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Innovative Pathways for Collaborative Governance in Technology-Driven Smart Communities

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Abstract: This study constructs an analytical framework to assess the effectiveness of collaborative governance in smart communities, focusing on six key elements: collaborative subjects, funding sources, community participants' literacy, community-specific systems, community culture, and supporting facilities. Using fuzzy set qualitative comparative analysis (QCA) on 20 typical cases of community governance, the study identifies that collaborative subjects and supporting facilities are necessary conditions for achieving effective community governance. Community culture and community participants' literacy are recognized as sufficient conditions for effective collaborative governance involving multiple subjects in smart communities. The study also identifies several pathways to enhance the effectiveness of collaborative governance in smart communities, including the subject–culture-embedded pathway, technology–resource-driven pathway, and system–talent-led pathway. These pathways highlight the integration of community-specific cultural elements and the leveraging of modern technologies to foster stakeholder engagement, enhance decision-making processes, and improve service delivery. The findings suggest that robust community culture and literacy, combined with advanced technological infrastructure and diverse funding sources, significantly contribute to the success of collaborative governance initiatives. By providing a comprehensive analysis of the interplay between these factors, the study offers valuable insights into the construction of smart communities and proposes strategies for enhancing the effectiveness of collaborative governance. This research contributes to the broader discourse on sustainable urban development and the knowledge economy, emphasizing the crucial role of innovation, technology, and community engagement in shaping the future of smart cities.



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1. Introduction

Smart communities have gained significant attention in recent years, particularly in China, where the government has actively promoted their development [1]. Since the 20th Party Congress of the Communist Party of China (CPC), innovation in social governance has been elevated to a political level, and numerous pilot smart communities have been launched nationwide [2]. These initiatives have led to the emergence of various smart community models with Chinese characteristics, such as the Dongcheng District in Beijing and the Baibuting Community in Wuhan. The construction of smart communities relies heavily on collaborative governance, which involves the joint efforts of government agencies, social organizations, and citizens to address community issues using digital methods [3]. This collaborative approach is crucial for achieving effective governance

and ensuring the satisfaction of community members. However, the effectiveness of collaborative governance in smart communities is influenced by various factors, including the funding mechanism, stakeholder participation, and digital methods [4].

According to recent statistics, the number of smart communities in China has been steadily increasing [5]. For instance, in May 2022, nine departments, including the Ministry of Civil Affairs and the Central Committee of Political and Legal Affairs, jointly issued the “Opinions on Further Promoting the Construction of Smart Communities”, which emphasized the importance of improving the funding mechanism and encouraging social forces to participate in the development of smart communities. Despite these efforts, there are still significant research gaps in the literature regarding the effectiveness of collaborative governance in smart communities [6,7]. Existing research has primarily focused on the technical aspects of smart community development, such as the integration of Internet of Things (IoT) technologies and data analytics. However, more comprehensive studies need to be conducted that examine the collaborative governance aspects of smart communities, particularly in the Chinese context [8,9]. This study aims to fill these gaps by analyzing the effectiveness of collaborative governance in smart communities and identifying the key factors that influence its effectiveness. The research objectives of this study are threefold: first, to identify the factors that affect the effectiveness of collaborative governance in smart communities; second, to determine the primary and secondary degrees of these factors; and third, to propose an effective path for collaborative governance in smart communities. By achieving these objectives, this study aims to provide valuable insights into the construction of smart communities and explore the effective governance of grassroots communities.

The structure of this paper is as follows: Section 2 will provide a detailed literature review of existing research on collaborative governance in smart communities, followed by Sections 3 and 4 that outlines the research design and methods used in this study. Section 5 will present the findings of the study, and Section 6 will analyze the implications of these findings. Finally, Section 7 will summarize the key findings and recommendations for future research.

2. Literature Review

The evolution and governance of smart communities involve integrating digital technologies to enhance community services, ranging from personalized services to crisis management. The concept, which began with IBM’s introduction in 2009, emphasizes collaborative governance models like the Bryson model and public–private partnerships to achieve synergy among stakeholders. Despite their potential, smart community governance faces challenges such as the need for more quantitative research, clear definitions, and integrating technology with governance processes. Digital technology has significantly impacted community governance by enhancing citizen engagement, enabling data-driven decision-making, and improving stakeholder integration. However, it also presents challenges like potential biases and security concerns. Addressing these issues is crucial for the effective development and operation of smart communities.

2.1. Evolution and Governance of Smart Communities

The concept of smart communities has evolved significantly since the term “community” was first introduced to China by Mr. Fei Xiaotong in 1933 [10]. With the widespread application of digital technology, smart communities were first introduced in 2009 by IBM based on the concept of “smart city” derived from the “smart world [11]”. This technological advancement has transformed the means of community governance from a single virtual platform to a human-physical system, enabling community services to extend to smart homes, personalized services, crisis warnings, and other aspects. Academics cur-

rently interpret the concept of smart communities from multiple perspectives. From a functional perspective, a smart community is a new community governance model that provides convenient, fast, transparent, and fair public services to community residents [12]. From a technological perspective, a smart community uses information and communication technology to integrate political, economic, social, and cultural resources to form a sustainable community [13]. This paper defines a smart community as a community that uses a new generation of information technology to integrate and coordinate the various elemental resources under the community field, optimize the overall community system, promote the connection and mutual assistance of stakeholders within the smart community, and comprehensively improve the level of community management services to form a sustainable community.

A review of the existing literature and practical examples of effective smart community governance reveals that the importance of collaboration among multiple actors has been emphasized in studies on smart community public services, community aged care, community building, emergency management, and other areas. Scholars have summarized various models of collaborative governance, such as the Bryson model, the six-dimensional synergy model, the public–private partnerships model, the SFIC model, and the integrated model of collaborative governance, in which conditions such as subject thinking, collaborative processes, community-specific systems, monitoring and feedback, and the external environment are constantly emphasized. It is worth noting that too much emphasis on the decisive role of organizations and institutions is prone to falling into the trap of path dependency or the reverse influence of institutions and the environment [14]. Integrating technology with organizations and institutions in both directions has become a breakthrough in the construction of smart communities [15]. The most apparent difference between smart communities and traditional communities lies in the use of digital technology to change and collaborate with multiple subjects to break the confinement brought about by the traditional hierarchy [16]. The use of digital technology to strengthen collaboration within smart communities is an important way to address the public challenges of the new era, and collaborative governance in smart communities aims to enable faster mutual adaptation, mutual recognition, interaction, and decision-making among the various stakeholders involved in community governance and joint problem-solving to achieve a satisfactory governance outcome. The effectiveness of collaborative governance is the key to measuring the effectiveness of smart community governance [17].

In the theory of collaborative advantage, scholars use four elements to evaluate the effectiveness of collaborative governance: collaborative parties working together to solve specific problems, gaining recognition from other organizations or the public, realizing self-worth by collaborative organizations when working together, and achieving unexpected gains. The solution of specific problems by the collaborating parties requires the joint action of various forces and elements within and outside the community [18]. It determines the quality and final effect of the collaboration. The openness and diversity of the subjects in terms of organizational structure and development types, as well as the establishment of a governance order regarding the functions, role positioning, and configuration of powers and responsibilities of the subjects, allow the organizations to trust and recognize each other, thus forming. Scholars have studied various factors that affect the effectiveness of collaborative governance in different dimensions [19].

Regarding subjects, each subject will take the initiative to communicate and be willing to take responsibility for their actions. Each subject has equal rights to deliberate, vote, give feedback, and monitor [20]. The relevant decision-making and management personnel have sufficient capacity and experience, and community workers and residents have the awareness and ability to apply information technology. In terms of conditions, in addition

to government financial allocations, the daily operating revenues of smart communities, as well as external investments, are important guarantees for their construction and operation [21]. The value of synergy can only be realized through specific collaborative systems and technologies, and it is important to promote the positive interaction and effective integration of community system reform processes, top-level design, technical support, and grassroots practices. In terms of environment, good community culture and supporting facilities, which contribute to adequate information sharing, directly affect the collaborative efficiency of community governance and the level of trust between subjects to achieve effective innovation promotion in community governance.

