Research on Regional Rural Governance Based on Two-Mode Network: Take Southwest China as an Example

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Abstract. In the last decade, complex systems in the form of network structures have become a popular research topic. Various biological, technological, transportation, social, and many others, have been modelled and analyzed as complex networks. In recent years, stakeholders of rural development have played a key role in solving rural problems. However, most of the previous studies have focused on only a few stakeholders (e.g., farmers, merchants, and local governments). A systematic analysis of stakeholders related to rural development is lacking. A true solution to rural development problems requires the collaboration of all rural stakeholders. Therefore, this study analyzes the stakeholder cooperation aspects of rural development issues from the perspective of complex networks. The case data of territorial development is modelled as a bimodal social network using Sichuan province in the southwest region as an example. The network is then observed in terms of global and local structure. The results show that all problems can be solved by at least two stakeholders, thus indicating the potential for cooperation in solving rural development problems. Local government, grassroots protection agencies, and villagers are the most influential stakeholders, with the highest centrality, intermediate, and eigenvector centrality. Villager satisfaction, infrastructure funding, farmers' legal rights, agricultural technology guidance, and industrial homogenization were the most influential impact issues. With an interaction density of 0.814, there were three core stakeholders and 14 core issues with close relationships. The core stakeholders accounted for 50% of the total stakeholders, while the core issues accounted for 82.35% of the total issues. In addition, three effective strategies to promote stakeholder collaboration were proposed and validated in this paper. After implementing the strategies, the collaborative network density increased from 1.242 to 2.652. This study not only helps researchers to understand the complex interrelationships between stakeholders and issues, but also helps practitioners to promote effective collaborative strategies.

Keywords: rural development · stakeholders · two-mode network · strategic research

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1 Introduction

With the implementation of the rural revitalization strategy, the production and lifestyle of farmers have been significantly improved, and the per capita net income has been significantly increased. However, there is still a big gap in the full realization of rural development goals [1]. Macroscopic policy-based development guidance is hardly universal and has great limitations in promoting revitalization in different regions. Therefore, it is very important to conduct targeted policy guidance and industrial development according to the development situation and location advantages of different regions.

Social network analysis is a set of theories and methods for analyzing the structure of social relationships and their properties. It mainly analyzes the structure of relationships constituted by different social individuals [2]. Unlike traditional social network analysis, which studies relationships within the same set of entities, bimodal network analysis studies relationships between two sets of entities. It can show the problems that can be solved together through them and the problems that are interconnected. In the process of rural development, the problems encountered in rural development and the cooperative relationship between different stakeholders happen to be two different entities. Therefore, the bimodal network in this study can not only explain the network characteristics of stakeholder collaboration, but also depict a roadmap for stakeholders to cooperate to promote the solution of regional rural development problems and rural revitalization.

The innovation of this paper is to use the bimodal social network analysis method to analyze the corresponding problems in rural development and the relationship between stakeholders. The bimodal network model can better avoid human interference and make the results more accurate for such social issues. We used eight villages in seven regions of China to collect expert data through a structured questionnaire. Subsequently, a bimodal network model was used to analyze the differentiated issues and stakeholders in different regions. Finally, we obtained the salient problems and stakeholder conflicts in different regions and proposed targeted policy advice for rural reform and development.

This paper is divided into five parts. Part I and Part II introduce the relevant research and background. Part III includes data acquisition and model analysis, describing the data sources and bimodal social network model. The fourth part presents a research analysis of the problems and stakeholders of rural development. Finally, rural development strategies and policy recommendations for locality are proposed. The method can accurately explore the development direction with regional characteristics, which is conducive to promoting the implementation of a rural revitalization strategy.

2 Literature Review

With the shift of stakeholder theory from a binary perspective to a network perspective, stakeholder collaboration has been emphasized as a new goal of stakeholder management [3]. Stakeholder collaboration is a process in which a group of autonomous stakeholders participates in a problem domain, using common rules, norms, and structures to take actions or make decisions on issues related to the domain [4] Due to the characteristics of autonomous stakeholders, factors such as different and competing interests, conflicting views, and complex relationships may hinder the collaborative process [5]. In the study of rural development issues, there are often multiple stakeholders with conflicting interests and mutual influence. The success of stakeholder collaboration relies heavily on coordinating the voices of stakeholders, so it is necessary to understand the prominent role of stakeholders in the collaborative process.

Based on the stakeholder salience model proposed by Mitchell [6], power is one of the most critical attributes. Power is defined as the ability of a social actor to change the behavior of others to suit his or her intentions despite resistance [7]. In the context of stakeholder collaboration, the power of stakeholders can be derived from their attributes and structural position [8]. The resource dependence perspective of stakeholder power and the network perspective complement each other by emphasizing that to understand stakeholder power, it is important to study the power relations of stakeholders in the collaborative network and the resources they have. The power advantage of stakeholders may arise from the position they occupy in the network, if they can control the flow of information and knowledge in the system, or if they have easy access to key resources in the network. Mote [9] investigated the complexity of R&D environments based on a dual-model SNA. Lin et al. [10] applied a dual-model SNA to investigate the power of stakeholders over social responsibility issues. In most studies using bimodal network SNA, one node set refers to the involved population and the other node set refers to the events (e.g., barriers and problems), and this research case provides a reference for this study.

