

Multi-level Landscape Analysis of Science and Technology Think Tank Development: Postprint

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Abstract

[Purpose/Significance] Currently, the construction of science and technology think tanks in China generally suffers from ambiguous positioning and an overemphasis on “tank” over “think.” Against the backdrop of new decision-making contexts, establishing their proper role and enhancing their intellectual capacity constitute the primary tasks for developing S&T think tanks. [Method/Process] To this end, this paper develops a multi-level framework for S&T think tank construction based on knowledge: a macro-level framework of attributes and boundary relationships, a micro-level framework of research systems and functional structures, and a meso-level framework of typological patterns and organizational evolution, aiming to “define position through framework” and “clarify wisdom through knowledge.” [Results/Conclusion] From multiple dimensions, this study defines the position of S&T think tanks through this framework and elucidates the knowledge-based pathway for S&T think tanks to enhance cognitive wisdom, improve wisdom capacity, and demonstrate wisdom capability, yielding several novel insights: (1) The bidirectional interaction between knowledge and decision-making represents the essential characteristic distinguishing S&T think tanks from other think tanks. The interactive relationships between S&T think tanks and other think tanks are categorized into strong-tie and weak-tie types, proposing that S&T think tanks constitute the most fundamental, most dynamic, and most innovative force within the think tank system; (2) The study clarifies the central role of core science in S&T think tanks and the feedback effect of S&T think tanks on core science, proposing that S&T think tanks should transcend the current “S&T consulting” model and expand into post-normal science issues and strategies characterized by high uncertainty and decision-making risk; (3) Based on knowledge system architecture and domain span, S&T think tanks are classified into four types: comprehensive, specialized, consulting, and platform types. On the basis of systematic integration, an organizational evolution framework for S&T think tanks is constructed, essentially clarifying

the development path for S&T think tanks and the direction for building world-class S&T think tanks. It is hoped that this will provide possible targets and reference points for the development of individual S&T think tanks and the macro-level management of national S&T think tanks, contributing to the diversified, systematized, and orderly development of S&T think tank theory and practice.

Full Text

Multi-landscape Analysis on Construction of Science and Technology Think Tank

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Abstract

[Purpose/significance] Currently, science and technology (S&T) think tank construction in China generally suffers from ambiguous positioning and a tendency to emphasize “tank” over “think.” Against this new decision-making backdrop, finding the right “position” and enhancing “think” constitute the primary tasks for S&T think tank development.

[Method/process] To this end, this paper constructs a multi-level landscape for S&T think tank construction based on knowledge: a macro-level landscape depicting attributes and boundary relationships, a micro-level landscape of research systems and functional structures, and a meso-level landscape of typological patterns and organizational evolution. This framework aims to “fix position through landscape” and “clarify think through knowledge.”

[Result/conclusion] Through multi-dimensional landscape analysis, we establish a “position-fixing” framework and clarify the knowledge-based path for enhancing “think”—from improving “think” awareness to elevating “think” capacity to demonstrating “think” capability. Our analysis yields several new insights: (1) The bidirectional interaction between knowledge and decision-making represents the essential characteristic distinguishing S&T think tanks from other think tanks. We categorize their relationships with other think tanks as strong-tie and weak-tie types, proposing that S&T think tanks constitute the most fundamental, dynamic, and cutting-edge force within the think tank system. (2) We clarify the soul status of core science in S&T think tanks and the 反哺作用 (feedback effect) of S&T think tanks on core science, suggesting that S&T think tanks should transcend the current “S&T consulting” model to address post-normal scientific issues with high uncertainty and decision risk. (3) Based on knowledge architecture and domain span, we classify S&T think tanks into four types: comprehensive, specialized, consultancy, and platform types, constructing an organizational evolution landscape through systematic integration

that clarifies construction pathways and directions for first-class S&T think tanks.

We hope this analysis provides possible targets and references for individual S&T think tank construction and national macro-management of S&T think tanks, contributing to the diversified, systematic, and orderly development of S&T think tank theory and practice.

Keywords: science and technology think tank; landscape analysis; communities of knowledge construction; professional consultancy; post-normal science; categorization and mode; network construction

Classification Number: G301

In recent years, with strong national advocacy and support, China's S&T think tanks have developed rapidly, with various institutions emerging continuously. The Chinese Academy of Sciences, Chinese Academy of Engineering, and Academy of Military Sciences were selected as the first batch of pilot units for national high-end think tank construction. The China Association for Science and Technology has also made decision-making consultation one of its primary functions. Universities, research institutes, professional associations and societies, and even S&T-related enterprises and media have established S&T think tanks, achieving positive progress. However, overall, the phenomenon of emphasizing "tank" over "think" remains widespread. Most S&T think tanks have vague functional positioning and convergent models. Some large S&T think tanks suffer from over-generalization of their main business and heavy academic orientation, while small think tanks have weak foundational capabilities and low specialization levels, lacking distinctive features. Meanwhile, with accelerated S&T development, increasingly integrated global information networks, and rapid integration of S&T achievements into economic, industrial, and social life, uncertain factors have increased, interest structures have become more diversified, and S&T decision-making issues and processes have become more complex. How to find the right "position" and enhance "think" under this new decision-making backdrop has become the primary challenge facing S&T think tank construction. Yet without a clear "landscape," an explicit "position" cannot be found; without systematic "knowledge," outstanding "think" cannot emerge. This urgently requires constructing a systematic "landscape" based on "knowledge" that fits the current situation, starting from the overall level and fundamental issues of S&T think tank construction—to "fix position through landscape" and "clarify think through knowledge."

