Payments for environmental services (PESs), institutional bricolage, and the performance of village-managed irrigation systems (VMISs) in China?

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Abstract: This paper explores the effect of payments for environmental services (PESs) on village -managed irrigation systems (VMISs) in China by solving the issue of positive externality. Based on critical institutionalism theory, this study divides the institutional bricolage into four types, formed through the combination of PESs and local institutions in relation to irrigation systems. We infer transaction cost reduction and trust-strengthening mechanisms as the two pathways for the institutional bricolage to illustrate the process, whereby PESs enable VMISs to internalize positive externality. We conducted a field survey in Xuwen county in Guangdong province, where PESs were implemented as a pilot policy in terms of economic instruments to promote the conservation of agricultural systems in China. Based on 155 responses at the household level, using factor analysis and OLS regression, this empirical analysis assesses the effect of the PES policy on the three dimensions of VMIS performance, namely environmental, economic, and equitable (3E) benefits. In conclusion, this study confirms that PES is an effective means of improving the performance of VMISs in terms of 3E benefits, because it enables consistency between private and social benefits for the village engaged in managing irrigation systems. This study also finds that PES is of greater benefit to villages with local institutions because local institutions can reduce the transaction costs of policy implementation and strengthen trust between the village and the farmers through supportive policies.

Keywords: village-managed irrigation systems, institutional bricolage, payments for environmental services, local institutions

Introduction

In China, most of the small-scale irrigation systems are managed by the village (Lohmar et al. 2003). The village is a quasi-administrative entity that is legally recognized as an autonomous entity, as well as an extension of the local government. The village is responsible for pooling efforts and resources to maintain infrastructure, regulate water allocation, and monitor violations. Thus, the village-managed irrigation system (VMIS) is like a centralized regime.

VMISs have been subject to insufficient maintenance and operation in China (Wang, Wu, 2018) because of the externality caused by managing irrigation systems. On one hand, from the perspective of private benefits at the village level, the village leaders can obtain the farmers' support and votes in return for managing the irrigation systems (Shu et al. 2018; Biltonen et al. 2005). However, because food production is not profitable, even a well-maintained irrigation system, and thus a reliable water supply, is not an important factor in determining whether the farmers support the village leaders[1]. On the other hand, from the national viewpoint, VMISs can

[1] Farmers rate the development of the rural economy as the most important indicator of the political performance

generate social benefits from environmental services such as ensuring food security (Yao et al. 2017; Gong, 2015), and even affect remote beneficiaries (e.g. water security and biodiversity conservation) (Zhao, 2016). Obviously, the social benefits greatly exceed the private benefit, indicating the positive externality exists. The gap between social and private benefits discourages the village from engaging in managing irrigation systems effectively.

Traditionally, proposed solutions to overcome the externality problem have focused on decentralized regulatory policy, as a means of increasing private benefits to the village. However, numerous studies have shown that this approach is dysfunctional. The most common policy since the 1990s, farmers' participatory VMIS reform, has been shown to be inefficient (Wang, Wu, 2018). Most of the WUAs (water users' association) were only implemented on paper (Wang, 2013), and were very similar to the original management entity, the village (Yao et al. 2017). Only a few of these projects, which were funded by the World Bank, succeeded (Wang et al.2016), because the reform only transferred some of the organizational costs from the village to farmers or the WUA (Merrey, Cook, 2012), while the burden for the latter also increased. The support from the farmers did not increase, and thus the externality issue remained. The weak performance of the WUA approach, which was also seen in other developing countries (Vandersypen et al. 2007; Merrey, 2013), reflected the shortcomings of the reform measures, and in 2010 management responsibility was returned to the village. As a result, the ineffective VMISs have continued, the result being that surface irrigation systems have been reduced, and the number of private wells used for pumping groundwater has been increasing. Groundwater-irrigated farmland in China increased from zero in the 1950s to 40%-70% by 2004 (Wang et al. 2016; Wang et al. 2009), and overuse of groundwater has become one of the most serious resource problems in China, causing adverse environmental effects.

More recently, the Chinese government has decided to invest capital to rebuild the irrigation infrastructure. Because of the externality issue, the virtuous cycle of "infrastructure built—bad management—rebuilt" has often been repeated and is difficult to break, because the financial investment necessary is much greater than the cost of repairing the existing facilities (Liu et al. 2013; Bueno, 2014). On the basis that a centralized irrigation management system offers advantages over a decentralized regime (Smith 2018), researchers have issued an urgent call for studies aimed at identifying effective policies to improve the performance of VMISs (Yao et al. 2017).

In the environmental management field, payments for environmental services (PESs) have become a popular solution to the externality problem (Ferraro, Kiss, 2002; Muradian, 2013). PESs are voluntary transactions between service users and providers that are based on agreed rules for natural resource management in generating offsite services (Wunder, 2005, 2015). PESs are applicable to environmental services featuring non-private goods, including the CPRs (common pool resources) (Engel et al. 2008). In CPR studies, it has been shown that under a PES scheme, external beneficiaries make direct payments to the resource managing entity, for instance the

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of the village leaders, followed by provision of public goods. Farmers regard irrigation systems as no more important for development than other public goods such as roads and drinking water (Liu et al. 2013).

village, in return for governing the CPR well, that is, the provision of an environmental service. In essence, PESs can internalize the externality by offering payments, as well as economic compensation, and thus motivate the managing entity to put more effort into managing the CPR. In this way, the CPR management entity is expected to receive a direct incentive to include environmental service in their manage decisions, ideally resulting in more socially optimal resource use than would otherwise be the case. Studies on CPRs have found evidence of the effectiveness of PESs in relation to collectively managed CPRs, such as forestry restoration and water conservation in Ecuador (Hayer et al. 2017; Bellver-Domingo et al. 2016), as well as in China (Chen et al. 2014).

Therefore, PESs could help to improve the performance of VMISs in China. However, little is known about the application of PESs to managing irrigation systems. Irrigation systems are typical CPRs, and are viewed as specimens similar to the fruit fly in the field of biology (Yu et al. 2015) because they feature dual dilemmas (Ostrom 1990). One is the shared infrastructure provision dilemma, related to the maintenance of elements such as dams, reservoirs and canals, and tasks such as cleaning silt, grass, and trash, which demands collective labor or an annual investment to maintain functionality (Yu et al. 2015). The second dilemma is water allocation, including overuse and unequal appropriation, which is particularly challenging given the upstream-downstream asymmetry stemming from the canal layout (Janssen et al. 2011). These two dilemmas make irrigation systems more complex to manage than ordinary CPRs, such as forests. Exploring effective policies for irrigation systems can both contribute to the literature on CPRs, and provide potential solutions to the problem faced by VMISs in developing countries. In theory, the study of PESs in relation to irrigation systems can fill the gap between PES knowledge and VMIS practice.

This study attempts to identify whether the PES policy is effective in improving the performance of VMISs by addressing how the policy works in practice and what kinds of VMISs can benefit from the policy. The rest of the paper is organized as follows. First, we present an analysis framework to demonstrate the possible impact of PESs on VMISs using the theory of institutional bricolage, and two mechanisms explaining how the PES system works with local institutions to improve the performance of VMISs. Then, we provide an overview of the data and methodology, which is based on a field survey and case study in Xuwen county in Guangdong province in China. Next, we present and discuss the results of the empirical analysis. We conclude with remarks on policy application and theoretical innovation.

Theoretical framework

The features of PESs for VMISs

Besides its function in proving a solution to the externality problem, the PES system exhibits the following three features. First, it is a direct approach. The PES system is the cheapest way for the service user to adopt a “pay for what you want” approach (Ferraro, Kiss, 2002). If the government wants a better irrigation system for food security, then it should pay the village to provide the necessary service. Such request by the government sends a signal to the village that managing the irrigation system well can enable them to obtain economic benefits.

