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Unveiling the Coordination Between Governmental Resources and Citizen Engagement in Open Government Data: A Citizen-centric Investigation using the Resource-based Theory

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Unveiling the Coordination Between Governmental Resources and Citizen Engagement in Open Government Data: A Citizen-centric Investigation using the Resource-based Theory

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The application of governmental resources for OGD and citizen engagement is often assumed to be interdependent, yet empirical investigation has been lacking. This study examines the reciprocal influence between the use of resources and OGD by quantifying both government resources and citizen engagement within the framework of resource-based theory. The significance of these metrics is determined using the entropy method. Data from 337 Chinese municipalities was gathered to explore the dependency between government resources and citizen engagement in OGD. The findings reveal that while there is a robust interaction between governmental resources and citizen engagement in OGD across 337 Chinese municipalities, the coordination between these elements is generally low, with most areas showing a coordination degree below 0.3. This discrepancy indicates a lack of alignment in the effective use of resources for public engagement. Cities on the eastern coast display moderately better coordination, which can be attributed to their advanced economies and infrastructure. Conversely, regions with lower coordination degrees highlight the urgent need for developing policy interventions to improve the synergy between OGD and citizen engagement.

CCS Concepts: • **Information systems → Digital libraries and archives;** • **Applied computing → E-government;** • **Human-centered computing → Empirical studies in HCI;** • **Social and professional topics → Government technology policy**;

Additional Key Words and Phrases: Open government data, citizen engagement, resource-based theory, regional discrepancies, alignment

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1 Introduction

Open Government Data (**OGD**) has become an important mechanism for fostering transparency, accountability, and public engagement by disclosing government data for public use across various fields [Khaltar 2024; Lnenicka et al. 2024]. This approach increases governmental transparency and facilitates interactions between governments and citizens by enabling better access to information [Janssen and Zuiderwijk 2014; Zhang and Li 2024]. As governments increasingly invest resources in OGD, the expectation is that such investments will generate more responses and requests from citizens, thereby fostering engagement [Cicatiello et al. 2022; Fang, Zhao, and Li 2024; Zhang et al.2024]. Increased **citizen engagement** (**CE**) with OGD can also push local governments to refine their practices and improve responsiveness to OGD-related requests [Cicatiello et al. 2022; Lnenicka et al. 2024]. Hence, there is a reciprocal relationship between government resources and CE.

However, despite acknowledging this relationship, the mechanisms governing the interaction between government resources and CE remain insufficiently examined. In particular, there is a lack of research on how these two elements are coordinated within OGD initiatives, especially in governance contexts with distinct administrative structures [Janssen and Zuiderwijk 2014; Zhang and Li 2024; Zhang et al. 2024]. While existing studies have investigated aspects of OGD implementation and its impact, few have explored the extent to which government resource allocation aligns with CE across different municipalities. Understanding this coordination is essential for optimizing digital governance practices and improving OGD efficiency. This study addresses this gap by investigating the twofold research questions of one) how can the coordination of government resources and CE be measured and two) whether the coordination of government resources and CE is effective for OGD within Chinese municipalities. This study examines the spatial distribution and regional differences in coordination to uncover systemic variations and policy implications.

Coordination refers to integrating different parts within an organization or system to accomplish collective tasks [Malone and Crowston 1990; Selznick 1996]. Scholars such as Zuiderwijk [2015] have examined coordination within the realm of OGD activities, focusing on how different actors coordinate open data rather than traditional coordination between institutions [Zuiderwijk and Janssen 2015]. Despite this, no established framework currently exists for systematically measuring the coordination between government resources and CE, nor is there a comprehensive method to assess regional variations in coordination effectiveness [Zhang and Janssen 2022; Zhang and Li 2024]. Therefore, developing an approach that systematically quantifies and evaluates coordination is essential for advancing both research and practice in this field.

Previous research has explored the coordination between data providers and users, highlighting significant disparities across different regions and service areas. For example, Cordella, and Paletti [2019] identified substantial differences in digital governance capabilities among Italian regions, emphasizing the need for more equitable digital infrastructure [Cordella and Paletti 2019]. Janssen and Zuiderwijk [2014] also addressed the relationship between governments and citizens through various business models but did not delve into the deeper mechanisms of coordination and their implications for policy development [Janssen and Zuiderwijk 2014]. More recent studies [De Tuya et al. 2020; Xanthopoulou et al. 2024] have shown that the absence of key institutional roles, such as a **Government Chief Information Officer** (**GCIO**), can negatively affect both governments and citizens, further highlighting the challenges in OGD coordination.

This study fills this theoretical and empirical gap by examining the interaction and coordination between government resources and CE with OGD, particularly in the context of Chinese municipalities. Using a **coupling coordination model** (**CCM**), this study assesses the degree of alignment between these two systems, building on concepts from physics where systems influence one another through interaction [L. Liu et al.2002; Zhang and Janssen 2022]. In social sciences, coordination refers to the harmonious development of subsystems, and this framework is applied here to explore how government resources and CE evolve together [Kunz et al. 2013; Zhang and Li 2024].

The study leverages ***Resource-Based Theory*** (**RBT**) to provide a theoretical foundation for analyzing the allocation and utilization of government resources in OGD initiatives. RBT has been widely applied to understand how organizational resources shape outcomes [Zhang et al. 2024; Zhao and Fan 2021a]. In this study, RBT serves as a framework for examining how the availability and strategic deployment of government resources influence the effectiveness of OGD coordination with CE. By applying RBT, this study highlights not only the significance of resource endowment but also the role of resource alignment in fostering meaningful public participation.

Drawing on data from 337 Chinese cities, this research develops an index system to evaluate the coupling coordination between government resources and CE, offering a new empirical perspective on this critical relationship.

The structure of this article is organized as follows: Section 2 provides an assessment of **governmental resources** (**GRs**) and CE with OGD, focusing on how these components are measured and analyzed. Section 3 presents the research methodology, including the application of the CCM and the entropy method for indicator weighting. Section 4 presents the results, which examine the interaction and coordination between GRs and CE across 337 Chinese cities, detailing the spatial distribution and regional variations. Section 5 discusses the findings and provides future research directions, exploring the findings' implications for policy-making and regional governance strategies. Finally, Section 6 presents the conclusions and the broader impact on the development of OGD initiatives. This article serves as an extended discussion on the subject, initially introduced at ICEGOV 2022, and adds depth to understanding governmental and public coordination through open data initiatives.