This paper constructs a three-level landscape for S&T think tanks based on "knowledge," with "positioning" and "think enhancement" as objectives, progressing step by step: a macro-level landscape depicting attributes and boundary relationships, a micro-level landscape of research systems and functional structures, and a meso-level landscape of typological patterns and organizational evolution. Here, "landscape" (图, tú) derives from "□ (wéi)," meaning scope and

planning; “scape” (景, jǐng) refers to an ideal situation. Regarding the “landscape” at each level, we aim to clarify boundaries, manifest elements, clarify structures, and 梳理 relationships. Through comprehensive landscape analysis, we hope to provide references for individual S&T think tank construction and possible targets for national macro-management and strategic layout of S&T think tanks.

1. Macro Landscape: Attributes and Boundary Relationships of S&T Think Tanks

S&T think tank construction should first clarify what S&T think tanks are and where their boundaries lie. This section attempts to construct a macro-level landscape for S&T think tanks from two aspects: their essential attributes and their boundary interactions with other think tanks, depicting their positioning within the think tank system.

1.1 Essential Attributes of S&T Think Tanks

S&T think tanks are a type of think tank that possesses both general characteristics of think tanks and S&T-specific traits [Figure 1: see original paper]. General characteristics can be extracted from authoritative think tank definitions and descriptions. For instance, Dickson proposed that “think tanks are stable, relatively independent policy research institutions whose researchers employ scientific methods to conduct interdisciplinary research on a wide range of policy issues and provide consultation on policy matters closely related to government, enterprises, and the public” [2]. The United Nations Development Programme (UNDP) stated that “think tanks are organizations that engage in long-term research and advocacy related to public policy, serving as a bridge between knowledge and power in modern democratic nations” [3]. James G. McGann and colleagues argued that think tank experts can bridge the gap between theory and practice, transforming knowledge achievements into productive forces and continuously providing decision-makers with independent, objective analytical solutions to reduce risks in the policy-making process [4].

In summary, this paper posits that think tanks serve as bridges between “knowledge” and “decision-making,” with the core mission of serving public decision-making, providing policy options, and reducing decision risks.

S&T think tanks act as bridges between “S&T knowledge” and “S&T-related decision-making,” exhibiting distinct S&T characteristics. Here, S&T knowledge emphasizes natural science knowledge, reflecting the intersection of natural and humanities/social sciences. S&T-related decision-making primarily includes two levels: decisions *for* science (policy for science) and decisions *containing* scientific factors (science in policy) [5]. However, the S&T characteristics of S&T think tanks refer not only to their S&T-related research content but also to

the distinctive features manifested during the knowledge-decision interaction process. (1) **High knowledge density and rapid iteration.** The dramatic transformation of modern S&T, accelerated scientific knowledge renewal, rapid differentiation and refinement alongside high integration determine that S&T think tank knowledge production and reproduction have higher professional thresholds. (2) **Dual uncertainties of science and society.** S&T think tanks operate at the frontier interface of science-society interaction, where social transformation uncertainties and inherent scientific uncertainties increase the difficulty and risk of public decision-making [6]. (3) **Greater emphasis on the scientific community's role.** The uncertainty of science, its nature as a public undertaking, and the forward-looking, strategic scientific analysis required for S&T-related decision-making exceed the capacity of individual experts, necessitating collective scientist participation in decision-making. S&T think tanks' function of enabling scientific communities to play advisory roles [7] is also their traditional function. (4) **Bidirectional knowledge-decision interaction.** In general think tanks, "knowledge" provides unidirectional service to "decision-making," whereas in S&T think tanks, "decisions for science itself" in turn affect "S&T knowledge," manifesting as bidirectional interaction. This determines the closer relationship between S&T think tanks and knowledge. It should be noted that since general think tanks' knowledge also encompasses S&T knowledge, the first three characteristics are also present to some degree in general think tanks. The "specialness" of S&T think tanks mainly lies in quantitative prominence and degree of intensity, while "bidirectional knowledge-decision interaction" represents a qualitative difference—the essential characteristic distinguishing S&T think tanks from others.

1.2 Boundary Interaction Relationships of S&T Think Tanks in the Think Tank System

Determining S&T think tanks' boundaries first requires delineating the think tank system's scope. The *Global Go To Think Tank Index* [8] classifies think tanks by domain into defense and national security, national economic policy, education policy, energy and resource policy, environment, foreign policy and international affairs, national health policy, global health policy, international development, international economic policy, S&T, social policy, and transparency and good governance. This classification is not a strictly "mutually exclusive, collectively exhaustive" (MECE) taxonomy but faithfully reflects current hotspots in international think tank development, constituting a relatively complete think tank system.

