WILLINGNESS TO PAY FOR IRRIGATION WATER IN LOUISIANA

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Abstract:

We conducted survey to collect information from Louisiana farmers to understand their concerns related to irrigation water quality and availability of sufficient water for crop irrigation. We used logistic models to estimate the willingness to pay (WTP) for irrigation water during critical crop growing periods. Variables affecting the participation in WTP are income, land holding size, risk aversion, and education. Our estimated results show that farmers with higher education are more likely to pay for irrigation water compared to farmers with high school and college degree. Age of the farmers, farm revenue, size of the rented land have negative effect on willingness to pay for irrigation water. The sizes of the owned land and risk aversion factor have positive effect on willingness to pay.

Key words: willingness to pay/Willingness to accept, water trading, irrigation technology, logit, soybean

JEL classification: Q12, Q25

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Introduction

Recent survey conducted by the United States Department of Agriculture[2] shows that the largest decrease in irrigated acres occurred in Texas, Colorado, Nebraska, Oregon, California and New Mexico. At the same period, Arkansas, Mississippi, Louisiana, Georgia and Kansas gained significant increase in irrigation acreage. It indicates a significant shift of water withdrawal from western states to southeastern states of the United States. On the one hand, water scarcity has been worsening in the western high planes and on the other hand, coastal states like Louisiana, Alabama might potentially face saltwater intrusion problem due to water table imbalance caused by over exploitation of groundwater to fulfil the higher demand caused by population growth, and climate change. In this context, irrigation water management could be a crucial issue in near future in that region. In order to tackle with the resource management problem, irrigation water trading among the farmers within Louisiana or neighboring states might be one of the most desirable alternatives for allocating water resource in efficient way in order to enhance the productivity of the region. For this purpose, farmers' perception regarding water trading could be important feedback for policy purpose in water resource management case. The main objective of this study is to determine the perception about water trading issue among the farmers and their willingness to pay amount for irrigation water.

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[2] United States Department of Agriculture, Economic information bulletin, Number 22, 2012 http://www.ers.usda.gov/media/884158/eib99.pdf

Irrigated farms accounted for roughly 40 percent of the value of U.S. agricultural production; nationwide, the average value of production for an irrigated farm was more than three times the average value for a dryland farm in 2007 and it is in increasing trend as indicated by Schaible & Aillery (2012). If the establishment of water trading market is viable and farmers are willing to adopt it, share of irrigated land will be increased leading to higher productivity of farm land.

In Many states and countries with water shortage issues have instituted a water trading program. Water cost varies by region and country in which water availability geographical location, land quality and demand are the major determinants of water price. We reviewed some relevant literature on willingness to pay for water focusing on trend, estimation process and major findings. In this nexus, Wichelns (2010)[3] explained that farmers in the U.S. especially in western states purchasing water in market transactions to finish an irrigation season or to ensure water supply for perennial crops might pay prices that exceed 100 dollar per 1,000 m3 for a portion of their irrigation supply. Compared to this amount, Southeastern states have very low water price. Hensher et al. (2006) estimated the WTP value to avoid drought water restriction using stated choice experiment household and business sectors in Canberra Australia. Results show that customers evidence a lack of WTP to avoid most types of drought induced restriction and they found to be unwilling to pay to avoid low level restrictions at all and to avoid higher levels of restrictions that are not in place every day. To estimate the WTP values they used logit framework then calculated the WTP value.

[3] Sustainable Management of Water Resources in Agriculture

https://www.oecd.org/unitedstates/45016437.pdf

Cho et al. (2008) estimated the willingness to pay for land conservation in North Carolina using Tobit and Probit model and found significant positive effect of income and knowledge. In another context, Kim et al. (2008) estimated farmers' WTP to adopt rotational grazing evaluating the role of uncertainty, risk preference, role of farmer, financial, managerial and attitudinal factors using logit framework. They found significant impact of management factor on rotational grazing. The relevance of this paper in our case is methodological approach that incorporated certainty scale to estimate WTP values. Kong et al. (2014) estimated determinants of farmers' WTP for ecological compensation of Lake Wetland in China using contingent valuation model and Heckman selection approach. They found significant effect of household income and location factor on wet land resources improvement, arable land area and contracted water area. Additionally, household income, location factor, arable land area and contracted water area found to be significantly related to their payment level. Bontemps & Nauges (2016) estimated how the perceived health impacts of tap water affect a household's decision to drink water from the tap using bivariate probit model and special regressor model incorporating risk perception in Australia, France and Canada. They find risk perception to be endogenous and significant in all models.