Second, it emphasizes the importance of providing good irrigation services. At the village level, irrigation system management is intertwined with other activities, and there is nobody focused solely on irrigation. Thus, it is difficult to attract extra attention from the village leaders (Wang, Shu, 2018). However, the implementation of PESs sends a signal that managing irrigation systems well is more important than other activities, and thus more effort should be expended on this activity.

Third, it is a voluntary system that features with a simple application procedure (Engel et al. 2008). The village has the right to choose whether to participate in the PES scheme, which suits the autonomous nature of the village (Hao, 2018). The village makes decisions about irrigation system maintenance and operation from the bottom up, rather than following the command-and-control, top-down approach of the government. Moreover, because the funding is provided for specific purpose, it is available immediately, rather than having to wait for the application to be reviewed by multiple layers of bureaucracy (Boyle et al. 2014). PESs can not only strengthen the fiscal autonomy of the village, but also provide the means of achieving this goal.

Insights from institutional bricolage

In recent years, the institutional bricolage approach proposed by scholars in the field of critical institutionalism has been widely used in CPR scholarship (Cleaver, 2012) because of its ability to frame the issues related to how outside institutions can work with local institutions in practice (Cleaver, Whaley, 2018; Peloso, Harris, 2017; Steenbergen, Warren, 2018; Hassenforder et al. 2015). Institutional bricolage, a term coined by Cleaver (2001), is referred to as "a process by which people consciously and unconsciously draw on existing social and cultural arrangements to shape institutions in response to changing situations." This study focuses on analyzing how the introduced institutions (the changing situation and the PES policy) are shaped by local institutions in relation to irrigation systems. Looking at through the lens of critical institutionalism, the functioning of formal institutions, when enforced by outsiders, depends on the institutional bricolage that the formal institutions are able to form with existing institutions in the region (Cleaver, 2015). Critical institutionalism proposes that when a new institution is introduced, it generates institutional dynamics not only for itself, but also for the existing institutions (Frick-Trzebizky, et al. 2017). The introduced and existing local institutions form an institutional bricolage that Bersaglio et al. (2018) regard as supplanting the functioning of the separate institutional arrangements to shape the subjects' behaviors. Sakketa (2018) proposed that to better understand the intervention effect, studies on irrigation system conservation should take institutional bricolage into account.

Managing irrigation systems, and dealing with the social dilemmas of insufficient infrastructure and excessive use of water (Ostrom, 1990) require coordination and cooperation (Tang, 1992), which are provided by the village, either in the form of local institutions (Baggio et al. 2015; Smith, 2018) or through a command-and-control approach.

In the CPR governance field, local institutions are generally defined in terms of the overarching framework provide by Ostrom and Basurto (2011), whereby the rules require s shared understanding by the various actors concerning what actions (or outcomes) are required, prohibited, or permitted. Roggero et al. (2018) propose a more specific approach based on a functional perspective, suggesting that local institutions can provide the necessary degree of coordination and cooperation to overcome the social dilemmas involved in governing the CPR. Local institutions are crafted through the participation of farmers and the village, based on a request from the village (Yao et al. 2017), and internal institutions, such as social norms, provide social information (Javaid, Falk, 2015). Three kinds of rules are particularly important in relation to VMISs: input rules for infrastructure maintenance, allocation rules for water withdrawal from the system, and penalty rules for punishing rule-breakers (Wang et al. 2016; Wang et al. 2018; Chai, Zeng, 2018).

Thus, at the village level, the existing local institutions can reshape the effects of the policy that is enforced (Wang et al. 2018), and thus a study of the PES policy is transformed into a study of the hybrid institutions. The PES policy, as a kind of formal institution, when introduced into the village, ignites a response from local institutions in terms of infrastructure maintenance and water allocation, and this process results in institutional bricolage. Thus, the PES policy's impact on the performance of the VMIS is subject to institutional bricolage, which reshapes the behaviors of the village to manage the irrigation systems well, and thus solves the externality issue.

As Cleaver (2012) noted, the process of institutional bricolage is enabled by agencies; meanwhile those agencies are also constrained by the bricolage process. On one hand, when the PES policy is implemented, the village becomes the agency of the government. The village plays dual roles in the process of integrating the PES policy with local institutions; they are both the bricoleurs and the subjects whose behaviors are shaped by the bricolage. In relation to the latter, the transaction is established between the government and the village, which initiates action aimed at meeting the government's request and also obtaining social benefits by managing the irrigation systems well to provide an environmental service and achieve food security. On the other hand, the village is initially the agent of the farmers, managing irrigation systems to obtain the farmers' support for private benefits. Combining these roles together, the identity of the village as an agent for both the government and the farmers serves to internalize the externality issue by uniting the private benefits and the social benefits.

How the PES scheme works: the importance of local institutions

Since the aim of this study is to improve the performance of VMISs, the following section focuses on the relationship between the PES scheme and local institutions, in particular the mechanisms underlying the operation of the PES scheme. There are two main mechanisms by which the PES scheme works in conjunction with local institutions, similar to the process of institutional bricolage (see Figure 1): a trust strengthening mechanism and a transaction cost reduction mechanism.

Trust strengthening mechanism

The trust strengthening mechanism works through intensifying local institutions by the PES policy (Faggin, Behagel, 2018), which is also a way of internalizing the externality. Local institutions are viewed as the keys to motivating farmers not to "free ride," resulting in increased trust, as well as cooperation, between multiple actors within and outside the village through the creation of social capital (Saunders, 2014; Chai, Zeng, 2018).

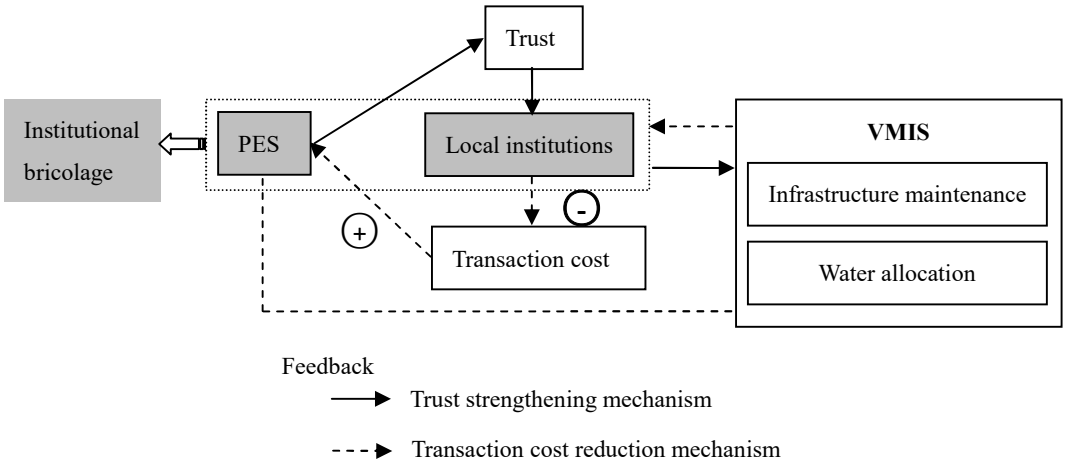

Figure 1 Mechanisms

On one hand, any policy that intends to improve the management of irrigation systems should aim to build trust among the stakeholders, otherwise it is likely to produce negative outcomes (Mosha et al. 2016) or even fail (Ostrom, 2011). An appropriate policy should work to reinvigorate, rather than undermine, existing local institutions (Peloso, Harris, 2017). Sarker (2013, 2014) provides robust evidence of the effectiveness of the PES policy, especially in the medium-sized community, and also proposes that the policy should only be implemented if it does not interfere with the operation of local rules. The PES policy, as an economic instrument via supply of funding, has been proved to be able to intensify and support local institutions to better address externality concerns and without lessening community control (Hayes et al. 2017). The average village in rural China is a typical medium-sized organization with a population of one or two hundred households. In addition, application for funding through the PES scheme is voluntary, and the scheme does not interfere with management practice in the field. Thus, payments can motivate the village to reinforce the existing local institutions, which can strengthen the villagers' trust that the village has the ability to manage the irrigation systems well. In this way, the PES can enhance farmers' support for the village, thus internalizing the externality issue through increasing their private benefits as a result of effective management of the irrigation systems.