In summary, previous studies have shown that the dominance of various firms in the countryside develops, and the stakeholder hinder development. At the same time, previous research on stakeholder power and stakeholder collaboration has shown that the greater the power of stakeholders, the greater their influence on problem areas. Existing research has rarely explored how to effectively remove various targeted barriers to rural development. This is inseparable from the actions of relevant stakeholders. To effectively overcome barriers to rural development, different stakeholders need to collaborate to provide different resources. Therefore, it is important to examine the influence of stakeholders on various issues of rural development.

3 Methodology

This study followed four steps: (1) identifying rural development-related stakeholders and impact issues, and (2) describing stakeholders' power over impact issues. (3) Develop a bi-modal SNA model. (4) Develop and validate strategies for regional rural development. In this study, we selected Pu Jiang County of Sichuan Province in the southwest region as an example for data collection de-regional analysis (Fig. 1).

3.1 Identification of Stakeholders and Impact Issues Related to Rural Development

This study used semi-structured interviews to collect data, and then conducted a bimodal social network analysis of them. First, based on the literature review, semi-structured interviews were used to identify issues and stakeholders. It is worth noting that the impact issues identified in the literature may be highly correlated and synonymous.

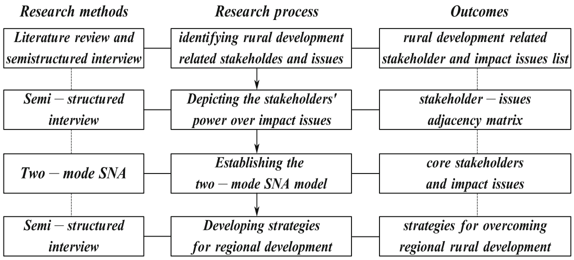

Fig. 1 The research process, corresponding methodology, and results

For example, "similar resources for enterprise development" and "homogenization of industrial structure" are synonymous issues. Therefore, semi-structured interviews can be conducted to help identify synonymous issues. Second, there are three main reasons for using semi-structured interviews. First, the purpose of this study was to investigate stakeholder power over rural development impact issues. Then, there is no project to record data on the influence of the involved population on regional rural development issues, and we need to collect data from experts. Second, semi-structured interviews can provide a great deal of information through the interaction between the interviewer and the interviewee [11]. The reliability of the data can be ensured through information sharing between interviewees [12]. Third, previous studies have demonstrated that interviewing and SNA methods can be well combined [13]. Specifically, data collected from interviews can be seamlessly used in SNA models.

In the course of the literature review, we initially identified 13 barriers, as shown in Table 1. Similarly, based on the study by Teng et al. [14], a list of six stakeholder groups with the authority to facilitate the removal of these barriers was initially identified. These six types of stakeholders include Local government, farmers, grassroots cadres, basic security institutions, banks, and Current industrial and commercial enterprises. The study also conducted semi-structured interviews to help identify synonymous issues and stakeholders related to rural development.

A pilot study was conducted to confirm the validity and reliability of the identified stakeholders and the associated barriers to rural development. By sending invitations to participate in the pilot study to 20 local experts in Pu Jiang County, Chengdu, and Sichuan, 11 of them expressed their willingness to participate. 11 experts had more than 5 years of research or grassroots work experience in rural development. Six of them were experts from local rural development centers, three were rural grassroots cadres, and two were leaders of manufacturing companies. The 13 barriers identified in the literature review, as well as the six stakeholders, were sent to the 11 experts via email for their comments and suggestions. The experts were asked to answer the following questions. (1) Were there any barriers and stakeholders identified in the literature review that was not relevant to rural development? (2) Were these barriers and stakeholders appropriately selected? (3) Are there additional barriers or stakeholder groups that could be included? These responses suggest that the experts' opinions strongly align with the barriers identified in the literature review.

Table 1. Barriers affecting the rural development

Code	Factors	Main references
F1	Infrastructure construction capital	[15] (Liu, et. al., 2022)
F2	Industrial village governance structure	[16] (Yu, et. al., 2021)
F3	Main capacity building of farmers	[17] (Zhu, 2022)
F4	Grassroots cadre pressure	[18] (Yang, 2020)
F5	Industry overinvestment	[19] (Simona, et. al., 2014)
F6	Will of famers	[19] (Simona, et. al., 2014)
F7	Blind governance	[19] (Simona, et. al., 2014)
F8	Cadre achievement	[20] (Liu, et. al., 2021)
F9	Legal rights of farmers	[21] (Pu and Yuan, 2019)
F10	Villagers satisfaction	[22] (Zhan, 2021)
F11	Agricultural capitalization	[22] (Zhan, 2021)
F12	Rural cultural construction	[23] (Wu and Jie, 2019)
F13	Rural environmental governance	[24] (Zeng, 2021)
F14	Agricultural technical guidance	[24] (Zeng, 2021)
F15	Rural credit	[25] (Du, 2021)
F16	Policy stability	[25] (Du, 2021)
F17	Industrial homogenization	[24] (Zeng, 2021)

3.2 Data Collection-Exploring Stakeholders' Power Status in Rural Development Issues

To explore the power status of the identified stakeholders over the barriers to rural development, a full semi-structured interview questionnaire was subsequently administered. In this study, the complete questionnaire was divided into three parts. A brief description of the study was given at the beginning of the questionnaire. In the second part, basic information about the respondents was collected, including their type of organization as well as their job position. In the final section, respondents were asked to assess the ability of six stakeholder groups to influence each of the 13 barriers through the use of 1 (yes) or 0 (no).