2 Research Background

The following section provides a comprehensive review of the existing literature to contextualize the research on OGD and its implementation in both global and Chinese contexts. This review highlights the key contributions and gaps in the field by examining the evolution of OGD concepts, its development in China, and the citizen-centric approaches taken by municipalities across Asia and other regions. Furthermore, GRs and CE are assessed to frame the study's empirical focus.

2.1 A Review of the Concept of Open Government Data and Scholarly Work from the Past Ten Years

OGD can be described as data collected with public funds, that is, neither confidential nor restricted by privacy concerns and is made freely accessible for anyone to download [Lim 2021]. In simpler terms, it refers to information from the public sector, that is, released to the public as open data [Kim 2018]. The concept of OGD has been studied from various perspectives over the past ten years, with scholars identifying four primary ways of understanding its significance and impact [Gonzalez-Zapata and Heeks 2015; Jetzek et al. 2014; Wirtz et al. 2022]. OGD research can be categorized into four main perspectives: data-driven, process-driven, behavior-driven, and outcome-driven in this research.

Data-driven Perspective: The data-driven perspective emphasizes that OGD consists of valuable public data, that is, made available to the public in standardized formats, ensuring that it meets open standards. This data is accessible to a wide range of stakeholders, including citizens, researchers, businesses, social organizations, and government institutions. The goal is to ensure that the data is not only available but also usable by different entities to meet their needs [Alexopoulos et al. 2018; Gonzalez-Zapata and Heeks 2015].

Process-driven Perspective: The process-driven perspective focuses on the complete lifecycle of OGD, highlighting the processes through which governments collect, generate, and make data publicly available. This includes the process of data sharing, distribution, modification, and even commercialization. The emphasis is on transparency in how data is handled and shared under open licensing terms, ensuring that all participants in the data ecosystem benefit from these practices [McNutt et al. 2016; J. Zhou and Hu 2025].

Behavior-driven Perspective: From the behavior-driven viewpoint, OGD is framed by the actions of government departments in making their data available to the public. This perspective emphasizes the governmental behavior in fulfilling its duties and exercising its administrative functions by making original (non-confidential) data openly accessible to citizens. This behavior is often seen as essential to promoting public trust in government and enhancing public engagement [Meijer 2015; Zhao and Fan 2018].

Result-driven Perspective: The result-driven perspective stresses the economic and social outcomes of OGD. It views OGD as a driver of innovation and economic growth, fostering new products and services by making public sector data available for commercial use. By enabling the commercialization of public data, OGD can create social and economic value, thus contributing to broader societal and economic development [Berrone et al. 2016; McBride et al. 2019].

2.2 A Review of OGD in China

The earliest discussions on OGD in China began in 2013, with research focused on analyzing the service functions of foreign government open data portals [Zhifeng and Ruhua 2013]. Subsequent studies expanded on this foundation by examining key aspects of government data platforms, such as technical construction, security frameworks, and value-added services [Xiaohong and Manggu 2014; Zhang et al. 2024]. During this initial phase, scholars primarily relied on conceptual and normative approaches, as OGD platforms were still in their infancy.

Between 2015 and 2020, OGD development in China gained significant momentum, driven by the 2015 "Action Plan for Promoting Big Data Development," which aimed to establish a unified national platform for government data by 2018. During this period, scholars have focused extensively on various aspects of OGD, including performance assessments of platforms [Haiqun and Jin 2016; Mu and Zhao 2024], platform architecture [Fang et al. 2024; Lei and Feng 2015], cross-country comparative studies [Gang and Liying 2016; B. Liu and Wei 2023], and the challenges associated with platform implementation [S. Huang and Zhang 2015; Zhang and Li 2024]. This period marked a shift towards empirical research, with a primary focus on qualitative methods such as interviews, case studies, and comparative analyses. Researchers sought to better understand the practical challenges and effectiveness of OGD platforms through these in-depth, context-specific approaches. Surveys and field studies were also employed to complement the qualitative findings and provide a more comprehensive view of OGD implementation [C. Chen and Zhang 2022; Mu and Zhao 2024].

Since 2020, Chinese research on OGD has shifted focus from "how to build OGD platforms" to evaluating "how effectively they have been built." This shift has led to an increasing body of studies assessing the outcomes, impacts, and overall effectiveness of these platforms. Earlier research relied heavily on objective metrics like statistical data and performance indicators, but recent studies emphasize a user-centric approach, focusing on user satisfaction, demand fulfillment, and public value creation [C. Chen and Zhang 2022; Lei and Feng 2015]. Scholars have analyzed local government data platforms through the lens of user experience, investigating how well these platforms meet the needs of their users [L. Zheng et al. 2019]. Additionally, user satisfaction assessments have been based on feedback and ratings, evaluating the perceived quality of services provided by OGD platforms [Islam et al. 2023; G. Liu 2019]. During this period, researchers have integrated traditional methodologies with newer techniques such as web scraping, key performance indicator analysis, statistical modeling, the Delphi method, and satisfaction surveys, alongside comparative analyses of domestic and international platforms, to gain deeper insights into the functionality and user reception of OGD platforms [T. Chen and Li 2015; Chu and Liu 2018; M. Huang et al. 2017].

2.3 A Review of Similar Empirical Work on Open Government Data and Citizen-Centric Approaches Around the World

Empirical studies across the globe underscore the pivotal role that OGD plays in fostering CE by offering accessible government data. In countries such as the United States and the United Kingdom, OGD initiatives have

promoted transparency and enabled citizens to participate actively in decision-making processes. Zuiderwijk, Janssen, and Davis [2014] demonstrate that the availability of open data can contribute to transparency, accountability and participation, although persistent barriers such as data usability and accessibility need to be addressed to enhance civic engagement [Zuiderwijk et al. 2014]. Similarly, in Canada, digital platforms have emerged as key tools for bridging the gap between government and citizens, despite challenges related to public infrastructure and citizen awareness [Cao 2021].

Comparative analyses provide crucial insights into the varied approaches taken by different countries in implementing OGD. For example, the experiences of Western countries are often juxtaposed with those in Asia, revealing significant differences in priorities related to data openness and public engagement. South Korea, for instance, has developed a robust OGD system that has improved both governance transparency and the delivery of public services. This system is frequently cited as a model for other nations pursuing similar OGD strategies [W. Zhou and Xiang 2019]. In contrast, European countries, such as the Netherlands and Finland, have prioritized the economic benefits of OGD, focusing on its potential to drive innovation and entrepreneurship [Colpaert et al. 2013].

