Inefficient Water Pricing and Incentives for Conservation

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Replication package by Blanchon Mathilde, Garson Jonathan

The full code is available on GitHub

1 Introduction

In the context of the intense use of water in the agricultural sector and increasing scarcity due to climate change, Chakravorty et al. (2023) (CDK) argue that water-saving technology in developing countries could be of great help to improve water management. However, according to them, the widespread payment scheme for water access by farmers, fixed charges, does not incentivize farmers to adopt water-saving technology such as the "Alternate Wetting and Drying" (AWD) - a perforated plastic pipe, which helps the farmer irrigating only when the crop needs water. Following the classical economic theory assumptions on consumer behaviors, CDK formulate the hypothesis that the implementation of marginal pricing should induce the adoption of water-saving technology and foster the reduction of water usage, without loss of revenue. This hypothesis motivates the following research question: is the implementation of marginal prices a necessary and sufficient condition to foster the adoption of water-saving technology in farms? To do so CDK have conducted two randomized control trials (hereafter RCT) in Bangladesh.

For the first RCT, villages were randomly selected, and pipes were freely provided, installed, and accompanied by training for 2,000 farmers. Another 2,000 farmers, serving as the control group, continued irrigating as before. The sample comprises 400 villages across different regions. Without intervention, 35% of farmers faced nonzero marginal irrigation prices, while the rest paid based on a seasonal contract tied to the cultivated area.

They found that, while the AWD has close to no effect under fixed prices, farmers facing volumetric payment were using the AWD technology appropriately and reduced their water consumption by 19 percent for their plots and the plots were 21 percent more likely to be dried when observed on random days. These results lead CDK to consider volumetric pricing as a necessary condition for AWD program's efficiency.

Then, the second RCT reverses the perspective by randomly assigning the payment system to examine its causal effect on AWD adoption and, ultimately, water savings. To achieve this, they selected areas with community tube wells equipped with meters compatible with pre-paid debit cards. Water was distributed on demand and priced by volume. Among these areas, they identified 144 villages without pre-paid cards and randomly selected 96 for a campaign that reduced the cost of adopting pre-paid debit cards[1].

Following this, sales teams offered AWD technology at prices randomly assigned across eight categories, ranging from 15% to 70% of the pipe's marginal cost. This allowed them to estimate the demand curve for AWD under marginal pricing. Finally, teams were sent to observe water usage and plot dryness, mirroring the approach of the first experiment.

The second RCT shows that encouraging the adoption of hourly pricing did not lead to water conservation. While the option to adopt marginal pricing did not increase AWD demand, it altered the demand curve, making it less responsive to price variations. Farmers facing the highest marginal prices increased AWD adoption by 35%, yet across the full sample, only 20% adopted the technology. Moreover, uptake of cost-free pre-paid card adoption remained low, around 40%.

Reconciling the findings from both RCTs suggests that voluntary adoption of marginal pricing alone may be insufficient to drive water-saving technology adoption. CDK argue that a mandatory shift to marginal pricing, combined with state intervention in technology adoption, may be necessary to reduce water consumption.

In the following sections, we replicate the key results from the paper, originally produced using Stata, using R. section 2 reproduces the results obtained from the first RCT 1 on the effect of water-saving technology on water consumption while taking into account different payment systems. section 3 reproduces the main output from the second RCT on the impact of marginal pricing on AWD adoption and the impact on water-saving.

[1]They identified that upfront cost was the main barrier to adopting the pre-paid card system.

2 The effect of AWD on water saving

In this section we reproduced the following output from Chakravorty et al. (2023): Figure 2, Figure 3, Figure 4, Figure 5.

2.1 Effect of Conservation Technology on Water Levels

We have divided Figure 2 of Chakravorty et al. (2023) into three smaller tables representing three different panels of the first RCT. Table 1 provides the main results, Table 2 the between upazila variation, and Table 3 the within upazila variation.

The regression we used to obtain these tables is the following :

$$\begin{aligned} y_{ivs} =& \beta_0 + \beta_1 Treatment_v + \beta_2 Volumetric_{ivs} \\ &+ \beta_3 Treatment_v \times Volumetric_{ivs} + \alpha_s + \epsilon_{ivs} \end{aligned} \tag{1}$$

With $Treatment$ corresponding to a dummy variable for being treated (i.e. receiving AWD), $Volumetric$ being another dummy for the marginal or volumetric payment system[2], β_3 captures the interaction of the two dummies and there is a fixed effect α_s by upazila (i.e. administrative unit).

