Original Paper

Study on the Effect of Regional Water Pollution—Take Huaxi River in Chongqing as an Example

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Abstract

Water pollution management plays a crucial role in China's ecological environment development. It has evolved from being solely the responsibility of the government to a collaborative effort involving multiple entities. This paper presents findings from a field survey conducted around the collaborative capacity and effectiveness of wastewater treatment in Huaxi River, Chongqing. The study collected 427 valid questionnaires and employed SPSS26.0 software and AMOS24.0 software, utilizing structural equation modelling and regression analysis to verify the relationship between the variables. The results highlight that synergy mechanism acts as a mediating variable between synergy capability and synergy governance effect, underscoring the role of mechanism in the relationship between capability and governance effect. The conclusion emphasizes the importance of enhancing synergistic capacity and synergistic mechanism to effectively promote synergistic governance effect in the water pollution management of Huaxi River in Chongqing. This can be achieved by improving the abilities of multiple stakeholders in managing water pollution, enhancing cooperation among parties, and encouraging participation of social organizations, the public, and enterprises in the management process to achieve sustainable development of ecological civilization.

Keywords

synergistic capability, synergistic mechanism, governance effect

1. Introduction

The issue of water pollution in China has become increasingly severe with the country's economic growth and development over the past decades, posing unprecedented challenges for the Chinese government in environmental control. Recognizing the urgency of addressing this issue, the Fifth Plenary Session of the 19th CPC Central Committee released a report on the long-term plan for 2035, outlining goals for economic, social, and ecological development during the 14th Five-Year Plan period, which emphasized the need to promote green and low-carbon development, increase environmental pollution control, and build a new path of ecological and environmental protection. The 20th National Congress of the Communist Party of China further emphasized the importance of strengthening the development of green ecology and promoting the harmonious coexistence of humans and nature, reflecting the Party's commitment to ecological civilization construction and sustainable development. Water pollution control has gained prominence both globally and domestically, and the Chongqing Municipal Government has also issued policy plans for environmental governance, such as the "Chongqing Municipal Implementation Plan for Building a Modern Environmental Governance System" and the "Chongqing Municipal Water Pollution Environmental Protection 14th Five-Year Plan (2021-2025)". In the context of rapid economic development and urbanization, water pollution has become a pressing issue faced by many regions, including Chongqing in southwestern China. Huaxi River in Banan District is a key water body for governance in Chongqing, but its water quality is affected by various factors, posing challenges in its management. Synergistic governance, involving cooperation among government, enterprises, social organizations, and residents, is recognized as an important approach to water pollution control, aiming to establish an effective governance mechanism and jointly promote the improvement of water environment. However, there are challenges in the operation of synergistic mechanisms, including insufficient synergistic capability, limited information sharing, and unclear responsibility definition, which can result in poor synergistic governance effects.

Therefore, the objective of this paper is to investigate the relationship between the effectiveness of collaborative water pollution management and the synergistic capacity of Huaxi River in Banan District, Chongqing. Additionally, the study will analyze the role of the collaborative management mechanism with the synergistic mechanism as a mediating variable. The research methodology will involve field observation and a questionnaire survey of Huaxi River in Banan District. The collected data will be analyzed using structural equation modeling, with the aim of providing theoretical support and practical guidance for advancing water pollution management in Huaxi River and offering insights for other areas as well.