The target respondents of the questionnaire survey were limited to those who are genuinely involved in village-related development industries. To increase the sample size, this study used a snowball sampling technique. Snowball sampling can sample many people through respondents' social networks and is particularly useful when the desired respondents need to have relevant experience in certain fields [26]. Initially, 11 experts involved in the pilot study were invited to distribute the questionnaire among colleagues, business partners, and senior practitioners they knew who had extensive knowledge and experience in rural development. Likewise, respondents were encouraged to distribute the questionnaire to their colleagues after completing it, thus satisfying the snowball sampling technique. The questionnaire was distributed to respondents through the largest academic online survey platform in China, i.e., in the form of an online form.

The online questionnaire received 78 valid responses with a return rate of 34.6%. 67.6% of the respondents had more than 5 years of experience in rural development engagement. More than 15.7% of these respondents had more than 10 years of experience. Respondents represented a variety of involved people, such as grassroots cadres and local businesses. The balanced respondent profile reduced the bias of the questionnaire and improved the representativeness of the sample.

3.3 Building a Dual-Mode SNA Model

Bimodal network analysis is a special form of a complex network. Its nodes can be divided into two different sets. And only links are developed between the nodes belonging to different sets. In this study, data analysis was conducted using bimodal social networks, with 13 barriers and 6 relevant stakeholders as bimodal sets.

3.3.1 Constructing a Stakeholder-Barrier Adjacency Matrix

The elements of the stakeholder-barrier adjacency matrix are the right status of the stakeholders to the barriers. The stakeholder-barrier adjacency matrix (Z) consists of a set of stakeholders (X) and a set of barriers (Y). X_i represents each of the 6 identified stakeholders. Y_j represents each of the 13 barriers. a_{ij} represents a stakeholder X_i who can address barrier Y_j. We define it as follows.

$a_{ij} = 1$, Barrier Y_j can be addressed by stakeholder X_i.

$a_{ij} = 0$, Barrier Y_j can not be addressed by stakeholder X_i.

In the stakeholder-barrier matrix, two stakeholders can be considered as co-participating if they can solve the same barrier. Then, he can be captured by the stakeholder-stakeholder matrix of co-participation. The stakeholder-stakeholder matrix was constructed by calculating the barriers to co-participation between stakeholders. According to Li et al. [27], the co-participation barrier w_{ij} between stakeholders x_i and x_j can be calculated by Eq. (1).

$$w_{ij} = \begin{cases} card\left(X_i \cap X_j\right), & i \neq j \\ 0, & i = j \end{cases} \tag{1}$$

X_i denotes the set of barriers that can be addressed by stakeholder x_i. X_j denotes the set of barriers that can be addressed by stakeholder x_j.

The (i, j)th element of the stakeholder-stakeholder matrix can be defined as the number of barriers that both stakeholder i and stakeholder j have to influence to solve. This value can be interpreted as the similarity of power of different stakeholders to indicate their potential for cooperation [28]. Similarly, a barrier-barrier matrix can be created, where the ij-th element of the barrier-barrier matrix indicates the number of stakeholder groups with power over both barrier i and barrier j. This can be interpreted as resource similarity between the two barriers.

3.3.2 Visualizing and Measuring Stakeholder Barrier Networks

Based on the stakeholder-barrier adjacency matrix, the visualization of stakeholder-barrier networks was developed using Ucinet software. Four indicators reflecting the bimodal social network, namely eigenvector centrality, mediator centrality, degree centrality, and core/periphery structure, were used in this study [29].

Feature Vector Centrality: Feature vector centrality is a measure of the influence of its neighboring nodes. Eigenvector centrality is based on the belief that a node is important if its neighboring nodes are important. If the eigenvector centrality of a rural development problem is high, the problem can be solved by most of the important stakeholders; similarly, if the eigenvector centrality of a stakeholder is high, it means that the stakeholder can handle most of the critical rural development problems. According to [30], the eigenvector centrality of nodes in a network can be measured by Eq. (2).

$$C_e = \sqrt{\frac{1}{2n_0}} \tag{2}$$

n_0 denotes the size of the vertex set to which the node belongs.

Intermediary Centrality: Intermediary centrality is an indicator of a node's strategic position in the network, meaning that it can alter or impede the flow of information through it. Stakeholders with high intermediary centrality have more influence in dealing with the problem. An issue with high intermediary centrality indicates that the issue requires more collaboration among the stakeholders involved. Mediation centrality can be calculated from Eq. (3).

$$C_B(i) = \sum_{j}^{N}\sum_{k}^{N}\frac{g_{jk}^{w}(i)}{g_{jk}^{w}}, j \neq k \tag{3}$$

g_{jk} denotes the sum of the total number of binary shortest paths between two nodes and $g_{jk}(i)$ is the number of routes passing through k.

