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The Holistic Capability of Open Government Data: Concept, Framework, and Evolutionary Mechanism (Postprint)

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Abstract

[Purpose/Significance] Capabilities determine the innovation potential of Open Government Data (OGD), and the exploration of OGD capabilities facilitates understanding of its operational patterns and promotes its sound development. [Method/Process] Based on capability theory and relevant literature, this study presents an exploratory investigation of overall OGD capability. First, from a systematic perspective, it analyzes the background for proposing overall OGD capability and constructs a framework for it. Then, drawing on the knowledge-based view of capabilities, it examines the subjects, objects, and constituents of OGD core capabilities and dynamic capabilities, and investigates the formation and evolution mechanisms of overall OGD capability. [Results/Conclusion] The study finds that overall OGD capability constitutes a synergistic combination of core capabilities and dynamic capabilities. The formation of core capabilities is an incremental and progressive process that gradually emerges through knowledge-based learning within the "Routine Learning Loop-Capability Learning Loop-Strategic Learning Loop," while dynamic capabilities are embedded in the knowledge creation process, influencing the enhancement of OGD core capabilities through "Demand Matching-Content Matching-Structure Matching-Capability Matching."

Full Text

The Integrated Capability of Open Government Data: Concept, Framework, and Evolution Mechanism

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Abstract:
[Purpose/Significance] Capability determines the innovation potential of

Open Government Data (OGD). Exploring OGD capability is essential for understanding its operational patterns and promoting its healthy development. [Method/Process] This study conducts exploratory research on OGD integrated capability based on capability theory and relevant literature. First, from a systemic perspective, it analyzes the background of OGD integrated capability and constructs its framework. Then, based on the knowledge view of capability, it examines the subjects, objects, and composition of OGD core capability and dynamic capability, and discusses the generation and evolution mechanism of OGD integrated capability. [Result/Conclusion] The study finds that OGD integrated capability is a synergistic combination of core capability and dynamic capability. Core capability formation is a gradual process, generated progressively through knowledge learning in the "conventional learning loop–capability learning loop–strategic learning loop," while dynamic capability is embedded in the knowledge creation process, acting upon the enhancement of OGD core capability through "demand matching–content matching–structure matching–capability matching."

Keywords: Open Government Data; Integrated Capability; Core Capability; Dynamic Capability; Generation and Evolution
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Since the new era, the integrated development of the real economy and the digital economy has accelerated. The Fifth Plenary Session of the 19th CPC Central Committee proposed making reform and innovation the fundamental driving force for national development. As a foundational strategic resource for innovation-driven growth, data has been integrated into the entire value creation process. Open Government Data (OGD) is key to unlocking data potential and a primary source of digital innovation, and thus we should "promote OGD sharing" to accelerate the cultivation of data factor markets (as stated in the "Opinions on Building a More Perfect System and Mechanism for Market-oriented Allocation of Factors," hereinafter referred to as the "Opinions"). However, merely opening data resources is only an input factor in the production process. As a service that uses data as a basic production factor to achieve value creation, whether OGD can fulfill its enormous potential is determined by its capability. Exploring OGD capability will help us understand its operational patterns and promote its benign development.

1. Foundation of OGD Capability Research

1.1 Relevant Concepts of Capability

Capability is the comprehensive quality demonstrated in accomplishing a goal or task. The internal growth theory of enterprises holds that differentiated division of labor determines that different subjects should master different knowledge and skills, which constitute enterprise capability. C.K. Prahalad and G. Hamel further pointed out that core capability is "the accumulated knowledge

within an enterprise," focusing on the heterogeneous growth of firms, with characteristics of being difficult to imitate and substitute, serving as the vital source for transforming resources into competitive market advantages. However, the formation of core capability is often accompanied by the generation of core rigidities, which cause path dependence and prevent enterprises from maintaining dynamic strategic adaptation in complex and changing competitive environments. To overcome core rigidities, D.J. Teece et al. proposed dynamic capability theory, emphasizing that the renewal and cultivation of core capabilities should be a continuous dynamic process that integrates, builds, and reconfigures internal and external resources to respond to rapidly changing environments.