2.Theory and Hypotheses

2.1 Theory

The German scholar Haken first proposed the theory of collaboration in the 1970s, and was introduced into the scope of public administration by a Harvard student in 2004, resulting in the concept of "collaborative governance". At present, international scholars have combined the theory and practice of collaboration with their actual situation. It is more discussed from the perspective of collaborative governance of multiple subjects and ecological environments. Rosinau compared the different management methods used in each region and pointed out that management emphasizes participation, cooperation, and interaction, and pointed out at the macro, meso, and micro levels that government management should integrate multiple elements such as society, market and citizens in the management process, and pointed out that the traditional management methods have been eliminated in the management process, and multiple subjects should be integrated. In 1962, Rachel proposed the first link between public behavior and ecological pollution from an ecological point of view, arguing that the cooperation of the government, the public, and enterprises was needed to promote ecological management. Tomas Koontz, from the perspective of collaborative management, suggested that although the government has carried out collaborative management mechanisms in environmental governance, the process lacks relatively strict management, public trust, and too "fragmented" management, which reduces the role of the government itself in collaborative governance. China has a vast river basin, and each region has certain water pollution problems. The key force in promoting ecological environmental governance is the initial motivation for public participation in river basin ecological environmental governance, but current research shows that public participation in basin environmental governance is generally not very enthusiastic. Zhao Laijun et al. linked the poorly connected characteristics of rivers in China and constructed a corresponding mathematical model in terms of administration, taxation, and emissions trading, and based on this comparison, they proposed an efficient pollution control model, which they believed should be compatible with the reality of the target to be examined for pollution to be effectively controlled. Zhang Guoxing et al. constructed a differential game model of the cooperative relationship in water pollution management and concluded that improving the compensation mechanism could promote the remediation of water pollution in the watershed. Xu Le et al. found that although government environmental regulation in watershed water pollution management produced significant environmental regulation effects, the effect with the presentation of the public's desired environmental demand was different. Yang et al. used a tripartite evolutionary game mechanism to propose that the cost of upstream pollution control could be financially compensated by downstream areas, thus promoting the control of water pollution in the basin. Shu Li et al. studied the establishment of the river chief system which played a significant role in promoting water pollution in regional watersheds.

Domestic and foreign scholars have conducted research through the use of collaborative governance in terms of subject structure, model construction, and river chief system, and then concluded that watershed water pollution occupies a large part of China's ecological and environmental problems. With the

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development of time and technology, the application of collaborative governance to watershed water pollution remediation can obtain obvious results, but there is no shortage of problems in the process of governance. Water pollution management is a complex and huge project, but because of the differences among the government, enterprises, and the public in the governance system, psychological cognition, value recognition, interest relations, and other influencing factors, lead to difficulty in forming effective collaborative governance in water pollution mechanism, and then, in turn, hinders the energy efficiency of environmental governance. Therefore, taking the Huaxi River in Chongqing as an example, this paper explores in depth the relationship between the effect of collaborative water pollution management and the ability of synergy from the perspective of synergy mechanism and realizes the practical path of collaborative management of multiple subjects.

2.2 Hypothesis

2.2.1 Co-governance Effect and Synergistic Mechanism

The effect of collaborative water pollution management is inextricably linked to the synergistic mechanism and the synergistic capacity. The initial condition for forming a collaborative mechanism is that the mechanism is led by the government and involves multiple parties from the public and enterprises, around the Huaxi River water pollution situation to develop a reasonable synergistic mechanism aims to make a consensus between the synergistic ability, and then can be more appropriate around the water pollution management of complete communication, which is an effective communication tool between the government and the synergistic ability. The impact of synergistic mechanisms on the synergistic governance effect can be analyzed from the following two aspects: firstly, from the perspective of resource information sharing. The establishment of a trust mechanism can maximize the public value of data resources and promote the effectiveness of the government to be able to be further enhanced with the joint participation of multiple subjects in governance. It also makes a reasonable interaction between the internal operation and information of the government and the demands citizens and enterprises want to express among themselves, thus making the occurrence of benign collaborative governance effect. Secondly, the synergistic capacity efficiency perspective. Existing data shows that Zhang Tongbin et al. found that public participation can improve the quality of environmental governance, and good institutional supply and full trust in the government are important prerequisites that can enhance the enthusiasm and willingness of the public to participate in environmental governance. Therefore, this paper proposes the hypothesis that:

H1: There is a positive effect between the synergistic governance effect and the synergistic mechanism.

