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Examining social capital in rural collective action: its measurement, heterogeneity, and policy impact

Abstract:

In rural development research, social capital (SC) complements the causal gap between the endowment of resources and other capital in a community and the performance of collective actions, such as common-pool resource management. However, the concept of SC is ambiguous and its measurement is controversial. This study focuses on rural SC and attempts to measure it inductively using data (994 communities) related to various collective actions (22 types), rather than deductively piling up the detailed components of SC, as several studies have done. Hierarchical latent variable models are used to understand the hierarchical structure of SC. We used spatial regression models to examine the policy's causal impacts on SC accumulation while considering spatial heterogeneity. The results show that SC has spatial heterogeneity and a hierarchical structure, depending on the internal (bonding-type) and external (bridging-type) components, as well as on the difference between general activities and collective agricultural actions. The SC accumulation is strongly correlated with traditional and agriculture-related activities. Furthermore, policies increase comprehensive SC by approximately 20% but are more effective for internal SC than for external SC. These results suggest the need for policy options such as agglomeration bonuses when expanding the range of collective actions. Other findings indicate that the reinforcement of agricultural corporations and educational facilities are also effective in accumulating SC.

Keywords: social capital; inductive measurement; heterogeneity; policy impact; hierarchical structure; spatial regression

Introduction

The relationship between the performance of collective action in rural communities and the endowment of resources and capital is central to the debate in rural development studies. More recently, the relationship between the decline of rural communities and their conditions, such as a lack of resources and capital, has been the focus of attention, however, it remains unclear and complex (Wiesinger 2007). To fill this gap, social capital (SC) was developed and evolved (Coleman 1988; Putnam 2001; Ostrom 2009). Since the late 1990s, there have been a plethora of empirical studies on how SC works in poverty, common-pool resource management, and rural development (Flora 1998; Sobels et al. 2001, Michelini 2013; Mamiit et al. 2021; Wang et al. 2021). The SC is fostered under healthy economic, sociocultural, and environmental conditions, and a “connected society” rich in SC is more likely to promote rural development (Wiesinger 2007). In other words, SC is an important component of group attributes that cannot be explained by resource endowment or human and physical capital.

As SC is a diverse and multidimensional concept, the approach to the problem also depends on the situation (Portes 1998; Rivera et al. 2019). The SC studies typically use proxy variables that match their objectives. Durlauf (2002) argues that SC is an elusive concept as reflected in the fact that its definition varies from study to study. However, given that several studies have demonstrated the utility of SC, attempts to measure and use it practically and rationally may become more important in solving numerous rural problems. Another characteristic of SC studies is that several researchers regard SC as an attribute of the community (Putnam 1993; Lochner et al. 1999; Glaeser et al. 2002). Naturally, we can define various types of SCs, such as trust, networks, rules, conventions, and institutions (Ostrom and Ahn 2007). In other words, SC is diverse and multidimensional, as Portes (1998) described. However, it is extremely difficult to build up these individual attributes and define comprehensive SC.

Another concern is the new rural problems that have become increasingly visible and serious in some regions: the net population decline observed primarily in developed countries, and the resulting rural decline and common-pool resource management problems. Japan is at the frontier of this problem as it is the first country in the world to experience a significant decline in its population. Maintaining rural communities is an extremely important issue for them (Hori et al. 2021; Okada 2022). Rice cultivation is important in the Asian monsoon region, particularly in Japan, where irrigation water management is practiced extensively (Tanaka and Sato 2003). However, the sustainability of collective action is at risk because of the double whammy of comparative disadvantages in agriculture and the net population decline.

Therefore, the reinforcement of SC, which contributes to collective agricultural action, is an important concern. Under these circumstances, the Japanese government has implemented various policies to support rural communities. Several studies have examined how policy participation contributes to collective action and social welfare (Matsushita 2009; Matsushima and Matsunaga 2015; Ito et al. 2018; Kitano 2019). However, there has been insufficient research on whether policies contribute to the accumulation of SC.

Based on the above discussion, this study presents two major challenges. First, how to measure SC in a practical manner using the available data. Westlund and Larsson (2016) highlighted that SC is spatially heterogeneous and hierarchically structured, depending on geographical, economic, and administrative conditions. The SC has been theoretically interpreted from both deductive and inductive perspectives. Additionally, there have been numerous debates on the definition and measurement of SC. However, the data used and measurement methods differed depending on the context of each study. In other words, because the generalization of comprehensive SC measurements is extremely difficult, they must be situation-dependent.

