Decentralizing Corruption? Irrigation Reform in Pakistan's Indus Basin

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Abstract

Does a shift from central bureaucratic control of a public service to local management reduce corruption? We consider governance reform in the world's largest canal irrigation system, that of Pakistan's Indus basin watershed. Using a large administrative database of water discharge readings covering the universe of irrigation channels in Punjab province from 2006-14, we construct and validate a measure of illegal water diversion along a channel. Based on this measure and two alternative panel-data strategies, we find that water theft on channels whose management was taken over by locally elected farmer organizations (FOs) *increased* compared to control channels that remained centrally managed under authority of the provincial irrigation department. We find no evidence that this apparent increase in rent-seeking under decentralization is mitigated when constituencies most vulnerable to water theft are better represented within the FO leadership.

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1 Introduction

Perceived corruption and lack of accountability associated with top-down public service delivery has led to calls for greater decentralization in developing countries. Participatory or grass-roots governance, in which management and control of resource allocation resides with local elected bodies rather than with bureaucracies, is now widely encouraged, even though communal authority too may be subject to rent-seeking in the form of elite capture.[1] Whether stronger accountability inherent in local control turns out to trump elite capture, however, is a question that must ultimately be resolved empirically. Yet, the empirics have been hampered by the lack of both objective measures of rent-seeking behavior (Olken and Pande, 2011) and large-scale 'controlled' experiments in decentralization.[2]

In this paper, we consider governance reform in the world's largest canal irrigation system, that of Pakistan's Indus basin watershed. During the last decade, in an effort encouraged by the World Bank, the management of several large sub-systems in the Punjab was transferred from the provincial irrigation department to grass-roots farmer organizations (FOs) organized at the channel level. The question we seek to answer is whether and, if so under what circumstances, this shift from bureaucratic to local control has reduced rent-seeking and corruption.

Effective management of large irrigation systems has proven elusive in both historical and contemporary experience (Meinzen-Dick, 2007). In the continuous flow and rotation systems most common in Asia, volumetric pricing and widespread water trading face daunting technical hurdles (Moore, 1989; Sampath, 1992). Instead, irrigation bureaucracies have been

[1] Alatas et al. (2013) and Beath et al. (2013) provide evidence of elite capture based on field experiments (in Indonesia and Afghanistan, respectively) in which the authority or accountability of local governments is randomly varied. In neither of these studies is centralized bureaucratic control the counterfactual.

[2] See Mansuri and Rao (2013) for a comprehensive and critical review of the evidence. A small literature looks at the impact of decentralization on corruption in cross-sections of countries (most recently, Fan et al. 2009). Aside from the aforementioned measurement issue, the difficulties here include heterogeneity in the nature of decentralization and, of course, reverse causation (See Bardhan and Mookherjee 2006b).

established to design and monitor the allocation of water as it makes its way down from the rivers and main canals to the network of distributaries, minors, and sub-minor canals, and finally to the watercourse outlets where it is distributed to individual farms. In this setting, users have a strong temptation to bribe local officials to "look the other way" as they illegally enlarge existing outlets or even create entirely new ones by cutting into a distributary channel. A consequence of such water "theft" in a gravity-based irrigation system is that users at the tail reaches of a channel inevitably receive less than their entitlement of water (see also Bromely et al. 1980, Wade 1982, and Chambers 1988). While decentralization strips authority from these unelected irrigation department bureaucrats, the leadership of the FO itself may be subject to capture by upstream irrigators and, hence, the FO may sanction as much, if not more, water theft than the irrigation department functionaries it replaces.[3]

The centerpiece of our analysis of Pakistan's irrigation reform is an administrative database maintained by the Punjab Irrigation Department and consisting of readings taken from water discharge gauges installed at the head and tail of each channel of the entire system. We argue that these data provide an objective measure of water theft– or, more precisely, of *changes* in theft–along a channel. Moreover, water discharge data are available over the years 2006-2014, a period encompassing significant devolution of irrigation management to FOs.

We adopt two strategies for constructing a control group against which we compare the changes in corruption after decentralization. Since FOs were phased in starting in 2005, our first strategy is to look solely at variation in outcomes across distributaries with early and late FO formation while controlling for channel-level fixed effects. In this 'pipeline' approach, we

[3]Punjab's irrigation reform exemplifies what Meinzen-Dick (2007) terms "externally initiated programs...[with] top-down imposition of a rigid structure of user groups and uniform rules that would allow state agencies to recognize and interact with [them]." Such irrigation management transfers, according to her review of the evidence, have had mixed success. Vermillion (1997), considering much the same body of country case-studies, concludes that "the literature on irrigation management transfer does not yet allow analysts to draw strong conclusions about...impacts, either positive or negative." p. 29.

only focus on the administrative zones where FO formation has been sanctioned; those FOs that became operational later serve as controls for those that became operational early. Our second strategy uses geographically *matched* controls drawn from adjacent administrative zones in which provincial authorities have not yet called for FOs to be established. That is, control channels are chosen on the basis of being within a *buffer* of given radius (e.g., 40 kilometers) around a particular FO channel. In this case, and in contrast to the pipeline strategy, we compare changes in discharges over the same time period between FO and non-FO channels.[4]

To preview our results, we find strong evidence of an *increase* in rent-seeking once an FO becomes operational in the sense that the relative allocation of water to the tail reaches declines. This increase is concentrated in channels that are presumptively more prone to rent-seeking. Finally, the negative effects of local control are not mitigated when tail-end irrigators, the farmers most harmed by water theft, are better represented within the FO leadership.

The next section of the paper provides a brief conceptual framework followed in Section 3 by the detailed context of irrigation reform in Punjab and our data-set. Section 4 lays out the empirical methodology. We present our empirical findings in Section 5 and summarize their implications in the concluding section.

2 Central bureaucracy versus local politics

Despite a vast literature surrounding corruption and government accountability, there is no general framework for thinking about the tradeoff between centralized bureaucracy and locally elected bodies in delivering public services. This lacuna is understandable given the difficulty of fully specifying the objectives and constraints of *both* institutions within

[4]In very different contexts, legislative discontinuities at the borders of US states have been exploited by Holmes (1998), Huang (2008), and Dube et al. (2010).

the same theoretical apparatus. Bardhan and Mookherjee (2006a) consider a bureaucratic hierarchy engaged in rent extraction under asymmetric information and compare it against a local government captured by elites:

> The switch from centralisation to decentralisation shifts control rights away from bribe extractors to those who respond to the interests of local users, owing to electoral pressures. However, they respond with a bias in favour of local elites. (p. 110)

They also emphasize the role of redistributive public finance as an alternative form of corruption, cautioning against equating rent-seeking with bribe-taking:

> The bribes associated with the centralised bureaucracy do disappear under decentralisation but are replaced by political influence of local elites, represented by regressive cross-subsidies hidden in government finances. Corruption measures based on bribes alone ignore political forms of corruption that may be equally or more important (p. 105).

Here, therefore, we find support for using an outcome rather than a single-input based measure of corruption in a context where rent-seeking may be effectuated *either* by bribery or by political influence.

These insights notwithstanding, Bardhan and Mookherjee elide a potentially important mechanism operating within bureaucracies: the disciplining power of career concerns. In the spirit of Becker and Stigler (1974), threats of dismissal, or (more likely) transfer, can be used to motivate lower-level officials (see Iyer and Mani 2012; Neihaus and Sukhtankar 2013). Moreover, inasmuch as it faces anti-corruption pressure both from above, by elected politicians, as well as from below, by citizen-protesters, even the upper-level bureaucrat, to some extent, has career concerns; in short, the bureaucracy faces a degree of accountability.[5]

[5]For concreteness, we may suppose that at *each* level of the bureaucracy, agents are motivated by expected

Is grass-roots governance more accountable and thus less corrupt (in the broad sense) than a centralized bureaucracy? As noted, theory is largely silent on this question. The literature suggests that under conditions of high inequality of wealth and political power, local government can end up serving the interests of the wealthy and powerful rather than, say, the median voter (see Mansuri and Rao, 2013). In such contexts, shifting control rights away from *constrained* bribe-extractors and toward local elected officials can simply unleash more corruption.