Overall, organizational capability is a complex system that gradually forms through knowledge "learning" in continuous interaction, feedback, and adjustment with the external environment. Core capability serves as the rigid hardware foundation, while dynamic capability functions as the flexible adaptive capability for responding to changes. The combined force of these two constitutes the organization's integrated capability.

1.2 Knowledge View of Capability

The knowledge view of capability holds that the essence of capability is knowledge, and that knowledge and capability are the result of subject-object interaction. When a subject masters knowledge to a certain level, it develops into capability. Core capability is the unique knowledge possessed by an organization, derived from the personalized tacit knowledge of its members. Knowledge acquisition and accumulation form the basis of core capability formation, while knowledge sharing, transfer, and utilization determine the extensibility of core capability. Various knowledge management activities positively influence the formation and effectiveness of organizational core capability.

Dynamic capability is the organization's ability to pursue new knowledge to achieve core capability enhancement. Its object is existing knowledge resources, representing the process of creatively using internal and external knowledge resources to adapt to market changes. It emphasizes the activation, application, and innovation of knowledge (especially tacit knowledge), including the perception, absorption, and exchange of existing knowledge, as well as knowledge creation based on these processes. The knowledge representation of capability and the knowledge management activities behind capability development have become important concerns in current capability research across various fields.

1.3 Relevant Research on OGD Capability

Current research on OGD capability is relatively limited, mainly focusing on capability definition, identification, and influencing factors. Cao Qian et al. argue that data release capability, data control capability, and data application capability are the three core capabilities of OGD. The first two emphasize the capabilities of government data providers (data providers and controllers), while

the third highlights the capabilities of data developers and users (the main force in creating data value). Research on OGD capability identification and influencing factors mainly follows several paths: skill analysis, value chain analysis, and resource analysis. Z. Mitrovic proposes that various e-skills required for government data supply and public data utilization form the foundation of OGD capability. F.A. Zeletti et al. analyze the capability architecture of OGD data users around value creation. Zhao et al. examine the impact of various resources on OGD capability from a resource-based perspective. These studies primarily focus on OGD core capability while neglecting the fact that endogenous resources and existing capability reserves must also adapt to the constantly changing environment. Dynamic capability that supports OGD adaptation to these changes should also constitute an important component of OGD capability building.

Existing research lacks a systematic understanding of OGD capability. How core capability, dynamic capability, and integrated capability manifest in OGD capability development and what relationships exist among them require further exploration. Therefore, this study attempts to construct an OGD integrated capability framework, analyze OGD core capability and dynamic capability and their interrelationships within this framework, and discuss their generation and evolution mechanisms.

2. Conceptual Proposal and Framework Analysis of OGD Integrated Capability

2.1 Background of OGD Integrated Capability

Since the global OGD movement swept the world in 2009, China's OGD has made considerable progress, basically forming an OGD ecosystem composed of government, developers, and the public. In this ecosystem, capability determines what OGD can do, how to do it, and the ultimate output quality and benefits. However, the current diversification of subjects and dynamic nature of the environment facing OGD development determine that OGD is a complex system. The system's environment, composition, and behavior all affect the output of the OGD ecosystem. Below, this paper analyzes its environmental status from the perspectives of subject diversification and environmental dynamism.

From the perspective of subject diversification, the content and structure of each OGD subject's capability are determined by its positioning. OGD makes government data available for social use, with its logical foundation being public demand-driven. For service providers, OGD means data transparency, in-depth interpretation of public needs, construction and maintenance of OGD utilization contexts, and timely response to public questions, which correspond to the capability requirements for OGD data providers. For data developers and the public, the capability to use and develop data is crucial, as this capability determines the scope and extent to which they can transform government data value.

From the perspective of environmental dynamism, the content and structure of capability change with external environmental shifts. As transparency, openness, and participation processes deepen and citizen awareness gradually strengthens, public demand for government data products and services also changes with factors such as policy formulation, technological updates, and emergencies, placing new demands on the capabilities of government, data developers, and the public.

The influence of multiple subjects and a dynamic environment determines that the OGD capability system must both ensure the realization of functions aligned with OGD positioning and enable flexible adjustment with environmental changes. This requires that OGD capability should be composed of rigid capability (core capability) and flexible capability (dynamic capability).