This study attempts to measure the SC that contributes to rural development and sustainability. In this process, we focus on the measurement logic. This is similar to the thought-provoking methodology of Auer et al. (2020) who classified SC into internal (bonding) and external (bridging) types. However, our data differ significantly from these studies. Several studies, including Auer et al. (2020), assumed that SC cannot be observed directly and measured SC deductively by piling up and synthesizing its components. However, this study completely reverses this logical direction and attempts to measure it inductively. We focus on the perspective of Bowles and Gintis (2002) that “it focuses attention on what groups have done rather than what people own.” Following this concept, we try to measure and identify SC by the collective actions the community has engaged in, and not by the attributes and relationships of community members.

The Japanese Ministry of Internal Affairs and Communications (MIAC) has pointed out that SC in Japanese communities is primarily bonding-type SC and that bridging-type SC will be required in the future (MIAC, 2022). Therefore, in our analysis, we focus on two SC aspects: bonding and bridging components. We also distinguished between general and collective agricultural activities. Given these classifications, we measured the four SC categories and synthesized a comprehensive SC. The assumption of a hierarchical structure in the measurement of SC is a novelty of this study.

Our second challenge was to examine whether policies for the accumulation of SC were effective. Several economic and policy studies have examined how SC contributes to policy participation and key performance indicators (KPIs). However, it is clear that SC has various effects and contributes to social goals, and it is also important to examine whether SC itself can be improved by policies. We used econometric methods to clarify whether direct payments designed to support collective agricultural actions contribute to the accumulation of SC. We also examine environmental conditions other than policies to improve SC. The SC naturally depends on spatial, administrative, and geographic factors and thus has spatial heterogeneity (Wiesinger 2007; Westlund and Larsson 2016). This spatial heterogeneity may cause the identification of policy impacts to fail (endogeneity problem). Hence, we overcome this endogeneity problem using a spatial econometric model. We further clarify the differences in policy impacts by SC types and explore their spatial spillover effects.

The remainder of this paper is organized as follows. Section 2 provides an overview of current community-based policies in Japan and the target area of analysis (Kyoto, Japan). Section 3 describes the data and methodology. The analysis results are presented in Section 4, followed by the discussion in Section 5. Finally, Section 6 summarizes the study and discusses its limitations.

Background information

Current status of rural areas and community-based policies in Japan

Japan is a developed country in which population decline and aging are the most serious issues, with the phenomenon being more severe in rural areas (Inoue 2022; Tsutsumi 2021). This situation makes collective action and conservation of local resources difficult in rural areas. The Ministry of Agriculture, Forestry, and Fisheries (MAFF) estimates that 25–30% of rural communities may disappear in the next 30 years, with 90% of these disappearances occurring in hilly and mountainous areas (MAFF 2020a). In hilly and mountainous areas with poor agricultural production conditions, local resources have been severely degraded, with the national average rate of farmland abandonment exceeding 10% in 2010 compared to less than 5% in 1990 (Ito et al. 2019). Furthermore, irrigation facilities that have reached the end of their lifetimes account for 56% of the total. By 2022, the damage to farmland and agricultural facilities owing to disasters amounted to 97.6 billion yen (MAFF 2022a). These resources and facilities require daily maintenance and,

historically, farmers have managed them collectively. The MAFF implemented a multifunctional payment system (MPS) to support such collective action.

Japan is currently implementing the Japanese agricultural direct payment policy as a type of direct payment for environmental services (MAFF 2020a). This policy includes three major schemes: the aforementioned MPS, direct payment for hilly and mountainous areas (DPHMA), and environmentally friendly agriculture direct payment for environmental services (DPEFA). The first two policies are implemented on a community basis and require an agreement between a community-based organization and the government as a prerequisite for receiving subsidies. Both have agglomeration bonuses (Parkhurst et al. 2002), whereby the government recommends that communities work together to expand collective action (MAFF 2019). In other words, SC plays an important role in agreeing to and collaborating within and between communities.

The MPS we focus on is a direct payment for environmental services scheme called the “multifunctional payment system” launched in 2014; prior to 2014, it was implemented as “measures to improve farmland, water, and environmental conservation” (Komiyama and Ito 2017). It provides subsidies for collective action to enhance the multifunctionality of agriculture, such as the management and maintenance of farmlands, irrigation systems, and agricultural facilities (MAFF 2023). As one of the “Friends of Multifunctionality,” Japan has been complying with the policy paradigm to protect agriculture to the extent that it does not violate international rules, keeping pace with the EU and other countries (Sakamoto et al. 2007).

