Transferring irrigation management to farmer’s associations: Evidence from the Philippines

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Abstract

Irrigation management transfer (IMT) is an important strategy among donors and governments that aims to strengthen farmer control over water and irrigation infrastructure. In this study, we use data from a survey of 68 irrigator associations (IAs) and 1020 farm households in the Philippines to examine the impact of IMT on irrigation association performance and on rice yields. We find that the presence of IMT is associated with an increase in maintenance activities undertaken by irrigation associations. While associations with and without IMT contracts undertake canal maintenance, the frequency of maintenance in IMT IAs is higher. IMT presence is also associated with an increase in farm yields by about 6%; rice production in IMT areas is higher even after we control for various differences amongst rice farmers in IMT and non-IMT areas. Finally, IMT may even give poorer farmers a small boost in terms of rice yields. We speculate that this boost may be a result of improved water delivery and better resolution of conflicts related to illegal use.

Keywords: Farmer associations; Impact evaluation; Irrigation management transfer; Philippines; Production function

1. Introduction

Participatory irrigation, where farmers gain certain rights over the management of irrigation water and infrastructure, is an important component of irrigation reform worldwide (Vermillion, 1992; Araral, 2005). Over the last two decades, it has resulted in the growth of a larger number of farmer-run irrigation or water user associations with a reduced role for government in operation and maintenance, fee collection, water management and conflict resolution related to irrigation. Participatory irrigation has been largely motivated by the inability of national irrigation agencies and exchequers to bear the financial burdens imposed by irrigation infrastructure (Vermillion, 1997; Samad, 2002; Araral, 2005). Evidence of water scarcity has also refocused attention on water-use efficiency and demand management by farmers (Brennan, 2002). This trend in participatory irrigation has been timely and has


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been supported by a general movement in the developing world towards decentralization of government functions.

Although participatory irrigation management is widespread, there is surprisingly little evidence about its impact (Samad, 2002; Araral, 2005). There are several studies that focus on government financial savings; however, few have sought to quantify the final impact of irrigation management transfer (IMT) on farm productivity or water conservation (see Vermillion (1997) and Araral (2005)). Samad & Vermillion’s (1999) work in Sri Lanka is one of the few studies that looks at agricultural productivity associated with management transfer. They find that productivity increased significantly in schemes that included IMT and infrastructure rehabilitation. Another interesting study is by Wang et al. (2006), who find that monetary incentives to water managers in China contribute to water savings but farmer participation in water user associations does not. Even more significant is their finding that the reductions in water use do not adversely affect farmer income or poverty. This link between irrigation reform and poverty is important because many critics suggest that irrigation reform has moved away from its objectives of improving poor farmers’ livelihoods, focusing instead on reducing the state’s financial burdens (Kloezen et al., 1997; Vermillion, 1997; Koppen et al., 2002; Shah et al., 2002). There is, however, little empirical literature that tracks the differential impact of institutional reforms on farming communities.

Our paper is motivated by the need to understand the farm and system level impact of irrigation management transfer. We address three questions in this paper: (1) Is irrigation management transfer associated with improvements in the irrigation system in terms of increased operations and maintenance and better revenue collection? (2) Does increased farmer control of irrigation translate into improvements in crop yield? and (3) Do these improvements differ for rich and poor farmers? We use an econometric approach to answer these questions and draw on data from a survey of 1020 households and 68 irrigation associations in a reservoir irrigation system in the Philippines. We examine irrigator associations and farm households that received an “irrigation management transfer” contract between 1998 and 2002 and compare them with similar groups that did not. We apply program evaluation techniques to control various observable factors and assess the impact of institutional change on association and farmer productivity.

2. Irrigation management transfer in the Philippines

Irrigation systems in the Philippines are divided into three groups: nationally managed, communally managed and private. The Philippines has a history of organizing farmers (Korten & Siy, 1988; Raby, 1998); a participatory approach to irrigation management was first developed in the mid-1970s for communal systems and then expanded to national systems in the 1980s (Raby, 1998; Mejia, 2002; Maleza & Nishimura, 2007). Today, irrigator associations, which cover some 82% of the area developed for irrigation (Mejia, 2002), are viewed as important institutions for water management and sustainable development (Maleza & Nishimura, 2007). In fact, in terms of farmer participation,

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1 For a history of the evolution of participatory irrigation management in the Philippines see Korten & Siy (1988).
2 From late 1999, some 2078 irrigators associations operated in nationally owned irrigation systems in the Philippines and 3018 IAs managed communal systems.
the Philippines can be considered among the most advanced countries in the developing world (World Bank, 2003).