The boundary of S&T think tanks is an abstract concept determined by their attributes and relationships with other think tanks, while attributes partially determine relationships. From the perspective of S&T think tanks' two types of S&T-related decisions, the "decisions for science itself" component represents their rightful core function. The high knowledge density and rapid iteration characteristics determine its professional threshold and exclusivity, making it

difficult for other think tanks to manage. Therefore, at this decision-making level, S&T think tanks hold absolute dominance, with minimal interaction with other think tanks that is primarily unidirectional—other think tanks influence S&T think tanks by raising S&T demands and focusing scientific questions. The “decisions containing scientific factors” component, however, has a broader scope that various think tanks engage with, showing bidirectional interaction characteristics—S&T think tanks radiate outward to provide professional S&T support to other domain think tanks, while other domain think tanks provide S&T think tanks with diverse perspectives on ethics, law, culture, and politics. Based on interaction strength, relationships between S&T think tanks and other think tanks can be divided into strong-tie and weak-tie types [Figure 2: see original paper].

Think tanks with strong-tie relationships to S&T think tanks include education policy, energy and resource policy, environment, national health policy, and global health policy think tanks. These think tanks’ research domains and content overlap with S&T think tanks, but differences in research angles, methods, and impact interfaces create a foundation and direct need for building think tank networks, resulting in frequent interaction. Think tanks with weak-tie relationships include defense and national security, national economic policy, foreign policy and international affairs, international development, international economic policy, social policy, and transparency and good governance think tanks. These think tanks lean more toward socio-political domains, with S&T think tanks primarily providing relevant S&T support. However, since “weak ties” often possess low-cost, high-efficiency transmission capabilities [9], S&T think tanks can obtain richer external information. Weak-tie collaborative relationships may be more important for producing innovative policy solutions and will promote S&T think tanks to play more active roles in broader decision-making issues.

From the attributes and boundary interactions of S&T think tanks, we can see that S&T think tanks provide universal support to other think tanks, representing the most fundamental type in the think tank system. Meanwhile, as S&T innovation’ s driving role in the economy and society becomes more prominent, S&T issues have become one of the most important research directions for think tanks. S&T think tanks may break through the current humanities/social sciences think tank dominance to become the most cutting-edge force in the think tank system. Furthermore, for many systematic, comprehensive decision-making problems, S&T uncertainty is often a key factor increasing decision-making complexity. S&T think tanks can play a leveraging role through think tank network construction, becoming the most dynamic force in the think tank system.

2. Micro Landscape: Research System and Functional Structure of S&T Think Tanks

On the basis of clarifying the macro landscape, we must further examine S&T think tanks internally, analyzing “what issues S&T think tanks should research and what functions they should perform” at the micro level. This clarifies their research and functional positioning—the key link in “fixing position through landscape” and the prerequisite foundation for “clarifying think through knowledge.”

At the ideal level, think tanks should regard knowledge production and reuse as their basic responsibility [10], and S&T think tanks even more so due to their S&T characteristics. This paper argues that Funtowicz and Ravetz’ s communities of knowledge construction framework [Figure 3: see original paper] can be used for in-depth analysis of S&T think tanks’ research systems and functional structures. This framework establishes a two-dimensional coordinate system through “system uncertainty” and “decision stakes” (referring to the degree to which decisions matter, i.e., the potential cost of wrong decisions), constructing logical connections from applied science (including core science) to professional consultancy and then to post-normal science, and proposing different scientific strategies for different problem types [11]. The core task of S&T think tanks is to reduce S&T-related decision risks. Combined with their dual uncertainty characteristics, this framework fits very well, allowing us to use the core science–applied science–professional consultancy–post-normal science architecture to 梳理 S&T think tank research systems and functional structures.

2.1 S&T Think Tank Research System Based on Knowledge Architecture

(1) The research system of S&T think tanks is a three-system structure radiating outward from “core science” as the soul. “Core science” refers to traditional pure or basic science (near the origin in Figure 3), a curiosity- or inquiry-driven research type with low or no external decision risk and low artificial uncertainty, generally handled through conventional problem-solving methods with quality control through peer review. The S&T characteristics of S&T think tanks determine that core science occupies the “soul” position. High-end S&T think tanks must be built on high-quality core science research. Without connection to frontline core science research, S&T think tanks would struggle to grasp S&T development pulses and serve S&T-related decision-making. However, core science alone cannot constitute an S&T think tank. Although core science is the “soul” for S&T think tanks, it cannot form a think tank “entity” without 依附 on applied science, professional consultancy, and post-normal science. Therefore, the research system of S&T think tanks should be a three-system structure radiating from core science to applied science, professional consultancy, and post-normal science [Figure 4: see original paper].