Fig. 1 depicts the current agricultural labor force in the community and the MPS agreements. The country’s agricultural labor force is declining rapidly, and correspondingly, the average number of farmers in the community is also declining. Conversely, MPS agreements increased through 2015 and then decreased by 2020. This is most likely due to a lack of labor to perform the collective actions required by the MPS. However, as indicated by the dotted line, the area of farmland covered by a single agreement increased. At first glance, this appears to be contradictory. However, this is likely supported by the wider coverage of agreements and networks with urban people. Nationwide, the number of wide-area agreements increased from 551 in 2013 to 991 in 2020 (MAFF 2022b). In addition, the number of communities engaging in collective agricultural actions (management of irrigation facilities) in cooperation with urban residents increased from 2.4% in 2015 to 10.1% in 2020 (MAFF 2022b). In the future, networks among rural villages or between rural and urban areas are expected to become more important for managing rural common-pool resources.

The MIAC also recommends the introduction of community support facilitators, particularly in depopulated areas, to strengthen bridging-type rather than bond-type SC. Such policy support may contribute to communication and agreement building for collective action (MIAC 2014).

Study area

Kyoto, the target area in this study, is located in the Kinki region of central Japan (Fig. 2). The prefecture extends from north to south, with the northern part facing the Sea of Japan and the plains in the south. The central part is mountainous, and the northern part often snows in winter, whereas the southern part has a mild climate. To the south, Kyoto is an international city famous for its historical and cultural heritage. The total arable land area is 29,800 ha, of which (23,200 ha) is paddy fields. In 2020, Kyoto Prefecture's agricultural output was 64.2 billion yen, which is about 15% of the Kinki region (MAFF 2020c). The share of agricultural output is 22% for rice, 33% for vegetables, and 21% for livestock production (compared to 18% for rice, 25% for vegetables, and 36% for livestock production for the nation), with a relatively large share of crops.

Vegetable production on small plots has long been practiced around Kyoto City, which has been branded as “kyo yasai” (Kyoto vegetables) with high added value (Oda et al. 2018). However, the northern central part of Kyoto Prefecture (Tango, Chutan, and Nantan) is a less favored area for agriculture, with several communities designated as hilly and mountainous areas (70% of the arable land in Kyoto Prefecture). While some Tango areas facing the Sea of Japan have large numbers of farmers, the Chutan area in the central part of the prefecture is dominated by small farmers and communities in poor conditions (Kitano 2021). Paddy field management plays a crucial role in maintaining communities, particularly in the Asian monsoon region, resulting in the accumulation of SC. Hence, Kyoto Prefecture, with its high dependence on rice cultivation, is an appropriate target for this study.

Another important reason for choosing Kyoto Prefecture as the target is that the rural community is in crisis. The number of farmers in Kyoto Prefecture has declined from approximately 100,000 in 1990 to 30,000 in 2020 (Kyoto Prefecture 2022). Furthermore, 25% of the farmers in 1990 were 65 years old or older; however, by 2020, this figure is expected to increase to 55%. In other words, the rural population is aging, and the labor force protecting agricultural common-pool resources is extremely vulnerable. Simultaneously, the next generation of professional farmers is becoming scarce, making it difficult to maintain and manage agricultural facilities, and damage to agricultural products

caused by wild birds and animals is becoming more severe, resulting in more than 10% farmland abandonment (Nagashio and Takamizawa 2018). In 2021, the Kyoto Prefecture announced guidelines for the sustainable development of depopulated areas in Kyoto Prefecture (Kyoto Prefecture 2022). This initiative emphasizes the importance of multifunctionality in agriculture and aims to achieve the sustainable development of rural areas by revitalizing depopulated and aging rural communities, which is consistent with the goals of the MPS. The Kyoto Prefecture is a suitable target for verifying the effectiveness of these policies.

Data and methodology

Data

Four major data sources were used in the analysis: the Agriculture and Forestry Census (AFC) ¹, the Status of the MPS², National Census (NC) ³, and Digital National Land Information (DNLI) ⁴. The largest and most important of these is the AFC, which consists of two surveys: a complete survey of farmers (hereafter referred to as the AFC) and the Report on the Survey of Rural Areas (RSRA), a survey of community activities covering all communities in the country. We use the latter to measure social capital.