The outcomes of OGD initiatives differ significantly by region, as highlighted in the literature. In Europe, OGD has been effectively leveraged to improve governmental accountability and stimulate economic growth through data-driven innovation [Zhang et al. 2024; Zuiderwijk and Janssen 2013]. In contrast, many Asian nations, including China and South Korea, focus primarily on enhancing public service delivery and governance transparency through OGD initiatives [W. Zhou and Xiang 2019]. These regional differences reflect the diverse political, economic, and technological contexts within which OGD initiatives are implemented, influencing how data openness is pursued and the outcomes it achieves.

Despite the widespread adoption of OGD, numerous empirical studies emphasize the challenges of realizing its full potential, particularly in terms of citizen participation. In the United States, large volumes of open data are available, but their utility is often constrained by issues of accessibility and the lack of technical literacy among citizens [Zhang and Li, 2024; Zuiderwijk and Janssen 2014]. Similarly, while OGD platforms have proliferated in China, Liu and Zhang [2021] research shows that citizens' ability to use these platforms effectively varies, especially in less developed regions. Best practices emerging from global studies suggest that for OGD to be truly citizen-centric, governments must invest in robust data infrastructure and build the capacities of public officials and citizens to engage with open data effectively [Cao 2021; Zhang and Li 2024].

To contextualize China's OGD development, this study compares global OGD strategies, illustrating regional differences in data openness, implementation goals, and citizen participation models. United States and United Kingdom: Focus on transparency, accessibility, and civic engagement. Open data initiatives such as *Data.gov* (U.S.) and *Data.gov.uk* (UK) emphasize usability and interoperability [Zuiderwijk and Janssen 2013]. South Korea: Prioritizes efficiency and digital governance, leveraging OGD for smart city initiatives and public service innovations [W. Zhou and Xiang 2019]. European Union: Emphasizes data-driven economic innovation, encouraging entrepreneurship and business applications through open data policies [Colpaert et al. 2013]. This comparative analysis underscores China's unique challenges and opportunities in implementing OGD at scale.

2.4 A Review of Citizen-Centric Scholarly Literature on Municipalities in Asia and China

In recent years, a review of citizen-centric scholarly literature on municipalities in Asia and China underscores the increasing integration of digital platforms to enhance public participation, transparency, and accountability in local governance [J. A. Malek et al. 2021]. Particularly in the context of OGD, studies highlight the vital role of such platforms in fostering CE. In China, local governments have been at the forefront of implementing OGD platforms, aiming to create more transparent and participatory governance frameworks. These efforts are seen as part of a broader regional trend in Asian municipalities, where digital platforms enable citizens to interact with government data, contributing to more informed decision-making processes and improving public trust [J. Malek et al. 2021; Smith et al. 2016].

The literature suggests that in China, municipalities like Shanghai and Beijing have successfully adopted OGD initiatives to engage citizens in areas such as environmental monitoring and public health. These platforms provide critical insights into governance and offer citizens the opportunity to participate in policy-making. However, ensuring that all citizens, particularly those in less digitally literate or resource-constrained areas, can access and benefit from these platforms remains a key challenge [B. Fan and Zhao 2017; Tan and Taeihagh 2020]. Scholars argue that without addressing these barriers, the potential of OGD to create a truly inclusive form of governance may remain underutilized [J. Malek et al. 2021].

Further, several studies have evident the positive relationship between citizen participation and the value realized from OGD initiatives. Public engagement not only enhances the utility of government data but also fosters innovation in public service delivery and governance practices [Zhang et al. 2024]. This dynamic has been observed in Chinese municipalities, where OGD platforms are increasingly seen as tools for fostering collaborative governance and citizen-driven policy reforms [J. A. Malek et al. 2021; Zhang and Janssen 2022]. Moreover, local governments' ability to manage these platforms effectively, ensure data accuracy, and provide user-friendly interfaces is critical to maximizing the benefits of OGD [Ruijer et al. 2017; Zhang and Li 2024].

2.5 Assessment of Governmental Resources and Citizen Engagement

RBT offers a crucial framework suggesting that an organization's diverse resources are pivotal in shaping performance outcomes [Barney 1991b; Zhang and Li 2024]. RBT has been increasingly applied to the realm of OGD to understand how GRs, such as technological infrastructure and human capital, contribute to variations in OGD performance [Barney 1991a; Vial 2019; Zhao and Fan 2021a]. The application of RBT to the realm of OGD has notably increased, employing the theory to elucidate how variations in OGD resources contribute to differing governmental outputs and practices [Kozlenkova et al. 2014a; Zhang and Janssen 2022]. While various resource classifications exist, this study adopts Grant's widely recognized categories from information systems research [Kozlenkova et al. 2014a; Zhang and Janssen 2022]. According to Grant, resources are categorized into three types: tangible, human, and intangible. Tangible resources include financial assets that reflect an organization's financial health and physical assets that indicate its operational capacity. Human resources encompass the array of competencies, knowledge, and decision-making skills contributed by organizational members. Intangible resources cover aspects such as technological assets and organizational reputation [Bharadwaj 2000; Chae et al. 2014; Melville et al. 2004]. This approach has proven particularly useful in studying OGD because it enables a detailed breakdown of how resources contribute to the success of OGD initiatives [Purwanto et al. 2020b]. This classification will be used to segment GRs into tangible, human, and intangible categories.

This section delves into tangible resources, such as financial assets and OGD platforms, that are pivotal for facilitating interactions and enhancing the effectiveness of open data initiatives [Z. Tang and Wang 2020]. Data quality is critical, influencing CE, with high-quality data fostering participation and poorly managed data potentially deterring it [Zhang and Janssen 2022; Zhao and Fan 2018]. Financial resources dictate the ability to support OGD initiatives and compete for budgets within government agencies [Benmohamed et al. 2024; Zhao and Fan 2018]. RBT provides a lens to understand how the allocation of these financial and human resources shapes the success of OGD platforms and policies [Bharadwaj 2000; Islam et al. 2023; Vial 2019]. Intangible resources, including OGD policies and activities, shape the developmental landscape of open data, influencing government interaction with the public and boosting CE [Gao et al. 2023; Harrison et al. 2012]. Human resources, especially leadership and OGD-specific agencies, play critical roles in overcoming resistance to data openness and ensuring efficient open data management [B. Fan and Pan 2023; Klievink 2011]. Leadership commitment and government agencies' capacity to manage OGD effectively have been emphasized in prior studies as crucial for enhancing both the quantity and quality of open data [B. Fan and Pan 2023; Zhao and Fan 2021b]. These resources and strategies collectively form the backbone of government efforts to successfully manage and promote open data initiatives.