Most of the previous literature on participatory irrigation systems in the Philippines has focused on the communal systems (de los Reyes & Jopillo, 1986). We spotlight recent reforms in nationally managed systems to give more control over irrigation infrastructure to irrigator associations. The national systems are owned and operated by the National Irrigation Administration (NIA), a semi-autonomous government corporation that is responsible for irrigation development in the Philippines (Bagadion, 2002; Sabio & Mendoza, 2002)⁴. Over the last 3–4 decades, NIA has evolved from a water delivery agency to one which seeks to make farmer associations increasingly responsible for irrigation (Ofrecio, 2006).

A typical irrigation association is an independent legal entity with a board of directors and officers. It is based on the physical layout of irrigation networks and oversees a variety of irrigation management and infrastructure maintenance related tasks and in some cases offers other services as well. The National Irrigation Agency facilitates the mobilization of IAs through paid community organizers, provides training and technical assistance and enters into different types of irrigation management contracts with them (Hassal/SDC Associates et al., 2006; Maleza & Nishimura, 2007). Irrigation management transfer (IMT) is of interest to us in this paper, a new type of contract that was developed in the 1990s.

IMT represents the latest phase in participatory irrigation in the Philippines and emerged from a confluence of interest from international organizations, local forces toward decentralization and a natural evolution within the irrigation sector. It was launched under a World Bank funded program and strengthened through a second loan. It also fitted in well with the Philippines’ on-going decentralization strategy, which mandated greater control to irrigation associations⁵. However, the driving force was NIA’s declining financial viability and need to reduce its operations and maintenance expenditure (Hassal/SDC Associates et al., 2006). Typically, with IMT contracts, NIA transfers operations and maintenance responsibilities of secondary canals or laterals to IAs, which collect irrigation fees and are entitled to a 50% share of the amount collected (World Bank, 2001; Hassall/SDC Associates et al., 2006; Maleza & Nishimura, 2007).

Underlying irrigation management transfer is the idea that self-reliant IAs would manage water better and improve agricultural productivity (Hassal/SDC Associates et al., 2006; Ofrecio, 2006). Figure 1 provides a conceptual overview of how this may happen. IMT is expected to increase the control local farmer associations have on irrigation distribution and timeliness. While NIA regulates the main canals,

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³ NIA was established in 1964 with strong domestic political from President Marcos as well as international aid support. It initiated participatory irrigation management in order to “improve its financial viability and support increased agency activities”. However, participatory management was timely and satisfied multiple political, academic, financial and service delivery needs (Panella, 2004).

⁴ Some 50% of the irrigation service area in the country is managed publicly by the National Irrigation Administration (Bagadion, 2002; Sabio & Mendoza, 2002).

⁵ IMT was launched under a World Bank funded project called the Second Irrigation Operations Support Project (IOSP II) and the first IMT contract was signed in 1998 in the Magat Integrated Irrigation System. The initial IMT guidelines were made more concrete and comprehensive under a second World Bank loan in 1996 under the Water Resources Development Project.

⁶ In December 1997, the Government enacted the Agriculture and Fisheries Modernization Act, which mandated transfer of national irrigation systems’ management from NIA to IAs and Councils of IAs (Hassal/SDC Associates et al., 2006).
for example, IAs become responsible for water monitoring and allocation from the diversion point at the head of lateral canals (Hassall/SDC Associates et al., 2006).

Associations with IMT contracts are expected to make better decisions regarding infrastructure maintenance through timely repairs of canals. Contracts generally specify maintenance responsibilities for the NIA versus the IAs based on expected costs. For instance, de-silting with equipment such as backhoe remains the responsibility of NIA, while IAs take over regular vegetation clearing, removing of debris and fixing of other minor problems. A recent survey of farmers and IA officers indicated that while a majority of the respondents perceived improvements in canal maintenance in areas with IA contracts, maintenance is hampered by problems with irrigation fee collection and delays on NIAs part in returning IAs' share of the fees (Hassal/SDS Associates et al., 2006).

Conflicts over water distribution and illegal water checking are common in irrigation management. A concern with the NIA was that it could not respond to farmer conflicts in a speedy manner; IAs being local could potentially respond more quickly. Both the national survey cited above (Hassal/SDS Associates et al., 2006) and our data suggest that conflict resolution may be better in IMT areas. The problem of illegal checking and water redistribution is, however, difficult to eliminate and can be influenced by the needs of influential local farmers (ITRC, 2003; Maleza & Nishimura, 2007).