For Panel A and B we followed closely the authors' approach. The only cleaning operation consisted of getting rid of the variable *waterunit* when the cell returned *NA*. For regression with fixed effect with used the *Fixest* package which also calculated the standard errors clustered at the village level. The p-value displayed are estimated with *car* and are the p-value for a Wald-test of joint significance of estimators.

As we can see in Table 1 we obtain results very close to Figure 2, such that the small differences are largely due to package differences. This table shows that treatment (i.e. receiving AWD) was insignificant in all configurations but the interaction between *Treatment* and *Volumetric Pricing* shows a robust correlation with a fall in water level of about 0.544 centimeters (23.5%). This effect seems stronger in the immediate 70 days following planting and disappears after that. These last results are coherent with the fact that farmers stop practicing AWD during the time when crop water requirements are high.

[2] In the paper CDK use indistinguishably "hourly paid", "volumetric payment" and "marginal pricing".

Table 1: Effects of Conservation Technology on Water Level (Panel A)

	Overall		0–70 days after planting		70+ days after planting	
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	−0.061	0.119	−0.350	−0.048	0.250	0.258
	(0.161)	(0.220)	(0.152)	(0.208)	(0.286)	(0.376)
Volumetric Pricing		−0.107		0.026		−0.488
		(0.333)		(0.363)		(0.420)
Treatment x Volumetric Pricing		−0.544		−0.788		0.014
		(0.287)		(0.287)		(0.474)
Num.Obs.	7598	7596	4188	4187	3410	3409
Control Mean	2.320	2.320	2.730	2.730	1.860	1.860
p-value		0.021		0.000		0.327

Notes: For the sake of brevity we invite the reader to refers to Figure 2 for the full note description.

For Panel B, which examines variation across Upazilas, we once again observe the same results as before. However, consistently with CDK, none of the estimates are statistically significant.

In Panel C, we introduced modifications to the original code due to the imperfect translation to R. To estimate within-Upazila variation as the causal source, the author interacted Upazila and treatment for the fixed effects. However, this approach induces collinearity between the fixed effects and the treatment variable when using *Fixest*. To address this, we tested different strategies and retained the one most aligned with the authors' methodology. Specifically, we demeaned the treatment at the Upazila level, obtaining results similar to CDK. We also experimented with alternative methods, such as interacting Upazila and treatment while using a reference Upazila, but ultimately preferred the former approach, as it closely matched CDK's results without assuming a specific reference Upazila.

Table 2: Effects of Conservation Technology on Water Level (Panel B)

	Overall	0–70 days after planting	70+ days after planting
	(1)	(2)	(3)
Treatment	0.094	0.016	0.143
	(0.227)	(0.212)	(0.380)
Treatment x Volumetric Pricing Upazila Mean	−0.476	−0.966	0.424
	(0.328)	(0.326)	(0.541)
Num.Obs.	7596	4187	3409
p-value	0.073	0.000	0.095

Overall, our findings align with CDK: no significant estimates and the same sign, though consistently lower than their estimations. The only notable discrepancy concerns the p-values from the Wald test in the first column of Table 3, which suggests rejecting the null hypothesis and indicates that the estimators are jointly significant.

All tests were conducted using the *car* package and the *linearHypothesis* function, which produced results highly consistent with those of the authors—except for this regression. We attribute this discrepancy to differences in package implementation. To verify this, we used the *fixest* built-in test function *fitstat*. The p-values obtained from *fixest*, displayed in Table 3, lead us to accept the null hypothesis, albeit with a smaller margin than in CDK. This reinforces our hypothesis that minor discrepancies stem from software differences and, marginally, implementation issue. Otherwise, all p-values, except for this one, remain qualitatively similar to those in Figure 2.