3 Context

3.1 Indus Basin irrigation system

The Indus Basin irrigation system, which accounts for 80% of Pakistan agricultural production, lies mostly in Pakistan's most populous province, Punjab, wherein it encompasses 23 thousand miles of canals and irrigates about 21 million acres. From the Indus, Jhelum, Chenab, Ravi, and Sutlej rivers ramify a dense network of main canals, branch canals, distributaries, minors, and sub-minors, eventually feeding 58 thousand individual watercourses in Punjab alone. Figure 1 provides a schematic view of the canal heirarchy.

Each watercourse outlet supplies irrigation to several dozen farmers according to a weekly rotational system known as *warabandi* whereby each farmer has a fixed turn at using the entire watercourse flow to irrigate his field. As noted by Rinaudo (2002):

> In theory, this water-quota system is based on the equity principle; the outlet dimensions are calculated so as to deliver a specific discharge to each group of farmers that is proportional to the area operated by them...[However,] practice is quite different from this theory. Groups of farmers located in the upper reaches

rent maximization, the product of rents extracted from the public (net of effort costs) and the probability of retaining the posting, which is decreasing in the size of the rents extracted.

> of the distribution canals may partly break their outlet or enlarge it in order to increase the discharge delivered to their fields...Farmers offer bribes to irrigation officials to avoid that the outlet be repaired and brought back to its official dimension, but also to avoid that the offense be taken to court. The outlet changes are typically made for a period of 6 months, after which it is repaired unless the farmers pay a new bribe. (p. 407-8).

Indeed, based on field measurements of 423 watercourse outlets in the Chishtian subdivision of southern Punjab, Rinaudo (2002) reports that 95 (or 23%) show physical evidence of illegal enlargement.

An analogous quota system operates at higher levels of the canal heirarchy. Thus, at the main canal level, for instance, irrigation department staff operate a series of gates regulating flow into the offtaking distributaries according to a rotational schedule. As is the case for the tertiary watercourses, discharges into these secondary canals are, at least on paper, allocated in proportion to their command area.

3.2 Irrigation management reform

The reform process, initiated in the early 2000s, was aimed at transferring existing functions of the Irrigation Department to four key institutions, the Punjab Irrigation and Drainage Authority (PIDA) at the provincial level, Area Water Boards (AWB) at the Canal Command level, Farmers Organizations (FOs) at the level of the distributary, and Khal Panchayats (KPs) at the level of a watercourse. Under these reforms, the Irrigation Department maintained its role as the overseeing body for daily functioning of the system.

PIDA was established as an autonomous entity, and was made responsible for overseeing all the functions previously performed by the Irrigation Department, with particular emphasis on improving irrigation performance, optimizing water use efficiency, introducing the concept of participatory management, and undertaking measures to improve the assessment and collection of *abiana* (water taxes). The ultimate goal was to make the authority self sustaining.

Administratively, Punjab's irrigation System was divided into 17 Circles (see figure 5 inset). Area Water Boards (AWBs) were established at the Circle level with the responsibility of promoting the formation of FOs covering every water channel within the Circle, with the FOs themselves tasked with the operations and management of distributaries and their off-taking channels. In particular, an FO is responsible for maintaining the channel, including the individual outlets, monitoring the rotational system to ensure equitable allocation, mediating and reporting water-related disputes among its irrigators, and collecting *abiana*.

Five AWBs were initially sanctioned to form FOs, and we will refer to them in the sequel as FO Circles. Based on conversations with irrigation department officials, these 5 were chosen based on the perceived ease of persuading farmers to participate in the process. Subsequent roll-out in the remaining 12 Circles has been indefinitely delayed by concerns about FO performance.

The formation of an FO involves the following steps: First, an outlet level chairman is elected by all landowners in each watercourse. Second, a secret ballot election is held at the level of the distributary (including off-taking channels), through which a nine members management committee (president, vice-president, secretary, treasurer, and five executive members) is selected from among the outlet level chairmen. The management committee exercises all powers of the FO. Once elected, an FO does not start operations until its members are trained and it is registered with the AWB. And, once operationalized, the FO membership remains in office for a tenure of three years, after which new elections are due.[6]

[6] In theory, FO members were to acquire formal training related to the daily operations and management of the system. Both PIDA and the Irrigation Department were also to provide ongoing institutional support to the FOs. However, despite drafting detailed rules and regulations to this effect, training and capacity building efforts stalled out after the pilot phase in LCC East.

Punjab's irrigation system consist of 1038 channels in FO Circles, covered by 407 FOs, and 1855 channels in non-FO Circles. The excess of channels over FOs in the former case reflects the fact that most distributaries have off-taking minors (and sub-minors) for which we also have discharge data. A distributary-level FO manages all of these minor canals as well. Table 1 presents descriptive statistics for all channels by FO status of the Circle. Across design features (number and location of outlets, position along parent channel), FO and non-FO circles look quite similar.

Table 2 gives a timeline of FO operationalization in each of the Circles where they have been formed. In the nine years from 2006 to 2014, PIDA records indicate that FOs in Circles LCC East and LCC West had completed one full tenure and started their second tenures, while FOs in Circles Bahawalnagar, LBDC, and Derajat were in their first tenure. Indeed, we do not have pre-reform data for LCC East because FOs there began their first tenure prior to 2006.

3.3 Canal water discharge data

Since 2006 the Punjab Irrigation department's Program Monitoring and Implementation Unit (PMIU) has maintained daily records of authorized (designed) and *actual* discharge at the head and tail of each channel. System design parameters account for the number of off-taking outlets (as well as off-taking channels and their outlets) and for conveyance losses, which vary according to extent of canal lining. As a result, design discharge at any point along a channel is, in general, a declining function of distance to the head of the channel (see Figure 1 inset). Figure 1 illustrates the location of PMIU discharge gauges along typical channels. Importantly, tail discharge is measured at the last watercourse outlet of the channel. For this reason, design discharge at the tail is never zero; all sanctioned outlets are entitled to some amount of canal water.

For our empirical analysis, we use data up to 2014 to construct aggregate discharge for the economically most important *kharif* (summer) season, which runs from mid-April to mid-October.[7] In particular, letting d index days and t index year, define

$$Y_{it}^{j} = \frac{\sum_{d \in t} Q_{id}^{j}}{\sum_{d \in t} \bar{Q}_{id}^{j}} \tag{1}$$

for $j = H(ead), T(ail)$, where Q_{id}^{j} is daily discharge at position j of channel i and $\bar{Q}_{id}^{T}$ is the corresponding *authorized* daily discharge.

Figure 2 shows how Y^H and Y^T vary across years for all channels in the 5 FO Circles and 12 non-FO Circles.[8] Two key facts emerge: First, the Indus basin irrigation system consistently under-provides surface water relative to its design parameters; i.e., the ratio of actual to authorized discharge is substantially less than one for the entire 8 year period. Second, the water shortfall is ordinarily *greater* at the tail than at the head.

3.4 Water theft

How to account for the fact that $Y^T < Y^H$? Recall that under the *warbandi* system, each watercourse gets a share (in terms of irrigation hours) of flow into the channel along which its outlet lies. Thus, if discharge measured at the head gauge of the channel is, say, 80% of authorized over the whole season, then each outlet along that channel would automatically receive 80% of its water entitlement or design flow. Critically, discharge measured at the tail of the channel would be 80% of authorized as well. If, however, outlets anywhere along the channel are enlarged, or if the canal is breached in any location, then off-take per hour is increased and relatively less water makes its way to the tail of the channel over the course of the season. Thus, for any given value of Y^H, such water theft would lead to a lower value of Y^T. Of course, illegal diversion may not be the only reason why discharge at the tail falls

[7] During *rabi* season, from November to March, 42% of channels in Punjab are closed.