2.2 Connotation of OGD Core Capability

What is OGD core capability? M. Javidan believes that core capability development is not achieved overnight. From resources to core capability formation, value continuously increases and difficulty continuously grows, manifesting as a development process of "resources–capability–competitive capability–core capability." Government, data, platforms, and the public are the foundational resources for OGD core capability development. OGD capability gradually forms as participants engage in the provision, development, and use of government data resources. This study argues that OGD core capability development should also follow a progressive hierarchical structure of "OGD resources–OGD functional capability–OGD competitive capability–OGD core capability," as shown in Figure 1 [Figure 1: see original paper].

Government data is the most important resource foundation for OGD. This data is a unique resource held by government and relevant departments, with scarcity. Simultaneously, since this resource has not yet been fully utilized, multi-subject participation is significant for tapping its value potential. The data resource itself and multi-subject participation have already determined the boundary between OGD and other public information services. The knowledge of managing, developing, and utilizing these data resources forms the basis of OGD capability formation.

On this foundation, OGD participants will gradually master the capabilities to provide and use data, also referred to as skills in relevant research. The mastery and application of these skill-based knowledge will prompt participants to gradually form habitual activity patterns in OGD participation, which this study calls OGD functional capability.

As OGD gradually standardizes, data provision capabilities and platform service capabilities continuously improve, the connection with social needs deepens, and knowledge supporting cross-professional and cross-domain collaboration gradually forms, becoming the competitive capability that demonstrates OGD advantages.

Finally, through continuous learning and accumulation, OGD develops core capabilities that significantly differ from other public information services, forming a knowledge system that is not easily imitated or acquired by external parties, fully embodying the scarcity, value, difficulty of imitation, and non-substitutability of OGD core capability.

OGD functions and services all revolve around the provision and utilization of government data. As a heterogeneous capability that distinguishes OGD from other public information services, its core capability should highlight its unique advantages in providing raw data, guiding public utilization, and creating data value. Therefore, its core capability should also develop around these three aspects: the ability to optimize, integrate, and allocate government data resources; the ability to solve problems using data; and the ability to operate and circulate data to create value. Subsequent research summarizes these as data asset management capability, which is also the focus of current OGD capability building in China.

2.3 Connotation of OGD Dynamic Capability

As an innovative initiative in public information services, OGD has continuously adjusted and moved forward in various aspects such as government data provision, development and utilization, and data operation over its decade-long development. OGD dynamic capability is precisely the ability to proactively or reactively transform current core capabilities to meet these adjustments and adaptations, ensuring that core capabilities always remain matched with new changes and demands.

The "dynamic" aspect of OGD dynamic capability is manifested when OGD participants can perceive changes and respond actively when facing environmental changes. Its "capability" aspect emphasizes that participants can integrate and reconstruct original knowledge and resources according to changing requirements, and master approaches and methods to respond to new demands and acquire new capabilities.

Knowledge updating and reconstruction are the two implementation paths of OGD dynamic capability. Adaptive dynamic capability focuses on reconfiguring existing resources, while innovative dynamic capability focuses on creating new knowledge. These are also the key points for building OGD dynamic capability.

The object of OGD dynamic capability is the existing OGD knowledge system. Its purpose is to address the mismatch between current capabilities and demands, ultimately achieving supply-demand balance through OGD core capability enhancement. It acts upon the entire process of core capability generation and updating.

2.4 Concept and Framework of OGD Integrated Capability

Based on the above analysis, this study examines the requirements of the OGD capability system from a systemic perspective, analyzing how multi-subject diversification and environmental dynamism shape OGD capability requirements. Through analyzing the connotations of OGD core capability and dynamic capability, it clarifies their respective positions. As a rigid requirement for system capability development, core capability can demonstrate OGD's uniqueness through multi-subject participation in government data development and utilization, distinguish OGD from other public information services, and ensure the realization of OGD's basic value, forming the foundational guarantee for implementing and advancing OGD. As a flexible requirement for system capability development, OGD dynamic capability can address environmental changes by acting upon core capability enhancement to meet OGD's continuously increasing value requirements, serving as the adaptive guarantee for responding to dynamic changes and making adjustments.