Table 3: Effects of Conservation Technology on Water Level (Panel C)

	Overall	0–70 days after planting	70+ days after planting
	(1)	(2)	(3)
Treatment	0.119	−0.048	0.257
	(0.220)	(0.208)	(0.376)
Volumetric Pricing	−0.378	−0.366	−0.481
	(0.312)	(0.318)	(0.440)
Treatment x Volumetric Pricing	−0.542	−0.788	0.018
	(0.287)	(0.287)	(0.473)
Num.Obs.	7596	4187	3409
p-value (car)	0.030	0.001	0.714
p-value (fixest)	0.079	0.000	0.423

2.2 Nonparametric Estimates of Treatment Effect as a Function of Days after Planting

In this section, we reproduced the following exhibit from Chakravorty et al. (2023): Figure 3. It uses the same data as the previous tables and highlights that the pricing scheme impacts the trend of water level and dryness overtime differently for treated and control groups : the AWD technology reduced irrigation withdrawal and increased drying only during the pre-flowering period of crops and only for farmers under volumetric pricing.

The top and middle panels present the results from the water level and the indicator for dry field over time. We use the Locally Estimated Scatterplot smoothing (LOESS) in R to reproduce the results obtained with the Stata command "fanreg". These methods both don't assume a specific form and allow us to fit a smooth curve by locally weighting observation and performing regression on small subset of data.

The bottom panel illustrates how frequently observations were recorded over time. We can therefore verify that the timing of data collection is balanced across treatment conditions.

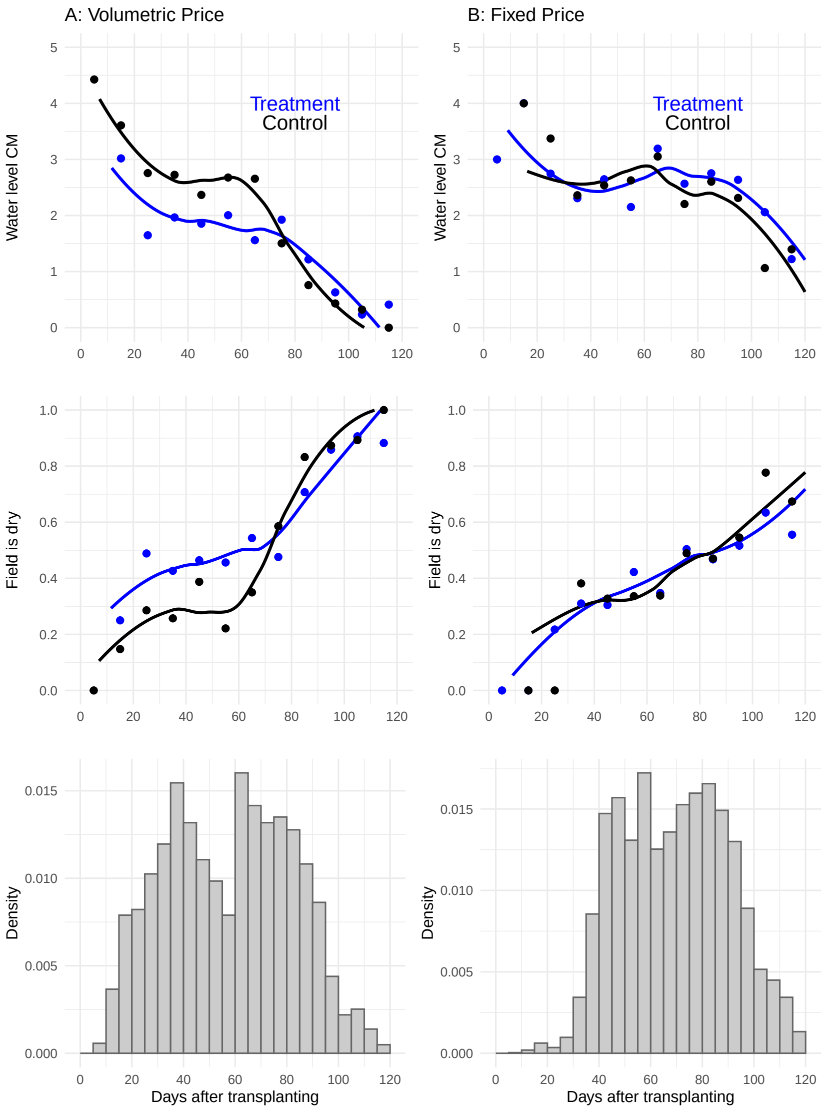

Figure 1: Nonparametric Estimates of Treatment Effect as a Function of Days after Planting

2.3 Effects of Conservation Technology on log Costs, Revenues, and Profits

In this section, we reproduced the following exhibit from Chakravorty et al. (2023): Figure 4.

