and protection. On one hand, ITRI has clear regulations on intellectual property ownership and application principles, formulated to balance protecting knowledge creators' interests with enhancing social benefits to promote technology promotion and transfer. To effectively utilize innovation resources, ITRI implemented a two-tier patent proposal review mechanism in 2015, establishing technology-specific management and hierarchical responsibility to better assess the problem-solving capability of specific technologies, industrialization opportunities, and required resources. This process further examines patent layout, international technology comparisons and positioning, industrial application value, and promotion strategy planning. On the other hand, ITRI' s dedicated Technology Transfer and Legal Center provides comprehensive patent services, including intellectual property management (strategy, operations, and rights maintenance), assisting internal units with patent layout and quality improvement, intellectual property value-added and technology commercialization, intellectual property promotion and professional services, and international intellectual property cooperation. This two-tier review system and optimization service mechanism ensure ITRI obtains high-quality key patent rights in relevant technology fields, thereby increasing opportunities for new technology industrialization [16]. Additionally, ITRI maintains a specialized patent retrieval system enabling researchers to search patent full texts, abstracts, application scopes, and world patent abstract indexes, while providing monthly patent intelligence publications, patent map analyses, intellectual property consulting, and guidance on domestic and international patent application procedures to avoid

infringement and disputes.

Regarding outcome distribution, ITRI stipulates that research outcomes from fully government-funded projects belong to the public domain. Enterprises wishing to participate in special technology research projects must contribute at least 10% of funding, commit to implementing R&D outcomes, and pay technology licensing fees, allowing them to share results proportionally. Without Ministry of Economic Affairs approval, these enterprises cannot authorize outcomes to third parties. Enterprises contributing less than the stipulated amount cannot refuse transfer of research outcomes to third parties. For non-government technology cooperation projects outside special programs, outcome distribution follows contractual agreements.

2.2.3 People-Oriented, Demand-Driven Talent Management Mechanism

As of April 2016, ITRI employed 5,820 personnel, including 1,220 bachelor' s degree holders, 3,214 master' s degree holders, and 1,386 doctoral degree holders, with master' s and doctoral degree holders accounting for 79.04% of total staff —compared to just 18.66% at ITRI' s founding. ITRI also serves as Taiwan' s training ground and talent reservoir for scientific and technological personnel. While continuously producing R&D outcomes, ITRI has trained and exported batches of high-level technical and management talent, with a cumulative total of 18,000 personnel transferred to various sectors by 2016, many becoming senior executives in science parks or enterprises [10]. Staff may apply to work at other enterprises or government agencies or start their own businesses, provided they do not affect critical projects and comply with intellectual property and related regulations.

Conversely, ITRI alumni established the ITRI Alumni Association in 1991 to provide a platform for exchange, networking, and collaboration. Leveraging alumni' s extensive industrial experience, professional knowledge, and broad networks, the association assists ITRI in meeting new challenges and giving back to society, further enhancing ITRI' s influence and social resources.

ITRI' s enterprise-style management model grants it considerable autonomy in talent management, compensation systems, and other areas. As a non-profit organization, ITRI can reinvest all revenues into internal management and operations to create better R&D environments and develop flexible compensation systems based on strategic needs, rewarding capable performers while phasing out those who no longer meet requirements, thereby optimizing employee income and motivating staff. In response to global economic changes and different development stages, ITRI has implemented various talent management mechanisms. In its early years, Taiwan's labor-intensive industrial structure and poor research environment caused significant brain drain. ITRI therefore positioned talent development to align with industrial transformation needs, actively attracting and cultivating scientific and technological talent to reserve human