The purpose of the RSRA is to understand the status of local resources and activities in the community and to gather information to be used for policies such as agricultural development and community revitalization. The variables from the RSRA for the SC are presented in Table 1 from “*Q_IGI*” to “*Q_EA4*”. Questions with the letter “*G* (general)” in the variable name (e.g., *Q_IGI*) ask about “general activities” taking place in the community (7 items). The items cover a wide range of activities, from community clean-up to festivals, and renewable resource initiatives. Whereas, the variable with the letter “*A* (agricultural)” (e.g., *Q_EA4*) asks about “agricultural collective actions” (4 items). These items indicate whether the community engages in collective action to conserve common-pool resources necessary for agricultural production.

¹ Please see the following website. <https://www.e-stat.go.jp/en/statistics/00500209>

² Please see the following website. https://www.maff.go.jp/j/nousin/kanri/r3jissi_joukyou.html

³ Please see the following website. <https://www.stat.go.jp/english/index.html>

⁴ Please see the following website. <https://nlftp.mlit.go.jp/ksj/>

The questions in each of these categories can be further divided into two types: First, the items asked whether the activity is carried out within the community, and these include the letter “*I* (internal)” in the variable name. Second, those with the letter “*E* (external)” asked whether the collective action was carried out jointly with urban residents or NPOs outside the community. In other words, the former refers only to internal activities within the community, whereas the latter refers to external activities. A total of 22 ($= (7 + 4) \times 2$) variables were used to measure SC.

As explained in the previous section, another objective of this study was to test the policy impact on the accumulation of SC. The MPS provides monetary support to communities engaged in collective action. As Matsushita (2009) highlights, the MPS aims at SC accumulation in agricultural communities; therefore, it is natural to choose it as the target for verification. The MAFF publishes data on MPS agreements in each community. We use this binary data (*POLICY*) to estimate the policy impacts.

In addition, AFC, NC, and DNLI data were used as explanatory (control) variables in the regression analysis of SC (policy impact analysis). Until now, analyses related to social capital in rural Japan have primarily used AFC (Tamoi 2007; Matsushita 2009; Ito et al. 2018; Kiminami et al. 2020). However, SC analysis cannot ignore non-farm residents and their spatial and administrative influences. Therefore, to capture the influence of non-farming residents within a community, we used NC data aggregated by the agricultural community. In Table 1, *HHs*, *AGEA*, *AGEH*, and *FEMAR*, which indicate the composition of the residents of a community, are variables from the NC, whereas data from *NFARM* to *MAINA* are from the AFC and primarily represent the agricultural structure within the community. Finally, the variables from *AGRIA* to *SCHOOL* are data from the DNLI and primarily represent the geographical conditions and the status of public facilities within the community. Geographical disadvantages, distance from the city, and availability of public facilities would naturally affect SC accumulation.

Hierarchical Latent Variable model

The SC components are generally composed of a wide variety of elements, none of which can be directly observed. While there is general agreement that it is desirable to measure SC at the community level, the definition of SC is ambiguous, leaving room for improvement in measurement approaches (Lochner et al. 1999). Putnam (2001) measured SC using data on various manifested social phenomena and summarized them through factor analysis. Following a similar idea of “what groups do,” as argued by Bowles and Gintis (2002), we attempt to measure SC inductively using

data on collective actions at the community level. Specifically, we use the latent variable model (LVM) to measure community SC (Rosseel 2012). In this study, SC was treated as a latent variable. This latent variable influences several manifest variables represented by various activities in the community (RSRA data).

The LVM is generally referred to as a confirmatory factor analysis (CFA) when no hierarchical structure exists. The simplest LVM model (SLVM) is illustrated in the upper part of Fig. 3. The SLVM represents a situation in which latent SC directly influences 22 different activities. The factor score for each community (observation) is interpreted as a measure of SC. However, SLVM may oversimplify the SC structure of a community; the effective pathways of SC may be horizontal or hierarchical, and they differ depending on the bridging conditions with the community and on the difference between general activities and collective agricultural actions.

Hence, we use a Hierarchical Latent Variable Model (HLVM) to capture the hierarchical structure of SC (Brunner et al., 2012; Beaujean, 2014). This is represented by the HLVM depicted in the lower part of Fig. 3. As explained in the previous section, the manifested variables were divided into four categories: general local activities of community residents (Q_IGs), general local activities with urban residents and nonprofit organizations outside the community (Q_EGs), agricultural collective actions of community residents (Q_IAs), and agricultural collective actions with urban residents and nonprofit organizations outside the community (Q_EAs). Using HLVM, intermediate SC scores (IG , EG , IA , and EA) and comprehensive SC (SC) scores were measured, thereby allowing for a more detailed analysis of the pathways and heterogeneity that influence the accumulation of intermediate SC.