Therefore, this study proposes that OGD integrated capability is: the combination of core capability for effectively managing government data assets, dynamic capability for reintegrating and reconfiguring resources to achieve renewal and reconstruction, and the generation and evolution mechanism for OGD capability cultivation and innovation, which OGD participants must possess to achieve effective data provision, utilization, and value creation. This concept includes not only the definition of the nature and objects of OGD core capability and dynamic capability but also incorporates the generation and evolution mechanisms of both capabilities into the scope of OGD capability research, providing a systematic description of OGD capability. Its framework is shown in Figure 2 [Figure 2: see original paper].

OGD core capability and dynamic capability together constitute OGD integrated capability. However, their different positioning determines their different objects and composition. The following sections analyze these two capabilities separately.

3. Deconstruction of OGD Integrated Capability

3.1 Analysis of OGD Core Capability

3.1.1 Subjects and Objects of OGD Core Capability OGD core capability is the foundation for its sustainable development in the digital economy era, composed of specific knowledge and knowledge systems. Regarding capability subjects, existing capability research often focuses on a specific organization. However, OGD capability differs from general organizational capability in that it is not limited to a single organization but involves all participants in the OGD ecosystem. The OGD ecosystem identifies three types of subjects: government (data providers), data developers, and the public (users of data products and services). Their different division of labor and participation methods determine different capability requirements. However, the common point among the three

subjects is that their capability objects all revolve around government data resources.

How does OGD core capability function? The "Opinions" propose that we can start from three aspects: management, sharing and opening, and development of government data resources. Therefore, taking government data resources as the center and specifically exploring OGD core capability around all aspects involved in government data provision, utilization, and value realization is a feasible approach.

3.1.2 Identification Approach for OGD Core Capability Based on Data Asset Management In the process of OGD creating value from open data, "scenario is king, data is secondary, and algorithm is last"—data value is demonstrated in specific scenarios. Therefore, research on OGD core capability cannot be separated from analyzing the specific business scenarios of OGD operation. In relevant capability research, scholars hold similar views, believing that organizations consist of a series of activities, and organizational capability is the knowledge required to complete specific activities.

How can OGD operations and activities be decomposed? The United States' "Open, Public, Electronic, and Necessary Government Data Act" proposes that "government data is a public data asset," and the data asset management process is defined as three stages: data governance, data utilization, and effective operation. Therefore, if we understand OGD operation from the perspective of data asset management, these three stages can serve as the basis for decomposing OGD activity processes.

From the perspective of OGD goals and positioning, in the data governance stage, government should possess capabilities such as integrating data resources, publishing data, and providing services, which can be summarized as OGD data provision capability. In the data utilization stage, data developers and users should possess capabilities such as development, utilization, and scenario construction, which can be summarized as OGD data utilization capability. In the data operation stage, all participants should possess capabilities such as data rights confirmation, data evaluation, and providing intelligent data circulation services, which can be summarized as OGD data operation capability. The differences in participants' capabilities will significantly influence their activities and final outputs.

The identification of capabilities in the three stages of data provision, utilization, and operation can be further achieved through three steps: "business activity decomposition–activity value-added analysis–knowledge (capability) matching." Essentially, this capability identification process can be applied to each level of the generation from government data resources to OGD core capability, forming a spiral learning loop from government data resources to OGD core capability. The final capability-based knowledge map and knowledge base formed around business activities in each stage can serve as a characterization of OGD core

capability. The structure and identification method of OGD core capability are shown in Figure 3 [Figure 3: see original paper].

3.2 Analysis of OGD Dynamic Capability

3.2.1 Subjects and Objects of OGD Dynamic Capability The core of dynamic capability is knowledge updating and reconstruction, emphasizing the breaking of original routines, continuous adjustment through perceptual learning, and updating and learning knowledge to adapt to internal and external environmental changes. In this process, OGD participants should identify changes, locate problems and gaps according to their role positioning, and then reconstruct and innovate original knowledge through knowledge learning, integration, and exchange to ensure that OGD can identify opportunities, integrate resources, and innovate.