This table employs the same baseline specification as previously described to gain a detailed understanding of the impact of AWD adoption on profit.

Using the *fixest* package in R and the *linearHypothesis* function from the car package, we successfully replicate results that closely align with the original study.

The minor discrepancies—on the order of one-hundredth in certain p-values, R^2 values, and coefficients—can be attributed to differences in software implementation and a slight variation in the number of observations (2–3 observations, depending on the model) between the author's dataset and our replication package.

Therefore, in line with CDK, we find that while profits per acre, in the absence of volumetric pricing, is close to zero and statistically insignificant, AWD technology increases profits by about 9 % for farmers under volumetric pricing.

CDK complement their analysis of the full sample—where volumetric pricing is assigned at the village level based on the presence of a prepaid card system for water pumping—with a focused study in the Rajshahi district. In this district, although the prepaid card system is widespread, CDK observed that some farmers did not use their cards and instead paid fixed prices. By defining volumetric pricing as owning a prepaid card, which is required to access the water system, they find an even stronger effect of the interaction between treatment and volumetric pricing on profit. This suggests that the estimates from the full sample likely represent a lower bound, as not all farmers in villages classified under volumetric pricing actually use this pricing scheme.

Table 4: Effects of Conservation Technology on Log Costs, Revenues, and Profits

	Profit	Water Cost	Yield	Revenue	Water Cost (Rajshahi)	Profit (Rajshahi)
Treatment	-0.036	0.023	-0.001	0.001	0.022	0.026
	-0.036	0.023	-0.001	0.001	0.022	0.026
	(0.046)	(0.024)	(0.014)	(0.017)	(0.062)	(0.044)
Treatment x Volumetric Pricing	0.122	-0.081	0.009	0.029		
	0.122	-0.081	0.009	0.029		
	(0.061)	(0.053)	(0.017)	(0.022)		
Volumetric Pricing	-0.123	0.066	0.013	0.003		
	-0.123	0.066	0.013	0.003		
	(0.070)	(0.043)	(0.018)	(0.028)		
Treatment x Has Card					-0.209	0.112
					-0.209	0.112
					(0.095)	(0.077)
Has Card					0.243	-0.072
					0.243	-0.072
					(0.074)	(0.071)
Upazilas treatment effect	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.273	0.347	0.329	0.351	0.455	0.083
Observations	3932	3983	3982	3982	1339	1331
p-Value:						
Treatment + Treatment x Volumetric	0.035	0.224	0.417	0.044	0.010	0.028

2.4 Robustness of Water-Usage Results to Interactions between the AWD Treatment and Covariates

In this section, we reproduced the following exhibit from Chakravorty et al. (2023): Figure 5. The objective of this table is to assess whether the treatment effects on water levels remain robust when accounting for baseline characteristics (such as household demographics, farm size, and prior farming practices), soil quality, and geographic variables, as well as the interactions between these later factors and the treatment. The table we produce is widely similar to CDK's, except some marginal variations attributed to packages' differences between Stata and R.

Overall, the results indicate that none of these aggregated soil factors distort the estimated impact of AWD. Column 1 shows that incorporating over 20 such interactions does not alter the water level results. Column

2 confirms that accounting for plot-level soil characteristics similarly leaves the findings unchanged. Columns 3–6 examine upazila-level soil conditions, addressing the concern that volumetric pricing might correlate with broader soil characteristics, such as moisture levels.

Table 5: Robustness of Water-Usage Results to Interactions between the AWD Treatment and Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.166	0.179	0.247	0.227	0.158	0.166
	(0.212)	(0.217)	(0.225)	(0.220)	(0.229)	(0.212)
Treatment x Volumetric Pricing	-0.674	-0.762	-0.926	-0.864	-0.651	-0.676
	(0.301)	(0.344)	(0.368)	(0.349)	(0.394)	(0.305)
Volumetric Pricing	-0.077	-0.084	0.016	-0.017	-0.088	-0.076
	(0.339)	(0.342)	(0.346)	(0.345)	(0.371)	(0.340)
Soil Clay Content			0.137			
			(0.086)			
Soil Sand Content				-0.063		
				(0.043)		
Soil Carbon Content					0.030	
					(0.276)	
Soil Water Content						-0.003
						(0.080)
Upazila Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls × Treatment	Yes	Yes	Yes	Yes	Yes	Yes
Geo Controls	No	Yes	No	No	No	No
Geo Controls × Treatment	No	Yes	No	No	No	No
Mean in Control	2.32	2.32	2.32	2.32	2.32	2.32
p-Value: Treat+Treat x Volumetric	0.012	0.012	0.005	0.006	0.061	0.014
R^2	0.051	0.055	0.052	0.052	0.051	0.051

3 The effect of marginal pricing on AWD adoption

In this section, we reproduced the following exhibit from Chakravorty et al. (2023): Figure 6.