2.2. Challenges and Limitations of Smart Community Governance

Despite its promising potential, the governance of smart communities faces several challenges and limitations that need to be addressed to ensure effective development and operation [22]. These challenges include the need for more quantitative research, the lack of clear definitions of smart governance concepts, and the difficulties in integrating technology with governance processes. One of the significant challenges in smart community governance is the lack of comprehensive quantitative research [23]. Much of the literature is qualitative, focusing on conceptual frameworks and case studies. While these provide valuable insights, they fall short of offering measurable data that can guide policy-making and implementation. Quantitative research is essential to understand the effectiveness of various governance models, identify best practices, and develop standardized metrics for evaluating smart community initiatives [24]. Without robust quantitative data, assessing the real impact of smart community projects and justifying investments in such initiatives becomes challenging.

Another major limitation is the lack of clear and universally accepted definitions of smart governance concepts [25]. Different stakeholders interpret the term “smart community” in various ways, leading to inconsistencies in implementation and evaluation. This ambiguity can hinder the development of coherent strategies and policies, as different interpretations may lead to conflicting priorities and objectives. Establishing clear definitions and frameworks for smart community governance is crucial for aligning the efforts of various stakeholders, including government agencies, private sector partners, and community residents [26]. Integrating technology with governance processes presents its own set of difficulties. While digital technologies offer numerous benefits, such as improved efficiency, transparency, and citizen engagement, their integration into existing governance structures is often met with resistance and technical challenges. Legacy systems, bureaucratic inertia, and a lack of technical expertise can impede the adoption of new technologies [27]. Additionally, issues related to data privacy and security, the digital divide, and the inclusivity of smart technologies need to be carefully managed to ensure that smart community initiatives do not exacerbate existing inequalities or create new forms of exclusion.

Addressing these challenges is vital for the successful development and operation of smart communities [28]. Comprehensive quantitative research will provide the data needed to make informed decisions and measure the impact of smart governance initiatives. Clear definitions and frameworks will ensure consistency and coherence in policy-making and implementation. Finally, overcoming the technical and organizational barriers to integrating technology with governance processes will be essential for realizing the full potential of smart communities. By tackling these challenges, smart communities can enhance their governance capabilities, improve public services, and create more sustainable and inclusive environments for their residents [29].

2.3. Collaborative Governance Models and Frameworks

The governance of smart communities often relies on collaborative models and frameworks that bring together diverse stakeholders to achieve common goals [30]. Several models have been proposed and implemented, each with its own strengths and weaknesses. Notable among these are the Bryson model, the six-dimensional synergy model, the public–private partnerships model, the SFIC model, and the integrated model of collaborative governance. The Bryson model, developed by John Bryson, emphasizes strategic planning and management in public and non-profit organizations [31]. This model advocates for a clear vision, mission, and strategic goals, focusing on stakeholder analysis and engagement. In practice, one of its key strengths is its structured approach to strategic planning, which helps organizations align their resources and actions with their long-term objectives [32]. However, its application can be resource-intensive and not flexible enough to adapt to rapidly changing environments, making it less suitable for the dynamic contexts often encountered in smart communities.

The six-dimensional synergy model focuses on integrating various dimensions of governance to achieve synergy [33]. These dimensions typically include political, economic, social, technological, environmental, and cultural factors. The strength of this model lies in its comprehensive approach, ensuring that all relevant aspects are considered in the governance process [34]. However, in practice, its complexity can be a limitation as it requires extensive coordination and communication among stakeholders, which can be challenging to manage effectively. Balancing these dimensions and achieving effective synergy remains a challenge. Taking China's efforts to deepen environmental governance as an example, although the aim is to achieve sustainable development by integrating these dimensions, there are still some inherent organizational and institutional issues, including strategic conflicts between different government departments. This indicates that when pursuing more effective environmental governance, it is necessary to understand the actual strategic interactions between different government departments, which is crucial for the implementation of cross-departmental coordination in practical projects.

Public–private partnerships (PPPs) represent another collaborative governance model that leverages the strengths of both the public and private sectors [35]. To address community needs, PPPs can bring together government resources and private sector efficiency. This model is particularly effective in infrastructure development and service delivery. Its main advantage is the ability to mobilize additional resources and expertise. However, PPPs can also face challenges related to the alignment of objectives between public and private partners, potential conflicts of interest, and ensuring accountability and transparency.

The SFIC (stakeholder, forum, information, and commitment) model emphasizes the role of stakeholders in collaborative governance [36]. It highlights the importance of creating forums for dialog, sharing information, and building commitment among participants. This model is valuable for fostering inclusive participation and ensuring that diverse perspectives are considered in decision-making. Nevertheless, it can be time-consuming to establish effective forums and maintain active engagement, particularly in large or fragmented communities [37].

The integrated model of collaborative governance seeks to combine elements from various models to create a more adaptable and holistic framework [38]. This model integrates strategic planning, synergy, public–private partnerships, and stakeholder engagement to address the complexities of smart community governance. Its strength lies in its flexibility and ability to incorporate multiple perspectives, making it suitable for a wide range of contexts. However, the challenge is to balance and manage the diverse elements effectively, which requires strong leadership and coordination [39].

Other theoretical models may not be as comprehensive or applicable in certain aspects, or they may fail to provide sufficient details to address specific issues in research. For example, game theory analyzes the decision-making processes of individuals or groups in strategic situations. Although game theory can help understand competition and cooperation in some cases, it may not fully consider non-strategic factors such as culture, history, and social capital in the collaborative governance of smart communities. Taylor's scientific management theory emphasizes the maximization of efficiency and productivity. These theories may not adapt to the complexity of collaborative governance in smart communities because they typically do not involve the participation and collaboration of multiple stakeholders.

Therefore, a comprehensive and adaptable framework that encompasses multiple perspectives is essential for effective smart community governance. In analyzing these models, it is evident that each has its own strengths and weaknesses. The Bryson model's structured approach can provide clear direction but may lack flexibility. The comprehensiveness of the six-dimensional synergy model may be difficult to achieve. PPPs offer resource mobilization but may struggle with alignment and transparency. The SFIC model is inclusive but can be time-consuming. The integrated model offers adaptability but requires careful balancing of diverse elements. Such a framework should leverage the strengths of each model while mitigating their weaknesses, ensuring that governance processes are robust and flexible to meet the evolving needs of smart communities [40].

2.4. Impact of Digital Technology on Community Governance

Digital technology has profoundly impacted community governance, revolutionizing the way communities engage with their citizens, make decisions, and integrate various stakeholders [41]. Information and communication technologies (ICTs) have enhanced citizen engagement, facilitated data-driven decision-making, and improved the integration of diverse stakeholders, transforming traditional governance models.

One of the most significant impacts of digital technology on community governance is the enhancement of citizen engagement [42]. ICTs enable communities to interact with residents through online platforms, social media, and mobile applications. These tools allow for real-time communication, feedback, and participation in decision-making processes. For instance, online surveys, public forums, and digital voting systems provide citizens with convenient and accessible means to voice their opinions and contribute to community development [43]. This increased engagement fosters a sense of ownership and responsibility among citizens, leading to more inclusive and democratic governance.

Data-driven decision-making is another critical impact of digital technology on community governance [44]. The availability of big data and advanced analytics tools allows community leaders to gather, process, and analyze vast amounts of information. These data can be used to identify trends, predict future needs, and evaluate the effectiveness of policies and programs. By leveraging data insights, community leaders can make more informed decisions, allocate resources more efficiently, and address issues proactively [45]. This approach enhances the effectiveness of governance and increases accountability, as decisions are based on empirical evidence rather than intuition or political considerations.

Digital technology also facilitates the integration of different stakeholders in the governance process. ICTs provide platforms for collaboration and coordination among government agencies, private sector partners, non-profit organizations, and community groups. For example, digital platforms can streamline communication and information sharing, enabling stakeholders to work together more effectively on common goals. This integration is particularly important for addressing complex, multi-faceted challenges that require collective action, such as environmental sustainability, public health, and economic development [46].