The object of OGD dynamic capability is the existing OGD knowledge system. Its purpose is to solve the mismatch between current capabilities and demands, ultimately achieving supply-demand balance through OGD core capability enhancement. It acts upon the entire process of core capability generation and updating.

3.2.2 Analysis Path for OGD Dynamic Capability Knowledge updating and reconstruction are usually achieved through two knowledge creation methods: incremental or breakthrough. Therefore, OGD dynamic capability can be mapped onto the knowledge creation process. The SECI model of knowledge creation presents the process of knowledge updating, creation, and utilization through the conversion of tacit and explicit knowledge in four processes: Socialization, Externalization, Combination, and Internalization. Therefore, this study combines OGD dynamic capability with the SECI model to depict the context of OGD dynamic capability formation and maps capabilities based on contextual analysis, as specifically shown in Figure 4 [Figure 4: see original paper].

(1) **Change Perception Capability in Socialization Context (Knowledge Gap Identification).** The socialization context is the originating field where OGD dynamic capability emerges. Participants form a shared perception of the policy environment, technological environment, and service needs based on shared experiences of using OGD. This perception is the experience participants gain in providing or using data products/services. These experiences gradually accumulate to form tacit knowledge for identifying needs and perceiving changes, helping OGD participants discover knowledge gaps between current data/services and goals. This is a change perception capability.

(2) **Absorption and Transformation Capability in Externalization Context (Knowledge Acquisition and Accumulation).** The externalization context is the dialog field where OGD dynamic capability is

acquired and learned. Based on perceiving changes and identifying gaps, OGD participants engage in dialogue and collective reflection to gradually form conceptualized expressions of needs and gaps (conversion from tacit to explicit knowledge) in order to narrow these gaps and enhance original capabilities. In this process, OGD participants' ability to acquire knowledge from internal and external sources for learning is an absorption and transformation capability.

(3) **Communication Capability in Combination Context (Knowledge Sharing and Transfer).** The combination context is the systematization field that connects OGD dynamic capability. OGD participants use formal or informal networks to connect the explicit knowledge they propose for improving OGD, selecting, classifying, and combining different knowledge to reach consensus and generate new knowledge through sharing and exchange. This process emphasizes interactive communication among OGD participants, focusing on how to achieve knowledge sharing and transfer among them through interactive communication.

(4) **Reconstruction and Innovation Capability in Internalization Context (Knowledge Integration and Innovation).** The internalization context is the action field where OGD dynamic capability is formed and creates value. Through the experiences of the previous three processes, participants combine external knowledge with individual internal knowledge and gradually transform it into valuable individual knowledge assets. The most important question in this process is how to apply these valuable experiences to solve various problems faced in OGD practice and explore new solutions. Therefore, forming reconstruction and innovation capability becomes the focus of capability development at this stage.

4. Generation and Evolution Mechanism of OGD Integrated Capability

From the knowledge perspective, the generation and evolution of integrated capability is a process of learning and matching. This study analyzes the generation and evolution of core capability through the knowledge learning mechanism, demonstrating how OGD knowledge subjects systematically learn to gradually understand and master knowledge, thereby developing resources into core capability. It analyzes the generation and evolution of dynamic capability through the matching mechanism, demonstrating how OGD knowledge subjects perceive changes in interaction with the environment and enhance original capabilities through absorption, transformation, communication, and reconstruction. Figure 5 [Figure 5: see original paper] shows the generation and evolution process of OGD integrated capability.

4.1 Learning Mechanism of OGD Core Capability

C.K. Prahalad and G. Hamel believe that core capability is formed through group learning that integrates and coordinates different production skills and technology streams. Therefore, the formation of core capability is a continuous learning process. Capability formation first occurs through conscious and organized learning, while capability development occurs through accumulation and improvement in practice. Core capability is an effective knowledge learning and transformation process. This paper will depict the generation and evolution process from government data resources to OGD core capability through the conventional learning loop, capability learning loop, and strategic learning loop.

4.1.1 Conventional Learning Loop The conventional learning loop corresponds to the formation process of OGD functional capability, where participants are in a state of beginning to contact and understand how to provide data, utilize data, and use data products/services. On one hand, participants learn how to use OGD and gradually form work routines, including specific and operational skills for publishing, utilizing, and using data. On the other hand, participants discover new data needs during the learning process, including needs regarding the content, provision forms, and usage methods of government data resources, prompting government data providers to continuously improve and update the resources they provide.