On the other hand, if there are no payments for irrigation systems, the village, even though it has local institutions, has neither the motivation nor the capacity to expend any additional efforts. For example, since 2010, most of the irrigation infrastructure has been modernized using concrete, and the village cannot afford the cost of maintenance if the investment in terms of labor and capital under PES rules is insufficient. Therefore, VMISs continue to experience dysfunction, let alone being able to solve the externality problem.

Transaction cost reduction mechanism

The transaction cost reduction mechanism operates via the local institutions forming a closed feedback loop (see the dotted line in Figure 1). Scholarship in the field of CPR management have reached a consensus that only development policies that succeed in creating institutional arrangements that reduce transaction costs will be effective (Mburu et al. 2003; Adhikari, Lovett, 2006; Araral 2013). The PES framework proposed by Wunder (2012) suggests that implementing PES policy involves a contractual process between the government and the village, with the former being the service buyer and the latter being the service provider. This process is accompanied by transaction costs in the form of coordination, organizational, and monitoring costs. These transaction costs are barriers that prevent the PES scheme from achieving the outcomes that are theoretically possible.

Prior work suggests that local institutions, as a platform for dialogue between the government and the village (Agarwal, et al. 2017), have the goal of transaction cost reduction. Because local institutions can provide clear definitions of boundaries, and measurements and knowledge related to VMISs, they can identify similar preferences and perceptions between the government and the village, and thus are able to manage the contract. This dialogue platform also enables a closed feedback loop, which is necessary for improving the systems of communication, as outlined by Bueno (2014) and Baggio et al. (2015), between the PES scheme and the VMIS, enabling a good fit between them (Anderies, Janssen, 2013). This feedback loop is associated with low uncertainty, similar preferences and perceptions, minimal asymmetric information, and rule compliance in relation to managing irrigation systems, which are the conditions necessary for low transaction costs, as outlined by Cox et al. (2010) and Libecap (2014).

Without the presence of local institutions, the implementation of PES schemes would face problems as a result of a lack of dialogue with the village, and thus an inadequate understanding of the state of the existing systems. This may result in considerable transaction costs in the process of contract implementation, which would stifle collective action among the community (Ayres et al. 2018), and thus prevent the PES project from being carried out successfully. Ultimately, the development efforts of the PES scheme would be undermined.

Hypotheses regarding the effect of PESs on the performance of VMISs

As Cleaver (2012) notes, even institutions that are well designed will not necessarily lead to better governance performance. Instead, there can be mixed outcomes on the ground (Faggin, Behagel, 2018). The PES policy may be exercised in various ways in the villages in terms of institutional bricolage, and so we hypothesize that the impact of the PES policy can produce different outcomes. The performance of the PES policy is subject to the solution to the externality problem in terms of institutional goodness of fit between the government and the village (Koppenjan, de Jong, 2018).

As Figure 2 shows, this study classifies institutional bricolage into four types based on whether

or not PESs have been received and local institutions exist. Bricolage type 1 provides the baseline for a VMIS, with neither PES payments received nor local institutions existing. Bricolage type 2 encompasses only one institutional arrangement, the PES policy. Bricolage type 3 involves only local institutions, with no PESs, and bricolage type 4 consists of both PESs and local institutions.

In relation to bricolage type 1, when it comes to managing irrigation systems, the role of the village only exists on paper, rather than in practice. Similar to open access CPRs that are subject to excessive exploitation and insufficient protection (Ostrom 1990), we infer that the VMIS does not perform well, and thus the irrigation systems declines over time and may eventually fail as a result of lack of proper management.

For bricolage type 2, vis-à-vis the baseline, the payment institution that is employed can generate an additional effect through mitigating the double dilemma in relation to irrigation systems. As proposed by Smith (2018), centrally managed irrigation systems have an advantage in dealing with the dilemma of infrastructure maintenance because the administrative organization has sufficient authority to overcome numerous barriers (Stodard et al. 2014). Therefore, the performance of VMISs in the case of bricolage type 2 could be better in terms of slowing down the process of irrigation system degradation. However, studies on external assistance in the field of CPR management have found that development efforts from the top down are difficult to implement without the involvement of the local community (Frost et al., 2007). Even existing local endeavors can be crowded out if the community perceives the funding as a means of external control instead of being supportive (Murtinho et al. 2013). We infer that in this case, the system is likely to gradually degenerate over time as a result of the changed behaviors of the village in response to the receipt of payments. However, these payments are introduced into an environment without institutional foundation, and the village must solve the externality issue alone. Obviously, performance under this circumstance could be moderately improved.

Similarly, for bricolage type 3, the performance of the VMIS should be better than that under bricolage type 1 if all of the local institutions can work to internalize the externality issue through solving the dilemmas relating to infrastructure maintenance and water allocation. However, the village cannot collect tax, making it difficult to finance large items of expenditure. Instead, it relies on individual contributions, often in the form of labor rather than cash. This marked financial weakness leaves the VMIS trapped in the critical dilemma of infrastructure maintenance. Thus, local institutions are insufficient to keep the irrigation systems performing well (Yao et al. 2017).

This study explores the potential effect of PESs on VMISs in general, and when differentiating between the various types of institutional bricolage, we simply focus on whether there are any local institutions, rather than comparing various local institutions. Since the village voluntarily applies to participate in the PES project, the introduced institution and the local institutions can produce co-benefits for both the government and the village, a process that can be termed "integration" (De Koning, Benneker, 2013; Faggin, Behagel, 2018). Therefore, regarding the bricolage type 4, we hypothesize that a VMIS under this condition should operate better than those under the other three types of bricolage. The irrigation systems should be able to be kept

well-maintained over a long period of time, and the institutional bricolage that is obtained should improve the functioning of either of the two institutional arrangements. Because this type of bricolage indicates the institutional goodness of fit between the government and the village, the payments can play a role in complementing the function of local institutions and help to narrow the benefit gap between the village leaders and the nation, and thus solve the externality issue. In another words, as shown by bricolage type 4, the PES policy is more useful in a village with local institutions than in one without local institutions (i.e. bricolage type 2).