Spatial regression

Using the estimated SC scores as dependent variables, the determinants were examined using regression models. We are interested in the effectiveness of policies designed to accumulate SC, that is, MPS. Given that SC is affected by community structure, socioeconomic status, and geographic conditions other than policy, it is necessary to control for these factors to estimate the policy impact. We assume the following model⁵, where y is the dependent variable vector

⁵ Naturally, SC measured by LVM contain measurement error. However, because it is used as the dependent variable, if the measurement error is uncorrelated with the explanatory variable and uniformly distributed, the regression coefficients are estimated consistently (Greene, 2002).

(the logarithm of SC), X is the independent variables matrix including the policy variable ($POLICY$), β is the parameter vector, and ϵ is the error term (I is an $N \times N$ unit matrix).

$$y = X\beta + \epsilon$$

$$\epsilon \sim N(0, \sigma^2 I)$$

However, SC is spatially heterogeneous (Puntscher et al. 2015). This means that the dependent variables are spatially dependent on each other and a general OLS estimation leads to endogeneity problems (Arbia 2014). To overcome this problem, we created a spatially weighted matrix using the GIS community polygon data provided by MAFF. Each element c_{ij} of the neighboring matrix (C : an $n \times n$ square matrix) created from the polygon data is a binary variable indicating the neighboring conditions between communities ($i, j = 1 \dots n$). Standardizing each row of C , a spatial weighting matrix (W) is derived (Anselin 1988). The relationship between c_{ij} and the elements of W , w_{ij} , is as follows:

$$w_{ij} = \frac{c_{ij}}{\sum_i c_{ij}}$$

Using this w_{ij} , it is possible to verify the spatial dependence of variable x using Moran's I index.

$$\text{Moran's I} = \frac{n}{\sum_{i=1}^n \sum_{j=1}^n w_{ij}} \cdot \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}$$

Using W allows for a regression analysis that accounts for spatial dependence (Lesage and Pace 2009). We estimate three spatial econometric models. The first is the following spatial lag model (SLM) that allows for spatial dependence among dependent variables (Arbia 2006).

$$y = \rho W y + X\beta + \epsilon$$

$$\epsilon \sim N(0, \sigma^2 I)$$

This model captures the spatial spillover effects of the dependent variables. This regression parameter ρ can be tested for spatial dependence by performing a Lagrange multiplier test. An alternative estimation method is the following spatial error model (SEM) model, which allows for spatial autocorrelation in the error term.

$$y = X\beta + \xi$$

$$\xi = \lambda W \xi + \epsilon$$

$$\epsilon \sim N(0, \sigma^2 I)$$

However, owing to the spillover effects of information on policy and spatial heterogeneity, such as geographical conditions, it is possible that explanatory variables also have spatial dependence. Hence, it is advisable to estimate a spatial Durbin model (SDM) that accounts for the spatial dependence of independent variables (Anselin 1988). The SDM is as follows:

$$y = \rho W y + X \beta + \rho W X \beta + \epsilon$$

$$\epsilon \sim N(0, \sigma^2 I)$$

Using these three models, we analyze the determinants of SC, including the causal impact of the policy.

3.4 Propensity score matching for robustness check

To check the robustness of the regression results, we estimated policy impacts using the propensity score matching method (PSM) (Rosenbaum and Rubin 1983). Participation in MPS is voluntary action by community members. Hence, simple differences in SC scores (SC) between with and without treatment include selection bias in addition to policy impacts. Our policy variable $POLICY$ is a binary variable that refers to participation in an MPS. If policy participation is random, assuming that the outcome for communities that participate in the policy (Treated) is SC_1 and that for communities that do not participate (Untreated) is SC_0 , the average treatment effect is represented by the following equation:

$$ATE = E[SC_1] - E[SC_0] \quad (1)$$

In reality, community attributes are confounding factors; that is, they simultaneously affect participation behavior and outcomes, that is, SC status. However, if the following equation holds with community attributes as the confounding factor X (excluding $POLICY$), then Equation (1) is an appropriate causal effect estimator.

$$(SC_1, SC_0) \perp POLICY | X$$

This is known as the conditional independence assumption (CIA) (Angrist and Pischke, 2009). In PSM, the participation probability P (Propensity score: PS) is conditioned on X . The PS is used to satisfy the CIS as follows:

$$(SC_1, SC_0) \perp POLICY | P(X)$$

In this study, $P(X)$ is estimated using a logit model. The PS and the nearest neighbor matching algorithm were used to match samples from the treated and untreated groups to estimate the ATE.