Water use in Louisiana report[4], 2010 stated that "total withdrawals for general irrigation increased by 17 percent from 2005 to 2010. During the same period, groundwater withdrawals for general irrigation increased by 16 percent, and surface-water withdrawals increased by 22 percent. From 2005 to 2010, water withdrawals increased in 37 of the 64 parishes in Louisiana (58 percent) that have general irrigation

[4] Water Use in Louisiana, 2010, Department of Transportation and Development, Water Resources Special Report No 17 (Revised)

withdrawals. Morehouse Parish had the greatest decrease, 15 Mgal/d, and Tensas Parish had the greatest increase, 13 Mgal/d. The median change in general irrigation water use was an increase of 0.04 Mgal/d. General irrigation withdrawals in Louisiana have increased by 780 percent since 1960". Continuous extraction of groundwater reduces the water table in long run and some of the parishes will face salt water intrusion. In this situation, water trading from neighboring farm could be a better option and solution for crops production during water shortage period.

The findings of our study provide valuable information regarding irrigation water trading issue among the farmers within Louisiana and among the neighboring states in future under water scarcity. Under the circumstances of decreasing irrigation acreage in Texas, farmers in that area might be willing to import water from Louisiana and Arkansas. In both interstate and intra- state water trading would be beneficial for farmers in the region in terms of high productivity and sustainable resource allocation.

This paper is presented in the following ways: First part provides short introduction of the topic and general trend in estimating WTP and WTA values reviewing relevant literature associated with this issue. Section two provides theoretical framework and empirical model, section three provides survey design and data description. Section 4 presents empirical results and finally concludes with concluding remarks and tentative plan of future work.

Theoretical framework and empirical model

We adopt well known discrete choice model to estimate the impact of explanatory variables on WTP for irrigation water. For this, we employ logistic framework to estimate the parameter and corresponding odds ratios. Logit model is derived from random utility model in which each individual has to make a choice between two alternatives. We assume that farmers make rational decisions. Farmers maximize a utility function that ranks the farmers' preference among available technological choices (participate or not to water trading is similar to technology selection in discrete choice). Farmer's adoption decision here is either to pay for irrigation water or not to pay. These adoption decisions are affected by a number factors such as size of land holding, sociodemographic and risk aversion factors. Factors affecting WTP for irrigation water can be represented by the following functional form:

$$P(WTP = 1/0) = f(Y, L, E, R)$$

Where,

WTP= willingness to pay for irrigation water (yes=1, no=0)

Y= vector of gross farm revenue,

L= vector of size of land holding

E= vector of educational attainment and age of farmers

R= risk aversion factor

Representing all explanatory variables by X vector, the econometric model can be written in the following form as explained by Greene (2003):

$$(1) \qquad P(WTP = 1/0) = X'_i\,\beta + \varepsilon$$

Here, β is a vector of regression coefficient and ε is the error term distributed logistically in logit framework. The problem in equation (1) is that the probability on left hand side has to be between zero and one, but the linear predictor on the right hand side may take any values. In this case, we transform equation (1) into logit framework by converting probability to the odds in the following format:

$$(2) \qquad Odds = \frac{P_i}{1 - P_i}$$

Equation (2) is the ratio of favorable to unfavorable cases. Finally, logit model becomes:

$$(3) \qquad \text{logit}\{P(WTP = 1/0)\} = X'_i\,\beta + \varepsilon = \log\frac{P_i}{1 - P_i}$$

Odds ratios are estimated by using equation (4).

$$(4) \qquad P(WTP = 1/0) = \frac{e^{(X'_i\beta)}}{1 + e^{(X'_i\beta)}}$$

The estimated parameter β in equation (1) represents the change in the logit of the probability associated with the unit change in the X_i (explanatory variables) holding other things constant. In logit model, odds ratios or marginal effects are easier to interpret. Thus, we estimate odds ratios using equation (4).

Survey design and data description

. We designed a survey questionnaire to access detail information regarding irrigation water availability and concerns among the soybean producers in Louisiana. We conducted survey employing Dillman tailored design method (Dillman, 2000) to collect information from soybean producers to understand their concerns about irrigation water quality, technology adoption, availability of water and future concerns for crop irrigation. Willingness to pay and willingness to accept for irrigation water is one of the issues in the survey. For this study, we used selected variables as mentioned in table1.

