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Think Tank Innovation-Driven Knowledge Service Ecosystems: A Conceptual Framework and Case Study Application

Yichao Li [1], Jing Shen [1,*] and Dilek Cetindamar [2]

[1] Department of Information Management, Peking University, No. 5 Summer Palace Road, Beijing 100871, China; liyichao@pku.edu.cn
[2] School of Computer Science, University of Technology Sydney, Ultimo, Sydney, NSW 2007, Australia; dilek.ck@uts.edu.au
* Correspondence: jshen@pku.edu.cn

Abstract: By drawing on ecosystem and innovation-driven development theories, the aim of this paper is to increase our understanding of their application to think tanks. The composition, structure, and features of the knowledge service ecosystem of think tanks are conceptualized via a literature review. The model developed from this was validated by analyzing the data collected from 25 think tanks in the United States (US). The model constructed provides a reference for the sustainable and healthy development of knowledge services in think tanks and an innovation-driven development perspective for researchers interested in their innovation ecosystem dynamics. The intake of talent forms a necessary part of think tank construction, but, more importantly, this continuous intake is a crucial driving force for their sustainable development. This paper suggests that an increasing focus on talents in knowledge service ecosystems can lead to and assist in establishing innovative think tanks in many countries.

Keywords: think tanks; knowledge service ecosystem; innovation-driven development; knowledge service value chain; human capital

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1. Introduction

A think tank is a policy research and advisory body composed of experts with clear research directions and multi-disciplinary backgrounds. Globally, there are many influential think tanks, such as the Cato Institute (US), Chatham House (UK), and the China Institutes of Contemporary International Relations (China). Based on the acquisition, development, utilization, and innovation of knowledge, a think tank could provide policymakers with theories, strategies, methods, and ideas for dealing with complex issues [1]. A think tank is a significant knowledge source for governments to govern scientifically, and supply policy knowledge to the public [2]. That is why a think tank is a knowledge service organization.

Current research on knowledge ecosystems mainly focuses on the concepts, theoretical systems, and their applications. For example, Robertson [3], from the perspective of critical participants and through case analysis of the University of Cape Town, proposes that a knowledge ecosystem is a complex and multifaceted system. The study indicates that the actors in a knowledge ecosystem are interdependent and heterogeneous knowledge-intensive organizations with common interests in creating, exploring, and using the shared knowledge base for the common interests of all participants. Thus, actors of knowledge ecosystems coevolve. Another study presents a case study of the evolution of artificial intelligence knowledge practices in the entrepreneurial ecosystems of Berlin and Sydney to explain the critical role of experimental knowledge in driving the momentum of the entrepreneurial ecosystems and the supporting role of policies imprinting knowledge practices [4]. Therefore, a knowledge ecosystem is an open and dynamic system comprising various knowledge resources. These include knowledge service activities and knowledge innovation activities. Their exchange and cooperation environment in a specific time and

space range is also relevant, supporting knowledge flow, value flow, material flow, and other functions [5].

Service ecosystems are relatively self-contained, self-adjusting systems. They are resource-integrating actors connected by shared institutional arrangements and mutual value creation through service exchange [6]. Service exchange originates from the business ecosystem, service-leading logic, and the service system itself. The core idea of a service ecosystem is that participants interact with each other through the integration of resources and institutional constraints and then create value together under specific circumstances [7]. Meanwhile, it can increase the level of actor commitment, participation in the co-creation process, support for public services, legitimacy, involvement in reciprocal services, sociability with other citizens, and communication [8]. Frow et al. [9] constructed the conceptual framework of well-being in a service ecosystem, drawing on four meta-theoretical foundations of S-D logic: resource integration, resource density, practices, and institutions, pointing out that service ecosystems consist of three levels of aggregation, which are micro level, meso level and macro level.

More research must be carried out on the knowledge service ecosystem of different service organizations such as think tanks [1]. Current relevant research mainly focuses on the concept, theoretical construction, and application of knowledge and service ecosystems [3,4,6]. A few studies examine these ecosystems in practice. One such study examines the academic journal knowledge service ecosystem, consisting of the hardware equipment, software tools, and environmental factors in journal publishing [10]. Wu takes scholarly academic journals as the research object and reveals the composition and characteristics of their knowledge service ecosystem. There is, however, a need in the literature for empirical tests to understand how knowledge service ecosystems operate.

This paper applies the knowledge service ecosystem lens to think tanks. Our goal is to explore how innovations could become sustainable in a knowledge service ecosystem of think tanks (KSETT), which consists of think tanks, clients, and the public linked with the flow of knowledge services. By deciphering the flow of knowledge services in think tanks, our model might help managers and researchers to understand and improve the innovativeness and service capacities of a KSETT.

Through a literature review, we put forward the concept and elements of the KSETT based on both the ecosystem and innovation-driven development theories. We validated the model through a case study of think tanks in the United States (US). We applied the framework to a qualitative method so that we can test whether our conceptual framework, the innovation-driven KSETT, could be treated as a viable tool for understanding how a KSETT works. By using secondary data from US think tanks, our case study results help to discuss how an innovation-driven KSETT's characteristics might affect its sustainable development similar to a natural one.

The paper is structured as follows: Section 2 presents an overview of the theoretical foundations, followed by a section describing the KSETT elements and the innovation-driven KSETT model in detail. Using the model as a guideline, a case study of KSETTs in the United States (US) is presented, and the paper concludes by highlighting implications for both theory and practice.

2. Theoretical Foundations

2.1. Ecosystem Theory

British plant ecologist A.G. Tansley first introduced the concept of an "ecosystem" in 1935. He believed the ecosystem was an ecological functional unit in which biotic and abiotic components interact, influence, and restrict each other through continuous material circulation, energy flow, and information delivery within a certain time and space [11]. Sociologist A.H. Hawley introduced the concept of the ecosystem into the social science field in 1986, and defined it as an "arrangement of mutual dependencies in a population by which the whole operates as a unit and thereby maintains a viable environmental relationship" [12].

The components of the ecosystem can be divided into two categories: main and environmental factors [13]. The former comprises producers, consumers, and decomposers, while the latter includes material, energy, climate, and substrate. The structure of an ecosystem refers to the relative order and stable state of various components in space and time, including the component structure and nutrient structure. The component structure refers to the system structure composed of different biological types and their different quantitative combinations. The nutrient structure is the food chain and food web formed by food nutrition between organisms and between producers, consumers, and decomposers, which is the primary means of material circulation and energy flow [14].