(2) The “applied science” system has clear policy orientation and can directly provide solutions. “Applied science” is a strategy applied when both uncertainty and decision risk are relatively small, operating in isolated, controllable natural systems with reproducible and predictable results, where expert knowledge is fully effective and quality control is generally guaranteed by research result users. This research system directly provides solutions through applied scientific research for decision-makers’ reference, guiding policy outputs. For example, regional functional zoning research and urban development research are closely related to S&T and public policy, where S&T think tanks can provide direct key support. These research questions have relatively clear policy 指向 and are launched in response to economic and social demands for S&T-related policy fields. Although application-oriented, they require in-depth, systematic foundational research on relevant domain issues, often directly producing forward-looking, systematic, macro-level policy options and recommendations. Applied science system problems are often comprehensive, requiring strengthened interdisciplinary research.

(3) The professional consultancy system represents the core function of S&T think tanks under traditional S&T decision-making models. “Professional consultancy” applies when uncertainty and controversy levels are moderate, requiring conventional technology applications to be supplemented by professional experience, judgment, and even courage. The methodology for handling problems in “professional consultancy” is completely different, and each expert may provide different results. In traditional “government-scientist” dominated S&T decision-making models, S&T consultation is often regarded as the core function of S&T think tanks. Professional consultancy can be roughly divided into two levels: first, matters with relatively high uncertainty and decision risk, where individual expert judgment is insufficient and expert groups are needed, such as disaster assessment; second, decisions concerning S&T itself, whose public undertaking nature and forward-looking analysis require scientific community participation in decision-making, such as scientific foresight, S&T strategy, and S&T planning. Professional consultancy is the traditional core function of S&T think tanks. In this system, professional consultancy is based on core science and applied science, requiring development of methodological systems different from traditional scientific research.

(4) “Post-normal science” issues with high uncertainty and decision risk should gradually become the focus of S&T think tank research. “Post-normal science” refers to scientific methodologies adopted for making major decisions under conditions of uncertain scientific facts and pluralistic value judgments, focusing on decision-making under factual uncertainty and insufficient information. Its core solution strategies are mainly reflected in new understanding and management of uncertainty and employing extended peer community participation for interdisciplinary research, social relevance research, and policy relevance research [12-13]. Post-normal science issues often have significant social impact and controversy. Improper handling can cause enormous consequences. For example, the domestic controversy over genetically modified

organisms in recent years, where scientific controversies refracted into public policy and media domains, caused social amplification of risk, generating social panic and government trust crises [6]. However, proper handling of post-normal science issues is extremely difficult, facing many conflicts and dilemmas: government agencies are overstretched, lacking corresponding response frameworks and mechanisms; most scientists and research institutions are unwilling to court trouble, leading to insufficient expression of scientific viewpoints; the public has strong desires and huge demands to participate in relevant decision-making but lacks professional scientific knowledge and participation opportunities. To resolve this dilemma, an information-open, fully discussed, and dispute-resolving platform is urgently needed—one that can provide compromised policy choices after multi-party participation and mediation coordination to reduce decision risk. As a bridge between S&T knowledge and relevant decision-making and the frontier interface of science-society interaction, S&T think tanks' core task is to reduce S&T-related decision risk. The higher the uncertainty and decision risk, the more it should be their mission responsibility to incorporate post-normal issues into their research scope. Moreover, considering that S&T think tanks better understand the crux of scientific uncertainty and controversial schools than other institutions, only S&T think tanks have the capacity to cultivate “scientific citizenship” [14], giving them unique advantages in constructing platforms for discussing and resolving post-normal science disputes. Furthermore, the huge social impact of post-normal science issues can demonstrate S&T think tanks' “think” capability and greatly enhance their influence. In view of this, S&T think tanks should transcend the current “S&T consultation” model and expand toward post-normal science systems. In this system, post-normal science is based on core science, applied science, and professional consultancy, requiring exploration of uncertainty management and multi-subject participation methods and strategies.

(5) The 反哺作用 (feedback effect) of S&T think tanks on core science.

The “bidirectional knowledge-decision interaction” characteristic of S&T think tanks determines that the relationship between core science and S&T think tanks is not unidirectional supply. S&T think tanks also have a feedback effect on core science, mainly manifested at two levels: First, at the macro S&T development level, S&T think tanks guide core science development directions and promote S&T priority layouts through research on “decisions for science itself,” including scientific foresight, strategic research, S&T planning, and research evaluation. Second, at the specific scientific research level, S&T think tanks influence core science in several ways: (i) Condensing scientific questions. As the frontier interface of S&T-society interaction, S&T think tanks condense practical problems from economic and social contexts into scientific questions through social relevance research. (ii) Focusing on key links of scientific uncertainty. For post-normal science issues with high uncertainty and controversy, S&T think tanks can provide possible ideas for core science research to focus on key links of uncertainty and achieve theoretical breakthroughs through multi-subject participation and uncertainty management. (iii) Boosting research paradigm trans-

formation. S&T think tanks' cultivation of "scientific citizenship" can provide the public with basic research literacy for scientific research, promoting the formation and development of open, mass-based new S&T innovation models like crowdsourcing and boosting research paradigm transformation.