2.6 Assessment of Citizen Engagement

CE with OGD involves citizen-driven activities that transform government data into useful outputs like apps, maps, visualizations, and articles, creating actionable insights, interfaces, and services [Purwanto et al. 2020a; Wirtz et al. 2023]. According to Linders et al. [2012], CE refers to a multi-faceted interaction between government and citizens that evolves beyond mere data consumption to collaborative governance processes [Linders 2012]. This article views CE with OGD through three dimensions: initially, data discovery, which encompasses searching and interacting with data on OGD platforms. The second dimension examines the outcomes of data use, including the variety of data users and the range of topics addressed. The third dimension assesses the feedback loop between citizens and government authorities. This approach aligns with previous studies on the role of CE in the digital governance space, emphasizing the importance of feedback mechanisms [Mergel et al. 2019; Zuiderwijk et al 2015]. Our research focuses on municipal cities, which are key areas for implementing OGD in China and are commonly featured in studies of Chinese local governments [Wirtz et al. 2023; Zhao and Fan 2018]. While most studies on Chinese OGD typically analyze provincial data due to the scarcity of city-level data, our approach contrasts by leveraging objective data from OGD policies, platforms, government websites, and the China Statistical Yearbook. This allows us to enrich and challenge the prevailing reliance on subjective data obtained from interviews and surveys in previous studies.

3 Research Method

This section outlines the methods used in the study, including the CCM, the entropy method applied for indicator weighting, and the validation steps conducted to ensure the robustness of the results.

The development of coordination between GRs and CE is crucial for enhancing OGD effectiveness, ensuring sustainable digital governance, and improving interactions between governments and citizens. In addressing this issue, our study employs the CCM, a widely used method for quantifying system interactions and dependencies [Ruehli 1974; Zhang and Janssen 2022]. The model allows for a dynamic assessment of how government resources and CE co-evolve in OGD ecosystems. Originating from physics, coupling describes the interdependence of two systems through multiple types of interactions, which in this context refer to government-led initiatives and public participation [Y. Fan et al. 2019; Li and Yi 2020]. Effective coordination necessitates a balanced and interactive exchange of these components, ensuring that government efforts align with CE levels to optimize OGD usage [Shi and Yang 2014; Zhang and Janssen 2022].

3.1 Indicator Weighting Using the Entropy Method

Before assessing the coordination of GR allocation and CE with OGD, assigning appropriate weights to each indicator within the evaluation framework is essential. Given the variations in OGD development among 337 municipal cities in China, the entropy method is selected as the primary weighting mechanism due to its data-driven nature and ability to reflect system variability objectively.

The entropy method follows a systematic process consisting of four main steps:

(1) Standardizing the initial data to remove inconsistencies in indicator units and scales.
(2) Computing the proportional weight of each index value within the dataset.
(3) Determining the entropy values based on the dispersion of the data.
(4) Calculating the weight coefficients for each indicator to reflect its significance in the overall assessment.

Building on this structured approach, the entropy method systematically quantifies the variability in data, ensuring a precise and unbiased evaluation. The method was chosen due to its ability to reduce human subjectivity when assigning weights, allowing for an objective representation of each indicator's importance [Zhang and Janssen 2022; Zou et al. 2006]. Unlike alternative methods such as the **Analytic Hierarchy Process** (**AHP**) and **Principal Component Analysis** (**PCA**), which require expert judgment or dimensionality reduction, the

entropy method directly captures the inherent variability of each indicator, making it particularly suitable for evaluating diverse government and CE metrics in OGD research.

3.2 Step 1: Standardization of Evaluation Indicators

The indicators used to measure government resources and CE vary in scale, type, and dimension. To ensure comparability, dimensionless transformation techniques are applied before calculating the final indicator weights. This study employs extreme value standardization, which is formulated as follows:

For positive indicators (where higher values indicate better performance):

$$X' = \frac{X - Xmin}{Xmax - Xmin}.$$

For negative indicators (where lower values indicate better performance):

$$X' = \frac{Xmax - X}{Xmax - Xmin}.$$

After standardization, the entropy values are computed, and the final weight coefficients for each indicator are determined. This ensures that each indicator's weight is derived from its inherent distribution in the dataset rather than being arbitrarily assigned.

3.3 Step 2: Coupling Coordination Model for Government-Citizen Interaction

Once the weights are established, the subsequent actions involve calculating the degree of coupling, the degree of coordinated coupling, and the comparative development between government resources and CE with OGD. This research adopts the physical coupling concept to quantify the interaction between the two. The CCM is commonly used to quantify system interactions [Fang et al. 2016; Huo and Chai 2008; Ruehli 1974]. This model helps to analyze the degree of coordination between two or more systems by assessing their coupling degree, which reflects the interaction strength, and the coupling coordination degree, which measures how harmoniously these systems develop. The model has been widely applied in fields such as urbanization and environmental systems, allowing researchers to assess the balance and interplay between components of complex systems [Fang et al. 2016]. The model for the coordinated coupling degree is formulated using the following equations[1].

$$C = \sqrt{\frac{U_{GR} * U_{CE}}{\left(\frac{U_{GR}+U_{CE}}{2}\right)^2}}, \tag{1}$$

$$T{=}aU_{GR} + bU_{CE},\ \text{a}{+}b{=}1,\ a > 0,\ b > 0 \tag{2}$$

$$D = \sqrt{C * T}. \tag{3}$$

Here, C signifies the degree of coupling, while D denotes the degree of coordination in coupling.$U_{GR}$and U_{CE} symbolize the overall GR and CE functions, respectively. T denotes the index for the level of development, that is, both coupled and coordinated. a and b are indicators of the contributions from GR and CE, respectively, and are

[1]The coupling degree (C) reflects the strength of interaction between government resources and citizen engagement. It measures how closely these two systems interact with each other. In this study, we categorize the coupling degree into four levels:$0 \leq C \leq 0.3$ represents a low level of coupling where there is minimal interaction. $0.3 < C \leq 0.5$ represents an antagonistic state, indicating that it may not be harmonious while interaction exists. $0.5 < C \leq 0.8$ represents a running-in state, suggesting the systems are working toward a closer, more productive interaction. $0.8 < C \leq 1$ represents a high-level coupling, reflecting a strong, well-established interaction between government resources and citizen engagement.

assigned a value of 0.5 to indicate their equal significance. β represents the relative development model, detailed in Equation (4)[2].

$$\beta = \frac{U_{CE}}{U_{GR}}. \tag{4}$$

The indicators for GRs and CE with OGD are listed in Table 1 [Zhang and Janssen 2022; Zhang and Li 2024]. Table 1 presents the key indicators used to evaluate the coordination between GRs and CE, categorized into tangible, human, and intangible resources. These indicators form the basis for the subsequent analysis of the CCM. This study expands upon previous research by collecting and analyzing data on Chinese OGD development from 337 municipal government websites, OGD platforms, and policies, all sourced from 2019.