[8] Even though a channel is in an FO Circle, it may not actually get an FO until as late as 2013 (see Table 2).

short of authorized. Lack of canal maintenance and excessive silting may lead to greater conveyance losses than allowed for under system design parameters. Nevertheless, forensic evidence adduced below suggests that water theft is a key part of the story.

As discussed, the incentive for water theft depends importantly on the perceived probability of detection. In the first instance, theft is more likely to occur at the head because that it is where there is the greatest distance between perpetrator and those most egregiously harmed. On top of this, the probability of detection falls with the number of outlets above the tail-end of a channel. In the extreme, with a single upstream outlet, any shortfall perceived to be beyond the normal fluctuation in channel flow would be attributed to illegal diversions at that outlet. With more upstream outlets, however, attribution of diversions to a particular outlet becomes increasingly difficult.[9] Furthermore, the ability to distinguish a shortfall from a normal fluctuation depends on the year-to-year variance in flow through a channel. That is to say, in channels with (exogenously) more variable in-flows, inferring the extent of upstream water diversion is a more challenging signal extraction problem for tail-end irrigators. Insofar as water theft can thus occur with greater impunity, we should see more theft along high variance channels.

Evidence summarized in Figure 3 bears out these two conjectures. The left panel, in which semiparametric regression is used to condition out Y^H, shows a strong negative association between residual Y^T over the 2014 *kharif* season and the log number of outlets along the head and middle (top 75%) of a channel.[10] So, channels with many outlets are particularly prone to theft. In the right panel, we find that the larger is the coefficient of variation in aggregate head discharge (the numerator in equation 1) from 2006-13, the smaller is Y^T in 2014 (conditional on Y^H for the same channel in the same year). Conclusion: theft appears

[9]Rinaudo's (2002) finding that the proportion of illegally modified outlets is greater in the larger distribution canals is consistent with this idea.

[10]Some 7.6% of channels (11% in FO Circles; 5.7% in non-FO Circles) have no head or middle outlets, only tail outlets. These channels are dropped from the semiparametric estimation.

to be more pervasive when the likelihood of being caught is lower.[11]

Official channel-level data on water theft complaints lodged with PMIU in *kharif* 2014 also corroborate our interpretation of Y^T.[12] The left panel of Figure 4 shows that aggregated complaints over the season are strongly increasing in the number of outlets that a channel has; so, again, the pattern with respect to outlets is what we expect. Moreover, conditional on Y^H *and* on the number of outlets, Y^T is decreasing in the number of complaints. In other words, channels with larger shortfalls of actual discharge relative to authorized tend to be the ones generating a higher volume of water theft complaints.

Return now to Figure 2, where it is evident that $Y^H - Y^T$ is quite a bit larger in FO Circles than in non-FO Circles. Given our interpretation, this differential gap indicates more water theft in FO Circles. However, inferring anything about the causal impact of FOs is premature. Indeed, the pattern could reflect selection; i.e., the reform experiment may have been initiated in areas where water theft was most pervasive to begin with.

4 Empirical Specifications

4.1 Pipeline strategy

Our regression model for exploiting the pipeline variation is

$$Y_{it}^T = \sum_j \alpha_j T_{it}^j + \sum_t \beta_t Y_{it}^H + \gamma_c t + \mu_i + \varepsilon_{it} \tag{2}$$

[11]Multivariate regression analysis (available on request), confirms the sign and significance of the two effects illustrated in Figure 3 both separately and jointly.

[12]Irrigation complaints have been recorded since 2008. Although user complaints are accepted, and nowadays even encouraged, most complaints are recorded by irrigation officials who make random inspections of channels. It is, of course, possible that the frequency of these inspections and the accurate reporting thereof vary by the degree of water theft along a channel.

where the T_{it}^j are indicators for whether channel i is in the midst of its first FO tenure ($j = 1$), its second FO tenure ($j = 2$), or an intervening period of administrative control ($j = M$), during *kharif* season of year t. Our baseline specification controls for relative discharge at the head of each channel, the effect of which is allowed to vary by year (the β_t), as well as for channel fixed effects, μ_i; these sweep out permanent channel characteristics, including those correlated with the likelihood of receiving an FO earlier rather than later. The third term in equation (2) captures pre-existing time trends at the Circle level, where γ_c is a Circle-specific coefficient. As is well-known, difference-in-differences (or fixed effects) estimation of treatment effects is predicated on the parallel trends assumption, which is to say that, absent intervention, average outcomes would have evolved similarly for both treatment (early FO adopters) and control (late FO adopters) groups. Here we estimate separate time trends for each FO Circle, with the exception of LCC East, which has no pre-reform observations (see Table 2).

4.2 Spatial matching estimator

Before setting out the regression model for use with spatially matched controls, we discuss our GIS buffer strategy. A buffer is a locus of GIS coordinates equidistant from each coordinate of an FO channel. Spatial matching consists in finding the set of channels from non-FO Circles that lie entirely within a buffer of given radius. Figure 5 illustrates a 40 kilometer buffer for a channel in Bahawalnagar Circle along with one particular control channel, of which there are typically many.[13]

The choice of radius for the GIS buffer presents a tradeoff. The smaller the radius, the more similar treatment and control channels are likely to be along unobserved dimensions (given spatial correlation in these unobservables). However, a smaller radius also implies a

[13]We do not have GIS shape files for Circle borders, so we cannot match on the basis of distance to these administrative boundaries.

smaller likelihood of finding *any* channels lying both within the buffer and within an adjacent non-FO Circle. A radius of 40 km, in particular, leads to a sample consisting of 320 FOs covering 782 channels, with 916 non-FO channels as controls (but each typically appearing in many buffers so that the total number of controls is actually 24,084). Thus, the choice of 40 km radius implies a loss of 87 of our original 407 FOs in the sense that we do not have spatially matched controls for them. By contrast, moving to a 60 km buffer radius matches 369 FOs covering 923 channels (with 1220 non-FO control channels). But shrinking the buffer radius down to 20 km nets only 147 FOs covering a mere 387 channels; we believe this is too few to constitute a useful sample.

Indexing buffers by subscript b, our regression model is

$$Y_{ibt}^{T} = \sum_{j} \alpha_j T_{ibt}^{j} + \sum_{t} \beta_t Y_{ibt}^{H} + \phi_{bt} + \mu_i + \varepsilon_{ibt} \tag{3}$$

where ϕ_{bt} is a buffer-year fixed effect.[14] To understand the source of identifying variation in equation (3), let us simplify the model so that we have just two time periods, before and after reform. First-differencing over time for each channel in this case is equivalent to channel fixed effects and yields

$$\Delta Y_{ib}^{T} = \sum_{j} \alpha_j \Delta T_{ib}^{j} + \sum_{t} \beta_t \Delta Y_{ib}^{H} + \tilde{\phi}_b + \Delta\varepsilon_{ib}, \tag{4}$$

where $\tilde{\phi}_b$ is a buffer fixed effect. Thus, the average treatment effect of an FO tenure is identified off of *within buffer* variation in channel-level discharge differences (pre/post) between FO and non-FO channels that lie in adjacent FO and non-FO Circles, respectively. In contrast to the pipeline approach, *the spatial matching estimator uses none of the variation in the timing of reform across FO Circles*; this is for the simple reason that, by construction,

[14]Due to the high dimensionality of both the channel and buffer-year fixed effects, we must estimate equation (3) using an iterative technique (Guimaraes and Portugal, 2010).

a given buffer only contains channels from one FO Circle.[15]

5 Results

5.1 Baseline treatment effects

Results for the pipeline approach (Table 3, column 2) indicate that the first FO tenure had a negative and significant impact on relative water supplies at channel tails. In other words, water theft appears to have substantially *increased*, by 7.9% relative to the mean of the controls. Neither the average effect of the second FO tenure nor of the intervening administrated period are statistically different from zero. However, it should be noted that the standard error on the second tenure coefficient is more than twice as large as that on the first tenure coefficient. Hence, we do not have as much power to detect a small negative effect of second FO tenure as we do in the case of the first tenure. Aside from the precision issue, as noted in Table 2, FOs had their second tenures in only two of the five FO circles; in fact, 84% of these observations are from LCC East, which, as already discussed, was intended to be a showcase for the irrigation reform.