Table 1: Variables description

Variables	Description
WTPYN	participation in water trading (dummy, yes=1, no=0)
WTPVALUE	Willingness to pay value (in terms of increased profit)
EDUC	Highest level of education attained by farmer
AGE	Age of the farmer
REVENUE	Gross income from farm (dollar value in continuous form)
OWNLAND	Owned land area in acres under operation
RENTEDLAND	Rented area in acres under operation
TOTALLAND	Total land for crops
RISKRESPONSE	What would farmers like to do if there is very low water supply in future

The dependent variable WTPYN is the response of farmers to the following question:

1. "Many states with water shortage issues have instituted a water trading program. In this situation, farmers are allocated a certain volume of water that can be used for irrigation in a given year. Farmers then can either buy *additional water from other farmers or sell water to other farmers if they do not use all of their allocated volume. If there was a market for water trading in your region, would you participate? "*

To represent farmers' response to seriously low water supply due to decrease in water table or high demand, we asked the following question:

2. "Continuous extraction of groundwater sources in your area could eventually lead to significant decreases in the water table and increased salt levels. Please indicate how you would change your farming and irrigation practices if groundwater supplies became seriously low. (Please choose only one)",

a. Continue to farm without using irrigation

b. Quit farming

c. Lobby for importing irrigation water from other areas & adopt efficient irrigation technology

d. Change crop mix to more drought resistant crops to reduce total water use

e. Not allow groundwater supplies get to critical levels by limiting the amount of water used

f. Would discuss with experts, examine options, and make decisions.

Response of farmers obtained from question 2 is treated as risk aversion factor. The education variables represents the highest level of education attained by principal farm operator. For estimation process, it has been categorized into three groups: high schools level, college level and professional level of education. The age variable represents the age of principal farm operator. Additionally, we classified land holding into two groups: rented and owned land assuming that the status of land ownership could have different degree of impact on water trading issue.

The descriptive statistics for the variables used in this study are shown in table 2.

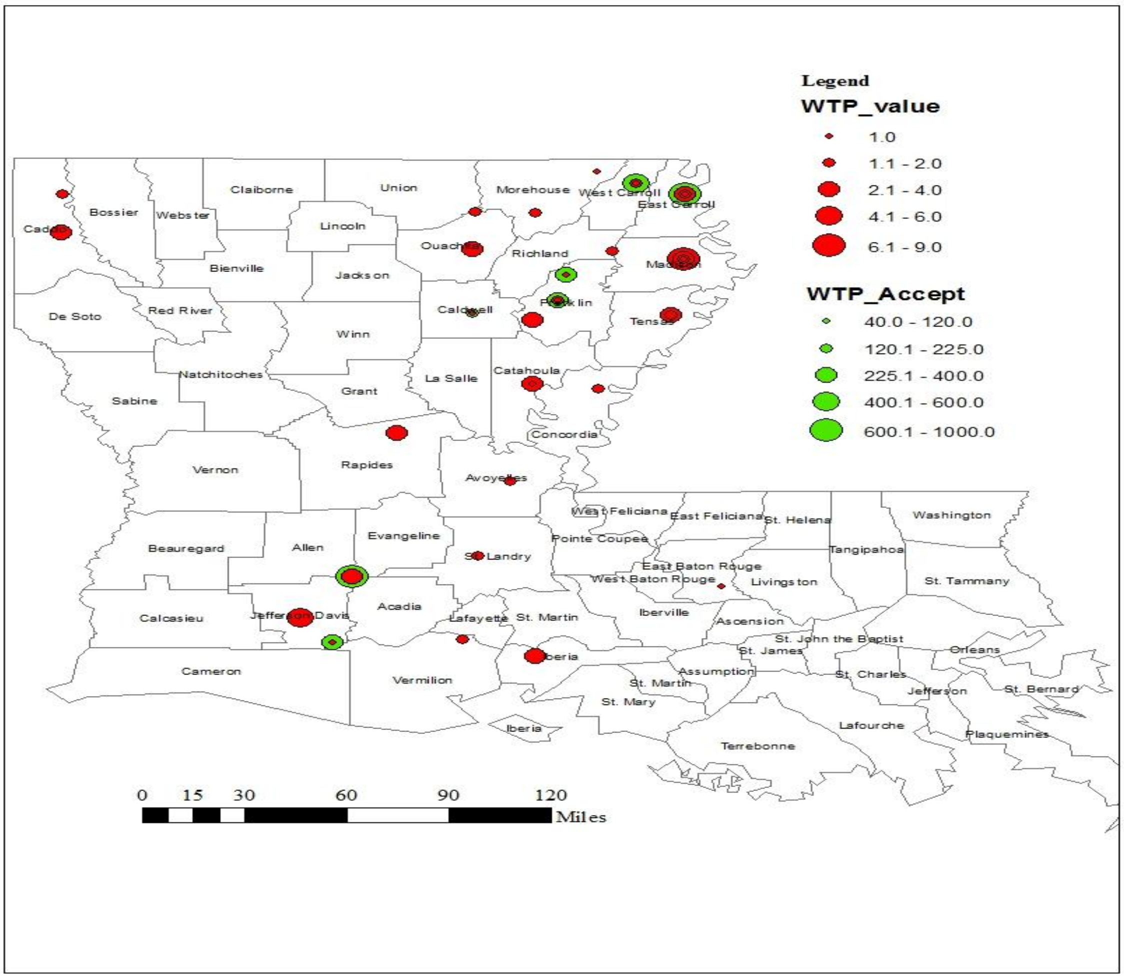
Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
WTPYN	76	0.434	0.499	0	1
EDUCAT	121	3.099	1.121	1	5
AGE	123	50-59	0.833	18-29	Over 60
AGES	123	30.715	7.750	4	36
REVENUE	121	50-100	1.822	below50	Over 2500
OWNED_LAND	159	437.391	2286.736	0	28430
RENTED_LAND	159	720.880	1341.741	0	7200
RISKRESPO	159	1.358	2.519	0	6
TOTALLAND	159	1158.270	2747.324	0	30916