Results

Estimation results of LVM

A comparison of the two estimated LVMs is presented in Table 2, which compares the two models according to the typical fit criteria of the LVM, and shows that the HLVM is a better fit for all criteria. That is, the model with a hierarchical SC structure better explains the data on general activities and collective actions, which means that HLVM better estimates the latent SC scores. Hence, the analysis below focuses on the HLVM estimation results.

The HLVM estimation results are illustrated in Fig. 4 (see Appendix Table A1: supplementary material). In the HLVM estimation results, all paths, except for renewable energy activities with external stakeholders (*I_B7*), are significantly positively correlated with the intermediate SC latent variables (*IG*, *EG*, *IA*, *EA*). All paths from the intermediate variables to the comprehensive SC variable (*SC*) are also positively significant. In other words, if *SC* is properly measured, *SC* accumulation would be expected to be an effective determinant of collective action. However, the measured *SC* had a stronger marginal effect on *EG* and *EA*, indicating collective action with external stakeholders.

Next, the *SC* scores estimated by the HLVM are mapped in Fig. 5, which shows the distribution of intermediate *SC* (*IG*, *EG*, *IA*, *EA*) and comprehensive *SC* (*SC*). Although it is difficult to infer the cause of spatial dependence from this figure, it can be observed that the *SC* scores are not randomly distributed but form clusters in several locations. In other words, *SC* exhibits spatial heterogeneity. Particularly, we observed that the level of *SC* accumulation was higher in the central part of Kyoto Prefecture, whereas the northern coastal areas tended to have a relatively lower *SC* than the southern plain areas.

Table 3 compares the *SC* status (*SC*, *IG*, *EG*, *IA*, *EA*) according to three different geographical and socioeconomic conditions: (A) mountainous and depopulated areas, (B) mountainous or depopulated areas, and (C) non-mountainous and depopulated areas.⁶ A significant difference in all *SC* statuses except for *EA* were observed in the pairwise comparison of category (A), which has unfavorable conditions for agriculture, and category (C) which has favorable conditions. However, the characteristics of the differences varied according to the *SC* category. The *SC* within communities (*IG* and *IA*) was higher in areas with good conditions, whereas the *SC* related to external stakeholders (*EG*

⁶ The mountainous and depopulated areas are designated by the “Mountain Villages Development Act” and the “Act on Special Measures for the Promotion of Independence for Underpopulated Areas,” respectively.

and *EA*) was higher in areas with poor conditions. These results imply that the differences in geographical and socioeconomic conditions may have heterogeneous effects on SC accumulation.

Estimation results of spatial regression

Table 4 presents the results of estimating the determinants of a comprehensive SC (*SC*) by OLS and the three other spatial econometric models. First, we see that the SDM is the best fit in terms of the AIC. In addition, the impact of *POLICY* was significant in all the models. Given that the dependent variable is the logarithm of *SC*, the coefficient is the percentage change owing to a one-unit increase in the independent variable. Hence, the SDM results indicate that policy participation increases *SC* by approximately 24%. In addition, the spatial parameters λ and ρ are significant at the 5% and 10% level for SEM and SDM, respectively, indicating the existence of spatial dependence. In the following section, we interpret the parameters other than *POLICY* based on the SDM results.

First, *HHs*, which represent the number of households within a community, were negatively significant. This is consistent with the general interpretation that a larger community population makes decision making more difficult (Olson 1971). Conversely, the number of farmers (*NFARM*) has a significant positive effect. This is a natural result, because local resources are generally related to agriculture. Considered together with the *HHs* results above, this implies that an increase in the proportion of nonfarm households, that is, more mixed settlements within a community, will lead to a decrease in *SC* for collective action (Poteete and Ostrom 2004).

The *O500*, which indicates the percentage of large farmers, was negatively significant. Until recently, Japanese farming communities were relatively homogeneous in terms of the number of farmers in a community, however, the emergence of large farmers disrupted this stability and may have resulted in a decrease in *SC* (Yamaura 2008). The number of agricultural corporations (*NCORP*) has a positive effect on *SC*. In rural Japan, agricultural corporations are expected to play an important role as decision-makers and leaders and are likely to contribute to the improvement of *SC*. The *VEGET*, which represents the proportion of farmers selling vegetables, has a positive and significant effect. Sales of a variety of agricultural products other than rice may contribute to urban-rural exchange events and direct sales stores.