3.4 Step 4: Robustness Checks and Model Validation

To ensure the accuracy and reliability of the model, this study incorporates other validation techniques: Cross-Year Validation: The model is applied to 2020 and 2021 data to confirm its consistency across different time periods.

4 Results

Applying the computational techniques for GRs, CE, and the CCM, we computed the degrees of coupling and coordination, along with the relative development index across 337 municipal cities in the year 2019. These findings contribute to the broader OGD and public administration fields by empirically assessing how GRs align with CE. Our study highlights the spatial disparities in coordination and provides insights that can inform OGD policymaking, particularly in the context of the Chinese government.

4.1 Spatial Distribution of the Coupling Degree

The evolution of GRs and CE often reflects a reciprocal relationship, with higher resource availability theoretically encouraging greater citizen participation in OGD. This study utilizes the coupling degree to illustrate the level of interaction between these subsystems. The findings reveal that the coupling degree for 270 cities in China ranges from 0.50 to 0.80, indicative of a run-in phase, suggesting that these systems are still undergoing mutual adaptation.

4.2 Spatial Distribution of the Coordination Degree

The computed coordination degree results indicate a generally low level of coordination between GRs and CE in China. The coordination degrees range from 0 to 0.3, with most cities exhibiting minimal coordination. However, cities along the eastern coast, such as Shanghai, Beijing, and Hangzhou, demonstrate relatively higher levels of coordination. This regional disparity suggests that OGD effectiveness is closely tied to local governance structures, economic development, and technological infrastructure.

[2]The coordination degree (D) evaluates how harmoniously these two systems are developing together. It examines whether government resources and citizen engagement are advancing at a similar pace and in a complementary manner. The coordination degree is also categorized into four levels: $0 \leq D \leq 0.3$ represents low coordination, suggesting significant misalignment between the systems. $0.3 < D \leq 0.5$ represents moderate coordination, where there is some alignment but still room for improvement. $0.5 < D \leq 0.8$ represents well coordination, indicating a strong alignment between government resources and citizen engagement. $0.8 < D \leq 1$ represents advanced coordination, reflecting a highly integrated and complementary relationship between the two systems. Finally, the coupling coordination degree combines both the coupling degree and coordination degree to provide an overall assessment of how well the two systems are interacting and advancing together. This metric offers a holistic evaluation of the balance between the strength of interaction and the level of harmonization in their development.

Table 1. Metrics for GRs and Citizen Involvement with OGD[3]

Variable	Dimension	Index I	Index II	Score standard
GR	Tangible resources	OGD platform	Equipped with OGD platform	No 0; No but has cooperation with a compony 1; Enacted-way 2; independent platform 3
		Data resource	Showing data set quantity	Yes 1; No 0
			Showing data quantity of platform	Yes 1; No 0
			Data field diversity	More than one field, 2; only one field, 1; None 0
			Without data fragmentation	Yes 1; No 0
			Without data missing	Yes 1; No 0
			Data update	None, 0; Year, 1; Month, 2; Week, 3; Day, 4
		Finance	Financial general budget revenue	Local general public budget revenue in 2019 with primary data
	Intangible resources	Policy	Local regulations > local rules> regulatory ducuments > act opinions > No OGD related policy	Local regulations, 4; Local rules, 3; Regulatory ducuments, 2; Act opinions, 1; No OGD related policy, 0
			Municipal government has specific OGD policy	Yes 1; No 0
			Policy consider OGD as an impormant program of government	As an important project, 2; involve but not important, 1; no, 0
			Policy contain OGD catalog or list	Yes 1; No 0
			Involving opening method	Yes 1; No 0
			Involving data security	Yes 1; No 0
			Involving data governance Involving data quality	Yes 1; No 0
			Involving data privacy	Yes 1; No 0
			Involving collection of citizen requirements	Yes 1; No 0
		OGD activity	Having a continuous and large open data competition	Yes 1; No 0
			Having small and continuous open data activities	Yes, 2; Small activities but not continuous, 1; None, 0
	Human resource	Leaders	The leader's governmental work report involves OGD	Yes 1; No 0
			The annual work plan of government involve OGD	Yes 1; No 0
		Agencies	Establishing a data management department	Yes 1; No 0
			The data management department has clear responsibilities	Yes 1; No 0
CE with OGD		Data finding	Administrative level of the data management	Provincial level 3; Sub-provincial level 2, Prefecture-level city, 1
			Whether the data set display is eye-catching	Yes 1; No 0
			Whether to provide an open data catalog	Yes 1; No 0
			Having a search function	Yes 1; No 0
		Data use	Providing related data or applications on the same subject	Yes 1; No 0
			Data can be obtained unconditionally	Unconditional, 2; conditional, 1; can not be obtained, 0
			With platform interoperability	Yes 1; No 0
			No irrelevant results	Yes 1; No 0
			No unavailable results	Yes 1; No 0
			No data source unknown	Yes 1; No 0
			Diversity of data users	Yes 1; No 0
			Diversity of results	Yes 1; No 0

[3]As an example, one of the key metrics in the study is the assessment of tangible resources, particularly the presence of an OGD platform. For each city-level government, we scored their OGD platform capability as follows: 0 points for cities without an OGD platform, 1 point for cities that collaborate with external technology companies but do not have an independent platform, and 2 points for cities with a fully independent OGD platform. In the Chinese context, city governments with stronger technological capabilities tend to establish independent OGD platforms, which is why this differentiation is crucial. Similarly, other metrics assess various aspects of GRs and citizen engagement. For instance: Data resources: Metrics like the number of datasets available on the OGD platform are scored as 1 point if the platform provides

4.3 Spatial Distribution of the Coupling Coordination Degree

The analysis of the coupling coordination degree reveals that the alignment between GRs and CE remains at a low level overall. The coordination degree falls within the 0 to 0.3 range, indicating significant room for improvement in most cities. However, several economically developed provinces, including Guangdong, Jiangsu, and Zhejiang, exhibit moderate coordination levels.