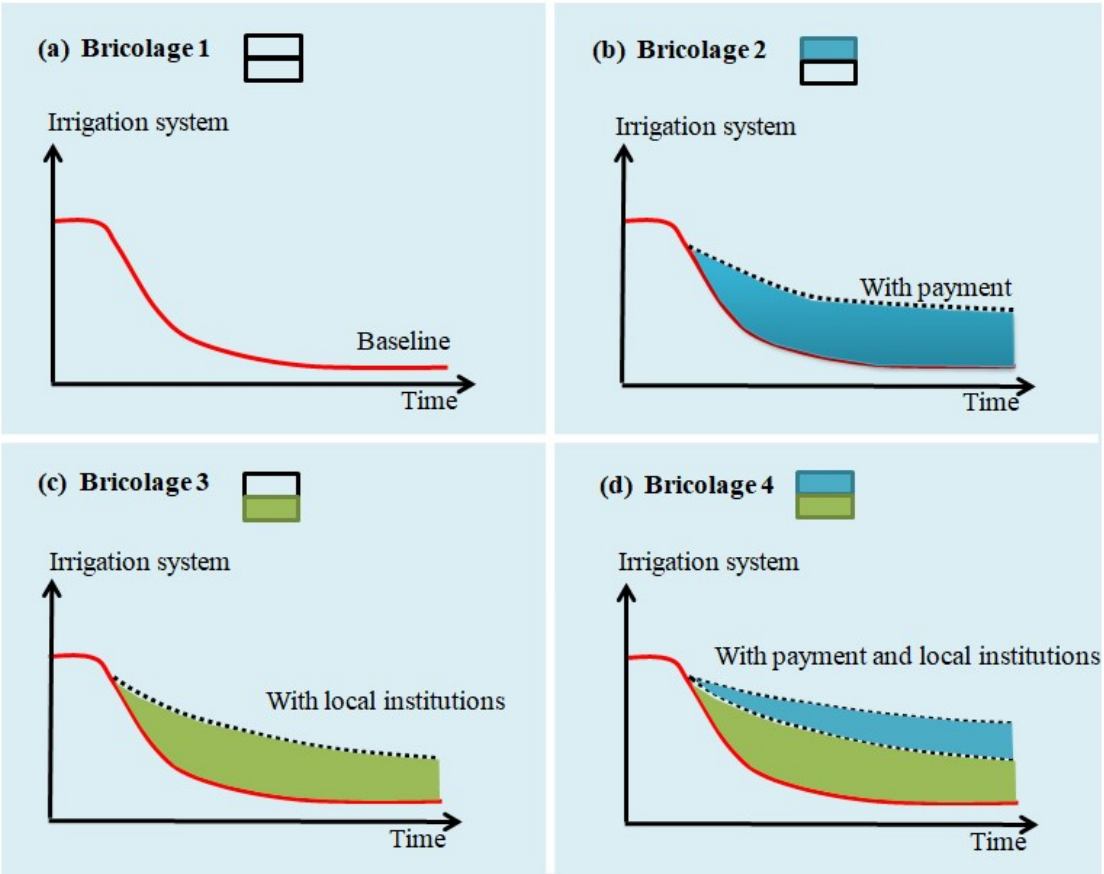

Figure 2 Hypotheses regarding the performance of institutional bricolage

Method

PES scheme in relation to irrigation systems in Guangdong

In 2012, Guangdong created a funding policy that was a pilot scheme in terms of the use of economic instruments to promote the conservation of cropland in China. This policy has several objectives, including protecting the productive power of the cropland, ensuring the cropland environmentally sustainable, and preventing cropland from being transformed into non-agricultural uses. The funding specifically targets entities that are responsible for cropland conservation, such as villages. The policy is designed to provide an incentive, with annual payments of 30 yuan/mu provided by the Guangdong government. At the beginning of every year,

each township government encourages the village to apply for funding. The villages voluntarily apply for funding based on their requirements. Normally, in a paddy rice planting region, the villages use the funding to update or maintain irrigation infrastructure. Therefore, in practice, this initiative is a PES policy in relation to irrigation systems.

This PES scheme has the four characteristics of a general PES scheme proposed by Wunder (2015). First, the village voluntarily applies to the government for funding. The scheme is entirely based on the village's willingness to participate, rather than being a command-and-control intervention initialed by the government. The scheme provides compensation for the cost of maintaining an irrigation system. An annual payment of 30 yuan/mu is set based on a document titled "Fixed cost of maintaining small-scale irrigation systems" from Ministry of Water Resources. From the government's point of view, this funding is sufficient to cover the cost of maintenance. A village that applies for and receives this funding should bear all other cost (such as labor costs and operating costs).

Second, this is a transaction between the government (service buyer) and the village (service provider). Given their function of ensuring water and food security, irrigation systems were viewed as China's agricultural arteries by Chairman Mao, and are currently seen as the foundation of a revival of China's rural areas (Liu, Li, 2017). Thus, it is the government that seeks the provision of services necessary to keep the irrigation system in good condition. Therefore, the government must pay the village to maintain and operate the irrigation system. Since the village is responsible for the irrigation system in Guangdong, it is clearly a service provider to the government.

Third, it is conditional on the agreed rules of irrigation management, which uses cropland that has previously benefitted from funding as a benchmark against which the level of service provision is measured. In their funding application, the village states the area of cropland that would benefit from the program. This is an indirect way of measuring irrigation management performance, and is widely used by researchers (Lam, 1998; Wunder, 2015). After being verified by the township's government, this conditionality is assumed in the contract.

Fourth, it is designed to internalize the positive externality of the increasing investment by the village in infrastructure maintenance and water allocation management. The Guangdong government is external to the physical sites where the conservation service is provided by the village. Since the government is enjoying the benefits in a separate location, it cannot be charged directly for them, making the PES scheme an appropriate alternative arrangement. The benefits that the government obtains include multiple non-use values such as food security.

Data and case study community

The data used in this study were collected via a field survey and interviews conducted in the first half of 2018 in Xuwen county in Guangdong province. Xuwen was chosen for three reasons. First, the entity responsible for the management of irrigation systems in this region is the village, unlike other counties, which vest responsibility in different entities such as WUAs or contractors. The use

of this single entity is helpful for measuring the impact of the policy on the VMIS. Second, irrigation systems are very important for planting paddy rice because this is the only food that is available, and precipitation is scarce during the cropping season. Third, Xuwen only implemented the PES policy in 2016, later than other counties in Guangdong, which provided a neutral institutional background against which the impact of the new policy could be evaluated. These features enabled us to accurately measure the effects of the introduction of the PES scheme.

The following strategies were used to select the sample. First, only those villages planting paddy rice were chosen. To identify the impact of the PES scheme, we chose both villages that were participating in the project and those that were not participating. The water source for the irrigation system in these villages is water stored in reservoirs or small ponds, which are public infrastructure and provide free water. Second, the sample villages are distributed across Xuwen, and thus capture diversity in local conditions. Thus, the sample can be viewed as a county-level representative sample. Third, in each town, to exhibit the diverse range of village characteristics, the administrative villages are selected based on the non-neighboring principle. In each village, two or three households are randomly selected from the list of names with the proviso that their farmland must be situated at different locations along the canal. We also selected an additional household in each village as an alternative in case one of the selected households was not available at the time of the survey. The final sample consisted of 155 households in 75 villages within ten administrative villages in five towns (see Figure 3).

We conducted a series of face-to-face interviews to collect information at local level. We interviewed ten public servants at the county level and 30 public servants working in township-level agencies who were responsible for the construction and management of irrigation systems and agricultural development and planning. Then, at the village level, we interviewed the leaders responsible for irrigation system management, who were generally the village party secretaries or village heads. The interviewees provided information about the PES scheme (including policy documents and files related to funding applications), local views on the operation and maintenance of irrigation systems, the current status of the irrigation systems, and agricultural production.

The household-level questionnaires were distributed in 2017 and consisted of questions on the following areas: the PES scheme, local institutions, community attributes (demographic characteristics, interaction with the government), biophysical conditions (irrigation technology, area of cropland), and initial outcomes (physical condition of irrigation systems, water supply, paddy rice production, water availability both upstream and downstream, water quality, and soil quality).