resources for future industrial development. ITRI attracted university and institute graduates, enhanced their R&D capabilities and management skills through systematic training and practical experience in applied research projects, then transferred them to industry to accelerate technology diffusion and drive Taiwan' s industrial innovation, transformation, and upgrading. By the 1990s, economic globalization and rapid development of Taiwan' s technology industries increased talent outflow frequency, causing structural gaps and hindering research progress. To ensure high-quality, on-schedule project completion and better serve Taiwan' s industrial development, ITRI introduced talent balance policies that both encouraged talent transfer to enterprises and implemented measures to attract more domestic and international talent while enhancing member cohesion. These policies included launching forward-looking research projects and related awards, cooperating with renowned international research institutes to provide staff with overseas training opportunities while inviting distinguished experts for exchanges and training, and proactively recruiting talent from universities [17]. In the 21st century, as internet 普及 accelerated information flow, ITRI introduced an international talent strategy to help staff rapidly develop and integrate with global standards. ITRI optimized internal management, strengthened external personnel utilization, rationally allocated R&D, management, and support staff, clarified responsibilities, and established scientific evaluation and reward mechanisms to ensure competitive salaries. While recruiting top international talent, ITRI also implemented targeted training programs for internal staff. To facilitate rapid integration of overseas personnel, ITRI provided comprehensive living assistance and benefits. Additionally, ITRI established stations in multiple countries to strengthen exchanges, cooperation, and talent recruitment with renowned research institutes and enterprises, hiring overseas experts to cultivate international talent and ensure ITRI remains at the forefront of global development, continuing to serve as Taiwan' s technology development engine [18].

2.2.4 Balanced Government-Enterprise Funding Mechanism

Established with government funding, ITRI received adequate financial support during its startup phase. Through continuous development and exploration, ITRI accumulated experienced scientific personnel and commercially applicable technological achievements. Through technology transfer, spin-off company establishment, and various services for industry, ITRI gradually reduced its dependence on direct government funding and ultimately achieved financial balance. Currently, ITRI primarily relies on contract research projects as its main funding source, with specific financial structures shown in .

The table shows that special project research refers to government-funded R&D projects undertaken by ITRI. Technical service income comes from commissioned or collaborative research projects with the military or enterprises, as well as consulting and testing services provided to industry. Project-derived income refers to income from specific product development commissioned by enterprises

or government based on new technologies developed in special projects. Non-operating income 主要包括 donations and book publications. The data reveals that government project funding and industrial service funding are nearly at a 1:1 ratio, granting ITRI greater autonomy in R&D selection and enhancing staff understanding of cost-effectiveness and customer orientation. Notably, within special projects, to promote ITRI-industry collaboration, government-approved research funding typically does not exceed 50% of project budgets, with the remainder encouraged to be secured through industry collaboration or technology transfer income [19].

2.2.5 Long-Term Thematic Cooperation Mechanism

As Taiwan' s industrial technology R&D center, ITRI serves as a lever and bridge for integrating, connecting, and coordinating domestic and international resources, as well as an interactive platform among government, industry, academia, and research. Since its establishment, ITRI has collaborated with domestic and international industrial and academic institutions. Through long-term development, ITRI recognized that close, trusted alliances can only be built on the foundation of long-term cooperation, enabling better resource utilization, in-depth exchanges, promotion of heterogeneous knowledge flow, inspiration, and development. To address challenges from accelerating industrial innovation and technological progress, ITRI has developed different cooperation mechanisms for various partners, effectively promoting synergies and maintaining its position at the forefront of global technology development.

For domestic industry collaboration, since 1994 ITRI has required all technology development projects to align with industrial needs and ensure R&D outcomes can be absorbed and utilized by industrial enterprises, with mandatory enterprise participation in the R&D process. Enterprise participation brings not only tangible and intangible assets such as funding, patents, human resources, and R&D prototypes but also helps acquire relevant technical information during project execution and facilitates demand-responsive strategy formulation during technology transfer. To strengthen industry interaction and effectively utilize R&D resources, ITRI launched open laboratories in 1996, relocating collaborative thematic R&D projects and enterprise personnel to enable close interaction that significantly enhances R&D quality. Moreover, since small and medium enterprises constitute the majority of Taiwan' s businesses with limited capabilities, ITRI' s enterprise-level collaboration could only assist individual companies rather than comprehensively enhance Taiwan' s industrial competitiveness on the global stage. Consequently, leveraging its R&D and information advantages, ITRI has led the establishment of various industry technology R&D alliances and cross-industry R&D alliances. In these alliances, enterprise needs guide the direction of generic technology R&D, ITRI provides technology and the latest development information and trend analysis, and enterprises participate in different R&D stages according to circumstances and receive corresponding rights. These R&D alliances effectively improve technology transformation rates and

cycles while enhancing Taiwanese enterprises' international competitiveness [20].