Table 6: Impacts of Hourly Irrigation Cards on Water Usage and AWD Demand

	AWD Install		Water Level		Purchase AWD		Use AWD	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Card Treatment	0.035	0.044	0.130	−0.013	0.044	−0.138	0.019	−0.129
	(0.011)	(0.029)	(0.303)	(0.709)	(0.016)	(0.043)	(0.010)	(0.027)
Pipe Price	0.000	0.000	−0.005	−0.007	−0.010	−0.013	−0.002	−0.004
	(0.000)	(0.000)	(0.005)	(0.013)	(0.000)	(0.001)	(0.000)	(0.000)
Pipe Price x Card Treatment		0.000		0.003		0.003		0.003
		(0.000)		(0.014)		(0.001)		(0.000)
Num.Obs.	3477	3477	3479	3479	3479	3479	3479	3479
R2	0.018	0.018	0.013	0.013	0.242	0.246	0.035	0.044
FE: *Upazila*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in control	0.009	0.009	2.252	2.252	0.414	0.414	0.073	0.073
Elasticity at price = 55 (treat)					−1.008	−1.140	−1.083	−0.653
Elasticity at price = 55 (control)					−1.092	−1.686	−1.362	−2.796
p-value: Equal elasticities						0.015		0.000

Notes: Four full notes see Figure 6.

In this section, we alternate between *Fixest* and the base function *lm* for our regression. This is due to the ease of extracting the Intercept with lm which we needed for our elasticity estimations. We estimated our regression with the following formula

$$\begin{aligned} Adoption_{ivs} =& \beta_0 + \beta_1 CardTreatment + \beta_3 PipePrice \\ &+ \beta_4 CardTreatment \times PipePrice + \alpha_s + \epsilon_{ivs} \end{aligned} \tag{2}$$

With *CardTreatment* being an indicator variable for villages where the 25 farmers were assisted with filling out the application for a prepaid (hourly) irrigation card and a waiver of the Tk150 sign-up fee. And *PipePrice* corresponds to a random price ranging between 15 and 70 percent of the marginal cost of the pipe. We have a fixed effect by Upazila α_s. From there we derived the elasticity which was calculated as[3]:

[3]For the elasticity the variable *Price*,*Intercept*, *CardTreatment* correspond to their

$$Elasticity = \frac{Price \times 55}{(Intercept + CardTreatment + Price) \times 55}$$

Finally to obtain the p-value of the elasticity we used the delta method to derive an asymptotic distribution of the elasticity, and from there we conducted a t-test of significance and derived its p-value.

Our results align with CDK. We observe a relatively high take-up of AWD when implementing marginal pricing through the Card Treatment, which increased the probability of AWD adoption by 3.5 percentage points (a substantial increase from a baseline of 1%). However, the effect on AWD purchase and use, as well as observed water levels (in cm), is disappointing. We find no impact on water levels and negative effects on both AWD purchase and usage.

This outcome may be attributed to the relatively low adoption of the pre-paid card system (40%) and potential local resistance—either from farmers rejecting the more individualistic nature of this system or from pipe operators favoring fixed-fee payments. The interaction between pipe price and receiving a pre-paid card yields a small but significant effect. The most important finding likely concerns elasticity: treated farmers' demand for pipes is less elastic than in control areas, supporting the idea that exposure to marginal pricing and pre-paid cards made them less responsive to pipe price changes.

The second RCT further supports CDK's argument that mandatory marginal pricing may be necessary to sustain the causal chain of water-saving technology adoption. Voluntary marginal pricing alone appears insufficient for optimal technology choice and resource management.

estimated β from Equation 2.

References

Chakravorty, U., M. H. Dar, and K. Emerick (2023, January). Inefficient Water Pricing and Incentives for Conservation. *American Economic Journal: Applied Economics 15*(1), 319–350.