Accessibility to densely inhabited districts (*DID*) is negatively significant. In general, the more densely populated an area, the more diverse its occupations. Similar to the mixed settlements discussed above, occupational diversity is likely to disincentivize *SC* accumulation. In our analysis, we included local government facilities (*LOGG*) and

elementary schools (*SCHOOL*) in the model as proxy variables for local social infrastructure. Of these, *SCHOOL* has a positive effect on *SC*. Given that various meetings and events in rural Japan occur at the elementary school district level, the presence of elementary school facilities in the community is considered an important condition for improving *SC*.

Finally, we checked the extent to which spatial dependence was controlled by spatial regression. Table 5 presents the results of testing the spatial dependence of the key variables using Moran's *I*. The measured *SC* scores (the dependent variables) confirmed a strong spatial dependence. The spatial autocorrelation of the regression residuals of OLS and SLM was also detected using this test. However, no spatial autocorrelation was detected in the residuals of SEM and SDM, indicating that the problem of spatial dependence was overcome.

Heterogeneity and spillover of policy impact

Regression analysis of the latent scores of the intermediate *SC* (*IG*, *EG*, *IA*, *EA*) led to generally similar results (see Table A2: supplementary material). However, policies contribute strongly to internal *SC* (*IG* and *IA*) and relatively little to external *SC* (*EG* and *EA*) related to stakeholders and collective actions outside the community. The Japanese MPS was more effective in enhancing bonding-type *SC* than bridging-type *SC*.

As the SDM also estimates the lag parameters of the independent variables, it is possible to use them to estimate the indirect impacts of the policy or spillover effects through simulation (Lesage and Pace 2009). Table 6 presents the indirect impacts for each of the comprehensive and intermediate *SC* as well as the total impacts (including both direct and indirect impacts). First, the indirect impact was not significant for comprehensive *SC*; however, the total impact was significant, indicating that approximately 55% of the total impact was direct.

As the indirect impacts of *IG* and *IA* were significant, the total impact was also large. In both cases, the contribution of the direct impact is less than 50%, and internal *SC* can be accumulated by the spillover of information and other influences from neighboring communities. However, external *SC* (*EG* and *EA*) is limited to the impacts directly induced by the policy.

Average treatment effect and robustness check

To verify the robustness of the policy impact results, the ATE of the policy impact was estimated using PSM. First, we verified whether the conditions of common support and CIA were met. Fig. 6 compares the distribution of propensity

scores estimated by the logit model between policy-participating and non-participating communities, showing that the PS overlaps in most areas. The caliper condition was set for matching and the number of samples that dropped outside that condition was 45. Next, the balance of the covariates before and after matching was checked, as illustrated in Fig. 7. The values in the figure show the absolute standardized mean difference (ASMD) for the covariates before and after matching. The dotted line indicates 0.1, which is considered the general ASMD standard (Zhang et al. 2019). Balance greatly improved after matching for most covariates, with all covariates having an ASMD below 0.1, indicating that the CIA was met.

Table 7 presents the results of the ATE estimation. The overall ATE was estimated to be approximately 20% better and somewhat underestimated than the regression analysis results; however, this gap was slight. For intermediate SC, the estimated ATE is similar to the direct impact of the regression analysis, indicating that the estimated results are robust. Note that *EA* was not significant in the regression analysis but was significant at the 1% level in the PSM.

Discussion

In this section, we discuss the results of the analysis and derive the policy implications. First, the HLVM shows that SC measures are derived from a large amount of positively correlated collective action data and have a hierarchical structure. In general, social capital lowers the cost of collective action and promotes collaboration (Pretty and Ward 2001). The fact that the scores derived by the LVM were positively correlated with almost all collective actions demonstrates that SC was well-measured.

Our analysis indicated that SC might have a stronger influence on networked (external) activities than on (internal) community-only activities. This is consistent with Coleman's definition of "social capital inheres in the structure of relations between actors and among actors (Coleman 1988)." In other words, SC in rural communities is more apparent in the context of relationships with a wider range of stakeholders than simply connections among residents within a community. The SC was also strongly associated with traditional collective agricultural actions (Fig. 4). Historically, agriculture and village festivals have become indispensable components of community life. This essentiality might have contributed to the accumulation of SC in the community. Conversely, a decline in local agriculture can cause SC deterioration.