### 3. Study area and differences between IMT and non-IMT associations

Our study was undertaken in the Magat River Integrated Irrigation System (MRIIS) in Region-2, Luzon, of the Philippines. This is one of the largest irrigation projects in the Philippines, covers 85,294 ha of service area and encompasses four irrigation administrative districts. It is a reservoir-based

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7 It has four administrative irrigation districts: District III (20,366 hectares) is on the left bank of the river and Districts I (21,797 hectares), II (23,241 hectares) and IV (19,890 hectares) on the right bank.
system that has multiple canals, three pumping stations and three diversion dams (ITRC, 2003). The dams provide year-round irrigation for rice production, which is the major crop grown.

Irrigation associations started in MRIIS more than two decades ago. As far back as 1976, MRIIS field staff had independently started organizing farmers into groups at turnouts (Panella, 2004). Some of the earliest IAs were registered in 1980 and the number of IAs rapidly expanded during the 1980s. While IAs with IMT contracts are a relatively new phenomenon, from 2003 some 60% of the service area is under IMT contracts.

IMT contracts in MRIIS basically mean two things: (1) improvements in certain infrastructure and (2) changes in management responsibilities over water distribution, irrigation revenue collection and maintenance activities. An IMT contract requires prior infrastructural improvements such as canal lining, modified pipes, improved gates and so on. These physical changes are important because they prevent seepage and loss and help improve water distribution. Water management also depends on the ability of the operators to manage water flows in different parts of the system. In MRIIS, NIA is responsible for the flow of water into the main canal and for managing cross regulators, while IMT IAs are responsible for operating most of the turnout structures in the laterals. A greater role for IAs is expected to increase the responsiveness of water management to suit real-time needs. IMT IAs also collect irrigation service fees (ISF) from their members and remit these to NIA, which is expected to return 50% of the fees.

Non-IMT IAs in MRIIS typically had Type I&II irrigation contracts, which gave them more limited management responsibilities. Type I contracts let IAs maintain a specific strip of a canal for a service fee charged to NIA on the basis of the length of the strip (Ofrecio, 2006). An IA may have Type I contract for only a part of the irrigation system within its jurisdiction or none at all. Type II contracts let IAs act as the agent of NIA and collect ISF for a commission that may vary from 2 to 15% based on the collection efficiency. Under these contracts the canal management and revenue allocation decisions rest with NIA. In contrast IMT IAs were able to allocate their share of ISF to various aspects of irrigation system management as appropriate.

For our study, we collected primary data from 68 irrigation associations or approximately 20% of the 349 IAs in MRIIS. The survey included questions on irrigation infrastructure, service fees, governance and system operations and maintenance (O&M). We selected a random sample of 43 IAs under IMT contract and 25 IAs that were under Type I and II contracts. Our sample data show that 86% of the selected IMT IAs had signed their IMT contract with NIA prior to or during 2001.

Our study also involved a household survey of 1020 farm households or approximately 9% of the total IA membership in MRIIS from May to August 2003. A random sample of 15 farmers was identified from each IA. The survey collected data on various farm level inputs and outputs as well as information on the effects of IMT. We tried to capture upstream and downstream farmers by obtaining information on water flow to farms. Secondary data were obtained on variables such as historical user fee collection from the irrigation district offices.

A simple comparison of IAs with IMT and IAs without IMT along different indicators is presented in Table 1. It shows that both IMT and non-IMT IAs are of approximately the same size in terms of hectares managed. The IMT IAs tend to service a somewhat larger number of farmers and seem to have slightly greater percentage of upstream and midstream farmers. In terms of irrigation infrastructure, the IMT IAs

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8 All but one non-IMT IAs had both Type I and Type II contracts. One IA had only Type II contract.
have a slightly larger number of gates, more lined canals and modified infrastructure. These differences are not huge and are logical because IAs tend to get some infrastructure assistance prior to obtaining IMT contracts.

It is interesting to note that there is little difference in governance indicators such as the fee collection rate from farmer members or number of female board members between IMT IAs and non-IMT IAs. However, from the household data we do find that IMT IAs are better at managing and resolving conflicts. While both IMT and non-IMT IAs help with illegal checking and pumping of water, a significantly larger percentage of farm households under IMT IAs reported that IAs play a role in conflict resolution.