Without controlling for Circle-specific trends (column 1), there is a significant second tenure treatment effect on the order of -0.05. But, since this specification is strongly rejected (with an F-statisic of 22), our baseline model retains controls for pre-trends at the FO Circle level. Recall, however, that we do not allow for a separate time trend for LCC East, as this FO Circle has no pre-treatment observations. To make sure that LCC East is not driving our results as a consequence, we drop this FO from the estimation in column 3. Although none of the coefficient estimates change appreciably, it should be noted that the second tenure effect in this specification is identified off of a mere 146 observations from LCC West.

[15] Roughly speaking, the pipeline strategy is a double-difference estimator and the spatial matching strategy is a triple-difference estimator.

Turning next to the spatial matching strategy, we obtain treatment effect estimates remarkably similar to those from the pipeline strategy regardless of whether we adopt a 40 km (column 5) or a 60 km (column 7) buffer radius.[16] Since the mean of Y^T for the controls is larger than in the pipeline case (because now they are drawn from non-FO Circles) the relative effect sizes are slightly smaller, i.e., 7.0% and 7.6%, respectively, for the 40 km and 60 km buffers. Estimated treatment effects for the second FO tenure remain insignificantly different from zero using the spatial matching approach, although, just as in the pipeline case, the standard errors are more than twice as large as those on the first tenure coefficients. So, here again, power to detect very small effects of the second FO tenure is relatively low.

Neither estimation strategy finds a statistically distinguishable difference in water theft between the administrated period after the first FO tenure and the pre-reform period. What is clear, however, is that once the first FOs relinquished control to PIDA administration, the theft situation improved, as though no devolution of irrigation management had ever occurred.

Given the strong correlation between number of outlets on a channel and water theft (Figure 3), it is sensible to ask whether deterioration under the first FO tenure was greater for channels with many outlets at the head and middle. Interacted models reported in columns 4, 6, and 8 of Table 3 and illustrated in Figure 6 suggest that this is indeed the case.[17] When there is merely a single outlet at the head and middle of the channel, the marginal effect of the first FO tenure is essentially zero, but the marginal effect rises to between -0.12 and -0.15 (or as much as three times the average treatment effect) for channels with the highest number of outlets.

[16]Recall that a 20 km buffer does not leave us enough sample for credible analysis.

[17]As noted earlier, 7.6% of channels have no head or middle outlets and thus must be dropped from these estimations.

5.2 Does representation matter?

Insofar as its leadership is drawn predominately from the tail of the channel, an FO should be less inclined to condone or facilitate upstream water theft, since such activity would harm tail-end users (its main constituency) the most. Aside from political career concerns, FO officers with landholdings at the tail have a purely economic motive in protecting water supplies to their own lands. Be that as it may, we consider two measures of tail representation on the FO: (1) a dummy for whether the president has land at the tail of the FO distributary and (2) the proportion of the four-member FO management committee with land at the tail.

For the 407 FOs with a first tenure, we have landholding information on the key FO office-holders for 391 of them; for the 128 FOs with a second tenure we have such information for 114. Among first tenure FOs, around 20% have a president with land at the tail (22% for second tenure FOs), whereas 50% have at least one member of the MC with land at the tail (71%). The modal number of MC members with land at the tail, conditional on at least one having such land, is one, both for first and second tenure FOs.[18] A final point before turning to the estimates is that channels under FOs with tail representation do not look substantially different in terms of their basic permanent characteristics than other FO channels (see Appendix Table)

We modify our baseline specifications (cols. 2, 5, and 7 in Table 3) to include interactions between T^1 and T^2 and each of the two tail representation variables just discussed. Note that, while we do not have to assume that tail representation is exogenous, we do assume that it is uncorrelated with the error term in either equation (2) or (3) *conditional* on the channel fixed effect. In the unlikely event that pre-reform shocks to water availability at the tail relative to the head of a channel determine FO leadership composition, this identifying assumption will be violated.

[18]Unsurprisingly, the correlation between these two measures of tail representation is fairly high, 0.57 for the first tenure and 0.49 for the second tenure.

Based on the results shown in Table 4, we cannot reject the hypothesis that FOs in which tail-enders had a significant leadership role performed no differently than FOs in which tail-enders had little or no representation. Again, a legitimate question is how powerful this test is. In the most favorable circumstance (first column of Table 4), we would be roughly 90% certain of detecting an effect size of 0.048.[19] An effect size of 0.048 would imply that having an FO president with landholdings at the tail *entirely* eliminates the negative impact of irrigation reform on relative water allocation to the tail. Thus, our estimates allow us to rule out a decisive role for tail representation in the FO, if not a marginal role.

5.3 FO governance and land inequality (preliminary)

We have noted already that local institutions are subject to elite capture, particularly where wealth and political power is highly concentrated. In rural Pakistan, landownership is the paramount indicator of both wealth and power. We use Agricultural Census data to construct measures of land concentration at the channel level by matching irrigated villages from the census with villages associated with channel outlets provided by the irrigation department.

As above, we augment our baseline specifications with interactions between T^1 and T^2 and the share of total land owned by the top x% of landowners, where x ranges from 3 to 10%. The results (Table to be completed) are consistent across specifications: In channels along which landholdings is more concentrated, the post-reform (first FO tenure) allocation of canal water worsened to significantly greater degree. In other words, tail users in such channels were left at a greater disadvantage after the establishment of FOs. The evidence thus suggests that decentralization may worsen corruption in contexts of high inequality.

[19] We use the standard error of 0.0164 and Andrews' (1989) inverse power function with a significance level of 95%.

6 Conclusion

How decentralization affects corruption has been an open empirical question. It is worth reiterating the reason why: It is rare to find a natural experiment in decentralization, and rarer still to find one in a context where corruption can be objectively measured. The devolution of irrigation management in Pakistan's Indus basin provides just such a felicitous combination.

We have examined changes in water discharge at the tail-end of channels whose management was taken over by locally elected farmer organizations (FOs) and compared these to changes that occurred in control channels that remained centrally managed. Rather than reducing rent-seeking, we find that shifting authority from irrigation department bureaucrats to an FO leadership leads to a modest increase in water theft. Thus, elite capture of local authority appears to be a real concern (contra, e.g., Atalas et al. 2013).

While the evidence is not favorable to the decentralization effort in the Indus basin, inasmuch as it did not deliver on its promise of a more equitable distribution of canal water, it would be premature to throw out the reform baby with the bathwater. Designing democratic institutions that mitigate elite capture could potentially tip the balance in favor of local control.

References

[1] Alatas, V., Banerjee, A., Hanna, R., Olken, B. A., Purnamasari, R., & Wai-Poi, M. (2013). Does elite capture matter? Local elites and targeted welfare programs in Indonesia (No. w18798). National Bureau of Economic Research.

[2] Bardhan, P., & Mookherjee, D. (2006a). Decentralisation and Accountability in Infrastructure Delivery in Developing Countries*. *Economic Journal*, 116(508), 101-127.

[3] Bardhan, P., & Mookherjee, D. (2006b). Decentralization, corruption and government accountability. *International handbook on the economics of corruption*, 6, 161-188.

[4] Beath, A., Christia, F., & Enikolopov, R. (2011). Elite capture of local institutions: Evidence from a field experiment in Afghanistan. *Unpublished manuscript.*

[5] Bromley, D. W., Taylor, D. C., & Parker, D. E. (1980). Water reform and economic development: institutional aspects of water management in the developing countries. *Economic Development and Cultural Change*, 365-387.

[6] Chambers, R. (1988). *Managing canal irrigation: Practical analysis from south Asia.* New Delhi: Oxford.

[7] Dube, A., Lester, T. W., & Reich, M. (2010). Minimum wage effects across state borders: Estimates using contiguous counties. *Review of Economics and Statistics*, 92(4), 945-964.

[8] Fan, C. S., Lin, C., & Treisman, D. (2009). Political decentralization and corruption: Evidence from around the world. *Journal of Public Economics*, 93(1), 14-34.

