If you build it, will they come? Use of Rural Drinking Water Systems in the Peruvian Amazon

Supplementary Materials

Methodology Discussion

We utilize a mixed methods research design using a sequential approach in a targeted sequence, beginning with a household survey followed by qualitative interviews to interrogate the results of the quantitative analysis. The originating motivation of the project was to conduct a survey in 2011 among rural communities living in the Peruvian Amazon within an area that one NGO had installed community drinking water systems in 22 communities, allowing for an investigation of how well the systems were working and how households were utilizing the systems. The results of the analysis of the survey data spurred further investigation, including interviews in 2012 and 2013 with community leaders, members of the water committees, water operators, political leaders and NGOs working in the communities. The study was approved by the University of XX Institutional Review Board in 2011, with renewals in 2012 and 2013. Two members of the research team from 2011 also returned in 2018 to visit ten communities among the original 22. This research was approved by the University of XX Institutional Review Board in 2018.

The survey was developed in collaboration with the NGO director, the NGO manager of the rural water program as well as two professors and eight students at the National University of the Peruvian Amazon (UNAP). Enumerators were recruited from UNAP and were accompanied by members of the research team. Communities were notified of our visit a week in advance through phone calls, where possible, and in-person notification. Of the 22 communities, water systems were operable in 19, of which we randomly sampled 12 given limitations of time and resources to procure boats. We assumed a confidence level of 95%, a population size of 407 households (the total of the 11 communities selected), and a confidence interval of 7 given the recommendation of the UN Department of Economic and Social Affairs (*Designing Household Survey Samples: Practical Guidelines*, 2005) to aim between five and ten. This yielded a minimum sample size of 133, which is approximately one-third of the population.

Robustness Checks and Diagnostics

The results from the article are presented in Table 1. They were derived using State SE version 14. The Hosmer-Lemeshow goodness of fit tests (with 10 groups) yields a chi-square for Model 1 and Model 2 respectively of: 10.00, p=0.265; and 5.73, p=0.677 providing evidence that the model fits the data well. The link test results shown in Table 2 indicate that the squared linear predicted value is insignificant for both models, giving no indication of possible omitted variables. Multicollinearity checks, shown in Table 3 do not yield concerning VIF or tolerance levels. Table 4 presents results compared to models with outliers and deviant observations omitted. Thirteen observations and two observations for models 1 and 2 respectively had standardized residuals greater than ±2. These were not related to obvious coding errors or other discernible patters. When dropped from the models, substantive results were not altered although gender and the age of the drinking water system became significant in model 1 as did the asset index in model 2. We also inspect deviant observations, dropping four observations with deviance scores of less than -2 in model 1, leading to no substantive changes in the model. Model 2 yielded no observations with deviance scores of ± 2.

Table 1. Article Results

VARIABLES	Model 1 Use	Model 2 Consistent Use
Meeting attendance	0.61***	0.31**
	(0.185)	(0.15)
Education	0.11**	0.03
	(0.05)	(0.05)
Distance to DWS	-0.05***	0.02
	(0.02)	(0.02)
Asset index	0.26	-0.223
	(0.30)	(0.16)
Water quality	0.26	0.59***
	(0.71)	(0.18)
Gender (female=1)	0.28	0.66*
	(0.59)	(0.37)
Age of DWS	-0.002	-0.000
	(0.002)	(0.000)
Community size	-0.003*	-0.001
	(0.002)	(0.002)
Constant	1.11	-1.53*
	(1.20)	(0.78)
Observations	153	130

Clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 2. Link Test Results

	User	Consistent User
Linear predicted value	0.745** (0.285)	1.065** (0.358)
Squared linear predicted value	0.126 (0.114)	0.458 (0.499)
Constant	-0.045 (0.415)	-0.128 (0.230)

Table 3. Collinearity Tests

VARIABLES	VIF	Tolerance
Meeting attendance	1.07	0.935
Education	1.24	0.806
Distance to DWS	1.09	0.915
Female	1.01	0.987
Asset index	1.04	0.960
Age of DWS	1.39	0.719
Community Size	1.12	0.890
Water Quality	1.23	0.810
Mean VIF	1.15	

Table 4. Outliers

	Model 1 Results in paper	Model 1 Without Outliers	Model 1 Without Deviant Obs.	Model 2 Results in paper	Model 2 Without Outliers
VARIABLES	Use	Use	Use	Consistent Use	Consistent Use
Meeting attendance	0.614***	1.432***	0.968***	0.309**	0.412**
	(0.185)	(0.347)	(0.229)	(0.154)	(0.164)
Education	0.109**	0.033	0.103	0.030	0.031
	(0.052)	(0.059)	(0.073)	(0.048)	(0.052)
Distance to DWS	-0.048***	-0.096***	-0.054***	0.016	0.017
	(0.016)	(0.030)	(0.018)	(0.017)	(0.018)
Asset index	0.282	1.112	0.352	0.659*	0.855**
	(0.593)	(0.826)	(0.632)	(0.372)	(0.403)
Water quality	0.262	0.865	0.176	-0.223	-0.313*
	(0.298)	(0.884)	(0.314)	(0.164)	(0.160)
Gender (female=1)	-0.002	-0.005***	-0.003**	-0.0002	-0.0006
	(0.002)	(0.002)	(0.001)	(0.0004)	(0.0004)
Age of DWS	-0.003*	-0.005***	-0.004**	-0.002	-0.002
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
Community size	0.257	0.682	0.510	0.592***	0.871***
	(0.714)	(0.591)	(0.713)	(0.180)	(0.191)
Constant	1.108	2.637**	0.931	-1.529*	-1.965***
	(1.199)	(1.229)	(1.279)	(0.782)	(0.748)
Observations	153	140	149	130	128

Household Asset Index

The index is created using principal components factor analysis of six household assets: motorized boat, refrigerator, cellular phone, television, radio and cooking with gas.