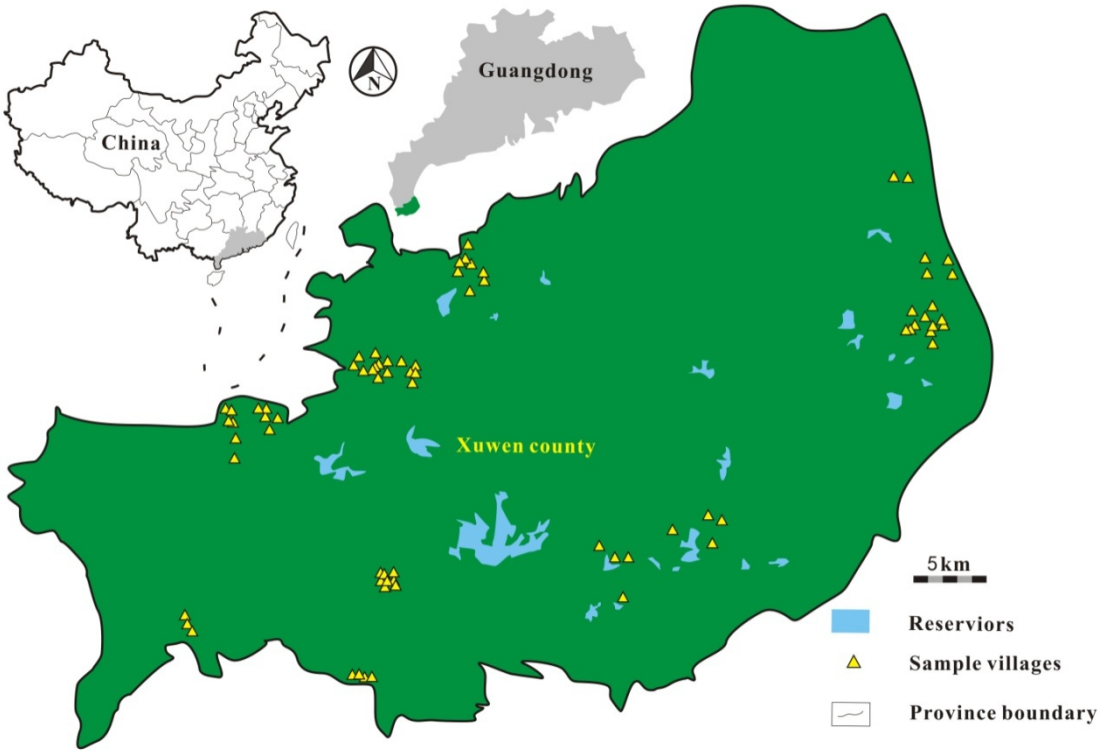

Figure 3 Map of study area

Background of Xuwen county

Xuwen, which is located in the most southern part of Guangdong, is a water-scarce county lacking surface water, because average annual evaporation (1472 mm) exceeds average annual precipitation (1387 mm). Moreover, Xuwen has a temporally and spatially unbalanced distribution of precipitation, with 70% of the average annual rainfall fallings during July-September. The wet season runs from July to December, and the dry season in the first half of the year accounts for only 30% of annual rainfall. Average annual precipitation in the western and southern parts of the county is about 1364 mm, almost twice as much as that in the eastern and northern parts (795 mm). The rice growing seasons are the same throughout the county, with the early crop from April to July and the late crop from July to October. Therefore, the early and late crops often suffer from drought and flooding, respectively. The climatic conditions make paddy rice planting extremely dependent on VMISs.

The irrigation systems below the main canals are collectively managed by the villages. These systems were built in the 1960s and 1970s, and have been operated and maintained by the villages since then. After the abolition of the national agricultural tax in 2002, the administrative villages and town governments lost the economic capacity to provide subsidies for the irrigation systems, which left the villages reliant on self-governance. On average, the villages have a population of 400 people living in 100 households, and 30 ha of irrigated farmland. Most households are engaged in agricultural work. While planting paddy rice is rarely the main source of income for

families, it can be an important part of a household's livelihood portfolio, and provides sustenance for most families in the study area. Since the price of paddy rice is about 2.6 yuan/kg, planting paddy rice is unprofitable.

The local institutions in relation to irrigation systems include those related to infrastructure maintenance and water allocation. For the former, which is based on the input rule, the village organizes periodical maintenance twice a year, and the rule states that the households should provide either labor or money as requested. For the latter, which is based on the allocation rule, the household appropriates water in accordance with the sequence rule, whereby upstream plots have priority. Rule violators are excluded by other farmers and serious conflicts are resolved by the administrative village through mediation. These local institutions are governed by informal rules that have been in practice for a long time. One point worthy noting is that the input rule is the most important rule, and plays a dominant role. If the input rule did not exist, the other two rules would most likely be dysfunctional. In our sample, all irrigation systems had the village as the management entity, but not every village had the local institutions in place.

The PES scheme is the most formal economic instrument used by the government to regulate villages in managing irrigation systems. In contrast to the national regulations, which generalize the responsibility of villages in relation to irrigation operation and maintenance and are weakly enforced, the PES scheme creates an institutional environment that incentivizes villages to develop their local institutions instead of being subject to direct intervention. In Xuwen, some of the irrigation systems used for paddy rice had previously been modernized by the government from the top down, however, these projects had not included village participation. Therefore, the PES scheme is the first one these villages have been able to obtain institutionalized investment.

Model

Dependent variables

The management of irrigation systems includes multiple dimensions. As Lam (1998) and Wang et al. (2016) have noted, performance measurement is typically solution-oriented, and includes dimensions such as physical condition, water delivery, and agricultural productivity. In the context of Xuwen and the problems facing the VMISs, this study uses ten initial outcomes to evaluate performance (see Table 1). Of the ten outcomes used in the analysis, two are continuous and the other eight are categorical. Each outcome corresponds to one of the three initial dimensions of performance.

Table 1 Descriptions of dependent variables

Initial performance	Definition	Mean	Std. dev.	Min.	Max.
Physical condition	1= the infrastructure is bad maintained, 2= the infrastructure is modestly maintained, 3= the infrastructure is well maintained	1.7	0.605	1	3
Water delivery					
Access to water	1= access by pumping, 2= access by pumping and gravity, 3= access by gravity	2.06	0.835	1	3

Water reliability	1= seriously unreliable, 2= modestly unreliable, 3= reliable	1.74	0.673	1	3
Water quality	1= the irrigation water is seriously polluted, 2= the irrigation water is modestly polluted, 3= the irrigation is not polluted	1.87	0.506	1	3
Water access to the tail-enders	1= no fallowed land or cropping anti-drought plants, 2= some fallowed land or cropping anti-drought plants	1.97	0.864	1	3
Equitable water supply between the head and tail enders	1= not equitable, 2= equitable	1.57	0.497	1	2
Soil salinization	1= the soil is seriously salinized, 2= the soil is modestly salinized, 3= the soil is not salinized	1.92	0.587	1	3
Agricultural productivity					
Output	Total output of paddy rice in the household(Chinese jin=500g)	2717.19	2224.122	400	14400
Cropping intensity annually	1= 1crop, 2= 2 crops	1.76	0.428	1	2
The degree of paddy rice self-supply	1= less than 100%, 2= 100% or more	1.75	0.596	1	3
Dependant variables					
Environmental	physical condition, water quality, and water reliability	0.000	1.000	-2.026	3.196
Economic	the degree of paddy rice self-supply, cropping intensity annually, output	0.000	1.000	-2.015	3.328
Equitable	equitable water supply between the head and tail enders	0.000	1.000	-2.083	1.795

Factor analysis is applied to reduce the ten individual items to a reduced number of dimensions. The KMO value is 0.561 and the cutoff point for the cumulative percentage of their variances accounts for 62% of the total variance. Three new dimensions, which represent the three most important factors, are extracted. The first includes items such as physical condition, water quality, and water supply, the second includes items such as paddy rice self-sufficiency rate, annual cropping intensity, and output, and the third includes just one item, equitable allocation of water between upstream and downstream locations. The common trait of each cluster in these three new dimensions is environmental, economic, and equality, respectively. Furthermore, the PES policy is also mainly concerned about these types of problems. We label these new performance dimensions as environmental, economic, and equitable benefits, respectively, and make them the dependent variables in this study.