The higher coordination in these provinces can be attributed to several factors, including:

(1) Strong economic and technological infrastructures that facilitate citizen interaction with OGD.
(2) Higher public awareness of open data initiatives.
(3) Proactive governmental policies that promote OGD accessibility and usability.

By contrast, central and western China cities demonstrate lower coordination degrees, reinforcing the need for targeted policy interventions to bridge regional disparities in OGD engagement.

4.4 Comparative Analysis of Coupling and Coordination Degrees

Several key insights emerge from this comparative analysis. Overall, the coupling degree across most cities is notably high (0.50–0.80), indicating strong interactions between GRs and CE. Despite strong interactions, the coordination between these elements remains low, as reflected in the coupling coordination degree, which is typically below 0.3. A comparative analysis of relative development suggests that in most cities, government resource investment has outpaced CE development, creating a misalignment in OGD adoption.

This finding highlights a critical policy gap: while significant resources are allocated to OGD, efforts to engage and educate the public in utilizing these resources remain insufficient.

4.5 Provincial Spatial Variability in Coupling Coordination Degree

A distinct spatial disparity is evident when analyzing the coupling coordination degrees across different Chinese provinces (Figure 1). The provincial averages provide insights into regional development trends:

Shanghai (0.546) and Beijing (0.515) lead the rankings, reflecting a relatively high degree of integration between government resource allocation and public involvement. Their status as China's most prominent urban centers means they benefit from advanced digital infrastructure, comprehensive public engagement policies, and robust OGD implementation strategies.

Zhejiang (0.413) and Guizhou (0.400) fall within the moderate range. Zhejiang's integration of digital governance and economic openness fosters better OGD coordination, while Guizhou's government-led digital initiatives, despite economic constraints, have contributed to rising public engagement.

Tianjin (0.373) and Guangdong (0.371) reflect reasonable but suboptimal coordination. These cities exhibit strong GR investment but have a need for further public engagement strategies.

Shandong, Guangxi, and Jiangsu show gradual improvements, hovering around 0.35, indicating a steady transition towards more integrated OGD development.

Henan (0.268) and Shaanxi (0.263) are at the lower end, signaling a significant gap between GR allocation and CE.

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data, otherwise, it receives 0 points. Other data-related metrics follow a similar logic, where indicators such as data update frequency or data accessibility are evaluated. Financial resources: The financial resources of each municipality are measured based on its public budget revenue, as sourced from the China Statistical Yearbook. This index uses actual financial data and is not subject to further conversion into scores. OGD-related activities: These metrics measure whether a municipality has organized OGD promotion activities. Large-scale and continuous activities are assigned 2 points, small-scale but less frequent activities receive 1 point, and no activity is assigned 0 points. Leadership involvement: To gauge leadership commitment to OGD, we evaluate factors such as whether OGD is mentioned in the government's work report or annual work plan. If either document includes OGD initiatives, the municipality receives 1 point for each. Similarly, other leadership-focused metrics follow this approach.

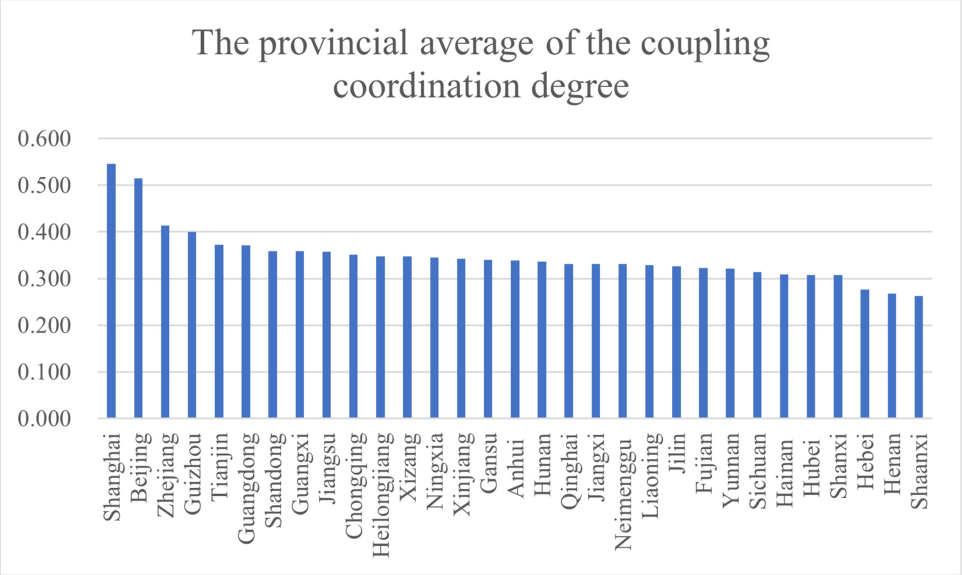

Fig. 1. The provincial average of the coupling coordination degree.

These findings underscore the importance of regionalized OGD policies that cater to specific economic, technological, and governance structures. A one-size-fits-all approach may not be effective in bridging these disparities.

4.6 Comparative Regional Analysis of Coupling Coordination Across China

China's regional stratification provides a valuable perspective on the alignment between GR allocation and CE. As shown in Figure 2, regional averages demonstrate notable variations in OGD effectiveness:

Eastern Region (0.358): Exhibits the highest coupling coordination degree, suggesting a strong government-citizen OGD relationship. This can be attributed to better economic development, technological readiness, and public digital literacy.

Northeastern Region (0.335): Despite industrial restructuring, this region shows promising coordination levels. However, transitional economic challenges may still limit the full realization of OGD potential.

Western Region (0.333): Reflects ongoing efforts to enhance government-citizen coordination. However, geographical vastness and cultural diversity pose challenges to unified OGD implementation.

Central Region (0.313): Ranks lowest in coordination degree, indicating weaker alignment between GRs and public participation. Slower economic growth and infrastructural constraints may be key factors in this lag.

These regional disparities highlight the need for tailored OGD strategies that recognize local constraints and opportunities. A cross-regional knowledge-sharing mechanism could be beneficial in fostering best practices and elevating national OGD development.