Table 5. Principal Components Factor Analysis of Household Assets

Factor	**Eigenvalue**	**Difference**	**Proportion**	**Cumulative**
Factor1	1.556	0.324	0.259	0.259
Factor2	1.233	0.277	0.206	0.465
Factor3	0.956	0.099	0.159	0.624
Factor4	0.856	0.106	0.143	0.767
Factor5	0.750	0.101	0.125	0.892
Factor6	0.649		0.108	1.000

Table 6. Rotated Factors

Variable	**Factor1**	**Factor2**	**Uniqueness**
Boat with motor	**0.721**	0.000	0.480
Refrigerator	**0.302**	0.202	0.868
Cellular phone	0.102	**0.767**	0.401
Cooks with gas (not wood)	-0.182	**0.696**	0.483
Television	**0.584**	0.412	0.489
Radio	**0.694**	-0.166	0.491

In Table 6, the varimax rotation shows that two measures load on the second factor: cellular telephone and cooking gas. In the paper, we extract the first factor score with all asset measures to use in the analysis. Our results are robust to dropping the asset measure as well as excluding telephone and cooking gas from the asset index factor analysis, as shown in Table 7.

Table 7. Alternative Model Specifications for Asset Index

VARIABLES	Alternative 4-Measure Asset Index: Use	Alternative 4-Measure Asset Index: Consistent Use	Model without Asset Index: Use	Model without Asset Index: Consistent Use
Meeting attendance	0.627***	0.322**	0.642***	0.284*
	(0.186)	(0.153)	(0.167)	(0.171)
Education	0.116**	0.023	0.120**	0.0316
	(0.048)	(0.044)	(0.053)	(0.043)
Distance to DWS	-0.048***	0.017	-0.048***	0.0153
	(0.017)	(0.017)	(0.017)	(0.015)
Female	0.277	0.681*	0.293	0.580
	(0.607)	(0.373)	(0.574)	(0.363)
Asset index	0.124	-0.272*		
	(0.266)	(0.163)		
Age of DWS	-0.002	-0.000	-0.002	-0.000
	(0.002)	(0.000)	(0.002)	(0.000)
Community Size	-0.003*	-0.002	-0.003*	-0.002
	(0.002)	(0.002)	(0.002)	(0.00141)
Water Quality	0.260	0.622***	0.264	0.526***
	(0.734)	(0.189)	(0.711)	(0.176)
Constant	0.964	-1.469*	0.904	-1.282
	(1.116)	(0.757)	(1.047)	(0.808)
Pseudo R^2	0.172	0.057	0.170	0.039
Observations	153	130	154	131

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Water Testing Supplementary Information

We used methods that are commercially available and standard for measuring water quality including turbidity measurements with a calibrated turbidimeter, a general water quality screening using well known HACH (Loveland, Colorado) test strips and field-based measures for bacterial contamination including the 3M Petrifilm product, backed up with methods such as Coliscan and Colilert. The data were collected on-site by the authors trained in water quality measurements and in collaboration with students from a local Peruvian university, under the supervision of the authors. As the study was not specifically focused on water quality, we did not dive into a long-term study of water quality and as such, the results presented are not representative of the precise water quality achieved by the water plants. It also does not capture variability of water quality into and out of the water systems over time and seasons, extreme events, etc. We do not attempt to correlate any incidence of bacterial contamination or non-detects with pathogen exposure or illness as there are many pathways of exposure and variations over time in water quality. As such the water quality test results are a snapshot in time and extrapolation of longer-term performance and water quality is not warranted by these data. The contaminants that were of concern to the water plants were typical of river water quality including particulates, organic matter and microbial pathogens. In terms of microbiological tests, E. coli is a widely used indicator bacteria of fecal contamination in water and, while not directly correlated to the presence of specific pathogens, it is a useful surrogate to estimate the risk of exposure to waterborne pathogens. Total coliform can be present in the environment (not limited to fecal in origin) and its presence/absence in the treated water, along with a decrease in turbidity and the presence of a chlorine residual, provides useful information about the efficacy of treatment. As such, both E. coli and Total Coliform are included in the Peruvian drinking water quality standards and required to be absent in 100-mL samples. E. Coli is a widely considered the most suitable indicator organism for fecal contamination in drinking water (World Health Organization, 2017, p. 296)

References

Designing Household Survey Samples: Practical Guidelines (Series F, No. 98; Statistics Division Studies in Methods). (2005). Department of Economic and Social Affairs of the United Nations Secretariat.

World Health Organization. (2017). *Guidelines for drinking-water quality, 4th edition, incorporating the 1st addendum*.