Under specific time and relatively stable conditions, the structure and function of each element of the system are in a coordinated dynamic state, and the ecosystem has six important features [15]. The first one is integrity. An ecosystem is a holistic functional unit with organisms as the main body. It presents unified integrity in its mode of existence, goals, and functions, ensuring stable network linkages among the elements. The second feature is the hierarchy. An ecosystem is a complex multi-level system because its life forms have many different levels, from the individual, population, to the community. The third feature is openness, which refers to an open thermodynamic ecosystem. In other words, it needs to continuously absorb energy and materials from the environment and output them to the environment after processing and transforming. The exchange of material and energy between the principal elements and the environment is an ongoing and dynamic process of change. The fourth is stability. An ecosystem can self-sustain and self-regulate positive and negative feedback from interacting and transforming with its environment. It can maintain or restore its structure and function in a relatively stable way. The fifth feature is evolvability. Organic organisms constantly adapt to environmental changes and transform the environment in various ways in favor of organisms. That is why an ecosystem shows long-term adaptability to environmental changes. The final feature is functionality. An ecosystem has clear goals realized through various functional flows, such as material, energy, or information.

2.2. Innovation-Driven Development Theory

Michael Porter, an American scholar, introduced the innovation-driven development theory in 1990. He believed that a country's economic development goes through four stages: production-factor-driven, demand-factor-driven, innovation-factor-driven, and wealth-factor-driven [16]. These different stages show the maturity of an economy. Innovation-driven development might be described as an economy based on the production, distribution, and use of knowledge and information. In other words, it is a knowledge economy that uses knowledge as its production factor created by human intelligence. Thus, the main economic activities consist of the possession, allocation, production, distribution, and consumption of intellectual resources [17]. According to Porter, innovation involves "the discovery and application of new knowledge and ideas to create new products, services, processes, and business models that generate economic value for firms, customers, and society as a whole". This definition is in line with the general definition given in the Oslo Manual [18] as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)". However, Porter's model puts extra emphasis on the inputs to innovation, namely new knowledge and ideas.

The innovation-driven development theory is mainly applied to economic development, but recently it has been popular to investigate think tanks [19,20]. For example, a study on social think tanks establishes an innovation-driven talent mechanism model and analyzes the application of the model through network surveys and case studies [20]. Another study develops a model of innovation-driven intellectual capital acquisition mechanism of university-affiliated think tanks by analyzing 100 well-known university-affiliated think tanks [21]. In the era of the innovation-driven knowledge economy, the knowledge

service activities of a think tank are a continuous process of exploitation of its knowledge and intellectual resources by the human capital of its organization. In this paper, we also draw on the above references to measure think tank innovation using the human capital introduced by think tanks. Human capital refers to aspects of the knowledge, skills, and abilities of the employees in an organization that are key factors in the innovation undertaken by the organization. This is in line with the innovation-driven development theory, which emphasizes knowledge created by human intelligence as a production factor.

Industrial organization is concerned with the working of markets and industries, particularly how firms compete. It is a field of economics dealing with the strategic behavior of firms, regulatory policy, antitrust policy, and market competition [22]. Since the late 1970s, industrial dynamics has emerged as a major research area for industrial economists. Within the growing interest in industrial dynamics, innovation has been recognized as a key element affecting the dynamics and evolution of industries [23]. Knowledge-intensive firms do not operate as structured and hierarchical organizations. Rather, they emphasize the values of mutual learning and knowledge [24]. Knowledge-intensive organizations use intellectual resources for knowledge activities in line with the theoretical content of innovation-driven development. Think tanks are typical knowledge-intensive organizations because their most significant characteristic is their rich knowledge and intellectual resources. Hence, innovation-driven development theory could apply to observe the process of innovations in a think tank ecosystem context.

3. Development of a Conceptual Model of an Innovation-Driven Knowledge Service Ecosystem of Think Tanks

From the ecology perspective, this study considered a KSETT as a composition of interdependent but heterogeneous think tanks, clients, the public, and the knowledge environment. It is a system that establishes links and provides knowledge services by transforming information and knowledge among think tanks, clients, and the public. An ecosystem shows the features of integrity, hierarchy, openness, stability, evolvability, and functionality. This study applied ecosystem theory to identify the elements of the KSETT by analyzing the different players' roles by analogy with the composition, structure, and characteristics of ecosystems [13] (Table 1) and constructed an innovation-driven KSETT model from the perspective of innovation-driven development.

Table 1. Characteristics of the KSETT based on ecosystem theory.

Ecosystem			KSETT	Description
Composition	Main Elements	Producers	Think tanks	Providers of knowledge services [25]
		Consumers	Clients	The target of the knowledge service [26]
		Decomposer	The public	Participants in knowledge services benefit from knowledge services while generating knowledge resources. [27,28]
	Environment Elements	Material	Knowledge resources	A public knowledge base for storing knowledge, techniques, methods, tools, etc. [29]
		Energy	Intellectual resources	Professionals with abilities, skills, techniques, experience, etc. [30]
		Climate, substrate	Knowledge network	Political, economic, social, technological, and other knowledge environments [31,32]
Structure		Component structure	Think tanks, clients, the public, knowledge resources, intellectual resources, and knowledge networks.	The system architecture of the providers, objects and participants of knowledge services, the public knowledge base, human resources, knowledge environment, and their combinations
		Nutrient structure	The value chain of knowledge services is formed by think tanks, clients, and the public.	With knowledge services as the link, the value chain of knowledge services formed by providers, objects, and participants is constructed through the circulation of knowledge resources and the flow of intellectual resources [33].

Table 1. *Cont.*

Ecosystem	KSETT		Description
Features	Integrity	Think tanks, clients, and the public are a whole functional unit for knowledge services.	Stable network connections, complementarity and interdependence among providers, objects and participants of knowledge services, and collaborative innovation to create value and realize knowledge sharing as a unified goal [29].
	Hierarchy	From a single think tank/client/social public to various types of think tanks/clients/social public groups that form a knowledge service value chain to construct a knowledge service ecosystem.	The knowledge service ecosystem is a complex multi-level system [8].
	Openness	Think tanks, clients, and the public constantly absorb knowledge and intellectual resources from knowledge networks, use and distribute them throughout the system, and then export them to the knowledge network.	The interaction of knowledge and intellectual resources between the providers, objects, and participants of knowledge services and the knowledge environment is constantly occurring and dynamic.
	Stability	Think tanks, clients, and the public can self-govern.	The providers, objects, and participants of knowledge services are regulated through autonomy and mutual adaptation with the knowledge environment to maintain the relative stability of the structure and function of the knowledge service ecosystem [34].
	Evolvability	Think tanks are constantly adapting to the changing environment and making an impact.	The subject of knowledge services must constantly update itself to adapt to the rapidly changing environment and modify the environment to some extent. Eventually, it shows long-term adaptability to environmental changes [35].
	Functionality	Knowledge resource circulation, intellectual resource flow, knowledge service delivery	To realize the functions of knowledge resource circulation, intellectual resource flow, and knowledge service delivery through knowledge flow, service flow, and value flow among the providers, objects, and participants of knowledge services and between them and the environment to maintain the sustainable development of the knowledge service ecosystem [36].