2.2.2 Co-governance Effect and Synergy Ability

The research on synergistic capability is mainly conducted from two aspects. One is to explore how to innovate synergistic capability; the other is to explain how to optimize the path of improving synergistic capability. From the perspective of innovating synergistic capability, improving synergistic capability is not simply absorbing external resources, but a process of absorbing various resources and combining them with one's situation and dynamically adjusting them, gradually developing into a capability suitable

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for oneself, and then innovating. That is innovation in the process of absorbing internal and external resources. Promoting the advantageous convergence and complementarity among various synergistic capabilities is a necessary condition for the innovation of synergistic capabilities, and the innovation of synergistic capabilities ultimately affects the good or bad effect of synergistic governance. In other words, enhancing the collaborative innovation capability is inseparable from the technique of acquiring external knowledge by the collaborative capability itself and integrating the knowledge with its situation. On the other hand, expanding the communication platform of synergistic capability can supplement the synergistic capability, while improving the synergistic system can effectively enhance the synergistic innovation capability to achieve path optimization. For innovation of synergistic capabilities, it is a dynamic process that needs to be carried out in continuous learning and assimilation of new knowledge. If this process is to be carried out smoothly, it needs to be complemented by a good supply of synergistic policies and an expanded communication platform for synergistic capabilities. That's the only way to achieve significant breakthroughs.

The influence of synergy capability on the effectiveness of synergy governance is related to the aspects of the synergy policy system and performance management. In terms of the synergy system, by positioning collaborative capabilities, improving collaborative mechanisms, and enhancing collaborative capabilities, a highly satisfactory collaborative governance effect can be achieved. Determining the goal of collaborative governance, constructing the framework of the collaborative model, and driving the improvement of collaborative capacity, the more perfect the collaborative policy system is, the more the collaborative capacity will be gradually improved and finally shows close to the ideal collaborative effect. At the same time, the improvement for modernization of governmental governance capacity can also promote the progress of synergistic governance. And the optimization of performance incentives can also be the part that can affect the synergistic ability and governance effect. Zhao Li and other scholars collected relevant panel data for theoretical and empirical analysis and found that the performance of government officials is closely related to the effect of environmental governance. The better the governance effect, the faster the promotion of officials, which in turn promotes the effectiveness of environmental governance again. Goncharuk's research also found that performance incentives for personnel can help improve the presentation of synergistic capability and results. Based on this, this paper proposes a hypothesis.

H2: There is a positive effect between synergistic governance effectiveness and synergistic capacity.

2.2.3 Synergy Mechanism and Synergy Capability

The establishment of synergistic mechanisms is an ongoing process, and Willem et al. pointed out that interdependence caused by organizational relationships and the need for and sharing of knowledge can influence the functioning of synergistic mechanisms, while the goodness of synergistic mechanisms can affect the synergistic capabilities. Yu Yingxiang et al. established a collaborative mechanism that is different from the traditional collaborative mechanism and formed with the support of information technology from the perspective of blockchain decentralization. Where the trust mechanism established

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by technological means can facilitate the realization of collaborative governance, and in the process also accelerate the progress of collaborative capabilities. The traditional and conservative system has long been unsuitable for the development and needs of the times, and it is also impeding the communication between subjects and inhibiting the development of synergistic ability in disguise. Völter and other scholars proposed creating an information resource-sharing platform through digital technology, which can help the synergistic ability to play. The synergistic mechanism is a bridge for effective communication between subjects, which can stimulate the enthusiasm and volunteerism of synergistic ability itself, and the ability of synergistic ability can also be demonstrated under the synergistic mechanism. Accordingly, this paper proposes the hypothesis that:

H3: There is a positive effect of synergistic mechanism and synergistic capability.

2.2.4 The Role of synergistic Mechanism in Synergistic Governance Effectiveness and Synergistic Capability

Collaborative governance capability affects the effectiveness of collaborative governance through the establishment and improvement of resource information sharing and incentive mechanisms, The more perfect the collaborative mechanism, the higher the collaborative ability, therefore the better the presented collaborative governance effect, and the better the collaborative governance effect, it can again improve the collaborative ability to expand the exchange platform of resource sharing and form a virtuous circle. The better the synergy mechanism is, the more it can stimulate the synergy ability and therefore the better the synergistic governance effect can be. Relevant literature shows that a synergistic mechanism is an essential part of collaborative governance, which accelerates the interaction between different subjects and departments, promotes the integration of resources among subjects, and brings out the efficiency of inter-subject capabilities. Accordingly, this paper proposes the hypothesis that:

