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The determinants of collective action in irrigation management systems: Evidence from rural communities in Japan

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ABSTRACT

We examine the characteristics of water user associations (WUAs) that affect the success of collective action for irrigation management. Using random-effects ordered probit models and a large panel dataset from 104,523 rural communities, the results of the econometric analysis verify the hypotheses in the existing empirical literature and confirm the robustness of the theory of collective action in the context of irrigation management. Our results show that collective action for irrigation management depends on the distance from the market, area of paddy field, share of non-farmers and elderly farmers, share of paddy field, and social capital. We also find that collective action has an inverted U-shaped relationship with the number of farm households and diversity in farmers' landholdings, and a U-shaped relationship with the diversity of a community's farmers. The results suggest that as the characteristics of irrigation systems and user groups can change little in the short run, policies aimed at suppressing deteriorating collective action for irrigation management need to enhance social ties in a community, thereby promoting community-level social capital.

1. Introduction

Irrigation systems are typical of common-pool resources that are characterized by rivalry of consumption and difficulty of exclusion. Under circumstances where it is hard to exclude specific users from irrigation systems or where many people can openly access irrigation systems, open-access irrigation systems would be overexploited and depleted if not properly administered. This is a collective-action problem, as described by Ostrom (2010); if each individual in an interdependent situation selects strategies (e.g., labor contribution for irrigation management) based on a calculus that maximizes their own short-term benefits, individuals will take actions that generate lower joint outcomes (e.g., the state of the irrigation canal as a result of everyone's effort) than could have otherwise been achieved. Therefore, it is essential for irrigation management to perform collective actions based on farmers' collective efforts or cooperation in rural communities or water user associations (WUAs). While it is reported in the literature that collective action for irrigation management faces difficulties in organizing resource users, monitoring, and enforcing the rules, a number of case studies highlight the success of collective actions based on farmers' collective efforts or cooperation. Examples from developing countries include joint maintenance of a canal under customary rules and the establishment of shared norms in rural communities or water user associations (WUAs) to restrict open access (see, for example, Wade, 1989 Ostrom, 1990; Tang, 1992; Bardhan, 1993 for earlier studies, and Bastakoti and Shivakoti, 2012; Wang et al., 2013; Ricks, 2016 for recent works).

The literature discusses factors facilitating or impeding collective action for the management of irrigation systems and describes such systems in detail. Ostrom (1990) and Agrawal (2001) identified nearly 40 essential factors that are categorized into four kinds: user group characteristics, resource system characteristics, different governance mechanisms, and external environment. It is, however, not simple to identify those factors just through case studies. To reinforce the findings in individual case studies, quantitative studies focusing on the irrigation systems in different countries also found factors in the four classifications (e.g., Bardhan, 2000; Meinzen-Dick et al., 2002 for India; Dayton-Johnson, 2000 for Mexico; Fujiie et al., 2005; Araral, 2009 for the Philippines; Gorton et al., 2009 for Macedonia; Nakano and Otsuka, 2011 for Uganda; Ito, 2012 and Wang et al., 2016 for China; Takeda, 2015 for Japan; and Nagrah et al., 2016 for Pakistan).

In this study, we examine the characteristics of WUAs that affect the success of irrigation management in Japan. Collective action problems exist not only in developing countries, but also in developed countries.

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In particular, there is a collective action problem that is unique to developed countries. Focusing on developed countries, this study contributes to expanding previous research centered on developing countries. We focus on irrigation systems in Japan, which is facing its own unique set of collective action problems. The main crop grown in Japan is rice, for which irrigation is of particular importance. Gravity irrigation systems are the most commonly used mechanism in Japan due to the steep geographical conditions. The system is usually managed by rural communities (the smallest units of regional society in rural villages), which in many cases are simultaneously functioning as WUAs. Conventionally, both farmers and non-farmers in a rural community have participated in collective action for irrigation management because irrigation canals provide water for both rice production and domestic use. Therefore, it is difficult to overcome collective action problems because both farmers and non-farmers are beneficiaries of irrigation, which causes free-riding behavior from both sides. However, as described by Aoki (2001), mutual monitoring and enforcement of rules with strict penalties have worked well to prevent free-riding from happening within rural communities. As a result, collective action has been carried out based on the cooperative efforts of farmers and non-farmers in rural communities. However, many rural communities have been suffering from rapid depopulation, population aging, and urbanization since World War II, all of which are thought to have negative impacts on collective irrigation management. Therefore, numerous rural communities have experienced a significant change in the status of collective action. Given this background, we attempt to capture the relationships between the level of collective action and the change in economic and socio-demographic conditions. The outcomes of this study will provide meaningful implications for developing countries, which will experience similar changes in rural communities with their economic growth.