While the benefits of digital technology in community governance are substantial, there are also significant challenges that need to be addressed. Increased transparency and efficiency are among the primary benefits. Digital tools can make governance processes more transparent by providing open access to information and facilitating public scrutiny [47]. This transparency helps build trust between citizens and their leaders and reduces the risk of corruption. Additionally, digital technology can streamline administrative processes, reducing bureaucracy and improving service delivery efficiency. However, digital technology also introduces potential biases and security concerns. Algorithms and data analytics tools can perpetuate existing biases if not designed and implemented with fairness and inclusivity in mind [48]. For example, predictive policing algorithms have been criticized for disproportionately targeting minority communities. Ensuring digital tools are free from bias and serve all community members equitably is a critical challenge. Furthermore, the increasing reliance on digital technology raises significant security concerns. Cybersecurity threats, such as data breaches and hacking, can compromise sensitive information and disrupt essential services. Protecting the integrity and confidentiality of data is paramount to maintaining public trust and ensuring the resilience of digital governance systems [49]. In addition, it is essential to ensure transparency, accuracy, security, and privacy protection when collecting, using, and sharing data responsibly. Complying with data security laws and regulations, such as the Data Security Law of the People's Republic of China, is significant for protecting the data rights of individuals and organizations, promoting the equitable distribution of information, and maintaining social stability.

3. Analytical Framework

According to the theory of collaborative advantage, the effectiveness of collaborative governance can be assessed through four primary indicators: solving specific problems, achieving self-worth while supporting a collaborative group, gaining recognition from other organizations or the public, and achieving unexpected gains. These criteria serve as the foundation for evaluating the effectiveness of collaborative governance in smart communities. Drawing on extensive literature and numerous case studies, the analysis can be structured around six key aspects: the collaborative subjects, conditions, and environment, including the quality of community participants, funding sources, community-specific systems, community culture, and supporting facilities.

When constructing a smart community model, the selection of these six indicators is for various reasons: firstly, they collectively ensure the comprehensiveness of the model, covering key areas of governance, including human resources, material resources, cultural resources, institutional resources, and actors; secondly, there is interdependence among these indicators, which are interdependent and jointly affect governance outcomes, such as the role of community culture in promoting collaboration among collaborative subjects; thirdly, these indicators can produce synergistic effects, enhancing governance efficiency through their combined action; fourthly, they demonstrate systemic characteristics, forming an analytical framework that helps optimize the overall efficiency of the community system; fifthly, these indicators are based on empirical research, reflecting key factors in actual governance; sixthly, they provide a framework for policy formulation and evaluation, helping to identify and improve deficiencies in governance; and lastly, these indicators are supported by theory, reflecting the core elements of collaborative governance theory, which are crucial for ensuring governance effectiveness.

Under these principles, collaborative subjects in smart communities refer to the various stakeholders involved in governance, whose interactions, levels of trust, and rights affect the depth and breadth of cooperation [3]. The extent of this cooperation is directly related to the effectiveness of collaborative governance. The theory of collaborative advantage

emphasizes that the quality and behavior of these collaborative subjects are crucial. Their knowledge, skills, and ways of thinking significantly impact governance outcomes, and high-quality human resources are key to the successful implementation of collaborative initiatives. Therefore, these indicators not only provide a comprehensive framework for assessing and understanding the collaborative governance of smart communities but also highlight how optimizing these key elements in practical applications can enhance the efficiency and effectiveness of community governance.

The breadth and reliability of funding sources are pivotal in determining the capacity of collaborative subjects to mobilize resources and gain social acceptance [50]. Adequate funding enhances the functionality of smart communities and supports effective collaborative governance, thereby directly influencing governance effectiveness. Community-specific systems and the role of community workers are integral to the collaborative process [51]. Well-defined and mutually agreed-upon systems ensure smooth collaboration and prevent conflicts among stakeholders. Effective systems streamline the collaborative process, ensuring that responsibilities are delineated and managed.

Community culture plays a vital role in collaborative governance. A supportive and cohesive community culture enhances the efficiency of collaboration among stakeholders, ensuring that collaborative governance processes are executed effectively. The cultural environment within a community can significantly improve the cooperation and engagement of its members, leading to more successful governance outcomes [52]. The hardware and infrastructure within a smart community are essential for facilitating collaborative activities. Quality resources and well-maintained facilities support the practical implementation of collaborative governance [53]. The synergy between human resources and physical infrastructure is crucial for the successful execution of collaborative initiatives.

The interplay of these factors can influence the development trajectory of smart communities [54]. By examining collaborative subjects, participant literacy, funding sources, community-specific systems, community culture, and supporting facilities, a comprehensive understanding of the factors affecting the effectiveness of collaborative governance in smart communities can be achieved.

The conceptual framework presented in Figure 1 provides a comprehensive structure for studying the factors that influence the effectiveness of collaborative governance in smart communities. It identifies four key sets of factors, each playing a crucial role in shaping collaborative outcomes. Firstly, community-specific subjects (wh) encompass the various stakeholders involved in the collaborative governance process. These stakeholders include community residents, organizations, government agencies, and businesses. Each group brings unique perspectives and resources, making their involvement vital for effective governance. Secondly, supporting facilities (pt) refer to the physical and technological infrastructure that underpins collaborative governance in smart communities. This includes community centers, online platforms, and communication networks. Robust infrastructure is essential for facilitating interaction and coordination among stakeholders.

Thirdly, the source of funding (zj) highlights the financial resources available to support collaborative governance. Funding can come from various sources, such as government grants, private donations, or user fees. Adequate financial support is crucial for sustaining governance initiatives and ensuring their successful implementation. Fourthly, community culture (wh) pertains to the shared values and norms that influence collaboration within the community. A strong community culture fosters trust and cooperation among stakeholders, enhancing the overall effectiveness of collaborative efforts. The framework also identifies four potential outcomes of collaborative governance in smart communities. These outcomes include collaborative solutions to specific problems (1), which refer to stakeholders' ability to work together to address community issues. Getting recognition

from other organizations or the public (2) measures the extent to which external entities acknowledge and value collaborative efforts. Self-worth of the synergistic organization in synergy (3) captures the sense of accomplishment and satisfaction stakeholders derive from participating in governance activities. Lastly, achieving unexpected gains (4) highlights the potential for collaborative governance to yield positive, unforeseen outcomes.

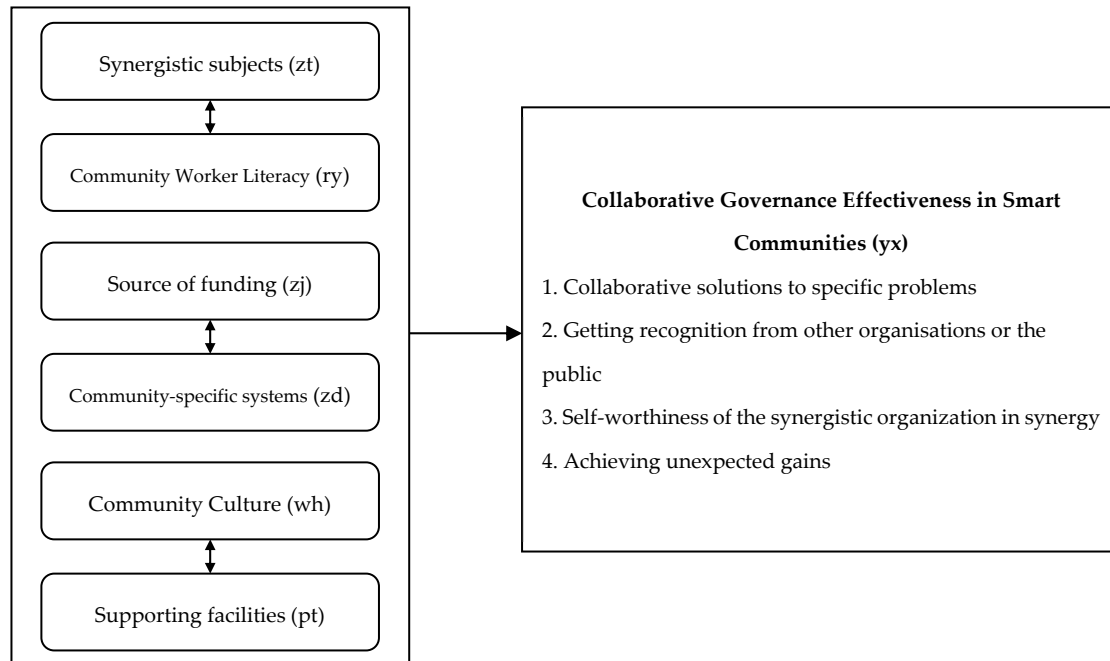


Figure 1. Research framework for influencing factors in the effectiveness of smart community collaborative governance.