Degree Centrality: Degree centrality is a measure of the even connectivity or popularity of a node and its vulnerability to capture any flow in the network [29] In the two-mode SNA model, the degree centrality of a node in a set corresponds to the ratio of the number of links on that node to the total number of nodes in the other set. Accordingly, in stakeholder-barrier networks, stakeholders with high centrality are more capable of handling problems, and problems with high centrality can be solved by more stakeholders. According to [31], degree centrality can be measured by Eq. (4).

$$C_D(K) = \deg_k = \sum_{J}^{N} A_{k_j} \tag{4}$$

K is the focal node, j denotes the other nodes, N denotes the total number of nodes, and A_{k_j} is an element of the stakeholder-barrier adjacency matrix.

Core-periphery structures are commonly found in social networks. They are usually decomposed into a tightly cohesive core and a peripheral, loosely connected periphery. Nodes in edge positions are only relatively closely related to certain core nodes, while peripheral nodes are sparsely connected and have a scattered edge distribution. In a stakeholder-deficient network, the stakeholders in the core position are considered to be the key stakeholders who play a role in network coordination [32]. Thus, the core-periphery network structure can be tested by Eqs. (5) and (6).

$$\rho = \sum_{i,j} a_{ij}\delta_{ij} \tag{5}$$

$$\delta_{ij}\begin{cases} 1\ if\ \ c_i = core\ or\ c_j = core \\ 0\ otherwise \end{cases} \tag{6}$$

a_{ij} refers to the presence or absence of nodes in the observed data, c_i indicates the class to which node i belongs, and δ_{ij} indicates the presence or absence of nodes in the ideal structure.

4 Results and Discussion

4.1 Stakeholder-Barrier

Stakeholder entitlement status on the barrier can be determined when more than 80% of the respondents believe that the stakeholder group influences the barrier. This principle has been used by [33] to conduct a similar study. The developed stakeholder-barrier adjacency matrix is shown in Table 2. Regarding the influence of different stakeholder groups, Table 2 shows that S1 (government) can address the most barriers (16 barriers) among the stakeholder groups, followed by S2 (grassroots protection agencies) and S3 (villagers). Similarly, for stakeholders who need to address these barriers, F10 (villager satisfaction risk) requires the most stakeholders (5), followed by F1 (infrastructure construction funding risk), F2 (industrial rural governance structure improvement risk), and F9 (farmers' legal rights risk).

Four stakeholder groups, S1 (government), S2 (grassroots protection agencies), S3 (villagers), and S6 (grassroots cadres), have a strong power over the basic governance barriers (F1, F2, F5, F12, and F13). On the technical side, each stakeholder can influence at least five barriers. 2 stakeholders have high power over governmental development barriers (F4, F8, F9, F16), including S1 (government) and S2 (grassroots guarantee agencies). The 2 stakeholders with higher power over industrial development barriers (F5, F11, F14, F15, F17) are S1 (government) and S4 (Local business enterprises).

By converting the stakeholder-barrier matrix into a barrier-barrier matrix, as in Table 3, the resource similarity of the barriers can be examined, with more than 95% of the barrier-barrier matrix being greater than.

This indicates that each pair of barriers can be said to be addressed by at least one of the stakeholder groups. The matrix indicates that four stakeholder groups can influence both barriers F1 (risk of infrastructure construction funding) and F10 (risk of villager satisfaction), which implies that the pair of barriers has a high resource similarity and

Table 2. Barriers affecting the rural development

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	SUM
S1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	16
S2	1	1	1	1	0	0	1	1	1	1	0	1	1	1	0	0	1	12
S3	0	1	1	1	0	1	0	0	1	1	0	1	1	1	0	0	1	10
S4	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	1	5
S5	1	0	0	0	0	1	0	0	1	1	1	0	0	0	1	0	0	6
S6	1	1	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	6
SUM	4	4	3	3	2	2	3	2	4	5	3	4	4	4	3	1	4	

Note S1 = Local government; S2 = Basic Security Institutions; S3 = Farmer; S4 = Local business enterprises; S5 = Bank; S6 = Grassroots Cadres.

Table 3. Barrier-barriers matrix

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17
F1	4																
F2	3	4															
F3	2	3	3														
F4	2	3	3	3													
F5	1	1	1	1	2												
F6	1	1	1	1	0	2											
F7	3	3	2	2	1	0	3										
F8	3	2	2	2	1	0	2	2									
F9	3	3	3	3	1	2	2	2	4								
F10	4	4	3	3	1	2	3	2	4	5							
F11	2	1	1	1	2	1	1	1	2	2	3						
F12	3	4	3	3	1	1	3	2	3	4	1	4					
F13	3	4	3	3	1	1	3	2	3	4	1	4	4				
F14	2	3	3	3	2	1	2	2	3	3	2	3	3	4			
F15	2	1	1	1	2	1	1	1	2	2	3	1	1	2	3		
F16	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	
F17	2	3	3	3	2	1	2	2	3	3	2	3	3	3	1	1	4

requires action by similar stakeholder groups. Similarly, the matrix represents several pairs of barriers with the least resource similarity, such as F5 (risk of overinvestment in the industry) and F6 (risk of farmers' willingness). This suggests that the pairs of barriers are very different from each other and require different actions by different stakeholders to address them.