An important objective of transferring management responsibility to IAs is to enable them to take over routine maintenance of irrigation infrastructure. A simple comparison of means shows that a larger percentage of IMT IAs is likely to prepare maintenance plans each year and participate in canal cleaning. Households in IMT IAs are more likely to participate in maintenance and cleaning of laterals and

| Table 1. Differences between irrigation associations and households in IMT and non-IMT areas. |
|---------------------------------------------|-----------------|-----------------|-----------------|
| IA characteristics                         | IMT mean        | Non-IMT mean    | Difference in mean |
| 1 Distance from head gate (KM)              | 5.9             | 4.8             | 1.1             |
| 2 IA located upstream (%)                  | 32.60           | 12.00           | 20.60**         |
| 3 IA located midstream (%)                 | 30.20           | 32.00           | –1.80           |
| 4 Total area under IA                      | 218             | 219             | –1              |
| 5 Farmers IA members                       | 165             | 128             | 37**            |
| 6 Length of lined canal/lateral            | 0.14            | 0.01            | 0.13            |
| 7 Number of turnouts                       | 8.6             | 7.3             | 1.4*            |
| 8 Number of modified pipes                 | 2               | 0.5             | 1.5**           |
| 9 Percentage of members paying ISF (%)     | 66.70           | 63.50           | 3.20            |
| 10 Number of board members                 | 11.5            | 9.2             | 2.3***          |
| 11 IA involved by NIA in system operational plans (%) | 42.00 | 44.00 | –2.00 |
| 12 IA operating gates (%)                  | 72.00           | 4.00            | 68.00***        |
| 13 IA solely responsible for canal maintenance (%) | 72.00 | 8.00 | 64.00*** |
| 14 IA prepare maintenance plan every year (%) | 62.80 | 16.00 | 46.80*** |
| 15 IA canal cleaning more than twice a season or when needed (%) | 62.80 | 20.00 | 42.80*** |
| Household characteristics                  |                 |                 |                 |
| 16 Wall materials of house made of concrete blocks (%) | 85.60 | 84.00 | 1.60 |
| 17 Value of livestock (Peso)                | 2,6343          | 2,9172          | –2,829          |
| 18 Protein food cons, expenditure (Peso)    | 795             | 890             | –95             |
| 19 Max HH education of HS graduate (%)      | 20.30           | 19.20           | 1.10            |
| 20 Area harvested (ha)                     | 5.47            | 5.36            | 0               |
| 21 Output (kg ha\(^{-1}\))                 | 5,366           | 4,996           | 369***          |
| 22 Water distribution schedule followed (% yes) | 74.90 | 65.90 | 9.00*** |
| 23 IA helps resolve illegal checking (% yes) | 87.70 | 80.50 | 7.20*** |
| 24 IA helps resolve unscheduled gate opening/closing (% yes) | 88.50 | 81.50 | 7.00*** |
| 25 Household often participates in maintenance of main farm ditch (% yes) | 75.30 | 69.10 | 6.30** |
| 26 Household often participates in maintenance of sub-laterals (% yes) | 64.50 | 57.60 | 6.90** |
| 27 Household often participates in maintenance of laterals (% yes) | 65.10 | 57.60 | 7.50*** |

Note: *** \( p < 0.01 \), ** \( p < 0.05 \), * \( p < 0.1 \). Significance levels based on \( t \)-tests.
sub-lateral canals relative to households in non-IMT IAs. Also, a significantly larger percentage of households in IMT areas (75%) relative to non-IMT areas (66%) said that the water distribution schedule was followed and they participated in routine maintenance activities. Thus, the raw data suggests that there are some differences in maintenance undertaken but these may not be very large.

There is little difference in education, household assets or livestock between farmers in IMT and non-IMT areas. This suggests that the populations we are comparing in our study are more or less similar. While household characteristics and assets are more or less equal among farmers in IMT and non-IMT areas, there are some interesting differences in farm output. Farmers in IMT areas have on average a 7% higher yield. In the next few sections we follow up this issue and ask if the higher yield is linked to the presence of IMT.

The survey also asked questions about perceptions of change over the last five years. A larger percentage of farmers in IMT areas (relative to farmers in non-IMT areas) said that they had seen improvements in three aspects: (1) services provided by IAs or NIA, (2) participation of farmers in O&M activities and (3) timeliness of water delivery (Bandyopadhyay et al., 2007). In general, the first level analyses of mean differences among households in IMT and non-IMT IAs suggests that households in IMT areas do better in terms of a variety of irrigation-related issues.