Another contribution to previous research is identification of some of the factors that influence collective action for irrigation management by using a large panel dataset at the WUA level. In previous literature, there has been no solid consensus about the direction, size, and significance of their impact on irrigation management. Therefore, the robustness of the previous results needs to be examined to identify the characteristics of WUAs that have proved successful in managing local irrigation systems. The lack of consensus among previous studies can be largely attributed to methodological issues, such as the cost and difficulty of collecting data (Araral, 2009). This study aims to address these issues. First, most empirical studies on irrigation management rely on cross-sectional data due to the difficulty of collecting information over the long term. Studies based on cross-sectional data cannot control for time-invariant unobserved characteristics of WUAs and irrigation systems, such as differences in geographical conditions and history. Therefore, the use of cross-sectional data potentially suffers from an omitted variables bias because some unobserved factors might affect irrigation arrangements in specific places (Wang et al., 2016). This is one of the causes inducing disagreement among researchers on the effect of some factors on the likelihood of collective action in irrigation management. Analyses based on panel data may help address this issue by controlling for unobservable characteristics of irrigation systems and WUAs. This study provides an opportunity to test the robustness of findings regarding the characteristics of WUAs that proved successful in managing irrigation systems by using a large panel dataset (N = 209,046; 2 periods) at the WUA level.

Second, most empirical studies on irrigation management do not specify, or incorrectly define, the nature of the collective action problem (Poteete and Ostrom, 2004; Araral, 2009). For instance, most studies use a subjective indicator, measured by “good” or “bad,” to evaluate the outcome or status of successful collective action, such as the level of activity of WUAs or the maintenance level of irrigation channels (Nakano and Otsuka, 2011). Indicators based on subjective appraisal may not precisely measure the exact levels of collective action in irrigation management. In this study, we use an objective indicator of irrigation management systems to denote different levels of collective action for irrigation management. This indicator is observable and provides objective information on the status of collective action. Third, many empirical studies censor a particular group of observations, such as inactive irrigation associations, from the data set (Araral, 2009). This type of exclusion would lead to a censoring bias in the estimations of the parameters of interest (Meinzen-Dick, 2007; Poteete and Ostrom, 2008). To circumvent a possible censoring bias, WUAs that do not continue or control irrigation management are also included in the sample.

The remainder of this paper is organized as follows. Section 2 provides an overview of farmer-managed irrigation systems in Japan. Section 3 reviews the empirical studies on farmers’ collective action in irrigation management to refine the fundamental indicators of irrigation management systems. The data and hypotheses are described in Section 4, while Section 5 discusses the proposed methodology and empirical results. The last section summarizes the main findings and provides our concluding remarks.

2. Irrigation systems in Japan

Cultivation of rice using gravity irrigation is the standard in Japan. Historically, rural communities have been the WUAs responsible for the operation and maintenance (O&M) of irrigation facilities. After World War II, both national and local governments began constructing large-scale irrigation facilities, such as dams, headworks, and main canals. Their management was transferred from the national and local governments to Land Improvement Districts (LIDs), which are organizations established in 1949 to undertake the construction, improvement, and management of irrigation/drainage facilities and land improvement projects, including farmland consolidation, within the boundaries of the district (Tanaka and Sato, 2003). At the same time, the rights of irrigation management were transferred to LIDs from each rural community. However, the Japanese government has endorsed a common rule for water use and assigned O&M to rural communities at the level of main and branch canals. The O&M of irrigation (except for large-scale irrigation facilities) has actually been implemented by rural communities to assure that the water from the river is stably delivered to the paddy field area through irrigation canals and efficiently allocated to various areas.

Rural communities clean, weed, and repair the main and branch canals. Through meetings held by rural community members a few times a year, rural community members decide how and when those activities are implemented. During the meetings, participants in those activities are determined through discussion or voting. Traditionally, all households (farm and non-farm) in the rural community were required to participate in such activities. The reason is that most households within a rural community were farmers, but even non-farmers used water from irrigation canals for their daily life. However, the participation rules for those activities have changed significantly over the last 50 years due to changes in the circumstances surrounding rural communities (e.g., rapid depopulation, aging of farmers, and urbanization) accompanying the rapid economic growth in Japan. In particular, the number of non-farmers and part-time farmers increased with urbanization, inducing significant heterogeneity among the members of rural communities. As a result, the involvement of all households of a rural community in irrigation management became more difficult. In recent years, participation in irrigation management has dynamically changed, shifting from participation of all households to the involvement of particular households (e.g., only farm households), or lack of management by WUAs.

Thus, it has become more difficult to overcome the collective action problem due not only to both farmers and non-farmers being beneficiaries of irrigation for rice production and domestic use, but also to the changes in circumstances surrounding rural communities. Therefore, since 2007, the government has been providing financial