By converting the stakeholder-barrier matrix into a barrier-barrier matrix, as in Table 3, the resource similarity of the barriers can be examined, with more than 95% of the barrier-barrier matrix being greater than 1 this indicates that each pair of barriers can be said to be addressed by at least one of the stakeholder groups. The matrix indicates that four stakeholder groups can influence both barriers F1 (risk of infrastructure construction funding) and F10 (risk of villager satisfaction), which implies that the pair of barriers has a high resource similarity and requires action by similar stakeholder groups. Similarly, the matrix represents several pairs of barriers with the least resource similarity, such as F5 (risk of overinvestment in the industry) and F6 (risk of farmers' willingness). This suggests that the pairs of barriers are very different from each other and require different actions by different stakeholders to address them.

Similarly, the stakeholder-stakeholder matrix indicates the number of barriers that the stakeholder group can address. As shown in Table 4, the highest functional similarity among all stakeholder pairs was found between S1 (government) and S2 (grassroots safeguards). Both S1 and S2 could influence 12 barriers, accounting for approximately

Table 4. Stakeholder-stakeholder matrix

	S1	S2	S3	S4	S5	S6
S1	16					
S2	12	12				
S3	9	9	10			
S4	5	2	2	5		
S5	5	3	2	2	6	
S6	6	3	4	0	2	6

70% of the total number of barriers. Stakeholders in S2 (grassroots safeguards) and S3 (villagers) also had high functional similarities. In contrast, one pair of stakeholders did not have the same barriers that specific stakeholders were empowered to address, namely S4 (Local business enterprises) and S6 (grassroots cadres). These combinations of stakeholders need to deal with different barriers.

4.2 Visualizing Stakeholder-Barrier Networks

The visualization of the stakeholder-barrier network generated by Ucinet is shown in Fig. 2. In the figure, the stakeholder barrier is represented by red and blue nodes, respectively. Three properties of the network are analyzed, namely degree centrality, mediator centrality, and feature vector centrality.

Degree centrality is reflected by the size of the nodes in Fig. 2. The larger the node size is, the higher the degree of centrality is. The two stakeholder groups with the highest centrality are S1 (local government) and S2 (farmers). This indicates that these two stakeholders can use different resources to address many barriers. The six barriers with the highest centrality are F10, F2, F9, F12, F14, and F17, reflecting the high complexity of addressing these barriers as more stakeholders become involved. The three barriers with the least centrality were F16, F1, and F5.

In terms of mediating centrality, the highest-scoring stakeholders included S1 (government), S2 (grassroots protection agencies), and S7 (villagers). The high centrality among these stakeholders indicates that they have a prominent position in the network and play the role of mediators who can have a relevantly large impact on the barriers to rural development. Barriers with high mediator centrality include F10 (villager satisfaction), F14 (agricultural technology guidance), and F17 (industrial homogenization). This suggests that more stakeholder groups could address these barriers. Similarly, in terms of eigenvector centrality, the highest scoring stakeholders were S1 (government) and S2 (grassroots protection agencies), and the barriers with the highest eigenvector centrality were F10 (villagers' satisfaction), F9 (traditional project process domination), F12 (rural cultural construction), F13 (rural environmental governance questions), F14 (agricultural technology guidance), and F17 (industrial homogenization) The ranking of feature vector centrality was consistent with the ranking of degree centrality. The

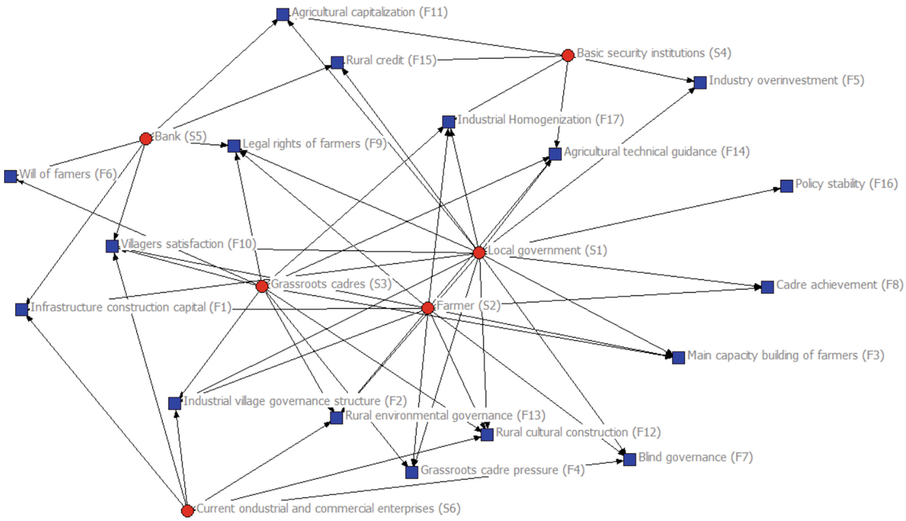

Fig. 2. Stakeholder-Barrier Visualization Network

identified stakeholders and high centrality barriers can be considered as key factors that have a significant impact on rural development.