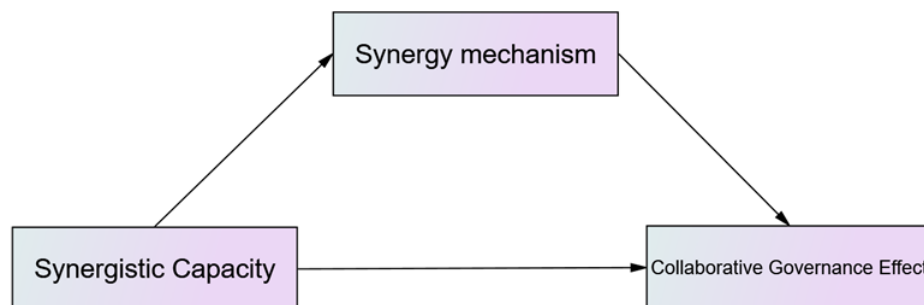H4: Synergistic mechanism plays a mediating role in synergistic governance effectiveness and synergistic capacity.

Figure 1. The Theoretical Model

3. Study Design and Data Analysis

3.1 Study Sample

This paper uses questionnaire surveys to collect data from the government of Banan District, Chongqing, enterprises, and social organizations around the Huaxi River, the public involved in the management of the Huaxi River, have their personal experience of water pollution management in the Huaxi River basin. The respondents were asked to evaluate the effectiveness of the collaborative water pollution management system, the collaborative system, and the collaborative capacity. A total of 467 questionnaires were distributed, of which 40 were invalid, with an effective rate of 91.4%.

Table 1. Table of Survey Respondents

Variable	Sample characteristics	Number of People	Scale
Sexual Distinction	Male	199	46.6%
	Female	228	53.4%
Age	Age 20 and below	80	18.7%
	21-35 Years old	91	21.3%
	36-55 Years old	173	40.5%
	Age 56 and over	83	19.4%
Degree of Education	Specialist and below	101	16.6%
	College Degree	121	19%
	Bachelor Degree	170	37.5%
	Master Degree Candidate	29	13.8%
	Doctoral Candidate	6	13.1%
Vocation	Peasant	37	8.7%
	Student	57	13.3%
	Enterprise personnel	113	26.5%
	Individuals	35	8.2%
	Public officer	94	22%
	Retired people	39	9.1%
	Other	52	12.2%

3.2 Definition and Dimensional Division of Variables

To ensure the reliability and validity of the measurement, this paper uses scales that have been used and are more mature at home and abroad, retaining the question items that can be used and modifying them on this basis according to the actual situation. The scale of synergistic ability is mainly from Tsang et al., Cousins and Menguc and Teec, and Chan, etc. The scale of synergistic ability has 11 items after validation

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analysis; the scale of synergistic mechanism is mainly from Tsai, Xie Xuemei and Willem and Buelens, had a total of 10 items after validation analysis; the synergistic governance effect had a total of 4 items. All of the above question items were measured on a Likert 5 scale, with 1 indicating strongly disagree, 2 disagree, 3 not necessarily, 4 agree, and 5 strongly agree.

3.3 Reliability Test and Analysis

The reliability coefficients of each variable of the species in this paper were tested for reliability using SPSS 26.0 and AMOS 24.0. The standard loadings, Cronbach alpha coefficient, combined reliability (CR), and average variance extracted (AVE) for each factor are shown in Table 2. The alpha reliability coefficients of synergistic ability are 0.918. The alpha reliability coefficients of the synergistic mechanism are 0.833, 0.772, and 0.796 for the three dimensions of policy regulation mechanism, communication and consultation mechanism, and assessment and evaluation mechanism, respectively, and the alpha reliability coefficient of the synergistic mechanism as a whole is 0.776; the alpha reliability coefficient of synergistic governance effect is 0.841. As can be seen from Table 2, the standard loadings are greater than 0.4, which indicates that the scale has a strong correlation; Cronbach α coefficient and combined reliability (CR value) are greater than 0.7, which indicates that the scale has good reliability and high convergent validity with good consistency; the average variance extracted (AVE) of the scale is greater than 0.5, which indicates the scale has good convergent validity.