The result of conventional learning is that participants master OGD usage skills and form OGD functional capability.

4.1.2 Capability Learning Loop The capability learning loop corresponds to the formation process of OGD competitive capability. As OGD participants' functional capabilities improve, OGD work routines gradually form (i.e., a set of inherent ways of doing things gradually formed on the basis of conventional learning, rooted in the knowledge participants acquire through learning), expressing what OGD is good at doing and how to do it. For example, government data providers have summarized and explored data provision norms through learning (such as the "Shanghai Municipal Government Data Resource Sharing Management Measures" and the "Chengdu Public Information Resource Open Dataset Organization Specification"). Meanwhile, changes in policies and technologies (such as the application of new technologies in OGD) also pose new requirements for original functional capabilities, driving participants to enhance their original functional capabilities and form new work routines.

Functional capabilities and work routines gradually stabilize and combine to transform into OGD service advantages, forming OGD competitive capability.

4.1.3 Strategic Learning Loop The strategic learning loop corresponds to the formation process of OGD core capability. The strategic learning loop is influenced by the strategic environment in which OGD operates. Against the

backdrop of building an open government and transparent government, OGD's goals are transparency, participation, and collaboration. This strategic background not only guides OGD in cultivating competitive capabilities into advantageous products and services but also helps participants further clarify what OGD can do, how to do it, and why they need them in the process of using these products and services. Consequently, OGD core capability can be confirmed. Meanwhile, in such a clear strategic context, OGD is also in a dynamic effectiveness state. When original social needs and tasks change, participants are prompted to re-examine and calibrate whether original core capabilities need to be abandoned or updated.

Regarding how to examine and calibrate whether a capability can become core capability, we can refer to the practice of enterprise core capability by using environment and tasks as reference points for OGD core capability. OGD is a public service oriented toward social needs. When calibrating with the environment, we can compare OGD with other public information services to identify which capabilities are valuable, scarce, difficult to imitate, and difficult to substitute. For example, no other public information service provides raw government data to developers besides OGD. Therefore, capabilities related to OGD data provision are likely OGD core capabilities. When calibrating with specific tasks, we can further discover that when certain capabilities are "fundamental" to completing a task, these capabilities are highly likely to be core capabilities. For instance, in government data provision, capabilities in metadata management and data rights confirmation are important foundations for ensuring effective data provision, making them candidates for core capability. In essence, the strategic learning loop maintains responsiveness to the strategic environment by continuously examining and calibrating the inherent relationships among capabilities, core capabilities, environmental changes, and specific tasks.

4.2 Matching Mechanism of OGD Dynamic Capability

As shown in Figure 5, environmental changes will stimulate OGD participants to continuously propose new demands for government data resources, new requirements for activities and skills to utilize resources, and new requirements for capabilities to respond to new tasks and demands. The generation of capabilities within each learning loop and the upward transition between learning loops must all address capability enhancement issues, which depend on problem discovery, knowledge learning, communication integration, and reconstruction and innovation of existing knowledge—this is precisely the function of dynamic capability. Xin Qing believes that the evolution of dynamic capability goes through three stages of "variation–internal selection–retention," but this study argues that there is an important change perception stage before variation to help OGD identify knowledge gaps. Therefore, this study depicts the generation and evolution process of OGD dynamic capability through four stages: "demand matching–content matching–structure matching–capability matching."

4.2.1 Demand Matching Demand matching is the starting point for OGD to achieve capability updating and reconstruction. It relies on change perception capability to identify knowledge gaps between current capabilities and new requirements, representing the predictive and judgmental capability that OGD participants must possess to adapt to changes.