4.3 The Core-Periphery Structure of the Stakeholder-Barrier Network

The results of the core-periphery structure model analysis are represented by the density matrix (Table 7). The final fitness was 0.739, which indicates that the real structure of the stakeholder-barrier network is highly similar to the ideal core/periphery structure. The density of interaction between core stakeholders and barriers was 0.795, indicating a close relationship between stakeholders in the core location and barriers. The density of the intersection part between core stakeholders and peripheral barriers and core barriers and peripheral stakeholders is 0.059 and 0.16 respectively which indicates that the core stakeholders are loosely connected to the peripheral barriers and the core barriers are loosely connected to the peripheral stakeholders. Therefore, it can be assumed that the stakeholder-barrier network exhibits a core-periphery structure.

Table 6 identifies the core stakeholders and barriers. 3 stakeholders and 14 barriers are located at the core, indicated by the top left corner. 3 core stakeholders include S1 (government), S2 (developers), and S3 (designers). A total of 14 barriers are at the core, except for F6, F8, and F16. This facilitates the flow of information between these core stakeholders who contribute to the development of shared values, attitudes, and interests regarding organizations involved in rural development (Table 5).

The core-periphery structure identified in this study guides how to develop an active network of stakeholder collaboration. For example, S1 (local government), located at the core, can address fourteen barriers, with thirteen barriers located at the core and three not. As shown in Table 6, these fourteen core barriers are more likely to be addressed by core stakeholders. Therefore, collaboration should be developed directly between these core stakeholders and S1 (local government). Since S1 (local government) has a high

Table 5. The centrality of nodes in the stakeholder-barrier network

Barriers	**DC**	**Rank**	**BC**	**Rank**	**EC**	**Rank**	**Barriers**	**DC**	**Rank**	**BC**	**Rank**	**EC**	**Rank**
F1	0.67	2	0.33	4	0.67	2	F13	0.67	2	0.22	8	0.67	2
F2	0.67	2	0.22	8	0.67	2	F14	0.67	2	0.35	2	0.67	2
F3	0.50	9	0.08	12	0.50	9	F15	0.5	9	0.23	6	0.5	9
F4	0.50	9	0.08	12	0.50	9	F16	0.17	17	0.00	17	0.17	17
F5	0.33	14	0.08	12	0.33	14	F17	0.67	2	0.35	2	0.67	2
F6	0.33	14	0.05	15	0.33	14	**Stakeholders**	/	/	/	/	/	/
F7	0.50	9	0.11	11	0.50	9	S1	0.69	1	0.32	1	0.69	1
F8	0.33	14	0.02	16	0.33	14	S2	0.59	2	0.22	2	0.59	1
F9	0.67	2	0.28	5	0.67	2	S3	0.48	3	0.20	3	0.48	3
F10	0.83	1	0.49	1	0.83	1	S4	0.40	5	0.12	6	0.40	6
F11	0.5	9	0.23	6	0.5	9	S5	0.32	6	0.15	5	0.32	5
F12	0.67	2	0.22	8	0.67	2	S6	0.44	4	0.18	4	0.44	4

Notes DC = Degree Centrality, BC = Betweenness Centrality, EC = Eigenvector Centrality.

Table 6. Core-periphery structure model of stakeholder-barrier network

	F1	F2	F3	F4	F5	F15	F7	F17	F9	F10	F11	F12	F13	F14	F8	F16	F6
S1	1	1	1	1	1	1	1	1	1		1	1	1	1		1	
S2	1	1	1	1	1		1		1	1		1	1	1	1		
S3	1	1	1	1	1	1	1	1		1	1	1		1			1
S4		1	1		1			1	1		1	1		1			
S6	1	1		1			1			1	1					1	
S5		1				1		1			1			1	1		

Table 7. Density network

		Barrier	
		Core	**Periphery**
Stakeholder	**Core** **Periphery**	0.795 0.160	0.059 0.014
Overall network density: 0.577 Final fitness: 0.739			

centrality index, S1 (local government) should play a key mediating role in fostering partnerships between these core stakeholders. The three peripheral stakeholders listed in the lower-left corner of Table 6 also can address these core barriers, although they are not as influential as the core stakeholders. Thus, in addressing core barriers, core stakeholders can also build collaborative relationships with peripheral stakeholders. As shown in Table 6, a peripheral stakeholder, S6 (grassroots cadres) can influence F10 (villagers' satisfaction), which can be solved by three stakeholders S2 (government), and S7 (manufacturers), and S3 (villagers).

5 Strategies for Promoting Collaboration

5.1 Strategy Identification

Based on an in-depth understanding of bi-modal social networks, three strategies to promote stakeholder collaboration are proposed. (1) Promote the importance of collaboration in promoting rural development. (2) Establishing a sound collaboration platform. (3) Establishing a collaborative blockchain system.