[9] Guimaraes, P. and P. Portugal (2010). A Simple Feasible Alternative Procedure to Estimate Models with High-Dimensional Fixed Effects, *Stata Journal*, 10(4), 628-649.

[10] Holmes, T. J. (1998). The effect of state policies on the location of manufacturing: Evidence from state borders. *Journal of Political Economy*, 106(4), 667-705.

[11] Huang, R. R. (2008). Evaluating the real effect of bank branching deregulation: Comparing contiguous counties across US state borders. *Journal of Financial Economics*, 87(3), 678-705.

[12] Iyer, L., & Mani, A. (2012). Traveling agents: political change and bureaucratic turnover in India. *Review of Economics and Statistics*, 94(3), 723-739.

[13] Mansuri, G., and Rao, V. (2013). *Localizing development: Does participation work?*. World Bank Publications.

[14] Meinzen-Dick, R. (2007). Beyond panaceas in water institutions. Proceedings of the National Academy of Sciences, 104(39), 15200-15205.

[15] Moore, M. (1989). The fruits and fallacies of neoliberalism: the case of irrigation policy. *World Developmen*t, 17(11), 1733-1750.

[16] Niehaus, P., & Sukhtankar, S. (2013). Corruption dynamics: The golden goose effect. *American Economic Journal: Economic Policy*, 5(4), 230-269.

[17] Olken, B. A., & Pande, R. (2011). Corruption in developing countries (No. w17398). National Bureau of Economic Research.

[18] Rinaudo, J. D. (2002). Corruption and allocation of water: the case of public irrigation in Pakistan. *Water Policy*, 4(5), 405-422.

[19] Sampath, R. K. (1992). Issues in irrigation pricing in developing countries. *World Development*, 20(7), 967-977.

[20] Vermillion, D. L. (1997). Impacts of irrigation management transfer: A review of the evidence. Sri Lanka: International Irrigation Management Institute.

[21] Wade, R. (1982). The system of administrative and political corruption: Canal irrigation in south India, *J. of Development Studies*, 18(3):287-328.