In the three learning loops mentioned in Section 4.1, government, developers, and the public should achieve perception of internal and external environmental changes, perception of technological update changes, and perception of service object demand changes. Perception of policy changes: important policy documents such as the "Open Data Charter," "Big Data Development Action Outline," and "Opinions on Building a More Perfect System and Mechanism for Market-oriented Allocation of Factors" serve as the basis for guiding and adjusting OGD development strategies. Perception of technological changes: the application of big data, cloud computing, Internet of Things, and artificial intelligence technologies has brought data from behind the scenes to the forefront. OGD has evolved from initially providing data browsing and downloading to currently enabling flexible API calls, data visualization services, and scenario-based customization, and will eventually achieve government data cloud exchange and sharing—all representing OGD's response to technological changes. Perception of demand changes: changes in social needs determine the depth, breadth, and methods of government data utilization, and ultimately determine the value creation degree of data products and services.

Demand matching helps OGD participants clearly define current knowledge status and keenly discover environmental changes. On this basis, they must further clearly define current knowledge reserves, identify gaps between existing knowledge and goals, and clarify knowledge gaps.

4.2.2 Content Matching Content matching is the process of expanding knowledge content through knowledge learning to fill OGD knowledge gaps, mainly achieved through knowledge acquisition and knowledge transformation.

Knowledge acquisition is the foundation of knowledge learning and absorption, derived from the accumulation of external and internal knowledge sources. Best practices from OGD development in the UK and US (external knowledge) and lessons learned from local government platform construction in China (internal knowledge) all provide sources for OGD knowledge learning. Meanwhile, newly acquired knowledge must be closely integrated with original knowledge to be transformed into usable knowledge that guides practice. OGD knowledge absorption and transformation should follow relevant literature and guidelines (such as the "Government Information Resource Cataloging Guidelines (Trial)") on one hand, and attempt to explore OGD standardization norms on the other. Additionally, relevant government departments such as big data centers actively cooperate with universities and research institutions (such as the Fudan University Digital Governance Laboratory) to obtain specialized support for significant capability enhancement.

Content matching enhances OGD participants' capabilities through purposeful knowledge learning.

4.2.3 Structure Matching Structure matching aims to achieve rational combination and allocation of knowledge resources. Through sufficient communication and exchange among OGD participants, knowledge is selected, encoded, and organized to achieve knowledge consistency and ensure matching between new knowledge and OGD demands.

This process relies on OGD's internal and external communication capabilities, including communication between government departments and communication between government and external stakeholders. Communication between government departments is internal communication with relatively formal channels, such as study visits and experience exchanges. Communication between government and external stakeholders can occur through interactive forums and demand suggestions, such as the "Government Data Open Utilization and Ecosystem Construction Forum" at the China International Big Data Industry Expo, which provides an important bridge for supply-demand matching.

The result of structure matching is the gradual formation of a knowledge system jointly recognized by OGD participants through communication.

4.2.4 Capability Matching Capability matching applies the new knowledge formed through previous knowledge learning, absorption, and transformation, and consolidated through communication to practice, filling knowledge gaps through reconfiguration or innovation of existing resources.

Capability matching relies on OGD reconstruction and innovation capability. Reconstruction is the reconfiguration of existing resources, including reorganization of OGD data resources and training of participant skills. For example, the Chengdu Public Data Open Platform provides scenario-based customization services, helping users achieve independent selection and personalized combination queries of government data through resource reorganization. Innovation encourages OGD participants to explore new knowledge in existing government data provision, development, and utilization, discovering new data and seeking new models. For instance, the Shanghai Public Data Open Platform took the initiative in its 2020 annual plan to "encourage the integration of government and enterprise data and create benchmark demonstration applications," collaborating with enterprises to create eight OGD innovative applications such as the "Guotai Junan–Credit Rating Modeling and Risk Early Warning Platform" under the theme of "Data Talks Openness," providing demonstrations for how OGD can use public data to develop social services, business innovation, and cost reduction and efficiency improvement.

The reconstruction and innovation of knowledge through capability matching is precisely the innovative solution proposed based on pain points faced by OGD participants in earlier stages, which can effectively fill OGD knowledge gaps and

ultimately achieve enhancement of OGD original capabilities.

Conclusion

This study constructs an OGD integrated capability framework and provides a preliminary discussion of the composition and generation and evolution mechanisms of its core capability and dynamic capability, hoping to offer an analytical approach for OGD capability research in China, provide reference for OGD capability cultivation, and make theoretical contributions to advancing government data open sharing, enhancing the value of social data resources, and strengthening data resource integration.

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

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