Table 2. Standardized Loadings, Cronbach Alpha Coefficients, CR and AVE Values for Each Factor (N=427)

Variable	Measure Item	Standard Load	Cronbach α	CR	AVE
Synergistic Capabilities	A1	0.789			
	A2	0.702			
	A3	0.815			
	A4	0.725			
	A5	0.734			
	A6	0.687	0.918	0.925	0.529
	A7	0.737			
	A8	0.691			
	A9	0.676			
	A10	0.706			
	A11	0.729			
Synergy Mechanism	C1	0.818			
	C2	0.813			
	C3	0.760	0.776	0.946	0.638
	C4	0.765			
	C5	0.823			

	C6	0.782			
	C7	0.822			
	C8	0.823			
	C9	0.771			
	C10	0.812			
Synergistic Governance Effect	D1	0.768	0.841	0.895	0.605
	D2	0.800			
	D3	0.740			
	D4	0.803			

Table 3. Mean, Standard Deviation and Correlation Matrix of Variables (N=427)

	1	2	3	4	5	6	7
Synergistic Capabilities	1						
Synergy Mechanism	.367**	1					
Synergistic Governance Effect	.323**	.509**	1				
Age	0.047	0.012	-0.01	1			
Degree of Education	-0.093	-0.042	-0.026	-.134**	1		
Sexual Distinction	0.01	0.042	0.025	0.05	0.018	1	
Vocation	0.076	.096*	.108*	-0.013	0.03	0.027	1
Mean Value	3.7004	3.3618	3.4959	2.6066	2.8782	1.534	3.9766
Standard Deviation	0.85884	0.71962	1.01434	1.00223	1.2273	0.49943	1.8075

** At the 0.01 level (two-tailed), the correlation was significant

* At the 0.01 level (two-tailed), the correlation was significant

3.4 Hypothesis Test

After analyzing the reliability and validity of each of the above scales and the validation factors, it can be seen that the reliability test in this paper is at an acceptable level, and the correlation of each variable, as well as the mean and standard deviation, are shown in Table 3, which shows that there is a significant correlation between synergistic capacity, synergistic mechanism, and synergistic governance effect, and a preliminary test of the hypothesis. To make the hypothesis have a clearer result, this paper uses the cascade regression analysis method to test the hypothesis based on the mediating variable test method proposed by Baron and Kenny. Firstly, the first step tests whether synergy competence has a positive and significant effect on synergy mechanism; secondly, the second step tests whether synergy competence has a positive and significant effect on synergy governance effect; secondly, the third step tests whether synergy mechanism has a positive and significant effect on synergy governance effect; finally, the fourth

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step tests whether the effect of synergy competence and synergy mechanism together on synergy governance effect is significant and if it is found that the effect of synergy competence on If it is found that the effect of synergistic ability on the effect of collaborative governance is weakened or no longer significant, then it indicates that the synergistic mechanism has reached the mediating effect, and the specific results are shown in Table 4:

Table 4. Mediating Effect of Synergy Mechanism on Synergy Capacity and Synergy Governance Effect (N=427)

	Model 1	Model 2	Model 3	Model 4
	Synergy Mechanism		Synergistic Governance Effect	
(Constant)	2.088***	1.932***	1.035***	0.618*
Age	-0.006	-0.026	-0.017	-0.022
Degree of Education	-0.008	-0.002	-0.007	0.002
Sexual Distinction	0.055	0.043	0.007	0.009
Vocation	0.027	0.047	0.034	0.03
Synergistic Capabilities	0.303***	0.375***	/	0.184***
Synergy Mechanism	/	/	0.709***	0.629***
R^2	0.141	0.112	0.263	0.284
ΔR^2	0.128	0.099	0.249	0.171
F	13.849***	10.653***	30.002***	27.705***
ΔF	62.871***	46.072***	142.436***	12.221***