The arrows in the figure suggest that the four sets of factors—community-specific subjects, supporting facilities, sources of funding, and community culture—influence the four potential outcomes of collaborative governance. This interconnectedness underscores the complexity of achieving effective governance in smart communities and the need for a holistic approach considering multiple dimensions and perspectives.

4. Study Method and Design

This study employs fuzzy set qualitative comparative analysis (fsQCA) to assess the effectiveness of collaborative governance in smart communities, utilizing 20 cases from China’s “2021 National Typical Cases of Grassroots Governance Innovation” database. Data were sourced from academic and government databases, focusing on representativeness, diversity, and development stage. The research identifies six factors influencing governance effectiveness: collaborative subjects, community participant literacy, funding sources, community-specific systems, community culture, and supporting facilities. Each factor is evaluated using a four-value fuzzy method, providing a nuanced assessment framework to identify strengths and areas for improvement in collaborative smart community initiatives.

4.1. Research Method

Qualitative comparative analysis (QCA) can be categorized based on the type of data under study into clear sets (csQCA) and fuzzy sets (fsQCA) [55]. This paper adopts the fuzzy set qualitative comparative analysis (fsQCA) method for several reasons. Firstly, the sample size is suitable for fsQCA. The study includes 20 cases, meeting the fsQCA requirement for analyzing small to medium-sized samples. Secondly, fsQCA is adept at

handling multiple complex and concurrent causal characteristics. The factors influencing the effectiveness of collaborative governance in smart communities are numerous and simultaneous [56]. Compared to other model methods, fsQCA is based on set theory and configuration thinking, effectively linking qualitative and quantitative analysis to explain the complex causal relationships behind phenomena. In a study, by combining PLS-SEM and fsQCA, the role of residents' sustainable intelligence in the management of agricultural heritage sites was investigated, revealing the impact of residents' attitudes, subjective norms, and perceived behavioral control on behavioral intentions. Ref. [57] fsQCA excels in identifying the combined paths of these factors. Lastly, fsQCA accommodates the range of values required for analysis. The conditional and outcome variables can take on values between 0 and 1, aligning with the requirements of fuzzy set comparative analysis.

4.2. Case Selection and Sources of Information

This study used the “2021 National Typical Cases of Grassroots Governance Innovation” database, published by the Ministry of Civil Affairs, as the primary sample source. We employed a triangular verification approach to ensure the relevance and depth of our research on multi-faceted collaborative governance in smart communities [58]. This involved integrating data from prominent academic databases such as China Knowledge Network, Web of Science, and Wanfang alongside information sourced from local government websites, People's Daily Online, and Xinhua Website. These resources, including their full-text search capabilities, were crucial in identifying 20 cases that exemplify smart communities and effective collaborative governance. The selection criteria for these cases focused on three key conditions. First, each case had to demonstrate representativeness by being recognized as a typical example of successful grassroots governance initiatives with a degree of social influence. Second, diversity was ensured by covering various regions across China, each with its unique developmental characteristics. This approach allowed us to capture a comprehensive view of collaborative governance practices in different contexts. Finally, the cases were chosen at a specific stage of development, representing a summary of successful collaborative governance experiences over a defined period. By adhering to these rigorous criteria, we aimed to provide an accurate and comprehensive analysis of the factors influencing collaborative governance in smart communities. This approach validates the relevance of our research findings and contributes to the broader understanding and advancement of effective governance practices in contemporary urban settings.

Table 1 provides a snapshot of selected cases from the “2021 National Typical Cases of Grassroots Governance Innovation” database, focusing on diverse initiatives to enhance community governance across China. These cases represent efforts from various regions, each addressing unique challenges and employing innovative strategies to improve community services and governance. Firstly, CASE1 from Chaoyang District, Beijing, involves the implementation of the “Community Growth Partnership Programme”. This initiative explores innovative paths in community governance specifically tailored for mega-cities, aiming to foster partnerships and improve governance efficiency in densely populated urban areas.

CASE3, located in Pudong New Area, Shanghai, focuses on building a “doorstep” service system to enhance the quality of community services. This system aims to provide convenient and high-quality services directly accessible to residents, improving overall community satisfaction and engagement. In Xihu District, Hangzhou, Zhejiang Province, CASE6 introduces a new model of community service system construction, integrating a livelihood complex. This initiative aims to create a comprehensive service ecosystem that meets the diverse needs of residents, enhancing community cohesion and quality of

life. In Foshan City, Guangdong Province, CASE11 utilizes “Big Data–Micro Services” to develop innovative community governance services. This approach leverages data-driven decision-making and agile service delivery to address community needs effectively and efficiently.

Table 1. Case information sheet (partial).

Case Number	Case Geography	Case Name
CASE1	Chaoyang District, Beijing	Implementing the “Community Growth Partnership Programme” to explore the innovative path of community governance in mega-cities
CASE3	Pudong New Area, Shanghai	Building a “doorstep” service system to “embroider” high-quality community services
CASE6	Xihu District, Hangzhou, Zhejiang Province	Building a new model of community service system construction with a livelihood complex
CASE11	Chancheng District, Foshan City, Guangdong Province	“Big Data–Micro Services” builds a new model of community governance services
CASE20	Zhongning County, Ningxia Hui Autonomous Region	Combination of blocking and unblocking efforts to crack the community “universal badge” stubborn miasma chronic problems

Meanwhile, CASE20 in Zhongning County, Ningxia Hui Autonomous Region, combines efforts to tackle chronic problems through a collaborative approach known as the “Combination of Blocking and Unblocking Efforts”. This initiative aims to overcome persistent governance challenges by combining regulatory enforcement with community-driven solutions. These cases illustrate a range of innovative approaches to community governance, highlighting themes such as technological integration, community engagement, and service enhancement. They reflect a broader trend towards digital transformation and data-driven decision-making in community management, aiming to improve governance effectiveness and responsiveness.

4.3. Variable Selection Assignment

In line with the definition of a smart community and the theory of collaborative governance, the cooperation and collaboration of multiple subjects necessitate the use of information technology to integrate diverse stakeholders and other community elements, achieving synergy. This approach ultimately facilitates effective governance of public affairs within the community [59].

4.3.1. Selection and Assignment of Resultant Variables

Based on the definition of collaborative effectiveness mentioned in the previous article and the actual situation of the selected cases, the effectiveness of collaborative governance in smart communities (yx) serves as the outcome variable for this study [60]. This variable is assessed using a four-valued fuzzy method grounded in the theory of collaborative advantage with four criteria for evaluating effectiveness. Firstly, collaborative problem-solving: This criterion evaluates whether specific problems are resolved collaboratively. It measures the degree of resolution of community conflicts and issues from the beginning to the conclusion of each collaborative case.

Secondly, recognition by other organizations or the public: This criterion involves comprehensive assessments from major media outlets, district and county official websites, and government reports. The top-performing cases are recognized and valued accordingly [61]. Thirdly, the self-worth of the collaborative organization: This criterion assesses the leadership and dedication demonstrated by participants in the collaboration, even if the primary goals still need to be fully achieved. Lastly, achieving unexpected gains: This

criterion evaluates whether there are positive outcomes beyond the stated goals of the collaboration.