4 Appendix - Original Tables and Figures

TABLE 2—EFFECTS OF CONSERVATION TECHNOLOGY ON WATER LEVELS

	Overall		0–70 days after planting		70+ days after planting	
Panel A. Main results						
Treatment	−0.0614	0.119	−0.350	−0.0485	0.250	0.258
	(0.161)	(0.220)	(0.152)	(0.208)	(0.286)	(0.376)
Treatment × Volumetric Pricing		−0.544		−0.788		0.0138
		(0.287)		(0.287)		(0.474)
		[0.193]		[0.0200]		[0.970]
Volumetric Pricing		−0.107		0.0256		−0.488
		(0.333)		(0.363)		(0.420)
p-value: Treat + Treat × Volumetric		0.021		0.000		0.328
Control mean	2.32	2.32	2.71	2.71	1.86	1.86
Number of observations	7,598	7,596	4,188	4,187	3,410	3,409
Panel B. Between-upazila variation						
Treatment		0.0936		0.0160		0.143
		(0.227)		(0.212)		(0.380)
Treatment × Volumetric Pricing Upazila mean		−0.476		−0.966		0.424
		(0.328)		(0.326)		(0.541)
		[0.256]		[0.00501]		[0.445]
p-Value: Treat + Treat × Volumetric		0.073		0.000		0.096
Panel C. Within-upazila variation						
Treatment		0.240		−0.723		1.667
		(0.757)		(0.766)		(1.155)
Treatment × Volumetric Pricing		−0.762		−0.147		−1.228
		(0.658)		(0.678)		(0.967)
		[0.394]		[0.790]		[0.279]
p-value: Treat + Treat × Volumetric		0.119		0.007		0.511

Notes: The data are from random unannounced visits to the study plots of sample farmers during the 2017 boro (dry) growing season. The dependent variable in all columns is the amount of standing water in the field, measured in centimeters. All regressions include upazila (strata) fixed effects. Panel A shows our main results where the volumetric pricing indicator is measured at the farmer level. Panel B uses only the between-upazila variation in volumetric pricing by interacting the treatment with the *upazila-level average* of the volumetric pricing variable. Panel C uses only the within-upazila variation by including treatment-by-upazila fixed effects. Standard errors that are clustered at the village level are printed in parentheses below each point estimate. The numbers in brackets are *p*-values when standard errors are clustered at the *upazila level* using the wild-cluster bootstrapping method of Cameron, Gelbach, and Miller (2008).

Figure 2: Table 2 of Chakravorty et al. (2023)