3.1. System Composition

System composition is based on leading and environmental factors, so the KSETT concept considers the think tanks as the service subject, the clients as the service object, and the public as the participants. These primary factors are all interconnected, and each has a different functional role in the system, thus reaching beyond the capabilities of any single organization or individual [3]. Think tanks meet clients' needs by producing knowledge services, establishing close ties with clients and the public using various service methods, delivering knowledge results, and increasing their influence [25]. As suppliers of knowledge services, think tanks are producers of the knowledge service ecosystem. Clients with different knowledge service needs trust think tanks to provide them. As the beneficiaries of knowledge services, clients are consumers of the knowledge service ecosystem. The public benefit from think tanks' outputs in various forms [26,32]. However, they also deliver knowledge and technology to think tanks. They are the decomposers of the knowledge service ecosystem.

A knowledge service ecosystem helps to collaboratively combine all knowledge into a shared knowledge base [3]. Knowledge resources, such as information, technology, methods, and tools are material elements of the knowledge service ecosystem [8]. They are stored in the public knowledge bases and used to communicate with the knowledge environment. Intellectual resources include academic resources, intangible resources (such as learning ability), tangible resources (such as machines), and people who have innovative

intelligence [27]. Therefore, intellectual resources such as ability, skills, and experience form the energy elements of the knowledge service ecosystem. Service subjects and participants can only exist within the knowledge environment. They benefit from the nutrition and support of the knowledge environment. Organizations rely on relationships and related entities, constituting the embedded interactive environment in which they exist. The political, economic, social, and technical environment includes the knowledge environment for think tanks, clients, and the public to coexist [28]. Therefore, the environmental factor is a crucial substrate element of the knowledge service ecosystem.

3.2. System Structure

System structure encompasses component and nutrient structures. In a KSETT, think tanks attract resources and clients to create cooperative networks [3] and rely on each other. Knowledge and intellectual resources and the political, economic, social, and technological environment constitute the knowledge service environment. In the knowledge service environment, think tanks, clients, and the public communicate with each other and create value together to form a knowledge service network [8]. Therefore, think tanks, clients, the public, and their combinations constitute the component structure of the KSETT.

The KSETT forms a knowledge service value chain by bringing together think tank production, client consumption, and public decomposition, resulting in an inseparable whole. All service subjects, objects, and participants are distributed in an ecosystem's operation in the knowledge service value chain. They jointly share knowledge and exchange activities and create value by matching supply and demand. By doing so, they provide a strong guarantee for developing high-quality knowledge services through think tanks [30]. Therefore, the knowledge service value chain is the nutrient structure of the KSETT and the primary way to circulate knowledge and intellectual resources.

3.3. System Features

Our literature review identified six key features of the KSETT. These are summarized below [15].

The KSETT establishes a stable network among the think tanks, the clients, and the public. These primary factors produce complementary, interdependent, collaborative, and mutually beneficial innovations [3]. Hence, the KSETT is instrumental in developing consistent goals and values that share knowledge to produce high-quality knowledge service results for think tanks.

The KSETT is a complex multi-level system composed of service subjects, service objects, participants, and the knowledge service environment. Each level is embedded and connected [7], and different groups interact. The whole ecosystem plays the role of "1 + 1 > 2" in collaborative innovation at all levels.

In the KSETT, the think tanks absorb knowledge and intellectual resources from the knowledge environment, realize exchanges with the environment, and carry out continuous knowledge service innovation activities. Openness allows the KSETT to handle dynamic changes in the competition and overcome market pressures [31]. This feature facilitates updating the ecosystem's mechanisms and reengineering the think tanks' processes.

The KSETT can maintain its own relatively stable state. Although the knowledge environment constantly changes, the system's structure and function are relatively stable. Service subjects have autonomy [5] to regulate service objects, participants, and the environment. This autonomy allows the system to maintain its regular operation.

The KSETT can integrate, build, and reconfigure internal and knowledge competencies to address a rapidly changing environment. The high-quality knowledge service achievements of think tanks need to mobilize the participation of a broader range of service subjects. By constantly improving evolutionary ability and exerting influence, the whole ecosystem is promoted to adapt to the environment through internal and knowledge coordination [15].

The complex relationship among service subjects, service objects, participants, and their knowledge environment is realized through various flows [33]. It provides knowledge services to clients and the public through the knowledge service value chain [25]. It plays the functions of knowledge resource circulation, intellectual resource flow, and knowledge service delivery. Finally, it maintains the sustainable development of think tanks.

3.4. Model Construction

Based on the ecosystem and innovation-driven development theories, we construct a KSETT model, as shown in Figure 1. The model's component structure comprises think tanks, clients, the public, the public knowledge bases, and the knowledge network. The public knowledge bases include various knowledge resources. The knowledge network comprises political, economic, technological, social, and other environments, while the innovation-driven human capital can be decomposed into knowledge resources and intellectual resources. A think tank's knowledge service value chain is based on the circular flow of knowledge and intellectual resources among think tanks, clients, and the public highlights. The solid line box represents the producers of the KSETT, while the solid line circle represents the consumers of the KSETT. The solid line polygon represents the decomposer of the KSETT. The cylinder represents the public knowledge bases of the KSETT. Finally, the dashed box indicates the knowledge environment of the KSETT, including the political, economic, social, and technological environments.