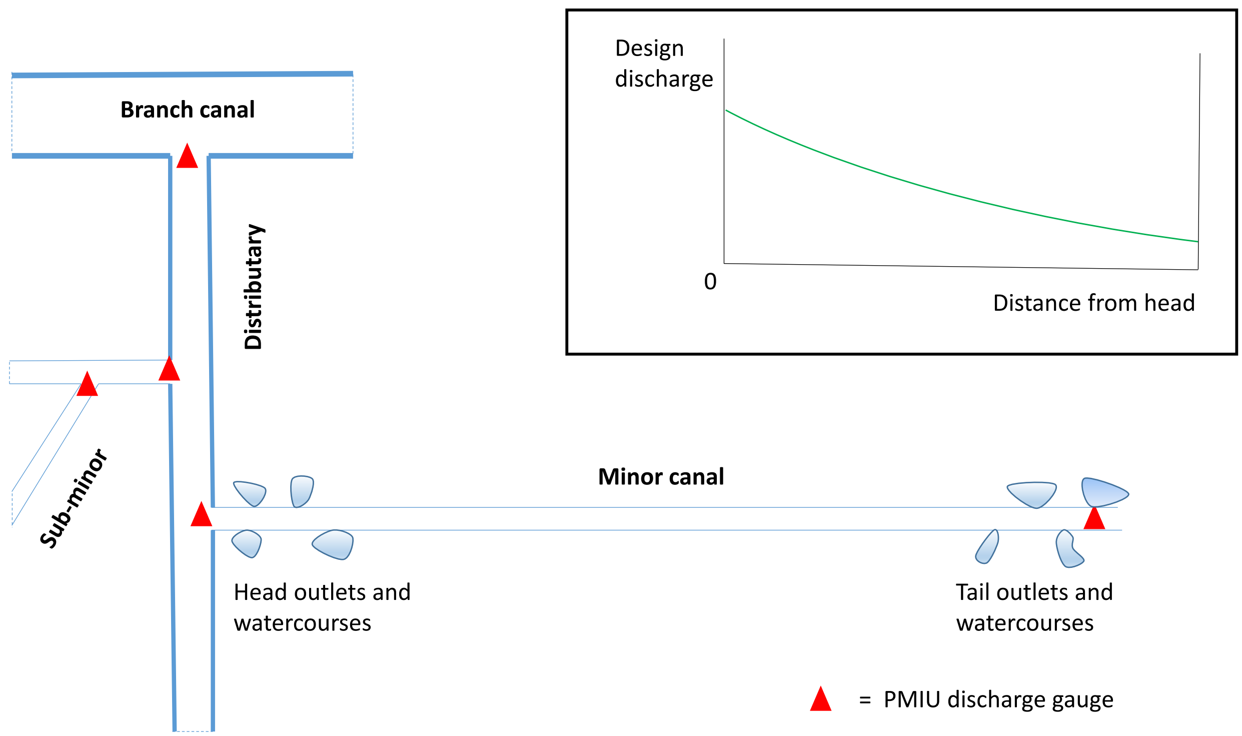

Figure 1: Channel schematic with discharge gauges

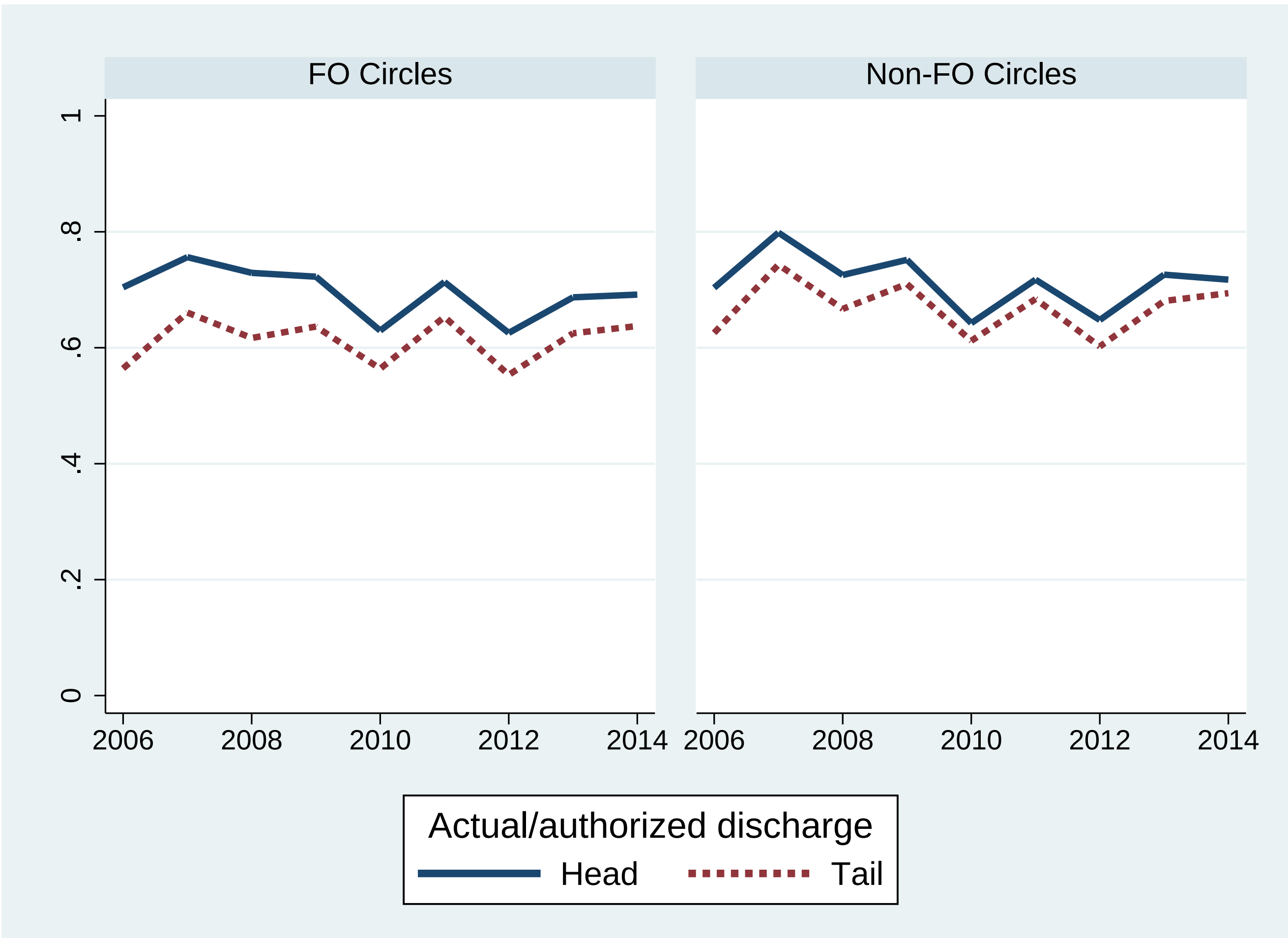

Figure 2: Mean discharge ratios by year for FO and non-FO channels

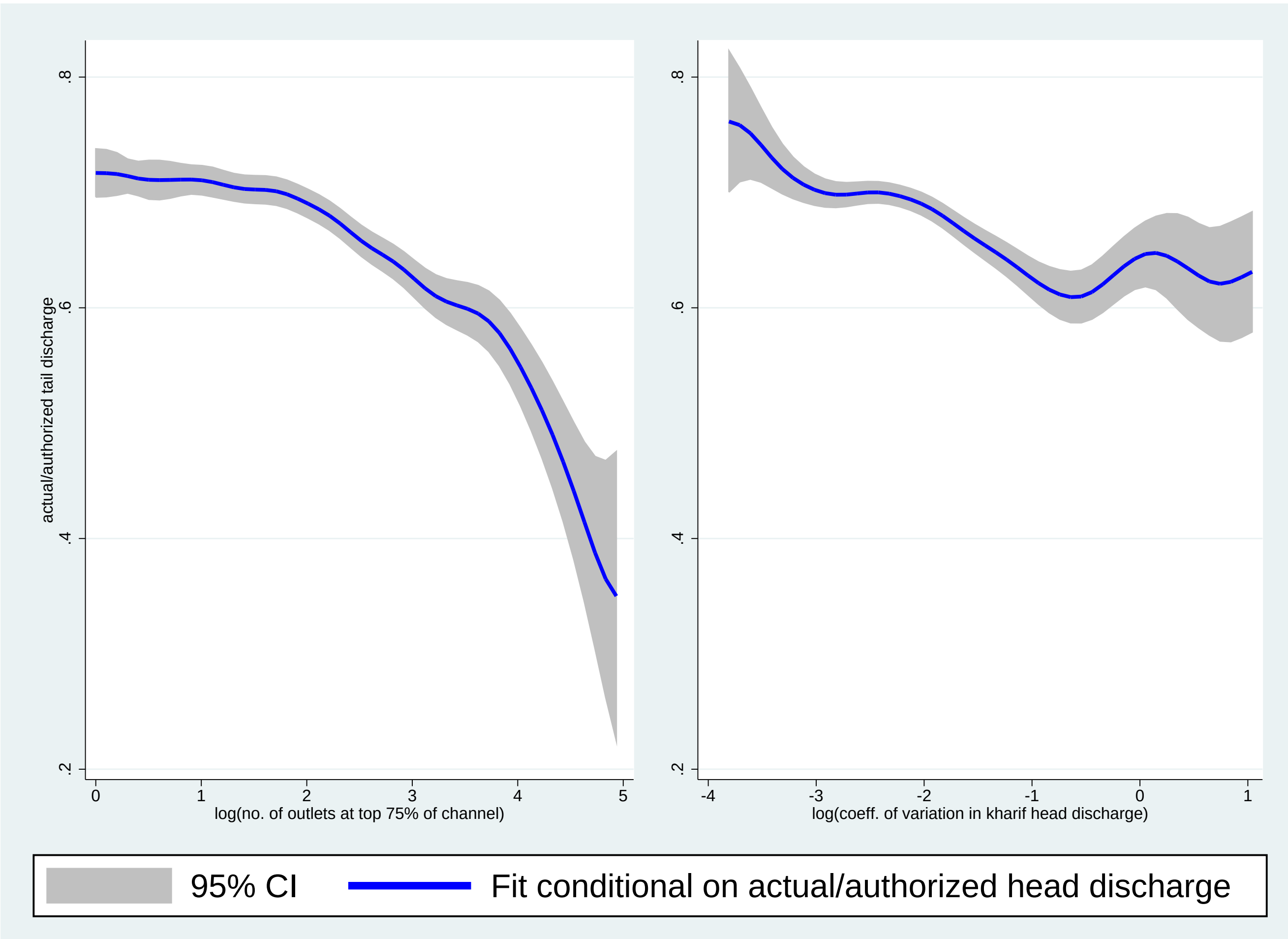

Figure 3: Correlates of water theft

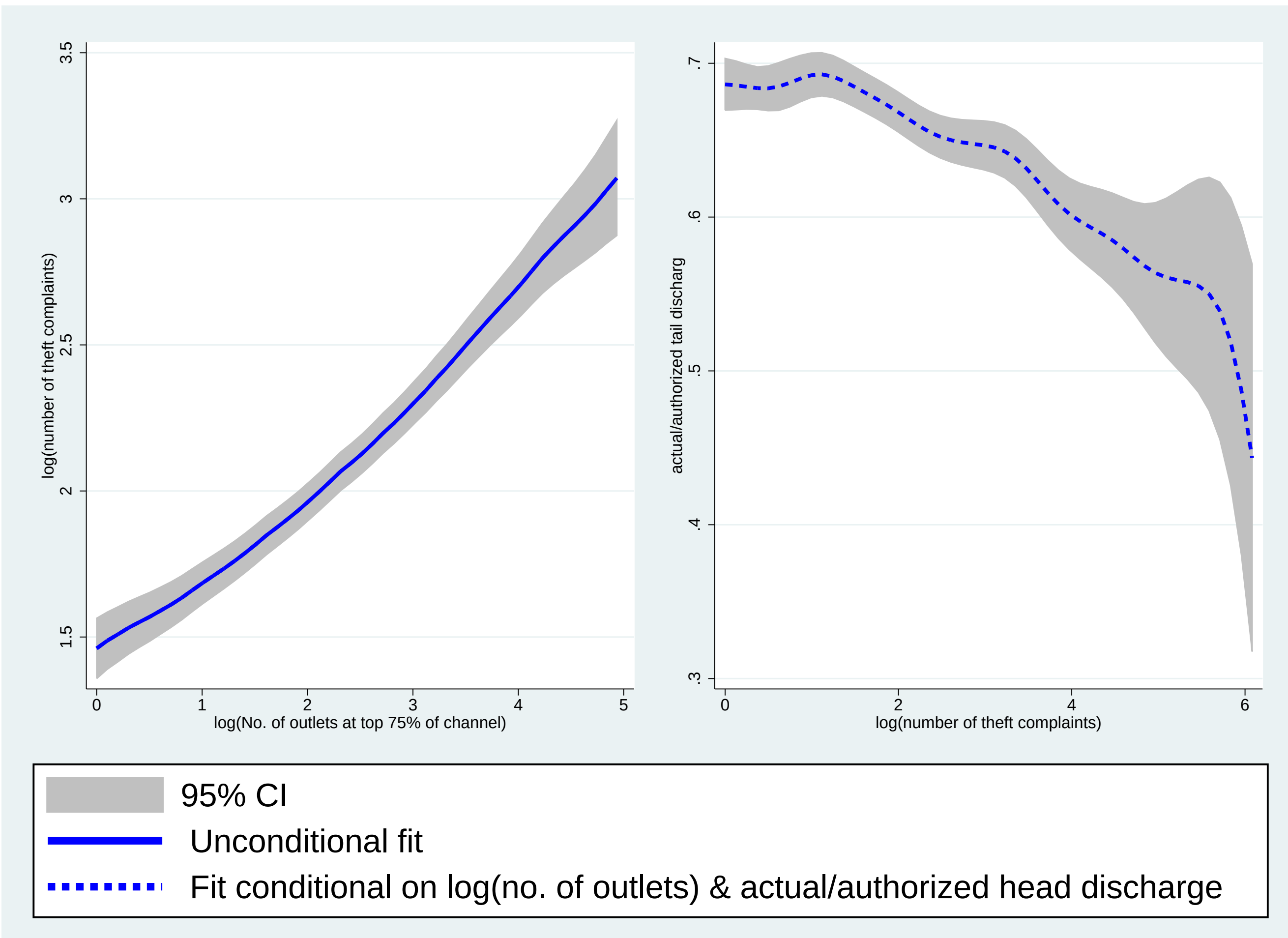

Figure 4: Water theft and theft complaints

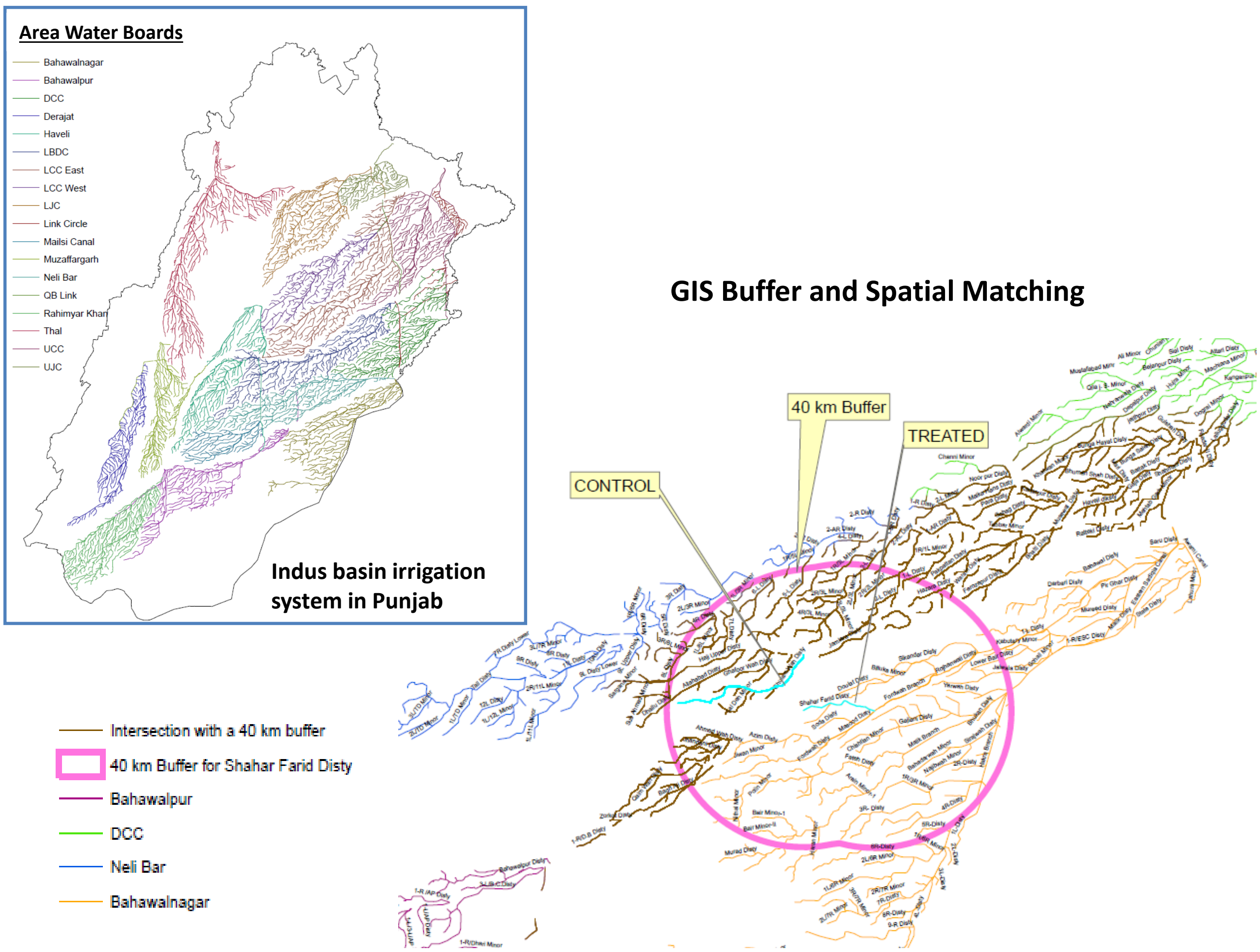

Figure 5: GIS mapping of Indus Basin irrigation system

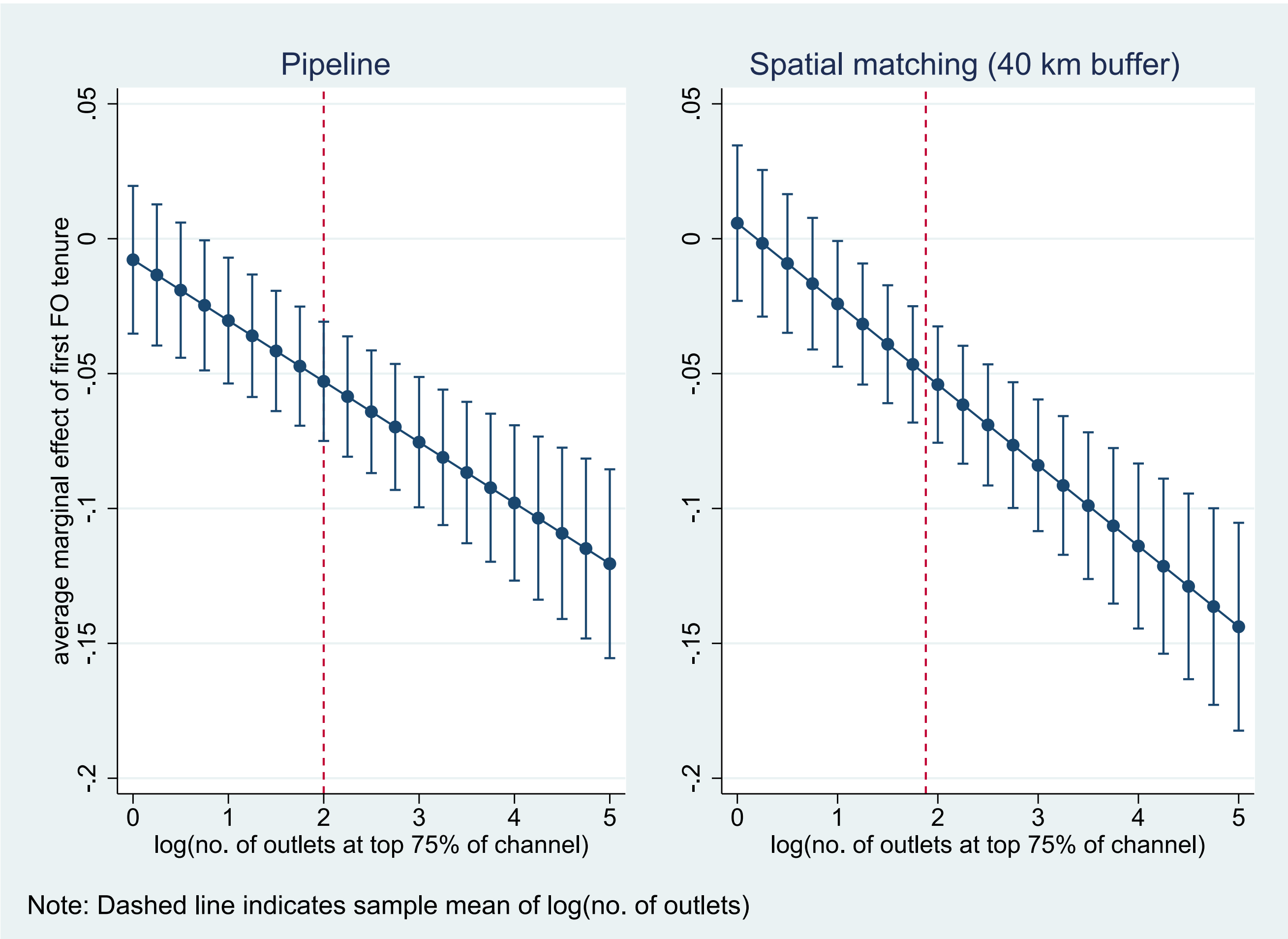

Figure 6: Marginal effects and 95% confidence intervals

Table 1: Descriptive Statistics for Sample Channels

	FO Circles							**Non-FO Circles**						
	N	**Number of outlets**			**Position on parent**			N	**Number of outlets**			**Position on parent**		
Canal type	(%)	**Head**	**Middle**	**Tail**	**Head**	**Middle**	**Tail**	(%)	**Head**	**Middle**	**Tail**	**Head**	**Middle**	**Tail**
Branch	7	20.3	18.7	19.6	0.14	0.14	0.71	0	-	-	-	-	-	-
	(0.7)	(15.9)	(15.5)	(24.9)	(0.38)	(0.38)	(0.49)	(0.0)	-	-	-	-	-	-
Distributary	457	10.0	7.0	9.8	0.31	0.40	0.28	782	10.5	8.0	10.5	0.28	0.38	0.34
	(44.0)	(11.1)	(8.3)	(9.8)	(0.46)	(0.49)	(0.45)	(42.2)	(10.7)	(8.2)	(9.5)	(0.45)	(0.49)	(0.47
Minor	503	3.1	2.8	4.7	0.44	0.37	0.18	925	4.3	3.7	5.6	0.41	0.42	0.17
	(48.5)	(4.3)	(3.5)	(3.5)	(0.50)	(0.48)	(0.39)	(49.9)	(5.1)	(3.7)	(4.3)	(0.49)	(0.49)	(0.37
Sub-minor	71	1.8	1.8	3.7	0.52	0.38	0.10	148	2.8	2.5	4.1	0.46	0.40	0.14
	(6.8)	(2.4)	(2.2)	(2.5)	(0.50)	(0.49)	(0.30)	(8.0)	(3.6)	(2.7)	(2.6)	(0.50)	(0.49)	(0.35
Total	1038	6.2	4.7	7.0	0.39	0.38	0.23	1855	6.8	5.4	7.5	0.36	0.40	0.24
	(100)	(8.9)	(6.6)	(7.7)	(0.49)	(0.49)	(0.42)	(100)	(8.5)	(6.4)	(7.4)	(0.48)	(0.49)	(0.43)

Notes: Figures are means or proportions (standard deviations in parentheses) unless otherwise noted.

Table 2: Timeline of FO Operationalization

Circle	Number of Channels	Number of FOs	2006	2007	2008	2009	2010	2011	2012	2013	2014
			Proportion of channels in Circle within regime								