For academic cooperation, ITRI systematically established university collaboration mechanisms in 2000 by integrating previously scattered cooperation resources and models, relocating its own R&D stations into university laboratories. Collaborating academic institutions sign "cooperation agreements"covering joint employment, personnel secondment, academic research collaboration, graduate training, equipment allocation, instrument sharing, and establishment of field-specific research centers. Current cooperation focuses on interdisciplinary integrated technology R&D, primarily with National Chiao Tung University, National Tsing Hua University, National Cheng Kung University, and National Taiwan University, as well as memoranda of understanding with Academia Sinica, the National Center for High-Performance Computing, the National Health Research Institutes, and the National Synchrotron Radiation Research Center in areas such as high-speed computing and biotechnology pharmaceutical research.

For international cooperation, Taiwan' s authorities created a favorable external exchange environment in the early stages. The Taiwan International Project Center, directly supervised by Taiwan's Vice President, actively promoted ITRI' s international work, including signing technology cooperation agreements with international research institutions and multinational corporations, undertaking international technology cooperation projects and exchange activities, serving as a global access window, hosting international technology conferences, planning and promoting overseas 据点 work, and enhancing functional flexibility. To rapidly integrate into overseas technology innovation networks and expand its global R&D cooperation footprint, ITRI established offices in North America, Europe, Russia, the Netherlands, and Japan. Through patent cross-licensing, managing key clients to become international innovation partners, technology transfer platforms, technology R&D alliances, and information collection and sharing, ITRI enhances its overall R&D strength, bringing resources into Taiwan and driving industrial development through project collaboration and personnel exchanges. Currently, with its outstanding research teams in various fields, high-quality manufacturing capabilities, and innovative technology industrialization strength, ITRI serves as an innovation partner for many overseas research institutes and international companies. By 2015, ITRI had established partnerships with 128 organizations across 21 countries in North America, Europe, Asia, and Oceania.

Regardless of partnership type, all collaborations follow ITRI' s Patent In Product (PIP) mechanism and receive intelligence support from the Industrial Economics and Knowledge Center. To maximize patent application benefits and ensure close integration between patents and technologies or products, shortening technology commercialization timelines, ITRI designed the PIP mechanism with strategies spanning cross-disciplinary, cross-industry, and cross-border dimensions. The cross-disciplinary strategy identifies suitable patents from various R&D units for specific technology themes based on customer needs, facilitating cross-domain collaborative product development and pilot production.

The cross-industry strategy provides creative ideation and feasibility assessment across industries, patenting results, and jointly commercializing with partner manufacturers to explore business opportunities. The cross-border strategy deepens or establishes long-term, stable cooperation channels with internationally renowned enterprises, promoting and assisting relevant R&D units in PIP collaborative development and pilot production. IEK leverages its team of over 150 industry analysts across different fields, drawing upon ITRI' s rich research resources, expert groups, industrial service experience, and extensive domestic and international networks to provide timely industrial intelligence services to government, domestic and overseas enterprises, non-profit organizations, and ITRI internal institutions. These services include market forecasting and industrial surveys (manufacturer/industry dynamic analysis, market size analysis and forecasting, production and sales surveys and output value estimation, industrial trend forecasting models), technology forecasting and product development (product/technology development roadmaps, product/technology demand analysis, innovative product technologies, screening of potential product technologies), expert consulting services (forward-looking planning guidance, market layout planning, product development strategies), industrial intelligence networks (database of charts and data, industrial development trend observations, leading manufacturer strategy analysis, real-time industry issue analysis), and seminars and publications (trend seminars, expert forums, research monographs, industrial yearbooks).