Independent variables

This study uses the institutional analysis and development (IAD) framework (Ostrom, 2005) to define the independent variables that could affect the performance of VMISs. The IAD framework classifies three clusters of exogenous factors that affect the outcomes of irrigation system management, namely, biophysical conditions, community attributes, and rules. Combined with the features at household level, we treat the rules, the PES policy and local institutions, as the main explanatory variables. Obviously, the PES policy is a formal rule, while the local institutions are informal rules.

The other two clusters of factors are used as control variables, and include demographic characteristics at the household level, interaction with local government, and irrigation technology

(see Table 2).

Table 2 Description of independent variables

Variables	Definition	Mean	Std. dev.	Min.	Max.
Explanatory variables					
PES	Dummy,=1 if the farmland of the household belongs to the PES scheme	0.5419	0.4999	0	1
Local institutions	Dummy,=1 if the household follows the O&M rules	0.4581	0.4999	0	1
Control variables					
HHage	Age of household head (in years)	56.6	11.4356	31	86
HHeducation	The level of education of the household head (1=complete primary education, 2=complete middle school, 3=complete high school)	1.9226	0.7774	1	3
Scale	Dummy,=1 if the household belongs to a big irrigation community with a reservoir as water source	0.4516	0.4993	0	1
Area	Area of irrigated paddy rice (in mu)	10.408	8.429	1	40
Social status	Dummy, =1 if the household belongs to a big clan with its surname being the top 3 ones	0.406	0.493	0	1
Population	Number of people in the household	6.329	3.336	0	24
Poverty	Dummy,=1 if the household is legally recognized as poor.	0.290	0.455	0	1
Out migration					
Outmig1: No emigrant	Dummy,=1 if the household has no emigrant	0.445	0.499	0	1
Outmig2: With 1 emigrant	Dummy,=1 if the household has one emigrant	0.219	0.415	0	1
Outmig3: With 2 and more emigrants	Dummy,=1 if the household has 2 and more emigrants	0.335	0.474	0	1
Interaction					
Interaction 1:No	Dummy,=1 if the household never communicated with the local government for the problem about irrigation systems	0.316	0.466	0	1
Interaction 2: Occasionally	Dummy,=1 if the household occasionally communicated with the local government for the problem about irrigation systems	0.452	0.499	0	1
Interaction 3: Frequently	Dummy,=1 if the household frequently communicated with the local government for the problem about irrigation systems	0.232	0.424	0	1
Technology					
Tech1: Traditional	Dummy,=1 if the irrigation infrastructure is built with traditional technology, such as earthen canals	0.555	0.499	0	1
Tech 2: Mixed	Dummy,=1 if the irrigation infrastructure is built with tradition and modern technology	0.355	0.480	0	1
Tech 3: Modern	Dummy,=1 if the irrigation infrastructure is built with modern technology, such as U-shape lining canals	0.090	0.288	0	1

To better identify and quantify the impacts of PESs and local institutions on the 3 E benefits, the following econometric model is developed:

$$E_i = \alpha + \beta_1 PES_i + \beta_2 \text{Local institutions}_i + \sum x_i \, \text{Controls}_i + \varepsilon_i \qquad (1)$$

Where E represents the three dependent variables, namely, environmental, economic, and equitable benefits. PES and Local institutions are the two main explanatory variables. Controls are other variables that could affect the 3E benefits, and i represents a household in the sample area.

Results

Estimation results of the econometric model

We conducted OLS regression to estimate the effect of PESs on each of the 3E benefits. Huber-White standard errors were used to adjust for heteroscedasticity. Columns (1)-(3) show the results with only the main explanatory variable of PES, and columns (4)-(6) display the results with the control variables added. Generally, column (1) in Tables 3-5 exhibit that the PES policy generates positive effects on all of the 3E benefits. This is because the PES scheme that was implemented in the samples with local institutions is significantly associated with these benefits, as shown in column (2) in all three tables. However, the PES scheme had different impact on each of the 3E benefits.

The effect of PESs on environmental benefits

Table 3 presents the influence of PESs on the performance of VMISs in the terms of environmental benefits. Columns (1)-(3) report the estimates for the explanatory variable of PESs for the overall sample, the sample with local institutions, and the sample without local institutions, respectively. Columns (4)-(6) report the estimates for the independent variables, including the control variable, for the three types of samples. The results show that PESs in the sample with local institutions can significantly generate more environmental benefits than that in the overall samples and the sample without local institutions. Obviously, when combined with local institutions, PESs improved physical condition, water reliability, and water quality (coefficient of 0.9309, at the 1% level). From column (5), it can be seen that after the control variables were added, the effect was reduced (coefficient of 0.7171, at the 1% level). It is worth noting that of these control variables, the interaction variable (interaction3) is significantly negatively correlated with environmental performance (coefficient of -1.1461). This means that the more people express concerns about the issues related to the environment to their local government, the worse the performance of their irrigation system becomes.

Table3 The effect of PESs on environmental benefits

	(1) All samples	(2) Local institutions=1	(3) Local institutions =0	(4) All samples	(5) Local institutions =1	(6) Local institutions =0
PES	0.4308***	0.9309***	0.0138	0.3787**	0.7171***	-0.0049
	(0.1600)	(0.2551)	(0.1892)	(0.1502)	(0.2452)	(0.1927)
HHage				-0.0060	-0.0112	-0.0103
				(0.0069)	(0.0101)	(0.0096)
HHeducation				0.0086	-0.2191	0.0553
				(0.1016)	(0.1875)	(0.1087)
Scale				0.2935*	0.4364	0.3958**
				(0.1601)	(0.2898)	(0.1815)

Area				-0.0011	0.0157	-0.0113
				(0.0086)	(0.0138)	(0.0107)
Social status				0.3377**	0.2564	0.4112**
				(0.1525)	(0.2299)	(0.2025)
Population				-0.0289	-0.0526	0.0171
				(0.0227)	(0.0336)	(0.0331)
Poverty				-0.1424	-0.5025	0.0271
				(0.2087)	(0.3832)	(0.2474)
Outmig2				-0.3706**	-0.2727	-0.3839*
				(0.1709)	(0.2720)	(0.2175)
Outmig3				-0.1490	0.2374	-0.4844**
				(0.1746)	(0.2673)	(0.2204)
Interaction2				-0.2765	-0.5707	-0.0272
				(0.1867)	(0.3642)	(0.1856)
Interaction3				-0.9123***	-1.1461***	-0.4310
				(0.2150)	(0.3513)	(0.2704)
Tech2				0.2066	0.2904	0.1876
				(0.1477)	(0.2401)	(0.1763)
Tech3				0.6265**	0.7962	0.5315
				(0.3102)	(0.7576)	(0.3256)
_cons	-0.2335*	-0.5884***	0.0578	0.4215	0.9746	0.3987
	(0.1258)	(0.1858)	(0.1580)	(0.5072)	(0.8339)	(0.6287)
N	155	71	84	155	71	84
R-Squared	0.05	0.16	0.00	0.29	0.46	0.29

Note: The dependent variable is environmental benefits. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Huber-White standard errors are in parentheses.