2.2 Functional Structure of S&T Think Tanks Based on Knowledge Architecture

Richard N. Haass proposed five classic think tank functions: generating new ideas and policy options, providing ready expert pools, serving as venues for high-level discussion, educating citizens, and helping coordinate and resolve conflicts [15]. These functions also apply to S&T think tanks. Additionally, the "bidirectional knowledge-decision interaction" characteristic endows S&T think tanks with the unique function of "establishing and improving science-society dialogue mechanisms." However, these functions are relatively abstract, making it difficult to embody and evaluate them during initial think tank construction. Considering that different knowledge systems have corresponding scientific strategies for problem-solving, and that strategies are closely linked to functions, a relatively simple approach is to internalize abstract functions into S&T think tank research systems [Figure 5: see original paper]. Researching a certain type of problem naturally equips one with corresponding functions; determining research positioning thus clarifies functional positioning.

(1) Generating new ideas and policy options, providing ready expert pools, and serving as venues for high-level discussion. These three functions are basic tasks of S&T think tanks, reflected in all three research systems but with different emphases. Generating new ideas and policy options is the most fundamental core task, equally important across all three systems. Providing ready expert pools is the core function of the professional consultancy system, but broadly speaking, applied science and post-normal science also possess expert pool functions. Serving as venues for high-level discussion is mainly a function of professional consultancy and post-normal science systems, with some manifestation in the applied science system.

(2) Educating citizens. Although this function is reflected in all three knowledge systems, its connotation differs. At the conventional science level of applied science and professional consultancy, the citizen education function is unidirectional, top-down dissemination-style, similar to traditional science popularization. However, at the post-normal science level, S&T think tanks' citizen education connotation should transcend science popularization to targeted "scientific citizenship" cultivation. Along with China's social transformation, changing social structures, awakening public rights consciousness, and shifting public decision-making models, public participation in S&T decision-making is imperative [16]. Providing the public with training opportunities and participation platforms for specific issues helps resolve the "knowledge dilemma" in S&T decision-making [17]—where ordinary citizens may be unable to make scientifically correct decisions and hinder effective decision-making.

(3) Helping coordinate and resolve conflicts. This function is entirely situated within the post-normal science system, emphasizing the establishment and improvement of mechanisms and platforms for coordination and conflict resolution based on scientific citizenship cultivation. Faced with scientific uncertainty, participatory, open, and transparent information communication will help the public strengthen understanding and judgment of S&T. This not only has democratic implications and forms a process of building public trust [18] but also helps the government coordinate and resolve conflicts. S&T think tanks have the responsibility and unique advantages to construct dispute-resolution platforms for post-normal science problems. They should combine China's specific national conditions and socio-political background to build multi-subject participation platforms, explore participatory research methods, and improve communication and coordination mechanisms.

(4) Establishing and improving science-society dialogue mechanisms. This function runs through all four knowledge levels, connecting with “educating citizens” and “helping coordinate and resolve conflicts,” but its connotation is richer, emphasizing bidirectional mechanisms of science speaking to society and society speaking back to science. The openness and complexity of modern social development require greater attention to balance and coordinated progress between science and society [19]. Particularly as the world welcomes a new round of S&T revolution and industrial transformation and China experiences rapid economic and social development and transformation, the interactive relationship between S&T and society is undergoing profound changes, urgently requiring the establishment of good science-society dialogue mechanisms. As S&T think tanks operate at the frontier interface of S&T-society interaction, establishing and improving science-society dialogue mechanisms and promoting coordinated evolution of S&T and society is their undeniable mission.

Overall, the landscape analysis of research systems and functional structures based on knowledge architecture clarifies the hierarchical levels of research problems and functional structures of S&T think tanks, elucidates the relationship between S&T think tanks and core science, provides a basis for S&T think tanks to position their research and functions, and basically clarifies the path for “clarifying think through knowledge” : First, at the cognitive level, improve “think” awareness by acknowledging the incompleteness, uncertainty, and value-relevance of knowledge itself, clarifying that the purpose of S&T think tank research is not to eliminate uncertainty but to respond to and manage these uncertainties under conditions of unpredictability, incomplete control, and multiple reasonable viewpoints to reduce decision risk. Second, at the operational level, elevate “think” capacity by not treating decision problems uniformly or providing supposedly correct and safe decision options, but by classifying research problems according to uncertainty and decision risk, adopting different methodological strategies for different issues. Third, at the strategic level, demonstrate “think” capability by focusing research 重心 on post-normal science issues with high controversy and decision risk, as these not only represent S&T think tanks' responsibilities and advantages but also better demonstrate their influence.