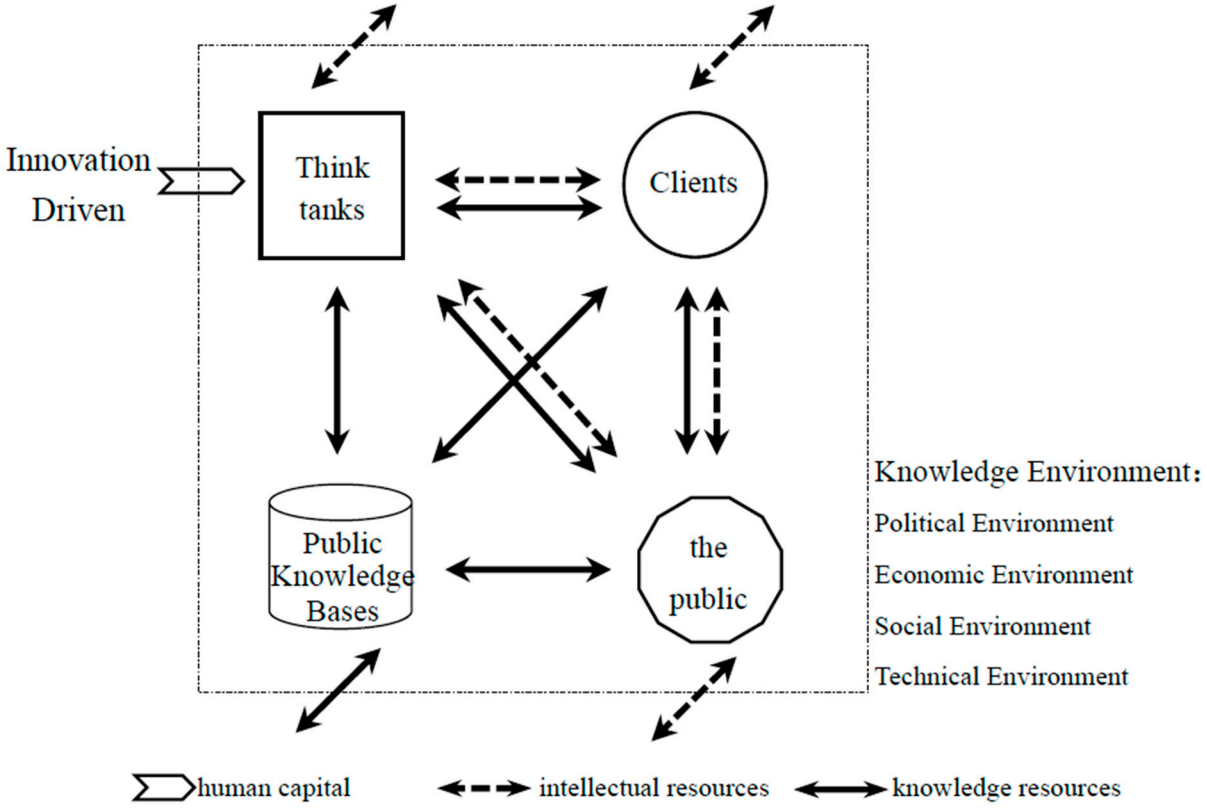

Figure 1. Model of innovation-driven KSETT. Note: The boxes represent the main elements, and the two-way arrows represent resources.

The hollow arrow in Figure 1 indicates human capital, the core element of innovation-driven development. After entering the KSETT, human capital can be divided into knowledge and intellectual resources. These resources facilitate the sustainable and healthy development of the whole ecosystem. The dashed two-way arrows indicate the intellectual resources, which can flow among think tanks, clients, the public, and the knowledge environment after entering the KSETT. The solid two-way arrows indicate the knowledge

resources, which can circulate among think tanks, clients, the public, or between the public knowledge bases and the knowledge environment after entering the KSETT.

In Figure 1, the model comprises think tanks, clients, the public, the public knowledge bases, and the knowledge network. Various think tanks are the providers of knowledge services, clients are the targets of knowledge services, and the public are the participants. Service subjects, objects, participants, and the knowledge service environment exist in the ecosystem. Based on the innovation-driven development theory, human capital is the core element of innovation-driven development. Therefore, human capital is the driving force of the KSETT, generating sustainable growth. Human capital continuously flows from the knowledge environment to think tanks and is decomposed into knowledge and intellectual resources in the knowledge service activities of think tanks. Think tanks interact with clients and the public through the circulation of knowledge resources and intellectual resources, forming a knowledge service value chain. Thus, the KSETT has a nutritional structure. Through the knowledge service value chain, think tanks realize the functions of knowledge resource circulation, intellectual resource flow, and knowledge service delivery. The ecosystem has functionality features. At the same time, think tanks take advantage of the flow of intellectual resources among clients, the public, and the knowledge environment to achieve the possession, allocation, and use of intellectual resources to maintain a stable network connection with clients and the public. Meanwhile, think tanks, through continuous interaction and mutual adaptation to the knowledge environment, support the relative stability of the system. This interaction also brings internal and external synergy to promote the adaptive evolution of the entire KSETT. Thus, the ecosystem has the features of integrity, openness, stability, and evolvability.

The contribution of this model mainly includes the following three aspects. Firstly, the hollow arrow represents human capital and belongs to the knowledge network. Innovation drives human capital into the KSETT and contributes to the sustainability of the entire ecosystem. Secondly, the knowledge network also includes political, economic, social, technological, and other knowledge environments in which the principal elements and resources coexist. Thirdly, the role of the public knowledge base is to store knowledge resources such as knowledge, technology, methods, and tools. Compared to human resources, knowledge resources are more concrete and tangible, so the public knowledge base is shown in the model like other primary elements.

4. Application: A US Think Tank Case Study

4.1. Introduction of Data

Think tanks in the US have been at the forefront of the world of innovation [37], since they are considered the earliest and most dynamic and complete decision-making consulting systems. A case study can clarify the many mechanisms, such as fund-raising, talent management, and unique "revolving door" mechanisms, as the essential guarantees for sustainable development [38]. Therefore, we chose the KSETT in the US as our case study organization to explore the applicability of our conceptual model in practice.

The case study think tanks come from the "Top Think Tanks Worldwide" [37] created by the Think Tanks and Civil Societies Program (TTCSP) of the University of Pennsylvania. Our list includes all well-known US think tanks in "Top Think Tanks Worldwide", 25 in total (Table A1 in Appendix A). Drawing on relevant studies in the literature, we designed a number set of indicators to investigate the US KSETT, as shown in Table 2. We first divided the survey into four sections: producers of knowledge service ecosystem, innovation driving force of knowledge service ecosystem, value chain of knowledge service ecosystem, and features of knowledge service ecosystem. Secondly, each survey section was further subdivided into different survey contents according to the theoretical model. Finally, we selected the corresponding indicators to be measured according to the metrics given in the literature.

Table 2. Indicators to investigate US KSETT.