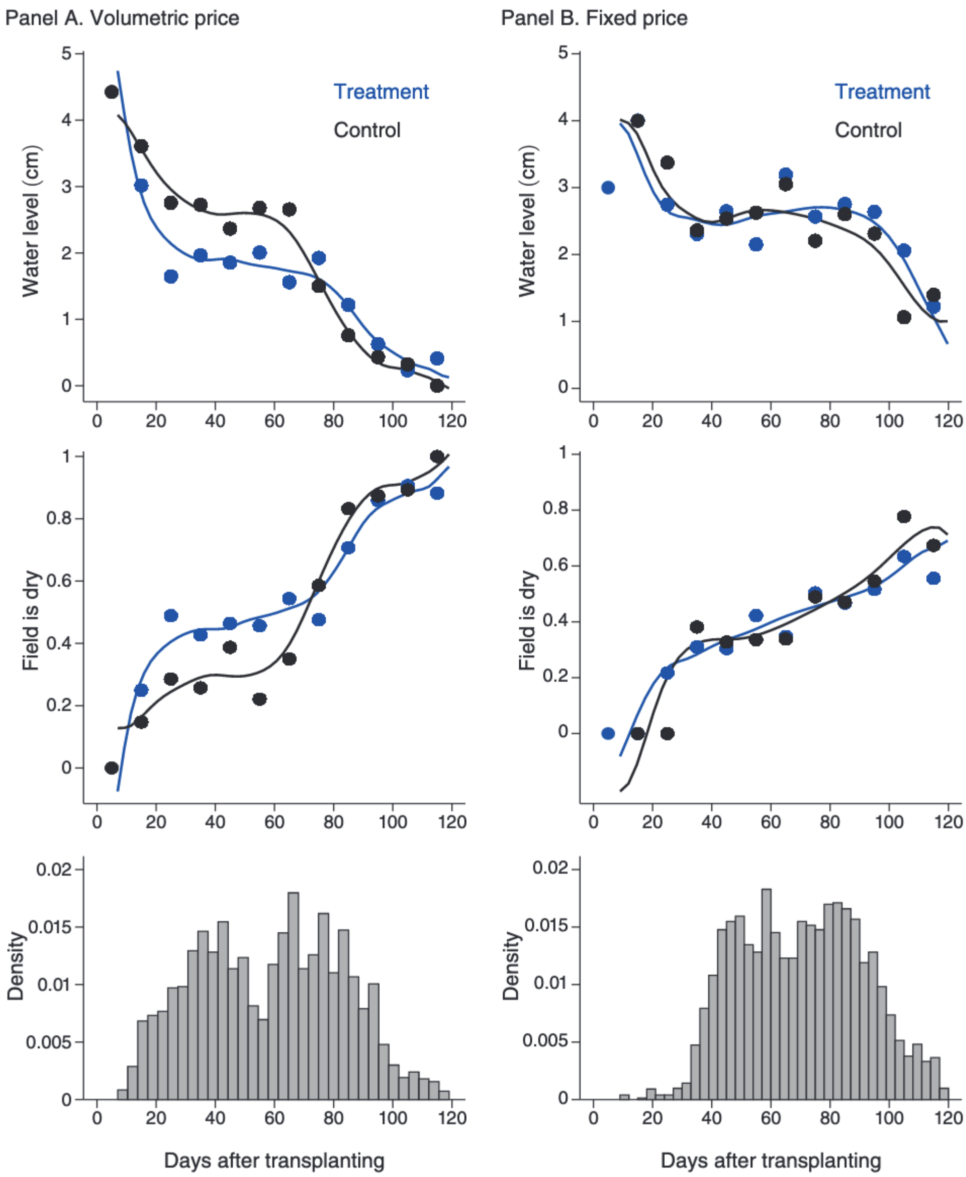

FIGURE 3. NONPARAMETRIC ESTIMATES OF TREATMENT EFFECT AS A FUNCTION OF DAYS AFTER PLANTING

Notes: The figure shows nonparametric fan regressions of water levels in centimeters (top panel) and an indicator for fields with no standing water (middle panel) on the days after transplanting. The dots show average values from ten-day bins, where each dot is centered at the bin midpoint. The bottom panel shows the distributions of observations (histograms of the date of observations, measured in days after planting).

Figure 3: Figure 3 of Chakravorty et al. (2023)

Table 3—Effects of Conservation Technology on log Costs, Revenues, and Profits

	Full sample				Rajshahi sample	
	Profit	Water cost	Yield	Revenue	Water cost	Profit
	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	−0.036	0.023	−0.001	0.001	0.022	0.026
	(0.046)	(0.024)	(0.014)	(0.017)	(0.062)	(0.044)
Treatment × Volumetric Pricing	0.122	−0.081	0.009	0.029		
	(0.061)	(0.053)	(0.017)	(0.022)		
Volumetric Pricing	−0.123	0.066	0.013	0.003		
	(0.070)	(0.043)	(0.018)	(0.028)		
Treatment × Has Card					−0.209	0.112
					(0.095)	(0.077)
Has Card					0.243	−0.072
					(0.074)	(0.071)
Upazila fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
p-value: Treat + Treat × Volumetric	0.035	0.225	0.417	0.045	0.011	0.030
Number of observations	3,932	3,983	3,982	3,982	1,340	1,332
R^2	0.273	0.347	0.329	0.351	0.455	0.083

Notes: The data are taken from the follow-up survey after harvesting. The dependent variables are log profit per acre (columns 1 and 6), log water cost in taka per acre (columns 2 and 5), log crop yield in kilograms per acre (column 3), and log revenue in taka per acre (column 4). Standard errors are clustered at the village level.