From the test in Table 2, it can be seen that the control variables in the three models do not have much influence on the effect of collaborative governance. From model 1, we can get that synergistic capability has a positive and significant effect on the synergistic mechanism ($\beta=0.303$, $p<0.01$). Therefore hypothesis 3 holds; model 2 tested that synergistic capability has a positive and significant effect on synergistic governance effect ($\beta=0.375$, $p<0.01$), hypothesis 1 holds; Second, Model 3, on the other hand, tests that the effect of collaborative governance mechanisms on the effect of collaborative governance is positively and significantly related ($\beta=0.709$, $p<0.01$), and therefore the Hypothesis 2 holds. As shown in Model 3, there is a significant effect of synergistic capability and synergistic mechanism in the effect of synergistic governance ($\beta=0.184$, $p<0.01$; $\beta=0.629$, $p<0.01$), thus synergistic mechanism has a mediating role between synergistic capability and synergistic governance effect, and Hypothesis 4 is further supported. To fully validate the mediating role played by synergistic mechanisms in the synergistic capacity and synergistic governance effects, the research design of Preacher & Hayes (2008)

was used in this paper to analyze mediating variables. The method employs the Bootstrap (5000) technique to verify the statistical significance of the mediating effect by generating multiple samples. The Bootstrap technique is a computational method used to estimate the precision of statistical model parameters and allows statistical inference without relying on the data distribution. In this method, we will generate 5000 samples, each of the samples is randomly selected from the original data, and by repeatedly sampling and calculating these samples, confidence intervals and p-values for the mediation effects can be obtained. Therefore, this method is a reliable way to analyze mediating variables and can help us to assess the impact of mediating effects more accurately. In this paper, we use the Bootstrap method to analyze the mediating effect of the synergistic mechanism between synergistic ability and synergistic governance effect by using 5000 repetitive samples, constructing 95% bias-corrected confidence intervals, and using PROCESS to obtain the direct mediating effect and profile mediating effect under different values of The direct mediating effect and the profile mediating effect of synergistic ability through the synergistic system were 0.186 (CI=[0.083,0.288]), the indirect effect was 0.166 (CI=[0.119,0.214]), and the confidence intervals did not contain zero, indicating that the direct and indirect effects of synergistic ability through the synergistic system on synergistic governance effect were significant. Indirect effects are significant. Therefore, hypothesis 4 that the synergistic system plays a mediating effect between synergistic capability and synergistic governance effect is supported, as shown in Table 5:

Table 5. Results of the Bootstraping-analysis of the Mediation Effects

Variable	Direct Effect				Indirect Effect			
	Effect	Standard Error	Confidence Interval		Effect	Standard Error	Confidence Interval	
			Upper Limit	Lower Limit			Upper Limit	Lower Limit
Synergy Mechanism	0.186	0.052	0.288	0.083	0.166	0.024	0.214	0.119

4. Conclusion and Insight

4.1 Research Findings

This paper discusses the influence of the synergy mechanism as a mediating variable on the relationship between synergistic capacity and the effect of synergistic governance. Based on the literature review and theoretical analysis, the following conclusions were obtained by applying the method of stratified regression analysis to the Huaxi River in Chongqing:

It is found that synergistic competence has a positive effect on synergistic governance effect, and there is also a positive effect and significance between synergistic competence and synergistic mechanism. On this basis, the synergistic mechanism also plays the role of mediating the effect between synergistic

competence and synergistic governance effect, which promotes the effect of synergistic competence on synergistic governance effect.

The main contribution of this paper is to introduce synergistic mechanism as a mediating variable into the relationship between synergistic capacity and synergistic governance effect, to explore the influence path of synergistic capacity on synergistic governance effect, to construct a research framework of synergistic capacity on synergistic governance effect and by the role of synergistic mechanism, and to expand the degree of influence of synergistic capacity on synergistic governance effect in water pollution governance.

4.2 Revelation

So far, the importance of collaborative cooperation in water pollution management has been widely recognized, and it is receiving more and more attention. Water pollution control is not just a unilateral matter for the government. The public, social organizations or enterprises should all participate in water pollution control. In the water pollution collaborative governance, many factors play a non-negligible role in governance. The improvement of the collaborative capacity of multiple parties and the improvement of the collaborative mechanism can make the governance effect more perfect and can also build more communication bridges between the government and the public and enterprises, so that all parties can get help, forming a virtuous circle, reducing government costs and also making the development of ecological civilization to a higher level. There may be other mediating variables between the synergistic ability and the synergistic governance effect that affect it, such as the synergistic relationship and the synergistic subject, which may be a direction for future research in this area.

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