Investigation Dimensions	Investigation Contents	Investigation Indicators	Indicator Quantification Methods	Indicator Source	Data Source	Data Average	Data Standard Deviation
Producers of knowledge service ecosystem	Types of think tank	Research-oriented think tanks Government-commissioned think tanks Advocacy-oriented think tanks Heritage-oriented think tanks	Counting the number of different types of think tanks	Donald [39]	Databases	/	/
Innovation driving force of knowledge service ecosystem	Joint cultivation	Jointly trained talents (number/year)	Counting the number of joint cultivation programs, such as training programs with universities, and counting the number of people enrolled in each program	Su and Fu [40]	Think tank website	43.56	34.84
		Joint talent training projects (number/year)				3.76	2.79
	Talent introduction	Introduced talents (number/year) Talent introduction projects (number/year)	Counting the number of programs organized by think tanks to introduce talent, such as internship programs, and counting the number of people in each program	Chen [41]	Think tank website	38.80	39.14
Value chain of knowledge service ecosystem	Knowledge resource circulation	Open database and/or Open data platform (number/year)	Counting the number of databases/data platforms	Yu [42]	Think tank website	2.84	2.41
		Public knowledge bases (number/year)	Counting the number of public knowledge bases in the US	Zhang and Chen [43]	OpenDOAR	3.00	3.59
	Intellectual resource flow	Hold important positions in clients/social institutions (number/year)	Counting the number of think tank members who hold important positions in clients or social institutions	Zhu [44]	LinkedIn	920.00	0.00
		Clients/social institutions staff work part-time in think tanks (number/year)	Counting the number of part-time members of think tanks			27.84	16.99
	Knowledge service delivery	Research projects (number/year)	Counting the number of think tank project results	Pang [45]	Think tank website	125.84	164.09
		Report meetings (number/year)	Counting the number of think tank meetings	Zhang and Shen [25]		179.92	133.87
Features of knowledge service ecosystem	Integrity	Social media (number)	Counting the number of think tank social media accounts	Fred [46]	Think tank website	5.24	1.20
		Knowledge management systems (number)	Counting the number of knowledge management systems with clients	Yin and Zhao [47]		1.00	0.00
	Openness	Publications (number/year)	Counting the number of think tank publications	Xiang and Zhang [48]	Think tank website	142.00	157.70
		Twitter followers (10,000)	Counting the number of think tank Twitter followers	Chen [49]	Twitter	16.58	17.35
	Stability	Revenue sources (number/year) Total revenue (USD 10 million/year)	Referencing annual reports of think tanks	Luan [50]	Think tank website	5.88	2.22
				Ren [51]		1.92	2.52
	Evolvability	Transformations (Time) Consolidations (Time)	Referencing history of thinks tanks	Chen [49]	Think tank website	3.20	1.96
				Ren [51]		1.12	0.44

Table 2. *Cont.*

Investigation Dimensions	Investigation Contents	Investigation Indicators	Indicator Quantification Methods	Indicator Source	Data Source	Data Average	Data Standard Deviation
Features of knowledge service ecosystem	Hierarchy	Client types (number)	Government/enterprise/institution/individual	Donald [39]	Think tank website, databases	4.00	0.00
		Research fields (number)	Counting the number of research fields	Ren [51]	Think tank website	7.08	2.50
	Functionality	Business types (number)	Policy research/decision-making/public opinion guidance/talent support	Shen and Yu [52]	Think tank website, databases	4.00	0.00
		Knowledge dissemination channels (number)	Discussing research reports/policy briefs/journal articles/column comments/blogs/videos/podcasts/events	Chen [53]	Think tank website, databases	8.00	1.32

This research mainly collected relevant data from three index sources. Firstly, we used think tank websites, LinkedIn, Twitter, and other official websites. Secondly, we utilized databases such as the TTFS global think tank discovery system, WanFang global think tank information system, Web of Science, and ProQuest. Thirdly, we employed OpenDOAR, a knowledge base directory.

We collected data on 22 survey indicators from 25 think tanks to obtain a matrix of 25*22, and the statistical information of different indicator samples is shown in Table 2.

After data collection, we cleaned and standardized data for analysis following Guo's methodology [54]. For data cleaning, we interpolated it according to the mean value of the same type of think tanks for the default value case. For data standardization, we adopted the Z-score method for dimensionless data processing.

Data analysis aims to understand the relationships among a conceptual framework's composition, structure, and features. That is why we adapted Guo's methodology, which involves three steps [53]. Firstly, we counted the number of various kinds of think tanks and the proportion to the total number. Then, we calculated the Pearson correlation coefficient between the knowledge resource circulation and the intellectual resource flow and conducted a correlation analysis. Finally, we calculated the standard errors (SE), coefficient a (a), coefficient b (b), and fit goodness (R^2) of the univariate linear regression model (Y = ax + b, n = 25) between the innovation driving force and the activities of the think tank knowledge service, the innovation driving force, and the features of the think tank knowledge service. We then conducted regression analyses. Excel 16.61.1 was used for data cleaning and standardization and SPSS 27 for data analysis.

4.2. The Analysis of Think Tanks in the US

We systematically analyzed the current situation of KSETTs in the US from four dimensions: producers, innovation driving force, value chain, and features of the knowledge service ecosystem.

4.2.1. Producers of the Knowledge Service Ecosystem

According to Donald's classification [38], US think tanks can be divided into the following four categories: research-oriented think tanks, government-commissioned think tanks, advocacy-oriented think tanks, and heritage-oriented think tanks. The survey results show that the government-commissioned think tanks account for the largest share of knowledge service providers, accounting for 40.00%; followed by research-oriented and advocacy-oriented think tanks, with 28.00% and 24.00%, respectively; and heritage-oriented think tanks account for only 8.00% (Table 3).

Table 3. Types of the producers of US KSETT.

Investigation Contents	Investigation Indicators	The Proportion of Various Types of Service Subjects (%)
Types of think tanks	Research-oriented think tanks	28.00
	Government-commissioned think tanks	40.00
	Advocacy-oriented think tanks	24.00
	Heritage-oriented think tanks	8.00

Diversified knowledge service providers are the producers of the KSETT in the US. Think tanks in the US have developed for a long time. The solid financial support and loose social, political, and cultural environment provides broad living space and fertile cultural soil for diversified knowledge service providers' development. Influenced by the international security situation during World War II, the US government faced a heavy international and domestic affairs burden. Hence, government-commissioned think tanks developed rapidly because they undertook the research issues entrusted by the government. They still play an essential role. Therefore, government-commissioned think tanks make up many types of think tanks. Heritage-oriented think tanks are created by candidates eager to run successfully for public office or by outgoing government officials, which have been gradually established and developed since the 1980s. They belong to a new think tank type, so their share is relatively small. A sustainable and synergistic variety of think tanks are producers of the KSETT in the US, giving their systems a component structure by providing knowledge services to their clients and benefiting the public.

4.2.2. Innovation Driving Force of the Knowledge Service Ecosystem

According to the model, human capital is the KSETT's innovation-driving force. Think tanks carry out knowledge service activities through knowledge resource circulation, intellectual resource flow, and knowledge service delivery with clients and the public, forming a knowledge service value chain. Through regression analysis of the innovation driving force and the knowledge service value chain of the KSETT, the study finds that the number of talents introduced by think tanks every year drives the knowledge service value chain. The more talents the think tanks bring in each year, the more open the think tanks' databases and data platforms will be, the more part-time staff the think tanks have from clients or social institutions, and the more research projects the think tanks develop (Table 4).