5 Discussion

This study investigates the reciprocal influence and low coordination between GRs and CE with OGD, highlighting the need for targeted policy interventions. Employing the resource-based framework, we have crafted a comprehensive model delineating GRs, encompassing physical, non-physical, and human capital. Our use of the RBT aligns with the work of scholars like Barney (1991) and Wernerfelt (1984), who emphasize the critical

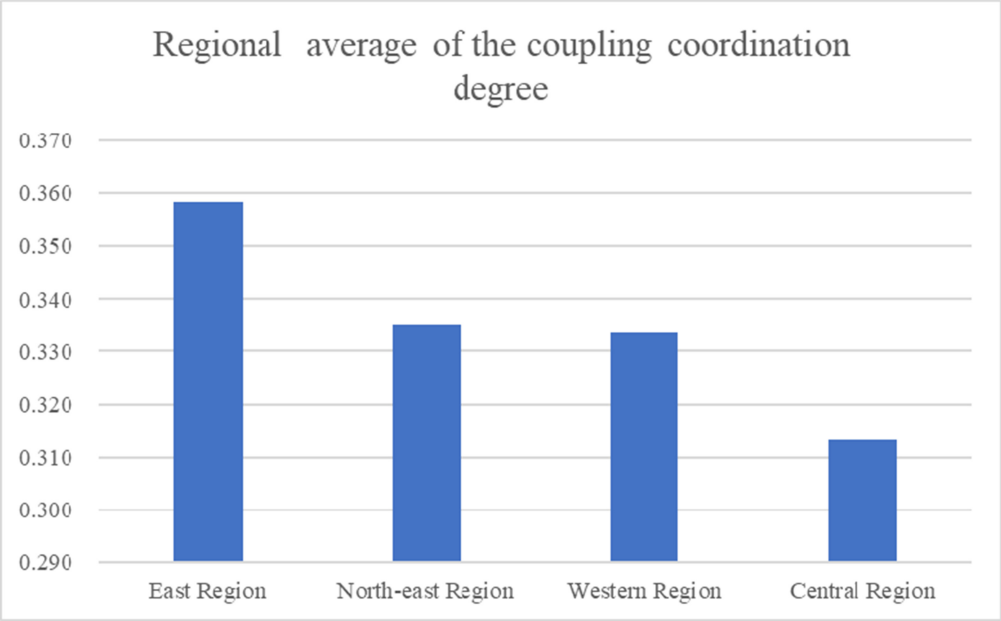

Fig. 2. Regional average of the coupling coordination degree.

role that an organization's resources play in shaping performance and outcomes. In our case, the diverse GRs—financial, technological, and human—demonstrate how variations in these factors can significantly influence CE with OGD. However, our findings also reveal an important distinction from previous studies. While prior research often focuses on the direct impact of resources on performance [Kozlenkova et al. 2014b; Zhang and Li 2024], our study highlights the necessity of resource availability and coordination between these resources and public engagement in achieving successful outcomes. The analysis of 337 municipalities within China was conducted to discern the reciprocal influences and the degree of public engagement. Our results indicate a *paradox where a stark imbalance exists in their coordination despite a robust interplay between the government's offerings and citizen interaction with OGD*. This misalignment is primarily attributed to the relatively slower progression of citizen involvement with OGD compared to the pace at which GRs are made available in most of these municipalities.

This finding aligns with and contributes to the growing body of literature on CE in the context of OGD, as explored in previous research [Lind and Arndt 2016; Tassabehji et al. 2016], and further reinforces the importance of CE within government data initiatives. However, our study goes a step further by *emphasizing the mutual dependency between governmental provisions and CE*, which is often overlooked in previous research. The equilibrium of data provisioning and utilization has garnered academic curiosity but remains underexplored in the empirical literature. By addressing this gap, our study constructs a model articulating the spectrum of government resources and employs a novel coupling coordination analysis within the context of OGD. Methodologically, we pioneer the integration of a CCM for the domain of OGD, setting a precedent for subsequent empirical assessments.

In synthesizing the insights from the spatial variability of the coupling coordination degree across Chinese provinces, we arrive at a nuanced understanding of the multi-faceted relationship between government resource allocation and CE [Zhang and Janssen 2022; Zhang et al. 2024]. Our comprehensive analysis confirms the existence of pronounced spatial disparities that hold significant implications for regional development policies. These disparities echo the findings of Janssen and Zuiderwijk [2014], who also noted significant variations in OGD implementation across regions, specifically in terms of digital infrastructure and local governance capaci-

ties. In addition to these factors, our study identifies the role of regional economic development and the maturity of public service delivery systems as additional influences on OGD effectiveness. For instance, regions with more advanced economic structures and well-established public services, such as those found in coastal cities, demonstrate higher coordination levels, whereas less developed regions lag behind. Our study builds on their work by providing a more in-depth analysis of the coupling coordination between government resources and public engagement, adding a quantitative dimension to the discourse.

However, it is important to position our study within the global OGD landscape. In the United States, OGD initiatives such as Data.gov emphasize transparency and citizen participation, aiming to engage citizens through easy access to data [Zuiderwijk and Janssen 2013]. Similarly, South Korea has made significant strides in integrating OGD into governance, particularly through the implementation of "smart city" initiatives, which prioritize technological innovation alongside CE [W. Zhou and Xiang 2019]. In contrast, China's OGD initiatives are shaped by unique political, economic, and cultural factors. For example, while the East Region of China boasts high coordination between government resources and CE due to advanced infrastructure and economic resources, the Central and Western regions face challenges related to slower economic development and infrastructural deficits, which directly impact the effectiveness of OGD initiatives.

The variability in government-citizen coordination across regions in China underscores similarities to global OGD practices observed in other countries, particularly regarding the disparities between urban and rural or economically advanced and developing areas. For instance, the differences between Shanghai and Shaanxi mirror the global divide between high-income, technologically advanced countries and regions still grappling with resource limitations. Our findings provide evidence for the argument [Berrone et al. 2016; McBride et al. 2019] that successful *OGD implementation requires more than just the availability of resources; it demands that those resources be strategically aligned with public engagement efforts.*

At the forefront of this regional evaluation, Shanghai's impressive average of 0.546, followed closely by Beijing's 0.515, exemplifies the epitome of synergy between governmental actions and citizen involvement. These figures reflect the success of China's key metropolitan hubs in harmonizing policy implementation with public participation, driven by their advanced infrastructural capabilities and mature public governance models [B. Fan and Pan 2023; Y. Tang and Li 2024]. The moderate coordination degrees observed in Zhejiang and Guizhou, with averages of 0.413 and 0.400, respectively, suggest that strong economic governance coupled with a culture receptive to innovation can substantially contribute to balanced regional development. This middle ground indicates a promising stage where policy and participation begin to coalesce more effectively.