From table 2, we can see that out of 76 respondents only 43% are willing to pay irrigation water during critical crop growing period if there is market for water trading. The education variable indicates that on average, farmers have some college degree. The average age category is 50- 99 years old indicates that youth involvement in farming is very low. The average land holding is 1158 acres (total land holding) but, the share of rented land is two times higher than owned land. If a landlord involves in farming then the willingness to pay for irrigation water probably be higher because water trading boost up the productivity of their farm and increases the land value as well. The average farm revenue lies within the range of 50 to 100 thousand dollar. Approximately 22% of the farmers indicated that they will discuss with expert or extension agent to make future plan when they encounter with extreme water scarcity.

Map 1 represents the concerntration area of farmers willing to participate in water trading. Red spots in the map represent farmers willing to pay values in water trading. Green color represents farmers willingness to accept values for irrigation water. Larger marks indicate higher willingness to pay and willingness to accept values. Major concerntration area includes north and south to St. Landry parish. Farmers in Caddo parish also show their willingness to participate in irrigation water.

Map 1: Concerntration area showing willingness to participate in water trading



Empirical results

Parameters estimated results are shown in the following tables:

Table 3: parameter estimation using logit model

VARIABLES	Logit coef. WTPYN	ODDS RATIO
WTPVALUE	-1.096***	0.334***
	(0.334)	(0.112)
HSCH_EDU	-4.465**	0.0115**
	(1.847)	(0.0213)
COL_EDU	-0.915	0.401
	(1.442)	(0.578)
AGE	-20.620***	0.0001***
	(6.615)	(0.00007)
AGESQ	2.381***	10.820***
	(0.764)	(8.261)
FARMREV	-1.394**	0.248**
	(0.706)	(0.175)
OWNEDLAND	0.014***	1.014***
	(0.005)	(0.0053)
RENTEDLAND	-0.002***	0.998***
	(0.0007)	(0.0007)
RISKRESPO	0.918***	2.504***
	(0.331)	(0.828)
CONSTANT	75.280***	493753***
	(23.720)	(117134)
OBSERVATIONS	68	68

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

Table 3 displays the estimated parameters and corresponding odds ratios associated to factors affecting willingness to participate in water trading issue. We could not find significant marginal effect. Hence, we have reported odds ratios only. From table 3 displayed above, we can interpret the impact of each variables to farmer's willingness to participate in water trading during extreme water shortage period.

Since the logit coefficients do not directly measure marginal effects. We interpret signs on the coefficients instead of interpreting their magnitude. Coefficients on FARMREV, RENTEDLAND and AGE are negative in the logit estimates. It implies that farmers with higher gross farm revenue are less likely to involve in water trading. Farmers with higher age are less likely to participate in water trading. Additionally, farmers those who have more rented land are less willing to participate in water trading. Furthermore, farmers with more owned land are more likely to pay for irrigation water.