The intake of talents into the ecosystem is the innovation-driving force of the US KSETT. Further research through the official websites shows that think tanks often organize and carry out programs, such as global economic programs. These programs continuously attract talent from enterprises, universities, and governments. Think tanks utilize the advantage of talents to establish open databases and data platforms. Further, think tanks encourage staff from clients or social institutions to work part-time in the think tanks. At the same time, think tanks rationalize their talent to complete programs and efficiently promote new knowledge service activities. In other words, think tanks build up a knowledge service value chain by bringing in talent, leading to knowledge service activities.

4.2.3. Value Chain of the Knowledge Service Ecosystem

According to the model, think tanks form a knowledge service value chain with their clients and the public through the circulation of knowledge resources and intellectual resources. For the former, think tanks in the US establish open databases, data platforms and public knowledge bases. For the latter, they motivate staff mobility from think tanks, clients, and social institutions, ultimately forming a knowledge service value chain to deliver knowledge services. The number of open databases and data platforms in think tanks per year is significantly and positively correlated with the number of part-time employees of

clients or social institutions in think tanks per year, with a correlation coefficient of 0.868 (Table 5).

Table 4. Regression analysis of innovation driving force and knowledge service value chain of US KSETT.

Regression Equation	Innovation Driving Force (x)		Value Chain(Y)		SE	a	b	R^2
Y = ax + b	Joint cultivation	Jointly trained talents	Knowledge resource circulation	Open database and/or open data platform	1.015	−0.115	-8.00×10^{-11}	0.013
				Public knowledge bases	-	-	-6.63×10^{-11}	-
			Intellectual resource flow	Hold important positions in clients/social institutions	0.96	−0.342	-8.00×10^{-11}	0.117
				Clients/social institutions staff work part-time in think tanks	1.008	−0.166	-9.48×10^{-11}	0.028
			Knowledge service delivery	Research projects	1.004	0.185	-9.17×10^{-11}	0.034
				Report meetings	1.01	0.147	-4.00×10^{-11}	0.021
		Joint talent training projects	Knowledge resource circulation	Open database and/or open data platform	1.009	−0.158	-3.33×10^{-11}	0.025
				Public knowledge bases	-	-	-4.00×10^{-11}	-
			Intellectual resource flow	Hold important positions in clients/social institutions	1.007	−0.168	-2.79×10^{-11}	0.028
				Clients/social institutions staff work part-time in think tanks	1.016	−0.103	-6.65×10^{-11}	0.011
			Knowledge service delivery	Research projects	1.01	−0.151	8.29×10^{-17}	0.023
				Report meetings	0.964	0.331	4.31×10^{-12}	0.109
	Talent introduction	Introduced talents	Knowledge resource circulation	Open database and/or open data platform	0.793	0.631	4.16×10^{-17}	0.398 **
				Public knowledge bases	-	-	-4.24×10^{-11}	-
			Intellectual resource flow	Hold important positions in clients/social institutions	1.016	−0.108	2.17×10^{-11}	0.012
				Clients/social institutions staff work part-time in think tanks	0.877	0.506	-4.49×10^{-17}	0.256 *
			Knowledge service delivery	Research projects	0.866	0.53	5.89×10^{-12}	0.281 **
				Report meetings	0.983	−0.271	-6.76×10^{-17}	0.073
		Talent introduction projects	Knowledge resource circulation	Open database and/or open data platforms	0.955	0.356	-3.21×10^{-11}	0.127
				Public knowledge bases	-	-	1.71×10^{-11}	-
			Intellectual resource flow	Hold important positions in clients/social institutions	1.01	−0.147	-8.00×10^{-11}	0.022
				Clients/social institutions staff work part-time in think tanks	1.005	0.174	-6.63×10^{-11}	0.03
			Knowledge service delivery	Research projects	0.935	0.402	-8.00×10^{-11}	0.161 *
				Report meetings	0.998	−0.214	-9.48×10^{-11}	0.046

Note: * $p < 0.05$, ** $p < 0.01$. There are currently 920 public knowledge bases across the US. As their number is a constant, regression analysis cannot show regression results between constants and variables, so the results in the table are shown with "-".

Table 5. Correlation analysis of the US think tanks' knowledge resource circulation and intellectual resource flow.

Knowledge Resource / Circulation	Hold Important Positions in Clients/Social Institutions (Number/Year)	Clients/Social Institutions Staff Work Part-Time in Think Tanks (Number/Year)
Open database and/or Open data platform (number/year)	−0.056	0.868 **
Public knowledge bases (number/year)	-	-

Note: ** $p < 0.01$. There are currently 920 public knowledge bases across the US. As their number is a constant, regression analysis cannot show regression results between constants and variables, so the results in the table are shown with "-".

There is a strong correlation between knowledge resource circulation and intellectual resource flow in the KSETT in the US. The knowledge and intellectual resources of think tanks flow among clients, the public, and the knowledge environment, forming the knowledge service value chain of the ecosystem. Further, databases and data platforms are the main carriers of knowledge dissemination and knowledge services; it is convenient for think tanks to obtain information and materials efficiently. The US think tanks' databases and data platforms are mature and relatively open, and knowledge resources can flow conveniently in both directions among think tanks, clients, the public, and public knowledge bases. At the same time, the "revolving door" mechanism of think tanks in the US provides many researchers with extensive social experience in think tanks. It bridges the communication between ideas and power, allowing think tanks' intellectual resources to flow in both directions among think tanks, clients, the public, and the knowledge environment.

4.2.4. Features of the Knowledge Service Ecosystem

According to the model, the operation of the innovation-driven KSETT has six features. The regression analysis of innovation driving force and features of the KSETT in the US shows that introducing talents by think tanks help to realize the features of the knowledge service ecosystem. The more talents the think tanks bring in per year, the more social media, publications, revenue sources, and knowledge dissemination channels the think tanks have and the more integrity, openness, stability, and functionality the knowledge service ecosystem will be. The more projects that bring in talent to think tanks per year, the more consolidations and research fields the think tanks have and the more evolvability and hierarchical the knowledge service ecosystem will be (Table 6).

Our study sample of US KSETTs is driven by innovation, showing the features of integrity, openness, stability, evolvability, hierarchy, and functionality. In terms of integrity, American think tanks build social network platforms by introducing talents to maintain close connections with clients and the public. Talent maintains the integrity of the KSETT by supporting the operation of social media. The openness feature of the KSETT in the US tells us that creating publications allows for the continuous export of ideas to clients and the public and gives policy guidance. Thus, think tanks continue to bring in talent and update the content and type of publications, thus maintaining the openness of the KSETT. Think tank publications might shape policy by providing new information, framing debates, and offering policy recommendations. While the impact of these publications can vary depending on their focus and findings, they are an important source of information for policymakers and the public. For stability, think tanks in the US utilize diversified revenue sources such as social donations, independent research income, subscriptions, and investment income and entrusted project funds to maintain the operational stability of the KSETT. Further, think tanks in the US absorb talents from different fields and adapt to changes in the political, economic, social, technological, and other knowledge environments to provide better knowledge services. They take a combined approach to continuously accomplish adaptive evolution in knowledge coordination, and because of the different backgrounds of introduced talents, they can conduct research in fields such as public security, education, and energy. Thus, the KSETT presents a hierarchical characteristic, which allows it to establish diversified knowledge dissemination channels such as research reports, column comments, and activity discussions to meet the needs of the public, improve the policy effect, benefit the public, and play a vital role of supporting government and enlightening the people. The KSETT also has a functional characteristic. Think tank knowledge services can play an important role in supporting economic growth at the municipal or regional level by providing research, recommendations, and expertise to policymakers.