3. Meso Landscape: Typological Classification and Organizational Evolution of S&T Think Tanks

The macro landscape determines S&T think tanks' external positioning within the think tank system, while the micro landscape describes their internal research and functional positioning. For S&T think tank construction, the most direct positioning should be selecting a type pattern among different S&T think tanks and conducting model selection and organizational construction according to different development stages. This requires combining macro and micro landscapes to construct a meso-level landscape centered on typological patterns and organizational evolution.

3.1 Typological Patterns of S&T Think Tanks

From the institutional level, not all S&T think tanks can or need to cover all knowledge systems and embody all functions. They need to focus according to their foundational capabilities and development visions. Meanwhile, from the perspective of traditional disciplinary domain divisions (mainly natural sciences), institutions also differ. Classification based on knowledge architecture and domain span helps S&T think tanks clarify positioning, elevate “think” capacity, focus priorities, and accelerate think tank construction. Overall, S&T think tanks can be divided into four types according to knowledge architecture and domain coverage: comprehensive, specialized, consultancy, and platform types [Figure 6: see original paper].

(1) Comprehensive S&T Think Tanks. Comprehensive S&T think tanks (hereinafter “comprehensive think tanks”) are “large and comprehensive” think tanks that can basically achieve full coverage of four knowledge levels and disciplinary domains. These think tanks are mainly transformed from large comprehensive research institutions or universities. In terms of domain span, they have complete disciplinary categories with advantages in macroscopic, strategic, comprehensive, interdisciplinary, and forward-looking problem research. In terms of knowledge architecture, having all four knowledge levels within one institution facilitates seamless connection and communication between levels, enabling rapid and direct production of high-quality think tank products—an integrated advantage irreplaceable by other S&T think tanks.

Comprehensive think tanks have several prominent features. First, they must be academic research institutions with first-class research capabilities. Considering that only powerful core science drivers can achieve full coverage of knowledge levels and disciplinary domains, comprehensive think tanks generally have strong research strength. Think tank construction is merely an outlet for their academic influence, and the quality of their core science largely determines their think tank influence. For example, the Max Planck Society, currently ranked No. 1 globally among S&T think tanks, does not deliberately pursue think tank

influence and even does not consider itself a think tank; becoming a think tank seems to be merely a spillover product. Second, comprehensive think tanks generally have composite structures. Since their main business is basic scientific research and think tanks are natural spillovers of their scientific influence, improper handling can easily lead to over-generalization of main responsibilities. Some experts [20] have proposed that if basic research institutions like the Chinese Academy of Sciences focus mainly on applied policy research, it will affect their understanding of basic natural laws and ultimately lead to declining quality of public policy research. The Chinese Academy of Sciences' solution is establishing the Institutes of Science and Development through a "small core, large network" and matrix research organization management model [21] to maintain the dominance of core science while effectively extending and connecting scientific research with society to perform think tank functions. If this model operates well, it can not only promote direct output of high-quality S&T public policies but also drive the development of scientific research itself. Of course, composite structures of comprehensive think tanks are diverse and may also be multi-centered or multi-type nested structures. Third, the long-term strategic, leading, and forward-looking nature of their scientific research generally gives them traditional policy channels with significant influence on policy-making.

Comprehensive think tanks also face many problems and challenges. First, they must properly handle the relationship between small core and large network. If the small core becomes detached from the large network or fails to achieve effective connection, it will lose its meaning as a comprehensive think tank. Second, due to their academic research tradition, comprehensive think tanks can easily fall into academic research patterns and should strengthen exchanges and cooperation with humanities and social scholars, government, and media. Third, domestic comprehensive think tanks have limited involvement in post-normal science work; they urgently need to strengthen work on cultivating scientific citizenship, building dispute-resolution platforms, handling S&T uncertainty, and constructing S&T-society interaction mechanisms.

(2) Specialized S&T Think Tanks. Specialized S&T think tanks (hereinafter "specialized think tanks") are "small but comprehensive" think tanks focusing on narrow disciplinary domains but covering all four knowledge levels, often able to balance academic achievement and policy relevance. Specialized think tanks generally evolve from past research institutions or units in specific fields expanding toward policy research. They can rapidly absorb relevant interdisciplinary, cross-domain experts, policy experts, and management experts based on original S&T experts to form think tanks. In terms of domain span, they involve relatively narrow domains, enabling the formation of targeted research and management models around those domains' characteristics. In terms of knowledge architecture, they can achieve seamless connection and communication between levels to rapidly and directly form think tank products.

Specialized think tanks have two main features. First, their research domains are often those with strong knowledge contextualization [19], such as policy research

in resource and environmental fields. This contextualized science more easily breaks away from traditional scientific research paradigms and expands toward post-normal science categories. Second, specialized think tanks often have flexible, mobile organizational models. Despite focusing on narrow domains, they must maintain sufficient personnel scale and multi-disciplinary expert structures across four knowledge levels, requiring flexible organizational models to overcome the need for multi-talent rapid response to new policy challenges and demands. For example, Germany's Ecologic Institute employs diversity strategies and a fluid matrix organizational structure, forming important influence at the EU policy level [22].