In logit regression, odds ratios are easy to interpret. If the value of odds ratio is greater than one, it indicates positive effect and less than one implies negative effect of the variable. The odds ratios associated to AGE, LAND and RISK FACTOR are significant at 1% significance level where as HIGH_SCH and FARMREV are significant at 5% significance level. For education variable, we compare the odds ratio of HIGH-SCH and COL-EDU with PROF-EDU. For a farmer with high schools education and college degree education, the odds of being participated in water trading are 0.011 and 0.401 times respectively than the odds for a farmer with professional degree. It can be interpreted in terms of probability conveying the same meaning. For example the odds ratio of 0.401 for college education indicates that a farmer with college degree has 60% lower odds than a farmer with professional degree for willingness to participate in water trading issue. It indicates that a farmer with higher education can accommodate the new technology and can analyze the importance of it in the production process.

The age factor has highly significant negative impact on water trading. The odds ratio would change by 0.0001 for every unit (age group) change in age holding other things constant. Older farmers are less likely to adopt new production technologies compared to younger farmers. The older people have almost 99% lower odds to participate in water trading. In this particular issue, involvement of younger people in farming would have positive effect on adopting water trading so as to increase the productivity. Land ownership has both negative and positive impact. If the land is owned, the predicted odds ratio would change by 1.014 for every an acre increase in owned land, holding other factors constant. On the other hand, when the land is rented, the predicted odds ratio change by 0.998 for an acre increase in rented land. The likelihood of paying for irrigation water decreases by 0.2% in the case of rented land. Land owners are free to decide resource allocation, input factors and operation strategies. However; farmers in rented land might have limited decisive power due to contract with landlord. Due to this fact, farmers with rented land are almost indifference in water trading issue.

The impact of risk aversion factors is highly significant. The odds of willingness to pay increases by 2.504 times than the odds for farmers without risk factors. Additionally, farm revenue has negative impact on willingness to pay. The odds ratio would change by 0.248 for every 1000 dollar increase in gross farm revenue. It indicates that the farmers with higher farm revenue have about 75% lower odds to pay for irrigation water. It can be viewed as farmers getting higher farm revenues tend to earn more profit and they do not want to lose a part of profit by paying for irrigation water.

Discussion and concluding remarks

We conducted survey to collect information from Louisiana farmers to understand their concerns related to irrigation water quality and availability of sufficient water for crop irrigation. We used logistic models to estimate the willingness to pay (WTP) for irrigation water during critical crop growing periods. Variables affecting the participation in WTP are income, land holding size, risk aversion, and education. Our estimated results show that farmers with higher education are more likely to pay for irrigation water compared to farmers with high school and college degree. Age of the farmers, farm revenue, size of the rented land have negative effect on willingness to pay for irrigation water. The size of the owned land and risk aversion factor have positive effect on willingness to pay. This analysis provides valuable information to formulate water trading policy with neighboring states or other farmers within Louisiana under the circumstances of irrigation water shortage caused by severe drought or decreased water table or salt intrusion.

This paper has some limitation regarding empirical work caused by limited observations. Due to the data constraint, rigorous empirical work has not been completed as we plan to conduct second round of survey in February 2017 hoping to get more responses. The ultimate goal of this paper is to find out more reliable WTP/WTA values for irrigation water by estimating baseline WTP/WTA values and certainty corrected values minimizing the selection bias. Those detailed aspects of the empirical works are missing in this study. Regarding data set, it has a problem of missing observations. In order to tackle with missing observations we need to adopt simulation, bootstrap and truncation method to get more robust results. We hope that the fully extended empirical results would be capable to predict more reliable WTP/WTA values for irrigation water which would be helpful in policy formulation associated to water resource management. If irrigation water trading market among the farmers in Louisiana or between Louisiana, Arkansas and Texas, found to be viable then it will help to maximize the productivity of the region.

Future works

This paper has some limitation in addressing the issue in detail. The main goal of this paper was to estimate more accurate willingness to pay (WTP) and willingness to accept (WTA) values for irrigation water in Louisiana incorporating certainty scale response we obtained from farmers. After conducting second round of survey, we estimate at least six more equations. First step would be estimating baseline model for both WTP and WTA values and then at least four additional models incorporating certainty scales (Lusk 2003; Morrison and Brown 2009; Tonsor and Shupp 2011). After estimating all equations, we find average WTP and WTA values from all predicted equations which facilitate us to compare certainty scale corrected WTP and WTA values to base line mean values. Additionally, we evaluate the difference between WTP and WTA taking into account of loss aversion comparing the results with the findings of Mansfield (1999). In that way we will get more accurate WTP and WTA values for irrigation water. We use data imputation, simulation and bootstrap approach to tackle with missing data and to validate the results.

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