4. Understanding IMT impact

We try to gauge whether or not IMT is successful by examining IA performance and by investigating farmer level benefits. There are many methodological challenges to assessing performance and ascribing improvements to IMT, which we discuss below.

4.1. Establishing IMT impact on irrigation association performance

At the irrigation system level, we examine the impact of IMT on three performance indicators: (1) whether the IAs prepare a maintenance plan every year, (2) whether canals in the IAs are reshaped/maintained more than twice a year or when needed and (3) irrigation fee collection efficiency in the dry season of 2003. Collection efficiency is the ratio of actual collection to the target set by NIA.

IMT IAs have to decide how to allocate their ISF share in maintaining their irrigation system while ISF resource allocation for other IAs was made by the NIA. So we expect more IMT IAs to prepare a maintenance plan. Non-IMT IAs with large Type I contracts or those wanting to get IMT contracts may also prepare maintenance plans. Similarly the frequency of canal maintenance was the decision of the IAs with the IMT contracts. For other IAs, the frequency was determined by the NIA’s resource allocation decisions either through direct maintenance or through the award of Type I contracts. Even though both IMT IAs and non-IMT IAs collected irrigation fees, they had different incentive structures. We want to find out if the incentives structure for the IMT IAs resulted in more collection.

In order to attribute differences in IA performances to an IMT contract, we have to account for pre-existing differences. A simple comparison of mean differences in performance indicators does not tell us whether this reflects IMT influence because pre-existing differences between IAs may be instrumental to specific IAs being selected for IMT. For example, IAs with more irrigation infrastructure are more likely to join IMT. Similarly, IAs with leaders with better leadership skills may be more likely to be selected for an IMT contract. In both these cases the factors influencing the participation in IMT are also factors
that influence the performance of the IAs. Correction for such biases in the evaluation of impact requires before and after IMT intervention data. However, without baseline “before IMT” data, we follow two widely used methodological approaches in program evaluation—propensity score matching and instrumental variables—to examine IMT impacts.

We estimate the impact of IMT on maintenance and fee collection by using a non-parametric propensity score-based matching of IMT and non-IMT IAs. The propensity score is an index of similarity based on a variety of observed association characteristics. Two IAs with similar propensity scores are considered comparable. Once two sets are matched, then outcome indicators related to the two groups can be compared (Rubin, 1973).

To calculate the propensity score, we model the probability of an IA getting an IMT contract as a function of aggregated household and community characteristics:

\[
\Pr(\text{IMT} = 1) = \Phi(\alpha_0 + \alpha_1 F + \alpha_2 IA_1 + e)
\]

where IMT is an indicator variable that takes the value 1 if an IA is an IMT-IA and 0 otherwise. The probability of an IA becoming an IMT IA depends on factors that influence the ability of IAs to obtain an IMT contract, local conditions and the process by which IMT reforms were implemented in the Philippines. Thus, our choice of the variables included in Equation (1) reflects our understanding of the factors that affect collective action, particularly in irrigation (Bardhan, 2000; Agrawal, 2001; Meinzen-Dick et al., 2002) and our knowledge of conditions that influenced IMT evolution in Magat.

We make particular note of a recent study of irrigator associations in the Philippines by Fujiiie et al. (2005) which finds that collective action in irrigation is influenced by water availability and variability, association size, population density, share of non-farm farmers and the history of irrigated farming.

In Equation (1), \( F \) is a vector of farmer member characteristics and includes a measure of the aggregate level of education of the head of households, which reflects leadership; percent of catholic households in the IA, an indicator of social norms; the average number of years a household in the IA has been a member of other user groups, reflecting a history of collective action; and average land size in the IA and the number of farmers that are IA members, which are indicators of association size.

\( IA_1 \) is a vector of irrigation system characteristics such as length of canals, number of head gates, number of duckbills and other community characteristics such as whether the IA has a post office and the ratio of IMT-IAs in the municipality. The last variable captures the peer effect of IMT on IA—an IA in a municipality with relatively more IMT-IAs is likely to be an IMT-IA. In Magat, IMT was implemented under two World Bank funded projects and most IAs that got an IMT contract needed to make some infrastructural improvements. Thus, controlling infrastructural differences is very important. All IAs with investments in infrastructure did not, however, get IMT contracts. Our understanding is that only in District 2 all IAs with improved infrastructure received IMT contracts. Staff redundancy concerns within the National Irrigation Administration meant that some IAs with infrastructural improvements in the other three districts obtained the contracts and others did not. We try to capture this difference through an indicator variable for District 2. It takes the value 1 when an IA belongs to that irrigation district and zero otherwise.