2.2.6 Comprehensive and Diversified R&D Outcome Diffusion Mechanism

ITRI' s founding mission is to promote Taiwan' s technology industrial development, and only by applying R&D outcomes to industrial development can maximum benefits be created. Therefore, considering outcome diffusion and transfer in all work has become subconscious for every employee. During project establishment and R&D phases, ITRI regularly holds technical conferences to showcase technical concepts, current development status, and research progress to industry, attracting enterprise participation in R&D or signing agreements to assist with marketization. During R&D, collaborative projects with domestic and international research institutes and enterprises serve as important channels for technology diffusion and intelligence dissemination. Through these collaborations, comprehensive interaction and in-depth exchanges of talent, information technology, and funding ensure that R&D technologies genuinely meet market needs, promote industry understanding and acceptance of new technologies, cultivate advanced technical and management talent, maximize external resource utilization, and shorten technology marketization cycles. Upon R&D completion, ITRI employs multiple channels to diffuse outcomes, transferring relevant personnel to industry when necessary to guide and facilitate technology transfer and transformation. ITRI' s outcome diffusion channels 主要包括 information dissemination, technology transfer, spin-off enterprises, incubating innovative enterprises, and comprehensive enterprise services.

Information dissemination began with ITRI' s drafting of the "ITRI Technology Diffusion and Implementation Procedures" in 1987, which includes procedures for releasing development status announcements to industry, disseminating new R&D information through conferences and exhibitions to interested enterprises and partners, publishing articles in professional journals, participating in professional conferences, and organizing seminars, short-term training, technology promotion workshops, and business presentations to publicly explain research benefits. Assistance services are provided to enterprises when needed. During technology dissemination, rules have been refined and improved, including technology transfer pricing principles, operational procedures, and technology transfer contracts to ensure open, fair, and just transfer to industry.

Technology transfer occurs through licensing (generally non-exclusive), sales, or contractual provision of technical consulting, development, and evaluation services to government or other organizations. Transfer projects are determined by industrial needs, with ITRI providing technical characteristics including content, developability, breakthrough potential, application scope, licensing status, specifications, distinctive features, and markets. Technology transfer valuation considers market potential and value, technological competitiveness, substitutability, R&D costs, number of potential technology recipients, and enterprise absorption capacity. During transfer, relevant personnel may be transferred to enterprises as needed. Enterprises can pay transfer fees through licensing fees, early research participation, stock options, or cross-licensing.

Spin-off enterprises represent a crucial technology commercialization model, established with ITRI approval through the transfer of mature technologies, talent (both technical and management), and related resources. ITRI officially released the "ITRI Spin-off Enterprise Establishment Measures" in 1990 to rapidly bring mature technologies that existing enterprises cannot undertake but offer clear benefits to Taiwan' s industries into the market. Spin-off technologies are generally forward-looking technologies developed in alignment with government industrial development strategies. Through key technology industrialization, spin-offs create demand, attract investment, drive industrial structural transformation, and pioneer emerging industries. Upon maturation, ITRI gradually exits through equity transfer to maintain focus on R&D.

Incubating innovative enterprises involves the ITRI Incubation Center, which provides quality R&D environments, commercial production assistance, management training, technical support, and capital investment for technical teams or SMEs with R&D capabilities wishing to establish companies or enter new business areas. This enhances entrepreneurial team competitiveness and accelerates the formation of emerging enterprises in domestic markets while simultaneously diffusing R&D outcomes and expanding audiences. Operational since 1996, the Incubation Center accepts applications from high-tech enterprises established within 18 months or technical teams planning to establish high-tech enterprises. Selection criteria include whether the product or service is technology-based, represents innovative or Taiwan-leading technology, has a

feasible business plan, possesses capable teams, has sufficient funding for basic incubation expenses, and can influence Taiwan' s industries. The Incubation Center also aggregates external resources including support from the Ministry of Economic Affairs' SME division, capital investment from Taiwan' s Venture Capital Association, and business plan writing guidance from partner universities, enabling resident teams to focus on their work and enhancing new venture success rates. Successful incubated enterprises typically reciprocate ITRI through equity or donations.