5.1.1 Strategy 1: Promote the Importance of Cooperation for Rural Development

The sense of collaboration among stakeholders related to rural development plays a key role in rural management. However, many stakeholders are not aware of the importance of collaboration. The government should enhance publicity and education to raise awareness among stakeholders. A series of campaigns through outdoor and public advertisements, newspapers, and radio is recommended to emphasize the importance of collaboration. In this way, the involved parties will be more proactive in communicating and collaborating.

5.1.2 Strategy 2: Establish a Good Cooperation Platform

Integrated village management is a complex system with multiple stages and involves people. It is recommended that the government establishes a collaborative platform involving all stakeholders, through which stakeholders know the best collaborators to solve specific problems and improve the efficiency of cooperation among stakeholders. First, a collaborative network is established based on the stakeholder problem network developed in this study. From this collaborative network, the stakeholders will know which stakeholders to collaborate with to solve the problems they encounter as barriers to development. Second, establish a trust mechanism. Third, provide technical support for collaboration. The government should encourage companies and research institutions to engage in technological innovation to facilitate collaboration. At the same time, introduce new technologies to stakeholders so that they can understand the important role of new technologies to improve the efficiency of collaboration.

5.1.3 Strategy 3: Build a Collaborative Blockchain System

Blockchain is the ideal technology for surveillance collaboration. It can provide a possible solution for any trust-building between two unknowing stakeholders. Trust is the cornerstone of cooperation between stakeholders. In addition, the tampering capability of blockchain makes possible the traceability of rural development issues and the definition of responsibility involving the public. The government should formulate appropriate policies to promote and implement the system.

5.2 Confirm the Effectiveness of the Strategy

To verify the effectiveness of the three strategies, the development of a collaborative network of stakeholders before and after the strategies was studied to achieve. We assumed that all strategies were considered effective. And the original matrix was modified with the corresponding impact weights.

Before the proposed strategies were implemented, the stakeholder collaboration network for rural development issues had 17 links with a low level of collaboration. After the implementation of the proposed strategy, the stakeholder network was changed to a 26-link structure. It can be observed that the new network has significantly increased the number of collaborations among stakeholders. For example, the number of collaborative relationships in the grassroots protection agency (S2) increased from two to five. In addition, there was a significant increase in the level of collaboration between most stakeholders. In terms of network attributes, the network density increased from 1.242 to 2.652. The simulation results indicate that the proposed strategy helps to promote collaboration among stakeholders. Therefore, increased collaboration among participating entities can be promoted by publicizing the importance of greater collaboration among stakeholders. The government and corresponding entities can establish a collaboration platform as well as a well-established blockchain system to efficiently quantify the energy efficiency of stakeholder collaboration.

6 Conclusion

Although the rural revitalization strategy has achieved phased results in China, many regions still suffer from poor policy adaptation and insufficient geographically targeted development. Based on social networks, this study explores the influence of stakeholders on regional rural development issues in the southwest region, using Pu Jiang County, Sichuan Province, as an example. A total of 17 rural governance problems were identified, and six stakeholder groups with the ability to solve these problems. Then, based on a structured questionnaire, the power status of stakeholders on each barrier was investigated using a two-model network analysis method. Network centrality indicators (degree centrality, intermediate centrality, and eigenvector centrality) were examined, and all issues were found to be solvable by at least two stakeholders, indicating the potential for cooperation in rural governance. Local government, grassroots protection agencies, and villagers were the most influential stakeholders. Villager satisfaction, infrastructure funding, farmers' legal rights, agricultural technology guidance, and industrial homogenization were the most influential impact issues in the network. The core-periphery structure revealed three stakeholders and 14 barriers at the core. This study presents theoretical contributions and practical insights for promoting the implementation of regional development policies. In addition, this paper proposes three strategies for promoting stakeholder collaboration. A comparison of stakeholder collaboration networks before and after strategy implementation reveals a significant increase in the number of collaborative relationships and a significant increase in the degree of cooperation. Therefore, stakeholders need to allocate their limited resources wisely to ensure that organizational and technical barriers are adequately addressed without ignoring certain obstacles.

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References

1. Han, J., 2020. How to promote rural revitalization via introducing skilled labor, deepening land reform and facilitating investment? China. Agr. Econ. Rev. 12(4), 577-582.
2. Yang, W.C., Lu, M.M., Chen, A.F., 2018. A Study on the Collaboration between Directors and Lead Actors in the Hollywood Film Industry from the Perspective of Social Network Analysis. Global. Journal of Media. Studies. 5(01), 81-97.
3. Missonier, S., Loufrani-Fedida, S., 2014. Stakeholder analysis and engagement in projects: from stakeholder relational perspective to stakeholder relational ontology. Int. J. Proj. Manag. 32(7), 1108-1122.