\footnote{We tested for more elaborate fixed effect differences between the irrigation districts and rejected the hypotheses. We report only fixed effects of District 2 in the results section.}
The probability function (1) allows us to estimate a propensity score for each IA. We then use four different methods to match the IMT IAs with non-IMT IAs: kernel density weighted, radius, nearest neighbor and stratification method. Each method uses a slightly different approach, the details of which can be found in Abadie et al. (2003) and Imbens (2004). The next step is to compute the average treatment on treated (ATT), which measures the average effect of IMT on the performance (maintenance of canals and fee collection) of those IAs with IMT contrasted with a hypothetical scenario where these IAs do not have IMT\(^{10}\). Thus, we arrive at four alternate measures of IMT impact for each performance indicator.

An alternate parametric way of estimating the impact of IMT on the irrigation system is to use the instrument variable method. For this we model the outcome indicators as a function of IA characteristics described above except the IMT peer effect indicator and include predicted IMT as one of the factors affecting the outcome indicators. The instrument variable, predicted IMT, is modeled as (1) above. This allows us partly to control for the fact that some IAs obtain an IMT contract and others do not and the underlying unobserved characteristics that enable IAs to obtain an IMT contract may also affect the outcome variables.

Both propensity score matching and instrument variable approaches to impact evaluation have known limitations. We report estimates based on all the methods to test the robustness of our results.

4.2. Effect of IMT on farm yield

An important objective of our study is to assess whether IMT has an effect on farm-level outcomes. Our hypothesis is that farm yield improvements are likely to occur in IMT areas because of increased timeliness in water delivery, better distribution of water delivery and decreased water losses owing to improved maintenance.

We model the impact of IMT on farm yield by estimating a paddy production function. Traditional economic analyses allow for different factors, including technical change, to shift the production function. Thus, one option is to estimate a production function and then allow IMT and household demographic factors to shift production. There are many examples of this form of modeling farm household behavior—one sees this done, for example, in understanding the effect of extension services (Birkhaeuser et al., 1991; Bindlish & Evenson, 1997)\(^{11}\).

To estimate the effect of IMT on production, we first start with a simple yield function:

\[
y = f(l, m; s)e^\epsilon
\]

where \(y\) is yield per hectare, \(l\) is the labor used per hectare, \(m\) is materials used per hectare, \(s\) a vector of factors including IMT that affect yield and \(e\) is an error term\(^{12}\).

\(^{10}\) In impact evaluation jargon, “treatment” refers to the participation of IAs in IMT and the “treated” IAs are the IMT-IAs.

\(^{11}\) We recognize the empirical possibility of endogeneity of labor and capital in estimating a production function, but were unable to estimate cost or profit functions because of the lack of variation in price and other data. This is a frequent problem with cross-sectional data and some care needs to be taken in interpreting results (Barrett et al., 2004).

\(^{12}\) One of the reasons we estimate a yield function is because of the way labor is used in rice production in the region. It is the local custom to contract out various labor intensive activities either on the basis of area cultivated or as a share of output harvested. For example, the cost of a weeding contract may be per hectare rather than wage hours. Similarly, costs of harvesting activities were measured as percentage of harvested output. Thus, the study does not have an independent measure of labor input and cannot estimate a standard production function.
Demographic heterogeneity of the households and agricultural and irrigation infrastructure may shift the yield function in Equation (2). More importantly, if the IMT results in more effective water delivery, then that too may shift the yield function. If we assume a Cobb–Douglas production function with constant returns to scale, the yield function together with demographic and IA characteristics may be specified as:

$$\log y = \beta_0 + \beta_2 \log l + \beta_3 \log m + \beta_4 HH + \beta_5 IA2 + \beta_6 IMT + e$$

where $y$, $l$ and $m$ are as defined above. HH is a vector of household characteristics including age of the head, total number of household members, an indicator variable that takes the value 1 if the highest level of education in the household is high school or better and 0 otherwise, an indicator variable that takes the value 1 if the household is not Catholic and 0 otherwise, an indicator variable that takes the value 1 if the household landholding has a drainage canal and 0 otherwise and the number of days water takes to reach the household farm. IA2 is a vector of IA characteristics such as an indicator variable that takes the value 1 if the IA has an agricultural extension office and 0 otherwise, the number of head gates, the number of modified pipes and the number of duckbills. IMT take the value 1 if the IA has an IMT contract or 0 otherwise.