4.3.2. Conditional Variable Design and Assignment

In this study, based on the development history, governance practices, relevant system research, and concept definitions of smart communities both domestically and internationally, six factors are identified as conditions that impact the effectiveness of collaborative smart communities [62]. These factors include collaborative subjects, funding sources, community participants' literacy, community-specific systems, supporting facilities, and community culture. Each factor is supported by specific theoretical frameworks and assigned values.

(1) Collaborative subjects (zt)

This factor represents the initial condition of the SFIC synergy model, serving as the driving force behind collaborative governance in smart communities [63,64]. Based on the specifics of each case, collaborative subjects are evaluated using a four-valued fuzzy method to assess several criteria: whether mutual trust exists among the multiple subjects, whether all parties engage in equal dialog and enjoy equal rights during collaboration, and whether they demonstrate a willingness to communicate, negotiate, cooperate, and take responsibility for their actions. For instance, in Xihu District, Nanchang City, Jiangxi Province, the "Happiness Roundtable" initiative was established, where representatives elected by each primary entity must participate in monthly meetings to discuss community (village) issues under the jurisdiction of the street (town). Opinions and suggestions gathered during these meetings are collaboratively resolved, with designated individuals responsible for formulating and executing solutions, actively coordinating resources, and leveraging collective strength to address challenges. The project is documented on the district's network party-building cloud platform and the "Party Group Service 365" intelligent management platform to ensure timely and high-quality project completion. This case is assigned a value of 1 based on the evaluation criteria.

(2) Community participant literacy (ry)

Community participant literacy refers to the professionalism of the people involved in the collaborative and the ability to continuously improve the capacity of the people involved in the collaborative governance so that the collaborative group can form a synergy to achieve the ultimate effect of " $1 + 1 > 2$ ", with emphasis on the continuous learning capacity. Learning capacity is the ability of multiple actors to learn new knowledge and skills. In addition to improving the capacity of personnel, smart community platforms or digital means can be used to link universities or professional social work organizations to improve the professionalism of personnel involved in collaborative smart communities or to introduce professional talents in a timely manner. The perspective of practical examples of smart communities and collaborative governance theory is integrated [65]. In this paper, three items are selected for examination: whether digital training and seminars are conducted regularly; whether relevant professional talents are introduced based on collaborative cases; and whether professional organizations such as universities or professional social work organizations are linked to use smart community platforms or digital means to provide professional collaborative guidance to community personnel, etc. Values are assigned according to the four-value fuzzy method. For example, relying on the incubation network in the Chancheng District of Foshan City, Guangdong Province, a large number of social organizations and social workers with both team size and service quality have become the driving force behind the professionalization of intelligent community services, giving rise to service brands such as "Hele Village Residence", "Senior Citizens' Dining

Hall” and “Social Service Venture Competition”. This has led to the formation of a healthy community service ecosystem and the participation of more than 140,000 social workers and community social organizations in community governance. This case is assigned a value of 1.

(3) Sources of funding (zj)

Funding refers to the source of finance in the collaborative governance of smart communities [66]. In order to guarantee the governance and development of the community, in addition to the daily operating funds given by the government, the difference is mainly manifested in whether the community governance can obtain additional government subsidies or assistance or donations from other organizations to further expand the community building funds. In addition, in the operation of smart communities, they use their own advantages to establish the community’s unique mode of operation, such as value-added use of services, advertising revenue, etc., and then use the profits back into the community construction and management services, the formation of a set of diversified participation in the construction and operation of the ecological, becoming the inevitable choice for the sustainable development of smart communities. The study was conducted by examining whether the case community received additional financial subsidies from the government, whether it received assistance or donations from the market and non-profit organizations, and whether it established a smart community operation ecology and received a profit return. For example, Shipingqiao Street in Jiulongpo District, Chongqing, has built a resource exchange platform to integrate social and caring resources to achieve self-blooding and renewal in five ways: financial support, links to social organization resources, online fundraising, special fundraising, and charity income generation. The case is assigned a value of 1.

(4) Community-specific systems (zd)

A community-specific system refers to the use of digital means to promote the simplification of the policy system and the improvement of the community management system in the process of smart community construction and governance, as well as the construction of an open governance system [67]. In addition to this, the wisdom community, as a digital product in information security, should pay extra attention to avoiding the mistrust of multiple subjects due to the leakage of information, which eventually leads to the breakdown of cooperation, so relevant measures should be introduced to provide legal protection for the operation of the wisdom community platform and data security. This paper combines the case and the collaborative governance of smart communities to examine whether to use the smart community platform to simplify and improve the traditional collaborative community management process, whether to establish a new collaborative management system for smart communities, and whether to introduce relevant measures to provide legal protection in three aspects, which are assigned according to the four-value fuzzy method. For example, Pingyi County in Shandong Province has improved its governance system, set up a four-level governance grid in parallel, divided its jurisdiction into four management zones, 27 urban communities, and 56 basic grids, built platforms for consultation and shared governance and comprehensive services, and achieved full coverage of the governance structure of urban and rural communities with the help of the Party building network to unify community governance. This case was assigned a value of 0.63.

(5) Community Culture (wh)

Community culture refers to the organization of cultural activities within a smart community, incorporating community cultural values into the lives of community residents and influencing or changing the existing patterns of community residents getting along [68].

A good community culture can effectively shorten the time it takes to reach goals in the synergy process as well as to unify the sense of synergy. The establishment of a community cultural and publicity department, the regular implementation of various cultural and publicity activities, and the creation of a community cultural atmosphere can help to enhance the cohesion of the various subjects and can better enhance the embodiment of synergy between the various organizations.

This paper examines whether “community culture” has formed a digital cultural propaganda department with the participation of multiple actors, whether it has linked multiple actors to organize special activities, and whether it has formed community cultural projects with local characteristics, and finally assigns values according to the four-value fuzzy method. For example, in Dongying District, Dongying City, Shandong Province, the construction of the “Oil City” community cultural space, the transfer of oil fields into the community as one national public cultural service system, and radio and television network resources to achieve networking and interoperability, the “oil and land family” mass cultural activities held more than a thousand. This has created a “family” culture and a “heart”. A value of 0.67 was assigned.

(6) Supporting facilities (pt)

Supporting facilities refer to the hardware facilities and technical basis that support the smooth operation of collaborative community governance and software construction in the wisdom community collaborative governance. Diverse and perfect collaborative business platforms and adequate information sharing are directly related to the collaborative efficiency of community governance, the degree of trust between subjects, and the effective innovation promotion of community governance [69]. In this paper, we choose the 2019–2020 China’s New Smart City Construction and Development Comprehensive Impact Assessment Results to examine the degree of infrastructure construction, ranked in order from highest to lowest, with the 10th being the median, with values assigned before the 10th and no values assigned after the 10th (see Table 2). The assessment content is based on the degree of infrastructure construction of the case smart community, whether the smart community platform is used to share information resources, whether the diversified collaborative platform (government, business, services, home affairs, etc.) is used to improve the efficiency of management services, and finally, the value is assigned according to the four-value fuzzy method.

Table 2. Smart community infrastructure ranking (partial).

Ranking	Case Number	Case Geography	Tahao SMILE Composite Index Score or Top 100 Smart Towns	Smart Industry Composite Index (Tahao Index)
1	3	Pudong New Area, Shanghai	86.95	AAAAA+
8	6	Xihu District, Hangzhou, Zhejiang Province	80.82	AAAAA
13	9	Xiangtan City, Hunan Province		AAAA+
16	7	Yidu City, Hubei Province		AAAA
20	20	Zhongning County, Ningxia Hui Autonomous Region		AA

Table 2 provides a snapshot of the smart community infrastructure rankings based on the Tahao SMILE Composite Index and the Smart Industry Composite Index (Tahao Index). This ranking assesses various smart community initiatives across different regions in China, highlighting their overall performance in terms of social, technological, economic, and environmental dimensions. Pudong New Area in Shanghai is at the top

of the ranking, securing the first position with an impressive Tahao SMILE Composite Index score of 86.95 and an AAAAA+ rating in the Smart Industry Composite Index. This indicates that Pudong New Area has excelled across multiple criteria, demonstrating robust infrastructure and successful integration of smart industry initiatives. It reflects a comprehensive approach to smart community development, encompassing high levels of social engagement, advanced technological integration, strong economic vitality, and effective environmental management.