Comprehensive enterprise services maximize ITRI research outcome diffusion by leveraging human resources, equipment, and facilities. Beyond IEK, the Technology Transfer and Legal Center, open laboratories, and the Incubation Center, ITRI has established the Industrial Service Center, International Center, Information Technology Service Center, Knowledge Economy and Competitiveness Research Center, and Marketing Communications Division. ITRI operates five service locations in Taiwan: the Taipei Office, headquarters at the Chung-Hsing Campus, Kuang-Fu Campus, Southern Branch, and Central Branch, with technical service centers in each institute and technical service windows or SME service centers in industrial parks and municipalities. This creates a complete, efficient industrial service network covering "technology R&D—commercialization—growth—maturity—transformation," establishing ITRI as Taiwan' s technology intelligence hub for industrial development.

3.1 Industrial Think Tanks Should Maintain Clear Positioning Without Overreach, Aligning Institutions with Practice

With strong government support and legal establishment, including full funding during its initial phase, government departments have maintained appropriate distance from ITRI, providing support and guidance without interfering in operations. This has maximized ITRI' s operational autonomy, enabling flexible responses to domestic and international environmental changes over 40 years and keeping ITRI at the forefront of Taiwan' s technology industrial development. ITRI has consistently maintained its fundamental positioning as a non-profit research institution conducting industry-oriented, forward-looking applied technology R&D and innovation. It avoids basic research that universities can conduct and research that enterprises can perform, focusing instead on key technology development and commercialization. Once technologies mature, they are transferred to the market through various channels, with ITRI gradually withdrawing and reinvesting proceeds into new technology development projects. This approach has found a balance between technology and market, created core competitiveness, become a crucial connection point for government-industry-academia-research collaboration, and effectively executed its strategic mission of revitalizing the economy and driving industrial development. Furthermore, as demonstrated above, ITRI' s development has benefited from both institutional support from government agencies and its own continuous introduction and optimization of various regulations and procedures through practice.

These normalize ITRI' s R&D, technology transfer, and information dissemination activities while providing valuable experience guidance, enabling more efficient operation across all units and departments.

3.2 Industrial Think Tanks Should Be Demand- and Service-Oriented, Operating Independently with Flexible Enterprise-Style Management

The philosophy and practice of being industry-demand-oriented and emphasizing both R&D and services permeate every operational mechanism at ITRI. To continuously grasp the latest industrial trends and needs, ITRI invites industry leaders to participate in and guide all activities or directly invites relevant enterprises to join activities. It has also established the Industrial Economics and Knowledge Center to provide information and intelligence services, ensuring maximum alignment between ITRI' s R&D products and services with actual needs and facilitating smooth transfer and commercialization. This approach achieves industrial upgrading and development while ensuring ITRI' s R&D benefits and sustainable development.

Operating with enterprise-style management while remaining a public institution enables ITRI to serve Taiwanese enterprises with a customer service attitude while maintaining its public welfare nature. This allows full reinvestment of surpluses into ITRI's development while emphasizing organizational operational efficiency, beneficial for gathering government-industry-academia-research resources and capital accumulation, ensuring ITRI' s healthy operation and long-term industrial development promotion. Moreover, this management approach grants ITRI considerable independence and flexibility in organizational structure, funding management, personnel recruitment, and compensation systems, enabling continuous optimization of management and organizational design according to environmental changes, industrial needs, and talent development requirements. This facilitates rational allocation of management, research, and support personnel, enhances organizational vitality, and stimulates employee creativity.