### 4.3. Effect of self-selection on farm yield

An important methodological concern relates to self-selection. As discussed in the previous section, the selection of IMT areas may have been based on the community characteristics. Some of the observed characteristics of the IMT and non-IMT areas are similar (Table 1). However, there may be other unobserved characteristics of these areas, that may have influenced the selection of an area for IMT and these same unobserved characteristics may also influence the yield of the farmers in the IMT areas. To test this hypothesis, we model the probability of an area being selected for IMT as a function of community characteristics as in Equation (1) above and then jointly estimate Equations (1) and (3). This estimation allows us to control any other factors that may actually be influencing yield. It is another way of checking to see if IMT’s impact on yield is robust and is not the result of some factors that we as researchers have missed.

### 4.4. Rich versus poor households

To assess whether rich households benefit more compared with poor households, we group the households by the value of household assets. Asset-poor households were defined as the bottom two quintile households based on the value of household assets. The rich and the poor households may not only benefit from IMT differently, but different factors like education and minority religions may affect the productivity of the rich and poor households differently. To control these possibilities we use separate estimations of the standard yield function for asset-poor and asset-rich groups of households instead of a fixed effect dummy variable in a single equation. We test the hypothesis that the respective

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13 Unobservable factors affecting both selection and outcome indicators are a source of concern in any impact evaluation analysis. To test the hypothesis that unobservable factors affect both Equations (1) and (3) we jointly estimate the two equations using maximum likelihood estimators and test if the correlation coefficient $\rho$ between the $e$ and $\epsilon$ equals zero.
coefficients for IMT for the two groups are significantly different, that is, we check to see if the effect of IMT on the productivity of rich households is different from its effect on poor households and we try to quantify this difference.

5. Results

5.1. IMT and IA performance

The results of propensity score and instrument variable based methods for understanding the impact of IMT on (1) development of maintenance plans, (2) canal maintenance and (3) irrigation service fee collection are presented in Table 2. We note that there are five different methods in which the impact of IMT on these outcome measures is assessed.

In terms of development of maintenance plans, the instrumental variable estimator indicates that an IA’s maintenance plan is associated with the presence of IMT 47% of the time. However, this conclusion is not supported by the four propensity score approaches.

All the five different statistical methods suggest that the difference in canal maintenance efforts between IMT IAs and non-IMT IAs is statistically significant and positive. IMT appears to be the reason for undertaking canal maintenance work in 60–80% of the IAs that undertake maintenance activities more than twice a season or when needed. These results reinforce anecdotal evidence that IMT IAs are undertaking more maintenance.

Only two of the statistical methods indicate that higher collection efficiency of irrigation service fees can be attributed to IMT. Thus, we cannot say with any confidence that IMT contributes to increased collection efficiency.

5.2. Farm yields

Columns 1 of Table 3 show the Ordinary Least Square (OLS) estimates of the yield function without the farmer and IA “shift” variables. The material and labor input coefficients are statistically significant. The sum of the two coefficients is less than 1, as expected.
Column 2 of Table 3 adds the heterogeneity shift variables to the estimation. The input coefficients are similar to those in Column 1. The shift variables that were significant have the expected signs. In particular the IMT indicator variable has a positive and significant coefficient. This indicates that IMT is associated with significantly higher rice yield productivity. By this measure, about 6% of productivity gain is associated with the presence of IMT. This result, showing an impact of irrigation management transfer on rice production, reinforces similar findings by Samad & Vermillion (1999) in Sri Lanka.

Column 3 of Table 3 shows the results of the instrument variable (IV) estimation of the yield function. The material and labor input coefficients of the instrument variable estimation for the yield function are close to the OLS estimations in column 1 and 2. As in the OLS estimation in column 3, the coefficient of IMT is statistically significant in the IV estimation. We further test and find no evidence of selection bias...
for IMT from unobserved community characteristics after controlling for community and IA characteristics\(^{14}\). Consequently, we consider IMT selection to be exogenous to the household rice productivity estimation and focus on the OLS estimation.

5.3. Rich and poor

Table 4 shows the OLS estimators of the yield functions for the rich and poor households. IMT appears to have an impact on rice yield for both the rich households, Column (1) and for poor

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\(^{14}\) While we do not report the probit regression of IMT on independent variables in Equation (1), our analyses show that the correlation coefficient \( \rho \) between the error terms of Equations (1) and (3) is not statistically significant.
households, Column (2). As expected some of the control factors have different parameter estimates for the rich compared with the poor households. For example, rich households in the irrigation district 2 appear to be more productive compared with the poor households in the same district. In contrast, drainage canals appear to increase the yield of poor households with no such corresponding effect for the rich. A 9% boost in rice yield for poor households is associated with the presence of IMT, whereas the increase in rice yield for rich households is 4%. The 5% difference in the gain in rice yield for the poor compared with the rich is statistically significant at the 5% level.