Figure 4: Table 3 of Chakravorty et al. (2023)

Table 5—Robustness of Water-Usage Results to Interactions between the AWD Treatment and Covariates

	(1)	(2)	(3)	(4)	(5)	(6)
Treatment	0.165	0.179	0.248	0.228	0.158	0.166
	(0.212)	(0.217)	(0.225)	(0.220)	(0.229)	(0.212)
Treatment × Volumetric Pricing	−0.673	−0.762	−0.926	−0.863	−0.650	−0.675
	(0.301)	(0.344)	(0.368)	(0.349)	(0.393)	(0.305)
Volumetric Pricing	−0.077	−0.084	0.016	−0.018	−0.089	−0.077
	(0.339)	(0.342)	(0.346)	(0.345)	(0.371)	(0.339)
Treatment interacted with						
Soil Clay Content			0.137			
			(0.085)			
Soil Sand Content				−0.063		
				(0.043)		
Soil Carbon Content					0.030	
					(0.275)	
Soil Water Content						−0.003
						(0.080)
Upazila fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls × Treatment	Yes	Yes	Yes	Yes	Yes	Yes
Geo Controls	No	Yes	No	No	No	No
Geo Controls × Treatment	No	Yes	No	No	No	No
Mean in control	2.32	2.32	2.32	2.32	2.32	2.32
p-value: Treat + Treat × Volumetric	0.013	0.012	0.005	0.007	0.062	0.014
Number of observations	7,588	7,468	7,588	7,588	7,588	7,588
R^2	0.051	0.055	0.052	0.052	0.051	0.051

Notes: The data are from random unannounced visits to the study plots of sample farmers during the 2017 boro (dry) growing season. The dependent variable in all columns is the amount of standing water in the field, measured in centimeters. The (baseline) controls in all columns are all of those in Table 1 (age, years of education, household size, number of livestock owned, landholdings, television ownership, refrigerator ownership, tube well ownership, indicator for knowledge of AWD, indicator for a rented or sharecropped plot, plot area, number of crops grown, indicator for growing two rice crops, number of boro irrigations, revenue per acre in boro, boro total cost per acre, and aman revenue per acre). The plot-level geographic control variables (column 2) are elevation, soil clay content, soil sand content, soil organic carbon content, and soil water content. Columns 3–6 add interactions between *upazila-level* average soil characteristics and treatment. Standard errors are clustered at the village level.

Figure 5: Table 5 of Chakravorty et al. (2023)

TABLE 7—IMPACTS OF HOURLY IRRIGATION CARDS ON WATER USAGE AND AWD DEMAND

	AWD installed		Water level		Purchase AWD		Use AWD	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Card Treatment	0.0343	0.0424	0.1449	0.3651	0.0430	−0.1428	0.0200	−0.1071
	(0.0104)	(0.0268)	(0.2896)	(0.6997)	(0.0436)	(0.1044)	(0.0278)	(0.1074)
Pipe Price	−0.0004	−0.0002	−0.0026	0.0002	−0.0105	−0.0129	−0.0016	−0.0033
	(0.0002)	(0.0003)	(0.0050)	(0.0121)	(0.0008)	(0.0012)	(0.0006)	(0.0014)
Pipe Price × Card Treatment		−0.0001		−0.0040		0.0034		0.0023
		(0.0004)		(0.0132)		(0.0015)		(0.0015)
Upazila fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean in control	0.008	0.008	2.214	2.214	0.413	0.413	0.068	0.068
Elasticity at price = 55 treat					−1.26	−1.14	−1.01	−0.60
Elasticity at price = 55 control					−1.39	−1.70	−1.31	−2.58
p-value: Equal elasticities						0.009		0.001
Number observations	3,598	3,598	3,600	3,600	3,569	3,569	3,600	3,600
R^2	0.017	0.017	0.012	0.012	0.249	0.254	0.033	0.041

Notes: The data are from the 144 villages that were part of the second-year experiment. The sample consists of 25 farmers per village. Columns 1–4 are for the one plot per farmer where water levels were measured. The specific plot is the closest to the village tube well for 75 percent of random farmers and the furthest plot for the remaining 25 percent of farmers. Columns 5–8 are at the farmer level (either purchasing AWD or using it across all plots). The dependent variables are an indicator for whether an AWD device was installed on the specific plot where water was being measured (columns 1–2), the observed water level on the plot in centimeters (columns 3–4), an indicator for whether the farmer purchased AWD during the demand elicitation (columns 5–6), and an indicator for whether AWD was used at all on any plots (columns 7–8). The card treatment variable is an indicator for villages where the 25 farmers were provided assistance with filling out the application for a prepaid (hourly) irrigation card and a waiver of the Tk150 sign-up fee. Standard errors are clustered at the village level.

Figure 6: Table 7 of Chakravorty et al. (2023)