Table 6. Regression analysis of innovation driving force and features of US KSETT.

Regression Equation	Innovation Driving Force (x)		Features (Y)		SE	a	b	R^2
Y = ax + b	Joint cultivation	Jointly trained talents	Integrity	Social media	0.925	0.424*	-8.00×10^{-11}	0.180 *
				Knowledge management systems	-	-	-1.21×10^{-10}	-
			Openness	Publications	0.988	0.254	-7.50×10^{-11}	0.064
				Twitter followers	1.021	−0.09	-8.76×10^{-11}	0.008
			Stability	Revenue sources	1.017	−0.095	-3.97×10^{-5}	0.009
				Total revenue	1.022	0.031	-8.00×10^{-11}	0.001
			Evolvability	Transformations	1.01	−0.149	-8.97×10^{-11}	0.022
				Consolidations	1.021	−0.034	-8.75×10^{-11}	0.001
			Hierarchy	Client types	-	-	-8.00×10^{-11}	-
				Research fields	1.003	−0.188	-4.00×10^{-11}	0.035
			Functionality	Business types	-	-	-3.85×10^{-11}	-
				Knowledge dissemination channels	0.943	0.385	-5.88×10^{-11}	0.148
		Joint talent training projects	Integrity	Social media	0.994	0.23	-4.52×10^{-11}	0.053
				Knowledge management systems	-	-	1.23×10^{-3}	-
			Openness	Publications	1.021	−0.009	-4.00×10^{-11}	0
				Twitter followers	1.014	−0.152	-2.36×10^{-11}	0.023
			Stability	Revenue sources	1.019	−0.065	-4.73×10^{-11}	0.004
				Total revenue	1.02	−0.117	-4.00×10^{-11}	0.014
			Evolvability	Transformations	1.022	0.002	5.25×10^{-17}	0
				Consolidations	1.02	0.058	-8.32×10^{-11}	0.003
			Hierarchy	Client types	-	-	1.62×10^{-11}	-
				Research fields	1.004	−0.183	4.01×10^{-11}	0.033
			Functionality	Business types	-	-	-5.82×10^{-3}	-
				Knowledge dissemination channels	0.992	0.237	4.32×10^{-17}	0.056
	Talent introduction	Introduced talents	Integrity	Social media	0.892	0.488 *	7.16×10^{-11}	0.238 *
				Knowledge management systems	-	-	1.38×10^{-11}	-
			Openness	Publications	0.873	0.520 **	9.03×10^{-18}	0.27 **
				Twitter followers	1.016	0.184	-6.06×10^{-17}	0.034
			Stability	Revenue sources	0.884	0.501 *	-2.89×10^{-11}	0.251 *
				Total revenue	0.993	0.101	2.66×10^{-11}	0.01
			Evolvability	Transformations	1.020	0.06	2.27×10^{-11}	0.004
				Consolidations	0.988	0.256	-8.41×10^{-3}	0.065
			Hierarchy	Client types	-	-	-6.88×10^{-17}	-
				Research fields	0.959	0.345	1.37×10^{-10}	0.119
			Functionality	Business types	-	-	1.67×10^{-11}	-
				Knowledge dissemination channels	0.866	0.531 **	-9.45×10^{-17}	0.282 **
		Talent introduction projects	Integrity	Social media	0.953	0.36	-8.00×10^{-11}	0.129
				Knowledge management systems	-	-	-1.21×10^{-10}	-
			Openness	Publications	1.005	0.181	-7.50×10^{-11}	0.033
				Twitter followers	1.007	0.391	-8.76×10^{-11}	0.153
			Stability	Revenue sources	0.979	0.284	-3.97×10^{-5}	0.081
				Total revenue	0.961	0.166	-8.00×10^{-11}	0.028
			Evolvability	Transformations	1.015	0.113	-8.97×10^{-11}	0.013
				Consolidations	0.890	0.491 *	-8.75×10^{-11}	0.241 *
			Hierarchy	Client types	-	-	-8.00×10^{-11}	-
				Research fields	0.928	0.417 *	-4.00×10^{-11}	0.174 *
			Functionality	Business types	-	-	-3.85×10^{-11}	-
				Knowledge dissemination channels	0.928	0.418 *	-5.88×10^{-11}	0.175 *

Note: * $p < 0.05$, ** $p < 0.01$. The regression analysis cannot show the results of knowledge management system because its values are distributed as 0 and 1, so the results in the table show "-." All think tanks in the US have four client types (government, corporations, research institutions, and individuals) and four business types (policy research, policy-making advice, academic support, and public awareness). Thus, regression analysis cannot show regression results between constants and variables, as shown in the table with "-".

The case study indicates that the US has formed an innovation-driven KSETT. The types of producers of the knowledge service ecosystem are diversified, mainly government-commissioned think tanks, supplemented by research-oriented think tanks, advocacy-oriented think tanks, and heritage-oriented think tanks. Talent introduction drives the

knowledge service activities of think tanks in the US. Talent also constitutes the knowledge service value chain with the circulation of knowledge resources and the flow of intellectual resources among think tanks, clients, and the public. The US KSETT, driven by talent introduction, shows the features of integrity, openness, stability, evolvability, hierarchy, and functionality of the service ecosystem. The current situation of the US KSETT is consistent with the model constructed in this study, indicating that the model is feasible and valid.

The adoption of a steady introduction of talent by the US think tanks has a significant positive impact on knowledge resource circulation, intellectual resource flow, and knowledge service delivery in the innovation-driven KSETT. Findings highlight three key mechanisms of introducing talent into the ecosystem. The first mechanism is increasing the number of open databases and data platforms through talent to build them to facilitate knowledge resource circulation. The second one is increasing the mobility of people by encouraging clients or social institutions staff to work part-time in think tanks to boost the low intellectual resources. The final one is offering research projects through talent to achieve knowledge service delivery.