3.3 Industrial Think Tanks Should Coordinate Internal and External Innovation Resources, Serving as Bridges Connecting Innovation Resources

As a government-supported non-profit organization with an open operational mechanism and proximity to universities and industrial parks, ITRI can integrate and coordinate various innovation resources from within and outside Taiwan, optimizing combinations to align resource supply with industrial needs. This creates innovation resource agglomeration effects, accelerates outcome transformation, enhances regional technological innovation capabilities, promotes industrial development, and effectively addresses issues such as insufficient supply of generic technologies, limited R&D capabilities of SMEs,

and lack of international industrial competitiveness. In practice, ITRI extends its reach throughout Taiwan and worldwide, establishing multiple service and research 据点 domestically and internationally, relocating laboratories into universities and overseas research institutions to ensure close spatial proximity for resource collaboration partners. This facilitates coordination of resource integration and allocation, maximizes effective resource utilization and efficient talent exchange, creates favorable environments for technology enterprise cultivation and development, and forms innovation clusters. Additionally, Taiwan government' s role in promoting social capital investment in technology industries deserves attention. In 1982, Taiwan authorities promulgated the "Venture Capital Regulations," actively promoting industrial investment through low tax rates and full tax rebate policies, establishing seed funds twice with government capital. To expand venture capital sources, insurance companies and private banks were permitted to establish venture capital firms in 1994, while actively attracting international venture capital investment from the US, Germany, Japan, and other countries. These measures provided ample financial support for Taiwan' s economic development [5].

3.4 Industrial Think Tanks Should Jointly Develop Talent and Technology, Maximizing Research Outcome Utilization

Talent represents the key to research institution and enterprise development. Since tacit knowledge embedded in technology products is often more valuable than transmittable explicit knowledge, particularly in technology operation, transformation, and application, which largely depend on people, ITRI actively conducts market-demand-oriented technology R&D while cultivating technical and management talent through its industrial college and practical research project participation. It then transfers both technologies and some personnel to industry, with outgoing employees contributing to enterprise development and sometimes becoming key drivers of industrial upgrading—an important manifestation of social benefits.

For ITRI as a public institution, maximizing research outcome utilization is as important as technology R&D itself. ITRI' s comprehensive and diversified research outcome diffusion mechanisms, service station networks spanning Taiwan, personnel mobility, accumulated partners and reputation, and institutional guarantees enable timely, efficient diffusion of the latest research outcomes to where they are needed during R&D and after technology maturation, promoting industrial development and enhancing social benefits.

3.5 Mainland China' s Industrial (Technology) Research Institutes Should Strengthen Think Tank Function Development

Currently, various provinces, municipalities, universities, and research institutes in mainland China have actively established industrial (technology) research in-

stitutes, such as the Beijing Tsinghua Industrial Development Research Institute, Shaanxi Industrial Technology Research Institute, Shanghai Zizhu Emerging Industry Technology Research Institute, Guangzhou Modern Industry Technology Research Institute, Shanghai Jiao Tong University Advanced Industry Technology Research Institute, Shenzhen Institute of Advanced Technology (Chinese Academy of Sciences), and Suzhou Institute for Advanced Study. However, it is worth noting that due to their relatively recent establishment, these institutes currently concentrate their research efforts primarily on industrial technology innovation, with limited involvement in industrial technology development policy or national/regional industrial technology development strategic planning. ITRI' s Industrial Economics and Knowledge Center serves as the primary unit for such research at ITRI, effectively leveraging ITRI' s existing scientific, technological, and human resources to make significant contributions to Taiwan' s industrial technology policy and development planning, with the goal of becoming an international think tank leading Taiwan' s industrial value creation. Mainland China' s industrial (technology) research institutes should similarly leverage their advantages to strengthen think tank function development, enhance government decision-making capacity for science and technology policy, and promote rapid, sustainable development of mainland China' s industrial economy.

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Note: Figure translations are in progress. See original paper for figures.