4. Wood, D.J., Gray, B., 1991. Toward a comprehensive theory of collaboration. J. Appl. Behav. Sci. A Publ. Ntl Inst. 27(2), 139–162.
5. Saito, H., Ruhanen, L., 2017. Power in tourism stakeholder collaborations: power types and power holders. J. Hospit. Tourism Manag. 31, 189-196.
6. Mitchell, R.K., Agle, B.K., Wood, D.J., 1997. Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts. Acad. Manag. Rev. 22(4), 853-886.
7. Gaski. J.F., 1984. The theory of power and conflict in channels of distribution. J. Market. 48(3), 9-29.
8. Tiew, F., Holmes, K., Bussy, N.D., Lockstonebinney, L., Holmes, K., Robertson, M., 2015. Tourism events and the nature of stake holder power. Event Manag. 19(4), 525-541.
9. Mote, J.E., 2005. R&D ecology: using 2-mode network analysis to explore complexity in R&D environments. J. Eng. Technol. Manag. 22(1-2), 93-111.
10. Lin, X., Ho, C.M., Shen, G.Q., 2017. Who should take the responsibility? Stakeholders' power over social responsibility issues in construction projects. J. Clean. Prod. 154, 318-329.
11. Yu, T., Shen, G.Q., Shi, Q., Lai, X., Li, C.Z., Xu, K., 2017. Managing social risks at the housing demolition stage of urban redevelopment projects: a stakeholder oriented study using social network analysis. Int. J. Proj. Manag. 35(6), 925-941.
12. Brinkmann, S., 2018. The Interview, Sage Handbook of Qualitative Research. Sage Publications, pp. 576–599.
13. Gan, X., Chang, R., Wen, T., 2018. Overcoming barriers to off-site construction through engaging stakeholders: a two-mode social network analysis. J. Clean. Prod.
14. Teng, Y., Mao, C., Liu, G., Wang, X., 2017. Analysis of take holder relationships in the industry chain of industrialized building in China. J. Clean. Prod. 152(20), 387-398.
15. Liu, Y. L., Yu, H. Y., Jing, T. R., 2022. Research on the efficiency of medical fiscal expenditure under the rural revitalization strategy——Taking Anhui Province as an example. Journal of Suihua University. 2022, 42(03), 28–31.
16. Yu, J. H., 2021. The subject consciousness of farmers participating in rural governance: An analysis based on the perspective of stakeholders. Theoretical Investigation. 2021(04), 91-96.
17. Zhu, H., 2022. The driving force and realization path of rural elderly care service model innovation under the background of rural revitalization strategy. Journal of China Agricultural University. 2022, 39(01), 180–195.
18. Yang, L., 2020. Returning, Controlling, and Binding: The Pressure Sources of Township Cadres and Their Explanations. Public Administration and Policy Review. 2020, 9(01), 63–72.
19. Simona, B., Carmen, B., 2014. Rural Education, an Important Factor of Regional Development in the Context of Local Government Strategies. Procedia-Social and Behavioral Sciences. 124, 77-86.
20. Liu, R. J., Wu, G. Y., Sai, J. L. F., 2021. The improvement of my country's rural endowment insurance system: realistic challenges and practical paths. Southwest Finance. 2021(12), 92-102.
21. Pu, S., Yuan, W., 2019. Rural residents' livelihood security, income growth and happiness from the perspective of rural revitalization: level measurement and optimization. Rural Economy. 2019(11), 60-68.
22. Zhan, G. H., 2021. The correlation effect between the improvement of rural governance quality and villagers' well-being. Probe. 2021(5), 151-163.
23. Wu, L. C., Jie, S. L., 2019. Rural cultural revitalization from the perspective of cultural governance: value coupling and system construction. Journal of Huazhong Agricultural University (Social Sciences Edition). 2019(01), 16–23, 162–163.
24. Zeng, J. W., 2021. Optimization path of new rural living environment from the perspective of rural revitalization. Agricultural Economy. 2021(12), 51-52.

25. Du, S., 2021. Research on rural financial demand and rural commercial bank service innovation under the background of rural revitalization. Tribune of Study. 2021(03), 109-114.
26. Zhang, X., Skitmore, M., Peng, Y., 2014. Exploring the challenges to development of wind power in China? A socio-technical barrier study. Energy Pol. 88, 465-476.
27. Li, H., Fang, W., An, Yan, L.L., 2014a. The shareholding similarity of the shareholders of the worldwide listed energy companies based on a two-mode primitive network and a one-made derivative holding-based network. Phys. A Stat. Mech. Appl. 415, 525-532.
28. Borgatti, S.P., Everett, M. G., 2000. M.G., 2000. Models of core/periphery structures. Soc. Network. 21(4), 375–395.
29. Sankar, C.P., Asokan, K., Kumar, K.S., 2015. Exploratory social network analysis of affiliation networks of Indian listed companies. Soc. Network. 43, 113-120.
30. Borgatti, S.P., Everett, M.G., 1997. Network analysis of 2-mode data. Soc. Network. 19(3), 243-269.
31. 32. Malik, H.A.M., Mahesar, A.W., Abid, F., Waqas, A., Wahiddin, M.R., 2017. Two-mode network modeling and analysis of dengue epidemic behavior in Gombak, Malaysia. Appl. Math. Model. 43, 207-220.
32. 33. Cattani, G., Ferriani, S., 2008. A core/periphery perspective on individual creative performance: social networks and cinematic achievements in the Hollywood film industry. Organ. Sci. 19 (6), 824-844.
33. 34. Shen, L., Song, X., Wu, Y., Liao, S., Zhang, X., 2016. Interpretive Structural Modeling based factor analysis on the implementation of Emission Trading System in the Chinese building sector. J. Clean. Prod. 127(20), 214-227.