In order to understand why the poor appear to gain from IMT, we examine some additional questions asked in the survey (Table 5). Our data shows that a larger percentage of the poor (32%) in IMT IAs are downstream farmers relative to the poor in non-IMT IAs (24%). Further, significantly more of the poor farmers in IMT IAs (relative to poor in non-IMT IAs) indicate that the IAs help resolve illegal use of water. Similarly, significantly more of the IMT IA poor indicate that the water distribution schedule is followed. Thus, one explanation for the boost IMT appears to give the poor lies in the fact that IMT helps increase timeliness of water delivery in general and, more specifically, downstream availability of water. A recent review of IMT worldwide suggests that one of the ways management transfer can help poor farmers is by increasing the flow of water from upstream to downstream areas (Araral, 2005). Our results appear to back this conclusion.

6. Conclusions

We draw several conclusions from this analysis. First, the presence of IMT is associated with an increase in maintenance activities undertaken by irrigation associations. While irrigation associations with and without IMT contracts both undertake canal maintenance, the frequency of maintenance in IMT IAs is higher. However, IMT contracts do not appear to make much difference to the collection of irrigation fees.

IMT areas also have higher rice yields to the extent of about 6% relative to non-IMT areas. Rice production in IMT IAs is higher even after we control for various differences between rice farmers in IMT and non-IMT IAs. Thus, increasing local control over water infrastructure does appear to help farm productivity.

Table 5. Differences in perceptions about irrigation water delivery among asset poor in IMT and non-IMT areas.

<table>
<thead>
<tr>
<th>Questions regarding timeliness of water delivery and conflict resolution</th>
<th>Percentage of asset poor who said yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IMT IA (%)</td>
</tr>
<tr>
<td>1 Is the water distribution schedule followed?</td>
<td>75</td>
</tr>
<tr>
<td>2 Does the IA help resolve illegal checking?</td>
<td>89</td>
</tr>
<tr>
<td>3 Does the IA help resolve illegal pumping?</td>
<td>92</td>
</tr>
<tr>
<td>4 Does the IA help resolve illegal turnout?</td>
<td>90</td>
</tr>
<tr>
<td>5 Does the IA help resolve unscheduled gate opening/closing?</td>
<td>91</td>
</tr>
<tr>
<td>6 Is your farm located downstream?</td>
<td>32</td>
</tr>
<tr>
<td>7 Do you get water when needed during the dry season?</td>
<td>71</td>
</tr>
<tr>
<td>8 Do you get water when needed during the wet season?</td>
<td>96</td>
</tr>
<tr>
<td>9 Did you pay your irrigation service fees twice in the last two seasons?</td>
<td>93</td>
</tr>
</tbody>
</table>

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Significance levels based in t-tests.
An interesting distributional finding is that IMT may give the asset poor a boost in terms of rice yields. We speculate that this boost may be related to increased timeliness of water availability and improved conflict resolution related to illegal use and maintenance.

Quantitative impact analyses of interventions such as irrigation management transfer are best done with pre-intervention and post-intervention data. In this study, we do not have baseline information on irrigation and farm yields prior to IMT, instead we compare farmers affected by the intervention and those who are not. A criticism of this type of study often is that the ‘impact’ we show could be a result of variables that we as researchers are unable to capture in our analyses. Thus, these “unobservables” may allow some farmers or farmer groups to become early adopters of IMT and the IMT “effect” that we find is simply the effect of these other variables rather than the impact of IMT itself. We cannot exclude this possibility. However, we are given confidence in our results because, as the data shows, the control and treatment groups that we compare are quite alike in many respects.

Could the productivity improvements in rice yield be a result mainly of the infrastructure investments that were associated with the IMT contracts? While we control for infrastructure improvements in our analyses, we do not discount the role of “hardware” improvements in facilitating productivity changes. We think, however, that on-going improvements in maintenance, an increased role in water allocation and more speedy conflict resolution may also be making a difference.

Finally, we note that another limitation of our study is that it is based on farmer and irrigation association member responses rather than any physical measures of irrigation indicators. Combining quantitative social science research such as this with careful qualitative and water research expertise is a good way forward and we understand that some of this is happening in the Philippines.

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