The core issue for specialized think tanks is balancing the contradiction between “academic achievement” and “policy impact.” In reality, due to institutional resource constraints, it is difficult to simultaneously maintain high-level basic research capabilities in academia while promoting public welfare and policy impact. Even some mature international think tanks often face trade-offs between scientific and policy impact. The key is to expand diverse cooperation channels, flexible staffing, and efficient organizational structures while ensuring minimum personnel allocation.

(3) Consultancy S&T Think Tanks. Consultancy S&T think tanks (hereinafter “consultancy think tanks”) generally refer to institutions specializing in S&T consultation. In terms of domain span, they may be multi-domain comprehensive consultancy think tanks or domain-specific specialized consultancy think tanks. In terms of knowledge architecture, consultancy think tanks generally do not engage in basic scientific research but only provide scientific advice from expert perspectives, often transformed from various professional associations or committees, such as the National Disaster Reduction Commission.

Consultancy think tanks have the following main features. First, their personnel composition mainly consists of strategic scientists who often have macro strategic vision, being top experts in their fields while also having broad understanding of socio-political, cultural, and economic development, enabling them to propose practical and valuable consultation suggestions. Second, their organizational structures are generally relatively loose and task-oriented, organizing consultation activities through major tasks.

The core issues for consultancy think tanks are as follows. First, consultancy think tanks cannot exist independently of core science and need to establish connection channels with core science and applied science. These connections may be implicit, realized through experts themselves who have not detached from core science research, or through establishing cooperative channels with relevant basic research institutions or universities. Second, they urgently need to develop systematic consultation methodological systems, exploring feasible expert organization models and systematic, effective methods for extracting expert opinions in combination with China's national conditions—areas where traditional S&T consultation in China is relatively weak.

(4) Platform S&T Think Tanks. Platform S&T think tanks (hereinafter “platform think tanks”) refer to intermediary and platform-type institutions specialized in S&T-related policy research, similar to S&T policy incubation platforms, multi-participation discussion platforms, and intermediary platforms linking stakeholders, including various pure policy S&T think tanks, evaluation-type S&T think tanks, and S&T innovation intermediary think tanks. Their advantage lies in policy sensitivity and social relevance.

These think tanks have the following features. First is cooperative symbiosis. Such think tanks have basically detached from core scientific research and expanded to policy, social, and economic levels, being most similar to general think tanks in nature, yet unable to exist independently of core science and must maintain a cooperative symbiotic relationship with core science in some form. Second is policy sensitivity and social sensitivity. These think tanks operate at the interface of various actors, being most sensitive to information from all parties, possessing policy sensitivity and sensitivity to social and economic dynamics. They are generally lean in structure with flexible management methods, enabling rapid and agile responses. The core issues for platform think tanks are how to find their irreplaceable distinctive positioning among various subject interfaces and how to maintain close connections with core science.

Overall, the boundaries among the four S&T think tank types—comprehensive, specialized, consultancy, and platform—are not absolutely strict but relatively fuzzy and dynamically transformable. For example, the composite structure of comprehensive think tanks can contain or derive several specialized, consultancy, or platform think tanks. If specialized think tanks fail to balance academic and policy research relationships, they may transform into pure research institutions, consultancy think tanks, or platform think tanks. Consultancy and platform think tanks can also transform into comprehensive or specialized think tanks through integration with other institutions. Moreover, further subdivisions can be made beyond the four basic types, such as by decision service objects (government-oriented, enterprise-oriented, public-oriented S&T think tanks) or by policy research spatial scope (global, regional, national, local S&T think tanks). S&T think tanks can directly conduct model selection and positioning based on basic types and subtypes.

3.2 Organizational Evolution Landscape of S&T Think Tanks

Think tank organizational construction generally undergoes three stages: startup stage (independence and merger), development stage (cooperation and coordination), and competition stage (networking and internationalization), achieving the leap from strengthening organizational foundations to building first-class think tanks [23]. S&T think tank construction also basically exhibits three-stage patterns, with model selection and network construction as two core themes—focusing on model selection in early stages and network construction in later stages. During the three-stage evolution, model selection shows a gradually weakening process from model selection and construction to dynamic

adjustment to optimization and maturity, while network construction shows a gradually strengthening process from basic network construction to think tank network construction to international network construction. These two aspects interact and promote each other synergistically [Figure 7: see original paper].

(1) Model selection in the startup stage is the foundation of S&T think tank construction. The main work in the startup stage is model selection and construction. S&T think tanks determine their key research systems, functions, and think tank types based on their domain span, research characteristics, relative advantages, and development vision. The focus is determining the research map of S&T think tanks under the framework of applied research, professional consultancy, and post-normal systems, clarifying main functional positioning, and determining the type model based on the four basic types and subtypes, thereby establishing overall development strategies. Additionally, S&T think tanks also need to conduct basic network construction in the startup stage. Here, basic networks refer to endogenous networks built between S&T think tanks and core science research, which is related to S&T think tank type classification, including internal network construction of comprehensive and specialized think tanks and connection network construction between consultancy/platform think tanks and core science research.