At the same time, this steady introduction of talent significantly impacts all features (i.e., the integrity, openness, stability, evolvability, hierarchy, and functionality) of the innovation-driven KSETT. Firstly, introducing talents can establish more social media to strengthen the network connection between think tanks, clients, and the public, enhancing integrity. Secondly, introducing talents is conducive to more publications, improving the think tank's influence and strengthening its openness. Thirdly, with the introduction of talents, there will be more diversified sources of income to maintain stable network connections between various elements in the ecosystem and strengthen its stability. Fourthly, think tanks can merge to adapt to changes in the knowledge environment to promote evolvability. Fifthly, in terms of hierarchy, as the number of introduced talent projects increases, the research field will also expand, and the hierarchy will be improved. Finally, introducing talents facilitates the establishment of more channels for knowledge dissemination, promotes the exchange between think tanks and the public, and strengthens its functionality.

5. Conclusions

Deriving from the ecosystem and innovation-driven development theories, this study developed a conceptual framework to analyze the composition, structure, and features of the KSETTs. Applying this conceptual framework in the US think tanks validates how the framework can be a valuable tool to understand the mechanisms behind becoming innovative in a KSETT. Our findings highlight that introducing talents into the ecosystem is the driving force of the innovation-driven KSETT and an essential guarantee for the sustainability of the KSETT.

Regarding theoretical contributions, this paper extends the application of ecosystem theory, applying ecosystem theory to the study of knowledge services in think tanks. Analogous to the natural ecosystem metaphor, knowledge service ecosystems need to similarly adapt and evolve with their environmental contexts, which is critical for the survival of the whole ecosystem. Knowledge service ecosystems do, however, show great potential to be as sustainable as a natural ecosystem. This paper extends the unit of analysis of the innovation-driven development theory from general industrial organization to knowledge-intensive organizations. Our model shows the role of innovation as a key driver for knowledge-intensive organizations driven by talent, and it enriches the innovation-driven development theory's content and application areas. Driven by talents, the knowledge service value chain has been formed in the KSETT, and various features have emerged in the knowledge service activities.

For practice contributions, the case study results of the conceptual model show that the innovation-driven KSETT model is feasible and effective and can provide a reference basis for the sustainable development of think tanks' knowledge services in different countries around the world. Many countries still need to complete think tanks and immature think tank development, which requires mastering the proper methods and paths. From the

case study results in this paper, think tanks need to recognize the importance of talent. By introducing talent to the value chain of knowledge services, think tanks could provide knowledge services more effectively, connect more closely with clients and the public, and build a KSETT to achieve further development.

Further, for policy contributions, the study provides a reference model for think tank policymakers and managers interested in the sustainable and innovative development of their KSETT. We answer the question of how innovation drives the formation and operation of the KSETT, helping policymakers recognize the importance of building multiple types of think tanks. Further, it becomes clear that many talented people could facilitate the flow of knowledge and intelligence between think tanks, clients, and the public, resulting in a harmony of think tanks and the knowledge environment. Thus, an innovation-driven ecosystem could achieve sustainable development only with abundant talent and think tanks.

Think tanks are pivotal in the significant hotspots at home and abroad today. Through the dissemination, sharing, and exchange of knowledge, think tanks interact with government departments, the public, and other stakeholders to form a complex with self-adaptive, self-regulating, and self-organizing functions. Think tanks provide knowledge services that require sustainable development to provide a constant stream of intellectual support for policymakers and a lasting impetus for economic and social development. At the same time, by presenting the perspective of innovation-driven development, the paper adds to our extant understanding of how the knowledge service ecosystem of think tanks operate, making this work valuable for policy.

The main limitation of our study is its reliance on data from a single country as a case study. As each country and region has unique characteristics and varying levels of development of think tanks, our findings may not apply to other contexts. Furthermore, it is important to consider the potential impact of political, economic, and social factors on the development and effectiveness of think tanks, which may differ across countries and regions. Another limitation is the fact that our case study does not present spatial data on the location of think tanks, clients, and the public in the US. Therefore, we cannot track the entire process of knowledge resource circulation and intellectual resource flow in the KSETT.

Our paper offers two potential themes for researchers to study in the future. Firstly, conducting more research in diverse settings would be valuable to refine and generalize the model. Researchers could explore more countries to provide advice on the sustainable and healthy development of think tanks by combining and differentiating local characteristics. Secondly, future research could use the theoretical lens provided in this paper to examine how the composition and characteristics of knowledge service ecosystems at different stages might change over time. By doing so, researchers might further contribute to understanding the inherent processes within the knowledge service ecosystem of think tanks.

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Appendix A

Table A1. The list of 25 well-known think tanks in the US.

Name	Website
Carnegie Endowment for International Peace	https://carnegieendowment.org (accessed on 3 May 2022)
Center for Strategic and International Studies	http://www.csis.org/ (accessed on 3 May 2022)
RAND Corporation	https://www.rand.org (accessed on 3 May 2022)
Peterson Institute for International Economics	https://www.piie.com (accessed on 3 May 2022)
Wilson Center, FKA Woodrow Wilson International Center for Scholars	http://www.wilsoncenter.org (accessed on 3 May 2022)
Center for American Progress	https://www.americanprogress.org (accessed on 3 May 2022)
Heritage Foundation	https://heritage.org (accessed on 3 May 2022)
Council on Foreign Relations	https://www.cfr.org (accessed on 3 May 2022)
Cato Institute	https://www.cato.org/ (accessed on 3 May 2022)
Urban Institute	https://www.urban.org (accessed on 3 May 2022)
American Enterprise Institute for Public Policy Research	https://www.aei.org/ (accessed on 3 May 2022)
Belfer Center for Science and International Affairs	https://www.belfercenter.org (accessed on 3 May 2022)
Atlantic Council	https://www.atlanticcouncil.org (accessed on 10 May 2022)
Asia Society Policy Institute	https://asiasociety.org/policy-institute (accessed on 10 May 2022)
Hudson Institute	https://www.hudson.org (accessed on 10 May 2022)
National Bureau of Economic Research	https://www.nber.org (accessed on 10 May 2022)
Mercatus Center	https://www.mercatus.org (accessed on 10 May 2022)
Hoover Institution	https://www.hoover.org (accessed on 10 May 2022)
Chicago Council on Global Affairs	http://www.thechicagocouncil.org (accessed on 10 May 2022)
Inter-American Dialogue, Washington	https://www.thedialogue.org (accessed on 10 May 2022)
World Resources Institute	https://www.wri.org/ (accessed on 10 May 2022)
German Marshall Fund of the United States	https://www.gmfus.org (accessed on 10 May 2022)
Acton Institute for the Study of Religion and Liberty	https://www.acton.org/ (accessed on 10 May 2022)
New America Foundation	https://www.newamerica.org/ (accessed on 10 May 2022)
Center for Global Development	https://www.cgdev.org (accessed on 10 May 2022)

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