LCC East	235	85	0.97	0.97	0.97	0.97	0.97	0.73	0.85	0.86	0.91
LCC West	198	73	1.00	1.00	0.97	0.97	0.98	0.98	0.98	0.98	0.74
Bahawalnagar	146	69	1.00	1.00	1.00	1.00	1.00	0.97	0.97	0.97	0.57
LBDC	237	60	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.98	1.00
Derajat	222	120	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Notes: Colors demarcate the relevant regime for the *majority* of FOs in a Circle: Red=pre-reform; Blue=first FO tenure operational; Yellow=administrator control; Green=second FO tenure operational.

Table 3: Baseline Treatment Effect Estimates

					Spatial Matching			
	Pipeline				40 km buffer		60 km buffer	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
First FO tenure (T^1)	-0.0648***	-0.0474***	-0.0538***	-0.00780	-0.0509***	0.00578	-0.0550***	-0.00290
	(0.00954)	(0.0106)	(0.0107)	(0.0140)	(0.0105)	(0.0147)	(0.00974)	(0.0138)
Second FO tenure (T^2)	-0.0497**	-0.00953	-0.00240	-0.0245	-0.00631	-0.0235	0.00700	-0.000416
	(0.0245)	(0.0251)	(0.0312)	(0.0320)	(0.0248)	(0.0340)	(0.0217)	(0.0284)
Administrated (T^M)	-0.0192	0.0303	0.00202	0.0333	-0.0107	-0.0239	-0.000346	0.00286
	(0.0192)	(0.0187)	(0.0220)	(0.0269)	(0.0196)	(0.0277)	(0.0184)	(0.0258)
$T^1\times$ log(no. of outlets)				-0.0225***		-0.0299***		-0.0266***
				(0.00443)		(0.00522)		(0.00471)
$T^2\times$ log(no. of outlets)				0.00907		0.0119		0.00937
				(0.0124)		(0.0136)		(0.0125)
$T^M\times$ log(no. of outlets)				0.00184		0.0120		0.00614
				(0.0108)		(0.0102)		(0.00946)
F-test $\beta_t = 0$	116.2***	123.0***	96.54***	110.4***	65.24***	55.48***	71.00***	64.20***
F-test $\gamma_c = 0$		22.11***	16.74***	21.75***				
R^2 (within)	0.308	0.339	0.353	0.330	0.869	0.868	0.855	0.854
$E[Y^T \mid T^1 = T^2 = T^M = 0]$	0.597	0.597	0.594	0.582	0.732	0.732	0.726	0.726
Observations	9,320	9,320	7,206	8,296	222,104	209,847	650,454	613,830
Number of clusters	407	407	322	405	756	749	925	918