(2) The interaction between think tank network construction and model adjustment in the development stage is the inevitable choice for S&T think tanks to mature. As S&T think tanks further develop, their research issues will move toward more challenging, systematic, complex, and comprehensive directions, requiring strengthened cooperation and coordination with other think tanks to build think tank networks. This allows think tanks to form reinforcement or complementarity in research directions, methods, and information collection, facilitating expansion of research domains, deepening of research content, improvement of research quality, and expansion of influence. S&T think tank network construction includes three levels: cooperation networks among S&T think tanks, joint cooperation networks with strong-tie think tanks, and collaborative cooperation networks with weak-tie think tanks. However, the cooperation methods, focuses, and interaction intensities differ across these three levels, requiring exploration of different network construction approaches. Meanwhile, the interaction between think tank network construction and model selection is most frequent in this stage. Through interaction and mutual promotion with other think tanks during network construction, S&T think tanks also reshape and adjust their own research positioning, think tank types, and development models. This dynamic positioning adjustment helps S&T think tanks shape competitive advantages and form unique features.

(3) International network construction in the competition stage is the basic direction for building first-class S&T think tanks. In this stage, S&T think tank model construction further optimizes and matures, with 重心 shifting toward international network construction. With globalization and information technology development, many first-class think tanks have accelerated

internationalization and networking construction. For example, the Brookings Institution has established research centers in North America, Europe, East Asia, West Asia, and India, committed to researching major strategic issues in those countries and regions and their relationships with the United States [23]. As China moves closer to the world stage center and develops international strategies like the “Belt and Road,” the networking and internationalization development of China’s high-end think tanks will be an inevitable trend. For S&T think tanks, since core science research itself has networking and internationalization characteristics, S&T think tanks built upon it have existing channels for international network construction, making it easier to build first-class think tanks and become the pioneering force for internationalization development of China’s think tank system. Specific development paths include: (i) Internationalization of research content, focusing on globalization of research issues and internationalization of perspectives, such as global problem research, forecasting and foresight of world S&T frontiers, and participation in global innovation governance; (ii) Internationalization of research talent, attracting and gathering high-level research talents with international vision; (iii) Internationalization of research networks, building international cooperation networks relying on core science research international networks such as international scientific organizations, forums, and conferences to enhance international research vision and China’s international discourse power; (iv) Internationalization of research institutions, establishing international branches of S&T think tanks relying on international networks or China’s overseas research institutions to lay foundations for national strategy international expansion and building first-class S&T think tanks.

Overall, the meso-level landscape centered on typological patterns and organizational evolution represents the most intuitive and comprehensive “position-fixing” for S&T think tanks. Particularly through systematic integration of various landscape levels on the timeline of S&T think tank organizational evolution, it basically clarifies the construction pathways for S&T think tanks.

4. Conclusion

Through multi-level landscape analysis, this paper distinguishes the essential attributes of S&T think tanks, clarifies two core relationships, proposes three research systems and related think tank functions, classifies four basic types, and depicts the dynamic evolution landscape of organizational construction, conducting multi-dimensional “position-fixing” for S&T think tanks. Simultaneously, it clarifies the knowledge-based path for enhancing “think” —from improving “think” awareness to elevating “think” capacity to demonstrating “think” capability. Several new understandings emerge:

- (1) The bidirectional interaction between knowledge and decision-making is the essential attribute distinguishing S&T think tanks from other think

tanks. We propose that S&T think tanks represent the most fundamental, dynamic, and cutting-edge force among think tank categories.

- (2) We clarify the soul status of core science in S&T think tanks and the feedback effect of S&T think tanks on core science. We propose the classification of strong-tie and weak-tie relationships between S&T think tanks and other think tanks, emphasizing that weak-tie relationships may be more important for producing innovative policy solutions.
- (3) We propose that S&T think tanks should transcend the current “S&T consultation” model and expand toward post-normal science issues. While deepening traditional functions, they should focus on strengthening post-normal science-related functions such as scientific citizenship cultivation, helping coordinate and resolve conflicts, and establishing and improving science-society dialogue mechanisms.
- (4) Based on knowledge architecture and domain span, we classify S&T think tanks into four types: comprehensive, specialized, consultancy, and platform types, clarifying the advantages, characteristics, and key issues of different categories to facilitate model selection and direct positioning for S&T think tanks.
- (5) We construct a three-stage dynamic evolution landscape for S&T think tank construction, basically clarifying construction pathways and proposing that international network construction is the direction for building first-class S&T think tanks.

This paper constructs a knowledge-based, multi-dimensional ideal landscape focusing on comprehensive aspects and fundamental issues of S&T think tank construction. Future work needs to further adjust and improve this framework in combination with China’s national conditions and specific practices, while conducting in-depth research on key issues such as methodological strategies for various research systems, multi-subject participation models, uncertainty management methods, and construction of cooperation networks at different levels.

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

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