Following closely is Xihu District in Hangzhou, ranked eighth with a Tahao SMILE Composite Index score of 80.82 and an AAAAA rating in the Smart Industry Composite Index. This district showcases significant advancements in smart community infrastructure, though it is slightly behind the Pudong New Area. The high ratings in both indices indicate substantial progress in creating a conducive environment for smart technologies, sustainable development practices, and innovative economic activities. Moving down the ranking, Xiangtan City in Hunan Province holds the thirteenth position with a strong AAAAA+ rating in the Smart Industry Composite Index. Although specific details about the Tahao SMILE Composite Index score are not provided, the high industrial rating suggests a primary focus on integrating smart industry initiatives into the community's development strategy.

Yidu City in Hubei Province follows in sixteenth place with a AAAA rating in the Smart Industry Composite Index. Similarly to Xiangtan City, Yidu City demonstrates a strong emphasis on industrial development within its smart community framework, contributing to economic growth and technological advancement. Lastly, Zhongning County in the Ningxia Hui Autonomous Region ranks twentieth with an AA rating in the Smart Industry Composite Index. This indicates moderate industrial integration within the smart community initiatives, suggesting ongoing efforts to enhance economic diversification and smart industry capabilities.

Table 3 provides a detailed variable assignment table using the “four-value fuzzy method” to assess the effectiveness of collaborative smart communities across various categories and specific indicators.

Synergy Effectiveness (yx): This category evaluates the overall effectiveness of collaborative governance in smart communities based on four specific indicators: solving specific problems, receiving recognition from other organizations or the public, self-valuation of the collaborative organization, and achieving unexpected gains [70]. The assignment rules reflect the degree to which these conditions are met, ranging from 0 to 1, based on the “four-value fuzzy method”. This allows for a nuanced assessment of the collaborative outcomes, highlighting whether the synergy is achieving its intended goals comprehensively or partially.

Synergy Main Body (zt): The variables under this category focus on the characteristics of the main collaborative entities within smart communities. It assesses mutual trust, equal dialog and rights, willingness to communicate and cooperate, and taking responsibility for actions. The assignment rules indicate the level of compliance with these criteria, which are crucial for effective synergy among community stakeholders. This assessment helps understand the relational dynamics and governance structure within collaborative initiatives.

Community Worker Quality (ry): This category evaluates the quality and professionalism of community workers involved in collaborative smart community initiatives. It assesses factors such as regular digital training and seminars, the introduction of relevant professional talents, and collaboration with universities or professional organizations. The assignment rules provide a graded scale from 0 to 1, indicating the extent to which these professionalization efforts are implemented and their impact on collaborative outcomes.

Table 3. Variable assignment table.

Variables Category	Variables Name	Specific Indicators	Assignment Rules (Variables Are Assigned Using the “Four-Value Fuzzy Method”)	Assignment
Knot Fruit Change Quantity	Synergy Effectiveness (yx)	1. Solving specific problems	None of them meet or conform to only one	0
		2. Receiving recognition from other organizations or the public	Two of these conditions are met	0.33
		3. Self-valuation of the collaborative organization	Three conditions are met	0.67
		4. Achieving unexpected gains	Fully compliant	1
	Synergy Main body (zt)	1. whether there is mutual trust	Neither of them is in line with	0
		2. Whether there is equal dialog and equal access to rights in the synergy process	One of these conditions is met	0.33
Article Pieces Change Quantity	Community Worker Quality (ry)	3. Willingness to communicate, consult, cooperate, and take responsibility for their actions	Two conditions are met	0.67
			Fully compliant	1
	Funding Source (zj)	1. Whether digital training, seminars, etc., are conducted regularly	Neither of them is in line with	0
		2. Whether relevant professional talents are introduced based on collaborative cases	One of these conditions is met	0.33
		3. whether to work with universities or professional social work organizations to provide professional and collaborative guidance to community members through the Smart Community Platform	Two conditions are met	0.67
	Community Special System (zd)	Fully compliant	Fully compliant	1
	Community Culture (wh)	1. Does it receive additional financial subsidies from the government	Neither of them is in line with	0
		2. Whether assistance or donations are received from the market and non-profit organizations	One of these conditions is met	0.33
	Community Culture (wh)	3. Whether or not it has established a smart community operation ecology to receive a profitable return	Two conditions are met	0.67
			Fully compliant	1
	Community Culture (wh)	1. Whether to use the smart community platform to simplify and improve the traditional community collaborative management process	Neither of them is in line with	0
		2. Whether to establish a new intelligent community collaborative management system	One of these conditions is met	0.33
	Community Culture (wh)	3. Whether relevant measures are introduced to provide legal protection	Two conditions are met	0.67
			Fully compliant	1
	Community Culture (wh)	1. Whether the group establishes a cultural promotion sector with the participation of multiple subjects	Neither of them is in line with	0
		2. Whether or not to organize special events in conjunction with multiple entities	One of these conditions is met	0.33
	Community Culture (wh)	3. whether community cultural projects with local characteristics are formed	Two conditions are met	0.67
			Fully compliant	1
	Community Culture (wh)	1. Level of intelligent community infrastructure development	Neither of them is in line with	0
		2. Whether to use the smart community platform to share information resources	One of these conditions is met	0.33
	Community Culture (wh)	3. Whether to use diverse collaborative platforms (government, business, service, home, etc.) to improve the efficiency of management services	Two conditions are met	0.67
			Fully compliant	1

Funding Source (zj): This variable category evaluates the financial resources supporting smart community initiatives. It includes government subsidies, market donations, and the establishment of a profitable smart community operation ecology. The assignment rules provide a measure of financial sustainability and resource diversification, which are critical for sustaining collaborative efforts over time.

Community Special System (zd): This category assesses the specific systems and measures to enhance community collaboration and management. It includes variables like the use of smart community platforms, the establishment of new intelligent management systems, and the introduction of legal protections. The assignment rules reflect the degree to which these systems are integrated and effective in supporting collaborative governance.

Community Culture (wh): The variables under this category evaluate the cultural aspects of community collaboration, including promoting cultural sectors, organizing special events, and developing local cultural projects. The assignment rules indicate how

these cultural initiatives contribute to a cohesive and inclusive community environment, supporting effective collaboration.

Complementary Facilities (pt): This category assesses the level of infrastructure development within smart communities, the use of smart community platforms for information sharing, and the diversity of collaborative platforms. The assignment rules measure the efficiency of management services and the integration of diverse stakeholders, which are essential for enhancing collaborative outcomes [71].

The table employs the “four-value fuzzy method” to assign values based on the level of compliance with specific indicators across different categories. This method allows for a nuanced assessment of the conditions affecting the effectiveness of collaborative smart communities, providing a comprehensive evaluation framework. The assignment rules are structured to provide clear criteria for assigning values, ensuring consistency and comparability across different cases. This approach helps identify strengths and weaknesses within each category, facilitating targeted improvements in collaborative governance practices. Each variable’s assignment reflects the degree to which the conditions for effective collaborative governance are met within smart communities. A value closer to 1 indicates higher compliance and effectiveness, while a lower value suggests areas for improvement. This structured assessment approach supports the development of strategies to enhance collaborative efforts, foster community engagement, and improve governance outcomes.

5. Empirical Analysis and Results

The study utilizes fuzzy sets for calibrating variables to analyze the necessity and combinations of conditions for effective collaborative governance in smart communities. Using fsQCA 3.0 software, the analysis identified “collaborative subjects” and “supporting facilities” as essential variables, with high consistency and coverage scores indicating their critical role. The study also presents five configurations of variable combinations, each showing varying degrees of consistency and coverage, highlighting different pathways to achieving effective governance. Key findings emphasize the importance of multiple collaborative entities facilitated by advanced information technology to ensure effective governance processes.