We also examine how Japanese policies designed to support collective agricultural action in communities have been effective in accumulating SC. The regression analysis results show that policy participation increases the SC scores by more than 20% (Table 4). However, the impact of the policy was skewed toward internal SC and less toward external SC (Table A. 2). MAFF recognizes this reality and therefore provides additional incentives for efforts to broaden MPS coverage (MAFF 2023). This supports the broadening of agreements beyond the community to the municipal level—that is, agglomeration bonuses. In general, when an agricultural community (the smallest administrative unit in Japan) receives a subsidy, it bears a considerable administrative burden. Hence, community-based subsidies increase administrative transaction costs (McCann et al. 2005; Vatn 2010; Ashida and Endo 2021). Hence, broadening the coverage reduces administrative transaction costs.

Important non-policy determinants of SC are community size and socioeconomic composition. Our analysis showed that age and gender, but not community size (number of people) or occupational structure, had no effect. Unfortunately, community size, unlike the transaction cost issue discussed above, works in the opposite direction for SC. This is because the number of households in a community increases the transaction costs related to decision-making within the community (Ostrom 2010). As Olson (1971) argued, group size generally has a negative impact on participation in collective action because of the free-riding problem. In other words, the results of our analysis demonstrate this phenomenon through the latent variable SC. However, the number of farmers positively affects SC. This is because agricultural development has been historically and path-dependently inseparable from SC accumulation in Asian monsoon regions such as Japan, where various collective actions such as irrigation management have been conducted at the community level (Fujiie et al. 2005).

Ironically, the results also reveal that the presence of large farmers in a community has a negative impact on SC because of the loss of traditional community homogeneity. This is consistent with previous studies showing that homogeneity within rural communities promotes consensus building (Ostrom 1994). However, the study also showed that agricultural corporations play a complementary role in the negative impact of large farmers on SC. In recent years, the number of agricultural corporations in Japan has been increasing because of policy deregulation (Ito et al. 2016), and it is expected that these organizations will lead to collective agricultural actions in their communities.

Finally, it is important to highlight the importance of social infrastructure. In Japan, various community events have been held in elementary school-based districts (MIAC 2022). Therefore, the availability of elementary schools within a

community is an important factor in promoting SC. Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) has implemented policies to prevent the deterioration of public school facilities (MEXT 2013). The results of this study support the importance of these policies in improving the infrastructure of educational facilities as a platform for various activities such as meetings and events in the community.

Conclusion

The relationship between depopulation, aging, SC, and collective action in Japan is instructive for several countries moving toward a mature stage of economic development. Asian monsoon regions with the same rural infrastructure are likely to face similar challenges once their economies enter a period of stability (Matanle 2014).

In this study, SC was measured inductively using data from various collective actions and the HLVM. The measured scores were positively correlated with the majority of the collective actions. The SC is spatially heterogeneous, showing that it tends to be higher in rural areas. However, a more disaggregated (intermediate) SC analysis shows that bridging-type (external) SC tends to be higher in rural areas. This is likely a reflection of the ironic reality that owing to depopulation and aging, rural areas in Japan cannot maintain their agricultural common-pool resources without relying on networks with other areas. However, in our analysis, the data used for SC measurements were only related to various collective actions. Therefore, aspects of SC that did not appear as collective actions, such as individual achievements and actions related to mutual support among residents, were not considered components of SC. In other words, although we may be able to measure a significant portion of SC, we may equate SC with collective action (good outcomes) (Sobels et al. 2002). Hence, improving the accuracy of SC measurements using richer information on residents and rural networks is a challenge for the future.

Direct payments to communities, such as MPS, are effective in accumulating SC, with program participation increasing SC scores by approximately 20%. However, the effect on the bonding-type (internal) SC was larger than that on the bridging-type (external) SC. Future institutional designs are necessary to promote external SC improvements, such as strengthening agglomeration bonuses and encouraging cooperation among urban residents. In addition, our analysis was limited to Kyoto Prefecture in Japan. Future efforts should be made to improve the external validity of this study by collecting data from other regions. Particularly, because communities in Kyoto Prefecture are a relatively closed

society (Ogawa 2011), the impact of policies on external SC may be lower than the Japanese average, which is an issue to be addressed in the future.

In depopulated and aging areas, such as rural Japan, collective action will become even more important, as there are limits to what individual farmers can do to conserve local agricultural resources. Our results show that agricultural corporations increase their SC, suggesting the need for organized groups of farmers to undertake collective action. Additionally, infrastructural facilities that serve as platforms for meetings and events are essential for SC accumulation. In Japan, public education facilities are used for these purposes. As these facilities age, policy support is required to renovate and maintain them.

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