Two conflicting accounts of how the local institutions work are presented below, provide evidence of the impact of PESs on environmental performance.

Our village planned to repair the aging culvert for water delivery, which serviced plots covering about 100 mu. We applied for funding, which was limited to 3,000 yuan. However, based on the project criteria for the culvert, which was 13m long and 4m wide, the village had budgeted about 6,000 yuan. Thus, the funding only covered half of the capital cost, and so the village had to finance the other half. Using the local institutions' input rule, the village can mobilize farmers to provide labor and cash to complement the funding, and thus finish the project. (Interviewee-A)

This interviewee provides confirmation that institutional bricolage type 4 works. The PES policy empowered the village to exercise the agency of the government and fulfill their responsibility of managing the irrigation system well. The bricolage incentivized the village to expend the effort necessary to provide a complete service to restore the irrigation system to good

condition and reap the related environmental benefits.

Our village applied for funding to repair the broken canals, but the money was only sufficient to cover the cost of materials, and did not cover the labor that was required. Because we do not have set rules regarding irrigation maintenance, it is difficult to organize the farmers to invest in the system. Furthermore, labor is very expensive, and no one is willing to undertake this construction work for free or for low wages. In the end, we contracted the work out to an outsider. As a result, the canal did not quite meet the farmers' requirements, and thus was not fully effective in terms of physical condition and water supply. (Interviewee-B)

On the contrary, the second interviewee described a failure under institutional bricolage type 2. Despite being empowered as an agency of the government, the village experienced difficulty in completing the project because of the absence of local institutions. Drawing on the insights provided by Cleaver (2012), this kind of bricolage generates adverse impact, which constrains the village's exercise of agency.

The effect of PESs on economic benefits

Table 4 presents the influence of PESs on VMISs in terms of economic benefits. Columns (1)-(3) report that the estimate for PESs in the sample with local institutions can significantly generate more economic benefits than that in both the overall sample and the sample without local institutions. Obviously, when combined with local institutions, PESs improved the paddy rice self-sufficiency rate, annual cropping intensity, and output (coefficient of 0.3606). It can be seen from column (5) that after the control variables were added, the effect was slightly reduced (coefficient of 0.3511). It is worth noting that of these control variables, household education (HHeducation) is significantly positively correlated with economic performance (coefficient of 0.6527). This means that the more education the household head has, the greater the value of the irrigation system generates in his plots.

Table 4 The effect of PESs on economic benefits

	(1) All samples	(2) Local institutions =1	(3) Local institutions =0	(4) All samples	(5) Local institutions =1	(6) Local institutions =0
PES	0.2942*	0.3606*	0.2306	0.0920	0.3511*	-0.1619
	(0.1585)	(0.2153)	(0.2277)	(0.1514)	(0.1835)	(0.2161)
HHage				-0.0039	-0.0026	-0.0069
				(0.0067)	(0.0100)	(0.0108)
HHeducation				0.2395**	0.6527***	0.0581
				(0.1126)	(0.1616)	(0.1512)
Scale				-0.1114	-0.1894	-0.2292
				(0.1600)	(0.2299)	(0.2169)
Area				0.0413***	0.0103	0.0644***

				(0.0100)	(0.0121)	(0.0179)
Social status				0.0581	-0.1138	0.3287
				(0.1517)	(0.2055)	(0.2312)
Population				-0.0107	0.0055	-0.0143
				(0.0190)	(0.0224)	(0.0291)
Poverty				-0.2492	0.1702	-0.4608
				(0.1832)	(0.2479)	(0.2846)
Outmig2				-0.1921	-0.3482	0.0098
				(0.1604)	(0.2526)	(0.2345)
Outmig3				-0.0665	-0.4131*	0.1626
				(0.1881)	(0.2245)	(0.2563)
Interaction2				0.0082	-0.1558	0.1730
				(0.1790)	(0.3163)	(0.2183)
Interaction3				0.0466	0.0354	-0.2611
				(0.2147)	(0.3715)	(0.2831)
Tech2				0.0125	-0.1752	0.1627
				(0.1568)	(0.2074)	(0.2364)
Tech3				0.0479	0.4019	-0.1355
				(0.3509)	(0.8220)	(0.3752)
_cons	-0.1594	-0.0309	-0.2649*	-0.5108	-0.9015	-0.2683
	(0.1106)	(0.1659)	(0.1479)	(0.4901)	(0.7756)	(0.7586)
N	155	71	84	155	71	84
R-Squared	0.02	0.04	0.01	0.26	0.35	0.36

Note: The dependent variable is environmental benefits. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Huber-White standard errors are in parentheses.

Below is an example of how the local institutions work with the PES scheme to generate a positive effect on economic performance.

In our village, before the PES project, some part of the canals had been blocked by silt for a long time. Water flow was slow, and was often insufficient to meet the demands of the farmlands. Some of the farmers were forced to grow only one crop of paddy rice, and so the village decided to address this problem. Cleaning silt requires at least 20,000-30,000 yuan to hire the necessary equipment. Although the village had rules about irrigation management, the farmers were willing to work for free to repair the canals rather than offering money. The PES project, by providing funding, solved this problem. In the end, all of the farmlands can access water readily and farmers can grow two crops of paddy rice annually, as they had done previously. Economic performance was improved without increasing the financial burden on the farmers. (Interviewee-C)

This interviewee explains how the PES scheme blends perfectly with local institutions, and why institutional bricolage type 4 can improve the performance of VMISs. Economic performance is

improved through eliminating the production risk presented by an unreliable water supply without increasing the farmers' economic burden. This institutional bricolage encourages the village to continue to exercise agency on behalf of the government.

The effect of PESs on equitable benefits

Table 5 presents the influence of PESs on the performance of VMISs in terms of equitable benefits. Columns (1)-(3) show that PESs in the sample with local institutions can significantly generate more equitable benefits than in both the overall sample and the sample without local institutions. When combined with local institutions, PESs improved water allocation between upstream and downstream locations (coefficient of 0.4666). Column (5) shows that after the control variables were added, the effect increased slightly (coefficient of 0.4949, at the 5% level). Of these control variables, population, poverty, and interaction 2 and 3 had a significant effect, with coefficients of -0.0366,-0.5489, -0.4903, and -0.4660, respectively. This means that the greater the impact of these variables, the more inequitable the performance of the VMIS between upstream and downstream plots.

Table 5 The effect of PESs on equitable benefits

	(1) All samples	(2) Local institutions=1	(3) Local institutions=0	(4) All samples	(5) Local institutions=1	(6) Local institutions=0
PES	0.0624	0.4666*	-0.2757	0.1264	0.4949**	-0.0822
	(0.1612)	(0.2344)	(0.2161)	(0.1672)	(0.2232)	(0.2616)
HHage				0.0064	0.0170	0.0004
				(0.0078)	(0.0110)	(0.0126)
HHeducation				0.0777	0.3030	-0.0395
				(0.1289)	(0.1817)	(0.1898)
Scale				0.1335	0.2984	-0.0994
				(0.1690)	(0.2613)	(0.2285)
Area				-0.0062	-0.0092	-0.0068
				(0.0094)	(0.0145)	(0.0135)
Social status				-0.0546	0.0896	-0.1295
				(0.1831)	(0.2662)	(0.2816)
Population				-0.0366*	0.0038	-0.0826**
				(0.0217)	(0.0254)	(0.0384)
Poverty				-0.5489***	-0.4836	-0.6833**
				(0.2008)	(0.3126)	(0.3238)
Outmig2				-0.2026	-0.2799	-0.1319
				(0.2149)	(0.3543)	(0.3020)
Outmig3				-0.2594	-0.3288	-0.1676
				(0.1762)	(0.2830)	(0.2290)

Interaction2				-0.4903**	-0.5107	-0.3896
				(0.1914)	(0.3212)	(0.2590)
Interaction3				-0.4660**	-0.2944	-0.4048
				(0.2180)	(0.3512)	(0.3288)
Tech2				0.0029	0.0226	-0.0055
				(0.1788)	(0.2560)	(0.2792)
Tech3				0.0336	-0.7363*	0.3818
				(0.2843)	(0.4253)	(0.3234)
_cons	-0.0338	-0.2981*	0.1830	0.2925	-1.3253	1.2711
	(0.1167)	(0.1619)	(0.1591)	(0.5975)	(0.9956)	(0.9043)
N	155	71	84	155	71	84
R-Squared	0.00	0.05	0.02	0.13	0.28	0.19

Note: The dependent variable is environmental benefits. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively. Huber-White standard errors are in parentheses.