Tianjin and Guangdong present a progressive but incomplete integration narrative, with their respective averages signaling a transition towards enhanced government-citizen coordination [B. Liu and Wei 2023; Y. Zheng et al. 2023]. Similarly, Shandong, Guangxi, and Jiangsu, with their slightly higher coordination degrees, are indicative of regions on the cusp of achieving a more seamless interface between administrative provisions and the populace's engagement. On the other hand, the lower coordination degrees in Henan and Shaanxi highlight critical gaps in this relationship, necessitating tailored policy interventions to foster a more robust public-sector partnership.

Our study's regional coordination contrasts with the observations of Tassabehji et al. [2016], who also identified significant regional variability in governmental digital initiatives. *Our findings contribute to this literature by these variabilities and show that they significantly impact the efficacy of OGD-related policies.* The contrasts unveiled through this study underscore the critical need for a policy approach, that is, as varied and dynamic as the provinces themselves. A one-size-fits-all policy is insufficient; a nuanced, localized strategy considering each province's unique socio-economic context is paramount. By acknowledging and addressing these differences, we can aspire to elevate the overall quality of governance and citizen participation across the nation.

Moreover, our use of RBT as a theoretical framework provides a valuable lens through which to understand these disparities. By framing GRs as key assets in shaping CE, RBT helps explain why regions with more developed resources (e.g., Shanghai and Beijing) demonstrate higher degrees of coordination while less developed

regions lag behind. Fostering a more coordinated coupling between government resources and CE requires an intricate blend of policy innovation, infrastructural development, and cultural adaptation [Wirtz et al. 2023; Zhang et al. 2024]. Such an approach would bridge the current divides and fortify the foundation for a prosperous future. Thus, the discourse generated by this article should serve as a catalyst for further academic exploration and a guide for the strategic policy-making that will drive China towards a more harmonious and integrated societal development.

This study provided an insightful comparative analysis of the degree of coupling coordination across China's four major regions—East, Northeast, Western, and Central. The findings reveal significant regional disparities in the interaction between government resource allocation and CE. Our findings confirm the suggestion of [B. Liu and Wei 2023; Wirtz et al. 2023] that *variations underscore the influence of economic development, urbanization, technological advancements, and cultural diversity on the effectiveness of governance and public participation.* The East Region, characterized by its developed economy and high urbanization, leads to coupling coordination. This suggests that areas with advanced infrastructures and strong economic foundations are better positioned to foster productive government-citizen interactions. Conversely, the Central Region, which lags in these areas, demonstrates the lowest coordination degree, indicating that economic and infrastructural development are critical to enhancing participatory governance [Z. Fan et al. 2023; Gao et al. 2023].

Despite facing distinct challenges such as industrial restructuring and geographical expansiveness, the North-east and Western Regions show promising degrees of coordination. This indicates that even amidst economic transitions and cultural diversity, effective strategies can still promote a high level of government-public synergy [Benmohamed et al. 2024; B. Fan and Pan 2023]. *The cross-regional analysis not only highlights the necessity for region-specific policies to address unique challenges but also suggests that regions can benefit from adopting best practices from one another.* For instance, the adaptive strategies employed in the North-east during its industrial restructuring could offer valuable lessons for the Central Region.

Finally, fostering effective governance and robust CE requires a nuanced understanding of regional dynamics and a commitment to addressing each region's specific needs and challenges. China can aspire to a more balanced and inclusive national development trajectory by focusing on tailored, dynamic policy-making and encouraging inter-regional learning [Mu and Zhao 2024; Zhang et al. 2024]. As we have done in this study, incorporating more comparative analyses between different regions and their respective resource allocations allows for a more robust understanding of how RBT can be applied in varying contexts.

Future research can continue to build on this foundation by integrating global data and examining the international applicability of these findings. Future research is also recommended to explore the qualitative aspects of government-public interactions and the role of policy frameworks in enhancing or impeding these interactions. Furthermore, longitudinal studies could offer insights into the dynamic changes in coordination over time, especially in response to policy interventions.

6 Conclusions and Research Directions

The research offers a critical analysis of the coordination between GRs and CE with OGD across China. Our findings highlight the imperative for refined policy-making that aligns GRs with CE to enhance the effectiveness of OGD initiatives. Through a detailed examination of 337 municipalities, we identified significant regional disparities that affect the success of these initiatives. Specifically, regions with advanced infrastructure and robust economic foundations, such as Shanghai and Beijing, demonstrate higher levels of coordination, likely due to the availability of substantial financial resources, advanced technological infrastructure, and a highly skilled workforce. These resources facilitate productive interactions between governments and citizens. In contrast, economically and infrastructurally underdeveloped areas, particularly in the Central Region, show lower levels of coordination. This is primarily due to limited technological resources, insufficient financial investment in OGD initiatives, and lower public data literacy levels. These disparities underscore the need for targeted policies that

invest in technological and financial resources and focus on enhancing data literacy and public awareness to bridge these developmental gaps.

Our study contributes to the growing body of research on OGD by highlighting the need for alignment between resources and public engagement, which is often underexplored in previous studies. This finding is in line with similar research conducted in other countries, such as the United States and South Korea, which also emphasize the importance of strategic coordination between government actions and citizen participation [W. Zhou and Xiang 2019; Zuiderwijk and Janssen 2013]. However, our study's unique contribution lies in its application of RBT, which helps explain how resource availability and coordination affect OGD initiatives.

Our comparative analysis of regional variations in resource allocation and CE, guided by RBT, enhances the understanding of how resource capabilities affect OGD outcomes in diverse contexts. The findings underscore the importance of considering China's unique political, economic, and technological context when designing policies, and how these factors might differ from those in more developed countries. This adds new insights to the global OGD landscape and calls for a deeper understanding of the local factors that shape OGD practices globally.

Future research should build upon these findings by integrating global datasets to assess the international applicability of these observations. Additionally, future studies should explore qualitative dimensions of government-citizen interactions, particularly how policy frameworks facilitate or hinder these interactions. Longitudinal research could also yield valuable insights into how coordination evolves over time in response to policy interventions, offering a dynamic perspective on the sustainability and impact of OGD initiatives. Furthermore, cross-national studies could provide deeper insights into the differences and similarities in OGD coordination practices across various political, cultural, and economic contexts.

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