5.1. Analysis of the Need for a Single Variable

In this study, fuzzy sets were utilized to calibrate conditional and outcome variables prior to conducting a necessity analysis. Fuzzy sets allow for calibrations ranging from 0 to 1, adjusting criteria using the Quine-McCluskey algorithm via fsQCA. Two main calibration methods were employed: direct and indirect. The direct method is based on case characteristics with anchor points—“fully affiliated, intersection, and fully unaffiliated”—calibrated using corresponding algorithms in software. The indirect method assigns data to individual variables in multiple fuzzy sets alongside relevant theories and cases rather than relying solely on software calculations [72]. Given the characteristics of the variables in selected cases, the study adopted the indirect calibration method.

Using fsQCA 3.0 software, the calibrated data were tested for consistency and coverage, with numerical results in Table 4. Consistency levels for collaborative subjects and supporting facilities exceeded 0.9, indicating their necessity for effective collaborative governance in smart communities. Additionally, indices for community culture and participants’ literacy were above 0.8, suggesting they are sufficient conditions for effective governance involving multiple subjects in smart communities. Among the six condition variables tested, supporting facilities and collaborative subjects explained approximately 92.4% and 85.1% of cases of collaborative governance, respectively, based on coverage rates. Community participant literacy and community culture accounted for about 96.6% and

89.9%, respectively. These findings align with current practices in collaborative governance within smart communities.

Table 4. Univariate necessity test results.

Analysis of Necessary Conditions (ANC)		
Outcome Variable: Collaborative Validity (yx)		
	Consistency	Coverage (Coverage)
Collaborative subjects (zt)	0.912211	0.851403
Community participant literacy (ry)	0.839016	0.966857
Source of funding (zj)	0.734593	0.868878
Community-specific systems (zd)	0.754593	0.943396
Community Culture (wh)	0.809800	0.899699
Supporting facilities (pt)	0.920884	0.924401

Source: Based on fsQCA 3.0 software.

As a prerequisite for collaborative governance involving multiple subjects in smart communities, “collaborative subjects” and “supporting facilities” underscore the essential role of dynamic participation by multiple collaborative entities facilitated by new-generation information technology. In the realm of smart community practices, it is crucial for these subjects to actively engage and collaborate, forming an influential community with a network-like structure. This collaboration should be facilitated in an organized manner through the use of advanced information technologies to achieve synergistic outcomes and efficient governance processes.

5.2. Analysis of the Combination of Conditions for the Collaborative Governance of Multiple Subjects in Smart Communities

Normative statistical analysis of the effectiveness of collaborative governance in smart communities (yx) was conducted following Fiss’s descriptive principle [73]. The findings from the intermediate and straightforward solutions were then formatted into Table 5 using appropriate notation. Table 5 presents various configuration solutions for the effectiveness of collaborative governance in smart communities, employing the fuzzy set qualitative comparative analysis (fsQCA) approach. This method allows for the examination of how different combinations of variables contribute to achieving effective outcomes in smart community practices. Each configuration is evaluated based on its consistency and coverage in explaining the effectiveness of collaborative governance [74]. Configuration 1, characterized by the presence of all five conditional variables (collaborative subjects, community participant literacy, source of funding, community-specific systems, and supporting facilities), demonstrates a high consistency score of 1 and an original coverage of 0.74. This configuration suggests that the simultaneous presence of these variables is necessary for achieving effective collaborative governance in smart communities.

Configuration 2 maintains high consistency (0.92) but has lower original coverage (0.30) compared to Configuration 1. It lacks community-specific systems but includes other critical variables. This indicates that community-specific systems enhance effectiveness but are not strictly necessary when other factors are strong. Configuration 3 emphasizes the importance of the source of funding, community-specific systems, community culture, and supporting facilities, achieving perfect consistency and covering 0.41 of cases. This configuration suggests that these factors compensate for the absence of community participant literacy. Configuration 4 also achieves a consistency score of 1 and covers 0.56 of cases. It highlights the significance of collaborative subjects, sources of funding, community-specific systems, and supporting facilities, indicating their sufficiency for achieving effective outcomes. Configuration 5 focuses on community participant literacy, community culture, and supporting facilities, with a consistency score of 0.92 and covering 0.30 cases. This configuration suggests that these factors contribute to effectiveness, although to a lesser extent compared to others.

Table 5. Configuration solutions for the effectiveness of collaborative governance in smart communities (note: The large circle is the core condition, • means the core condition is present, ⊕ means the core condition is missing, the small circle is the supplementary condition, • means the supplementary condition is present, and ⊕ means the supplementary condition is missing. Blank cells indicate that the condition variable may or may not appear).

Conditional Variables	Configuration 1	Configuration 2	Configuration 3	Configuration 4	Configuration 5
Collaborative subjects (zt)		•	•		
Community participant literacy (ry)	•	•	⊕		
Source of funding (zj)	•	•	⊕	•	•
Community-specific systems (zd)	•	⊕			•
Community Culture (wh)		⊕	•		⊕
Supporting facilities (pt)	•	⊕	•	•	⊕
Consistency	1	0.92	1	1	0.92
Original coverage (raw coverage indicates the proportion of cases that can be explained by the combination of conditions, and as the same result may be reflected by more than one pathway at the same time, raw coverage only indicates adequacy)	0.74	0.30	0.41	0.56	0.30
Unique coverage (the principle of unique coverage. It indicates how many cases can be explained only by this combination of paths, with larger values indicating that the combination of paths is more likely to lead to the outcome, i.e., reflecting the need for the combination of conditions, and is generally used as the main basis for analysis)	0.18	0.03	0.11	0.12	0.03
Solution consistency			0.90		
Solution coverage			0.92		
Frequency cutoff = 1			Consistency cutoff = 0.83		

Data source: compiled by the authors from QCA.

6. Configuration Path Discussion

According to the above-mentioned characteristics of the distribution of the core and complementary condition groupings, based on the principle of unique coverage and original coverage, combined with the analysis of smart communities and collaborative governance theory, we summarize and conclude the “subject–culture–embedded”, “technology–resource–driven” and “system–talent–led” effective paths.

6.1. Subject–Culture Embedded Type

This approach is encapsulated by Grouping 3, which exhibits an original coverage of 0.41 and a unique coverage of 0.11. In practical terms, the strategy focuses on leveraging the smart community platform to transform community culture through various forms and subjects. By directing multiple subjects toward smart community governance and collaborative cooperation, consensus on public value can be reached more swiftly during the collaborative process [75]. The subjects’ shared values influence community culture, contributing to the concentration, unification, and orientation of people’s ideological perceptions, value inclinations, and practices.

A representative example is found in Dongying District, Dongying City, Shandong Province. Dongying District’s smart community management platform is developed in alignment with provincial and municipal standards for smart community construction. It integrates fundamental functional modules such as party-building management, realistic maps, and basic information. It connects to the city’s grid-based management platform and other business platforms to deliver centralized, efficient, and comprehensive management

services [76]. Simultaneously, Dongying District has established community cultural spaces such as the “Oil City” theme park and industrial landscapes to revive shared cultural memories. We can observe how culture, in the unique social context of China, shapes and influences communities at various levels. Culture provides the spiritual bond and value orientation for communities, while changes in the special social environment drive the evolution of community structures and governance models. The traditional cultures of different regions, preserved through thousands of years, continue to impact the development paths and goals of communities as a form of historical accumulation. These factors work together to create the uniqueness and diversity of communities.

Moreover, the oilfield has been repurposed as part of the national public cultural service system to foster the sharing of cultural resources, facilities, and activities. The radio and television network resources have been networked and made interoperable, enabling over a thousand “Oilfield Family” mass cultural activities. This initiative aims to foster a cohesive “family” culture and build community solidarity [77].