The impact of PES on the performance of VMISs in terms of equitable benefits is made particularly clear in the following accounts.

In our village, farmers withdraw water based on the water allocation rule in terms of location sequence. However, the upstream farmers used to open the sluice all day long, and they even left the water running at night, with the extra water flow straight into the drainage canals. As a result, the water supply is insufficient for the downstream farmlands from the next day onwards. Some farmlands located downstream had to be either used to grow drought-resistant crops or abandoned because they cannot obtain equitable access to water. The farmers located downstream often reported this problem to the village. However, the keys for the sluice gate of the reservoir are easy to copy, and no household could be held responsible for closing the gate. With the introduction of the PES policy, the village used this funding to have two special keys made. These key were expensive, costing 4,000 yuan each, but they were unable to be duplicated. The keys are retained by the village leader, who is responsible for opening the sluice gate in the morning and closing it in the evening. This solved the problem of water being wasted during the night and enabled farmlands downstream to obtain sufficient water. Therefore, the PES project intensified the existing rules of water allocation and improved the performance of the VMIS in terms of equitable water allocations. (Interviewee-D)

This account demonstrates that the function of institutional bricolage occurs during the process of blending. When the village is empowered as an agent of the government, the externality issue is internalized, which creates incentives for the village to find ways to ensure that the water allocation rules continue to be applied. The bricolage is enabled by the village, and during the process, it reshapes the behavior of the village from ineffective to effective.

Before the PES project, the old sluice gate was dysfunctional, and water flow could not be adjusted, meaning that the water flowed too quickly and resulted in unequal water penetration

spatially. When the water entered the intake of a patch of farmland, it passed the head of the patch very quickly and continued on to the tail end of the patch. This means that the head of the patch cannot obtain sufficient water penetration to enable the roots of the paddy rice to grow. As a result, the production of paddy rice in a patch often varied, with less output at the head than at the tail end because of the unequal water distribution. After the PES project was implemented, the village used part of the funding to install a new sluice gate that enable the velocity of the water flow to be adjusted. Water can run into the intake at the appropriate velocity and penetrate the soil of the entire patch to the same depth, which enabled uniformly high production throughout the patch. (Interviewee-E)

This account exhibits that the PES fitted well with the request of the VMIS. Because local institutions regarding water allocation were able to provide complete information about water flow velocity, the inequitable water distribution was obvious. With the necessary facility provided by PES funding, the village was able to address the problem without incurring any costs. It should be noted that in contrast to the previous case, this case showed that performance in terms of equitable water supply was improved through a facility-directed intervention rather than via rules. These two cases are in line with the finding by Cleaver (2012) that institutional bricolage depends on the existing context that the entity faces.

Discussion

Our empirical findings broadly confirm that VMISs benefited from the implementation of the PES policy. The positive externality in terms of national food security that is generated by the village through managing irrigation systems is compensated for through PESs. The externality issue has been solved because the PES policy increases the village's ability to manage irrigation systems effectively, thus farmers' willingness to produce food increases, which is compatible with the government's food security needs. The funded VMIS can internalize the externality issue through uniting the private and social benefits. An economic instrument, the PES scheme incentivizes the village to manage irrigation systems well.

Our findings are consistent with the hypotheses relating to bricolage types 2 and 4 presented in the theoretical analysis. The empirical results provide evidence that PESs can improve the performance of VMISs in all of the 3E dimensions (bricolage type 2) because the PES works well in the samples with local institutions (bricolage type 4). The results present that the PES scheme is significantly correlated with the performance of VMISs in all of the 3E dimensions. Our interviews with the heads of village also provided robust evidence in support of this funding. The interviews also exhibited insight into the various mechanisms by which the PES policy is able to improve the performance of VMISs.

Although our empirical observations failed to provide sufficient evidence to test the hypothesis relating to bricolage type 3, which involves only local institutions, we can infer from the interviews with village leaders that local institutions are unable to sustain the VMISs in an optimal state. As elaborated by Cleaver (2012), local institutions are unlikely to be able to act as substitutes for the monetary assets that are necessary to maintain the infrastructure.

Our findings help to explain how PESs work in practice and why they are of most benefit to villages with local institution. As the success of the PES policy hinges on the involvement of local people in terms of their aspirations and needs (Frost et al. 2007), the absence of local institutions seriously constrains the effectiveness of PESs. This is consistent with the point made by Sarker (2013, 2014) whereby a policy of economic subsidies that does not intervene in irrigation management practices at the local level can generate positive outcomes in the community that uses local institutions. Our interviews revealed that the village is less likely to use the funding effectively when there is lack of local institutions. Even in villages with aging and poorly maintained irrigation systems, where PESs would be the most effective response, the scheme was not implemented as well as expected. These findings demonstrate the role of local institutions in increasing the effect of PESs through mediating the interface between the government's expectations and the economic incentives for the village leaders.

Generally, our findings are consistent with those of Wunder (2012) that the PES scheme is an effective approach to environmental conservation and governance of the CPR. Our findings are also consistent with those of Hayes et al. (2017) that the necessary condition for the PES scheme to perform well is a range of local institutions for governing the CPR. Specifically, in line with the finding of Muradian (2013), the institutional bricolage obtained by combining PESs and local institutions internalizes the externality, creating incentives for the village to manage irrigation systems well.

Conclusions

Nowadays, irrigation system management creates positive externality issue for villages, whose social benefits in terms of environmental service, and thus national food security, exceed the private benefits obtained through political support from farmers. Externality can discourage villages from providing good service, and it has been shown that traditional methods such as management reform and infrastructure construction generate poor performance by VMISs. This study provides new insight into attempts to improve the performance of VMISs using economic instruments, such as the PES policy that can also be applied to poorly managed CPRs. Our empirical evidence provides a first step toward better understanding the under-studied topic of PESs in relation to irrigation systems and explores a new alternative in terms of irrigation management reform in China and beyond. One precondition that is necessary for the effective implementation of the PES scheme is the presence of local institutions in relation to irrigation systems management.

Building on the work of critical institutionalism, which explains that differences exist between expectations in relation to policies and their practical impact because of various local arrangements (Cleaver, 2012), our findings extend the knowledge of institutional bricolage through empirically examining the diverse outcomes obtained through different types of bricolage. It also provides evidence in support of the concept of institutional bricolage in the field, and fills the gap between theory and practice identified by Hassenforder et al. (2015).

The results of this study also provide guidance for the development of policy-based interventions. Specifically, we present evidence of the effect of the PES policy on irrigation systems in China, thereby contributing to the body of research on governance of irrigation systems in developing countries. If the government intends to implement PESs and transition to new management regimes to improve the operation of VMISs, they must create a collaborative network between the village and the farmers to form local institutions, build trust, and lower transaction costs.

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