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1), clustered on FO (pipeline) or on FO/distributary (spatial matching). Dependent variable in all specifications is Y^T, the ratio of actual to authorized tail discharge. All specifications include channel fixed effects; spatial matching specifications include, in addition, buffer-year fixed effects. Specification (1) does not include Circle-specific time trends ($\gamma_c = 0$), whereas specification (3) drops LCC East from baseline specification (2), which does include Circle-specific time trends.

Table 4: Tail Representation and FO Performance

	Pipeline		Spatial Matching: 40 km buffer		Spatial Matching: 60 km buffer	
	President	MC	President	MC	President	MC
First FO tenure (T^1)	-0.0481***	-0.0496***	-0.0478***	-0.0467***	-0.0517***	-0.0506***
	(0.0110)	(0.0121)	(0.0112)	(0.0120)	(0.0102)	(0.0113)
Second FO tenure (T^2)	-0.0133	-0.0235	-0.0133	-0.0231	-0.00408	-0.0135
	(0.0270)	(0.0313)	(0.0257)	(0.0275)	(0.0223)	(0.0248)
Administrated (T^M)	0.0307	0.0313	-0.0109	-0.0126	-0.000678	-0.00238
	(0.0189)	(0.0190)	(0.0195)	(0.0199)	(0.0183)	(0.0187)
$T^1\times$ Owns land at tail	0.00365	0.0115	-0.0167	-0.0258	-0.0172	-0.0260
	(0.0164)	(0.0327)	(0.0204)	(0.0400)	(0.0199)	(0.0381)
$T^2\times$ Owns land at tail	0.0269	0.0645	0.0356	0.0609	0.0531	0.0757
	(0.0305)	(0.0595)	(0.0373)	(0.0580)	(0.0324)	(0.0584)
R-squared	0.346	0.346	0.869	0.869	0.855	0.855
Observations	9,127	9,127	222,104	222,104	650,454	650,454
Number of clusters	1,038	1,038	756	756	925	925

Notes: Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1), clustered on FO (pipeline) or on FO/distributary (spatial matching). See notes to Table 3. Under column labeled President, the "owns land at tail" variable is a dummy for whether the FO president (during the relevant FO tenure) owns land at the tail of the distributary. Under column labeled MC, the "owns land at tail" variable is the proportion of the four members FO management committee owning land at the tail of the distributary.