6.2. Finance and Technology-Driven

This pathway is represented by Grouping 4, with an original coverage rate of 0.56 and a unique coverage rate of 0.12. It highlights the performance of communities with broader and more diverse funding sources and more comprehensive community-supporting facilities. These factors collectively drive other conditions to promote effective synergy among the main stakeholders within smart communities. Enhancements in the composition of smart community management systems strengthen information processing capabilities through smart networks, enabling intelligent analysis and research of community issues [78]. This facilitates the resolution of both routine and extraordinary community challenges, thereby boosting the efficiency of collaborative and smart community governance. For instance, in Hangzhou City’s West Lake District, Zhejiang Province, the “Happiness Aloe” digital platform exemplifies leveraging digital reform to create a multi-cross-collaborative application scenario. Utilizing intelligent IoT infrastructure like livelihood complexes enhances the capacity for smart governance through livelihood services. The initiative has made significant strides in understanding service demand, optimizing spatial layouts, improving service supply, and empowering digital initiatives across five community linkages. This innovation has led to the creation of a “responsive” governance system and a “collaborative” governance structure [79]. It integrates various community services such as education, entertainment, healthcare, elderly care, property management, and cultural activities into an online platform. This enables residents to handle routine affairs remotely, enhancing efficiency and convenience.

Moreover, the initiative has addressed the “digital divide” among the elderly by introducing a “One-Click Elderly Care” feature. This transforms livelihood complexes into training and experience centers for the elderly, fostering digital literacy and inclusion. The project follows a participatory approach, continuously engaging community feedback to form a closed-loop mechanism of “decision-making–promotion–evaluation”.

6.3. System and Talent-Led

This pathway is derived from Histogram 1, achieving a unique coverage of 0.18 and an original coverage of 0.74. The study draws on the concept of institutional talent dominance, originally stemming from Polanyi’s notion of institutional dominance, which pertains to the economic behavior of dominant individuals or organizations within the structure of social relations. In the context of smart communities, institutional dominance can be seen as a logical choice [25].

Integrating a community workforce with a smart community infrastructure facilitates the operationalization of macro systems and policies and effectively addresses real-world community issues [80]. A notable case study is the smart community project developed collaboratively by Shipingqiao Street in Jiulongpo District, Chongqing, and Chongqing Zhong Shang Technology Co. This initiative gradually establishes Chongqing's first comprehensive community sunshine fund management process and institutional system [81].

Furthermore, the project regularly introduces social work professionals from various universities in Chongqing, focusing on enhancing their professional service capabilities. This effort aims to integrate talents, funds, and resources within the Shipingqiao district, fostering the initial development of the "1 + 7 + N" social organization incubation, volunteer team cultivation, and joint fundraising mechanisms for charity and public welfare.

This study is limited in scope as it needs to comprehensively assess the effectiveness of collaborative governance in smart communities and delve into the behavioral logic of local governments and their influence [82]. Furthermore, the findings are based on a small sample of cases, limiting the conclusions' generalizability. Future research should expand upon this study by incorporating larger sample sizes and conducting deeper case analyses. Additionally, there is a need for further investigation into the links between collaborative governance in smart communities and the behavioral strategies of local governments [83]. This would provide a more nuanced understanding of how local government actions influence the effectiveness of collaborative governance initiatives. Researchers can build upon this study to enhance the depth and breadth of analysis and interpretation. This includes exploring new methodologies, conducting richer case studies, and offering innovative insights and recommendations for the development and modernization of smart communities. By doing so, future studies can contribute to a more robust understanding of effective governance practices in the context of smart community development [17].

7. Conclusions

This paper constructs an analytical framework to assess the effectiveness of collaborative governance in smart communities, focusing on six key elements: collaborative subjects, funding sources, community participants' literacy, community-specific systems, community culture, and supporting facilities. Each of these elements is pivotal in shaping the dynamics of collaborative governance within community settings. To delve deeper into pathways for enhancing the effectiveness of collaborative governance in smart communities, the study conducts a fuzzy set qualitative comparative analysis (QCA) using 20 typical cases of community governance. This method offers a nuanced understanding of how various combinations of factors contribute to successful collaborative governance outcomes.

The study identifies that the effectiveness of collaborative governance in smart communities hinges on a diverse range of factors across these categories. Collaborative subjects and supporting facilities emerge as necessary conditions for achieving effective community governance. Collaborative subjects encompass the diverse entities and stakeholders involved in community governance while supporting facilities, which include the infrastructure and resources that facilitate collaborative efforts. On the other hand, community culture and participants' literacy are sufficient conditions for effective collaborative governance involving multiple subjects in smart communities. Community culture involves shared values, norms, and practices that guide community interactions, while community participants' literacy refers to the understanding and capability of community members to engage effectively in collaborative governance processes.

Furthermore, the study identifies several pathways to enhance the effectiveness of collaborative governance in smart communities. The subject–culture-embedded pathway emphasizes integrating community culture and values within the governance framework, fostering stakeholder ownership and commitment. The technology–resource-driven pathway highlights the role of modern technology and resources in enhancing communication, decision-making, and service delivery, thereby improving overall governance outcomes. Lastly, the system–talent-led pathway focuses on developing robust community-specific systems and empowering skilled community leaders to lead collaborative governance efforts effectively.

7.1. Theoretical Implications

This study makes significant theoretical contributions by developing an analytical framework to evaluate the effectiveness of collaborative governance in smart communities. The framework integrates six critical elements—collaborative subjects, funding sources, community participants’ literacy, community-specific systems, community culture, and supporting facilities—to analyze their roles and interactions. By identifying necessary and sufficient conditions for effective governance, the study provides a structured approach to understanding the complex dynamics of collaborative governance. This theoretical framework underscores the importance of integrating community-specific cultural elements and leveraging modern technologies to enhance governance outcomes. It serves as a foundation for future research on governance theories and practices, particularly in the context of smart community development.

7.2. Policy Implications

The findings of this study have significant implications for policymakers and practitioners involved in smart community development. Policymakers can use the developed analytical framework to design integrated governance approaches prioritizing collaborative subjects, funding sources, community culture, and supporting facilities. This can improve governance effectiveness by aligning policies with community-specific needs and resources. Emphasizing the role of modern technology and infrastructure in governance processes can enhance communication, decision-making, and service delivery. Policymakers can promote the adoption of smart technologies to improve the efficiency and transparency of community governance. Recognizing community culture as a sufficient condition for effective governance can guide policymakers in integrating local values, norms, and practices into governance strategies. This approach fosters community ownership and commitment to collaborative governance initiatives. Investing in community participants’ literacy and empowering local leaders can strengthen the capacity of communities to engage in collaborative governance. Policymakers can support training programs and educational initiatives to enhance community engagement and leadership in governance processes.

7.3. Limitations

The study on collaborative governance in smart communities has several limitations, including a limited sample scope, which is mainly focused on cases in China and may lack a global perspective; methodologically, the use of fsQCA may not fully capture dynamic changes and the impact of continuous variables; rapid technological development and policy changes may affect the timeliness and applicability of the research findings; insufficient integration across disciplines, which may limit a comprehensive understanding of governance; and limitations in practical application and the depth and breadth of research, as well as uncertainties in future research directions. These limitations suggest that future studies need to adopt a broader range of samples and diverse methods and delve into the complexity of smart community governance within a wider context.

7.4. Ideas for Future Studies

Building on this research, future studies can explore several avenues to advance the understanding and practice of collaborative governance in smart communities. Conducting larger sample size studies to validate and extend the identified pathways and conditions for effective collaborative governance. Longitudinal studies examine the long-term impacts of collaborative governance strategies on community resilience, sustainability, and well-being. Comparing collaborative governance practices across different regions and contexts to identify best practices and lessons learned, investigating collaborative governance's behavioral and policy implications on local government structures and decision-making processes, and exploring innovative approaches and technologies that can enhance the efficiency and effectiveness of collaborative governance in smart communities. These future studies will provide valuable insights and recommendations for policymakers, practitioners, and researchers to improve collaborative governance practices and enhance community resilience and well-being in smart cities and communities.

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