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Farmers' Decision and Willingness to Adopt Drying Technologies in Luzon, Philippines

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***Abstract*—** *Paddy farmers sell their produce right after threshing or after drying. The farmers' decision to dry or not to dry their marketable surplus was analyzed by fitting a logistic regression model on the 216 samples from survey conducted in 2019 to 2020. Results indicated that farmers' decision to dry is driven mostly by prices which were their barometer of size of incentives. Farmers are willing to adopt the drying technology if they would get higher prices for their products in the market. However, the amount farmers are willing to pay for the use of mechanical dryers are way below the existing prevailing fees set by the dryer service providers. Factors that drive farmers' willingness to pay and the amount they are willing to pay for drying need to be explored.*

***Keywords*—** *Adoption, drying technology, mechanical dryer, price gap, willingness to pay*

I. INTRODUCTION

Drying is the process whereby the grain moisture content is reduced to a safe level for storage and efficient milling. It is the most critical operation after harvesting a rice crop. The main advantages of drying include prevention of the growth of bacteria, fungi and the development of insects and mites. There are two main methods of drying, sundrying and mechanical drying. Sundrying remains to be the most popular in Asian countries. In contrast, mechanical drying utilizes technology to blow heated or ambient air into the grains to reduce the grain moisture. Despite these promising benefits of mechanical drying, quite a number of farmers opted to skip this practice and instead sell their paddy directly after harvest. Some of the reasons cited include farmers' immediate need of cash and urgent need to pay their loans to private lenders and/or traders. Most of the private traders provide the production input requirements of the farmers every cropping season (Salvador et al, 2018; Malanon & Sumalde, 2022). Also, the risk of exposure to inclement weather condition especially during wet season harvest prompt the farmers to dispose their wet paddy at the earliest possible time (Rodriguez & Paz, 2004; Malanon & Sumalde, 2022). Another reason is the farmers' lack of access to drying facilities which forced the farmers to sell their produce immediately after harvest (Arida, 2009). Other opined that there is minimal increase in added profit to farmers because of the small volume they handle due to small farm size.

The utilization of enhanced agricultural practices has been linked to increased income levels and decreased poverty rates, improved nutritional well-being, reduced prices of basic food items, and a rise in job prospects and earnings for landless workers (Kasirye, 2010; Mwangi and Kariuki, 2015). However, the adoption of farmers, particularly smallholder farmers, have been slow and low. Several studies have identified various factors that are crucial in farmers' decision-making process when it comes to adoption. Willingness to pay (WTP) is considered an important representation for adoption of an innovation, especially in a developing country's context where smallholder farmers have many preferences for certain innovations but often fail to adopt due to financial constraints (Collier & Dercon, 2014).

Result of the review of willingness to pay studies conducted by Olum et.al, (2019) showed that most of the studies employed stated preference for eliciting farmers' WTP for agricultural technologies or their attributes. The majority of studies have utilized a regression approach to analyze how different factors impact the price that farmers are willing to pay for a novel agricultural technology, as well as its characteristics. The determinants of WTP by farmers depends largely on the type of technology attributes that has been studied which includes socio-demographic, bio-physical, technological, institutional factors, and farmers' perception and behavioral factors. This study determined the factors that affect the choice of farmers to dry and the farmer's willingness to pay for the technologies using data gathered through face to face interview farmers.

II. METHODOLOGY

A. Location and Sampling Design

The study covered the rice producing provinces of Isabela, Pangasinan and Tarlac. Multi-staged sampling design was used. Two (2) municipalities were selected from each province and four barangays were selected from the sampled municipality based on rice area, production and accessibility of the production area. In each municipality, one area that is accessible and another one not accessible were selected purposively. Within the sampled barangay, a random sample were drawn from the master list of the sampled barangay.

B. Data Collection

Farmers in the sampled province were interviewed face to face to gather pertinent information on drying systems, drying preferences, amount they were willing to pay for drying among others. The survey was conducted with a total sample of 216 farmer-respondents per season, which were equally allocated to the three sampled provinces. The survey covered the 2019 wet season (WS) and 2020 dry season (DS) production periods.

C. Analytical Concepts

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The decision to adopt a technology is a distinct choice, as highlighted in past studies (Qaim and de Janvry, 2002; Alexander and Mellor, 2005). Therefore, this research utilized discrete choice modeling to examine the adoption of an innovation (Blazy et al., 2008). The simplest of the choice models are the binary choice models in which the dependent variables take up only two values, normally either zero (0) or one (1) or YES or NO (Maddala, 1983; Pindyck and Rubinfield, 1998). In the case of technology adoption, the value one (1) is assigned when an individual decides to adopt the technology and zero (0) otherwise. In this study, we employ the binary logit model to analyze the farmers' decision to dry or not to dry his marketable surplus.

Binary Logit Model

The Binary Logit model specifies a non-linear functional relationship between the probability of success (of drying in this case) and the various explanatory variables. The Logit model, however, has a cumulative logistic distribution function as the underlying distribution function. The Binary Logit Model is specified as follows;

$$P(Y=1)\, ln\left(\frac{P}{1-P}\right) = \alpha + \beta Xi$$

The analysis on farmers' decision to adopt a technology is assumed to be influenced by a set of characteristics. The process of farmers' choice, whether to use or not to use a given technology, is modeled using the expected utility framework (Kolady and Lesser, 2006) where choices may be selected among risky bundles (Autor, 2004). This study used the concept to identify the factors that can influence farmer's decision to dry his produce rather than selling it fresh. The logistic model was employed and parameters were estimated using the maximum likelihood method, i.e., the coefficient that makes the observed change in log of odds associated with one unit change in the independent variable. The hypothesis is that the probability of a farmer deciding to dry his paddy depends upon socio-economic variables of the sampled population and ability of the technology to save resources like labor. The model is specified as:

$$Y = g(Z) \; and \; Z = F(X_i)$$

where,

Y = Adoption status of a household (Y = 1 for farmer who decided to dry his paddy and Y = 0, for farmers who decide not to dry),

Z = Vector of explanatory variable

Xi = X_1, X_2, X_3,…,X_k are explanatory variables

The dependent variable in the equation is represented by the logarithm of the probability that a particular decision was made. The factors associated with the decision of the farmers to dry were grouped into three categories, namely: socio-economic, institutional, and market related factors. The socioeconomic factors include household size, gender, farm size, and yield. Institutional factors include membership in farmer's cooperative/association (FCA), land tenure and source of capital. The market related factors include price of dried paddy, marketable surplus, price gap between dried and fresh paddy, farm distance to market, and form sold, e.g., whether paddy is sold fresh or dried. Following the above construct, the logistic regression model was formulated as:

$$Ln\left(\frac{\mathrm{p}}{1-\mathrm{p}}\right) = \mathrm{z} = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3$$

where:

p is the probability of adoption and (1-P) is the probability of non-adoption

z = log of odds of adoption (to dry=1/not to dry=0)

βi are vector of coefficient of the explanatory variables

X_1 =vector of socio-economic factors

X_2 = vector of institutional factors

X_3 = vector of market and related factors

III. Results and Discussion

The descriptive statistics of the socio-economic, institutional and market and related factors used in the analysis in this section are summarized in Table I. The average rice farming experience of the farmer respondents was 26.7 years. This is less than 50% below the mean farming experience. In terms of household size, the mean number of members in the farming family was four, of which 66% of households have lower than the average. Majority of the farmers interviewed were males. Less than 20 percent (17%) of the sampled farmers were females. The average yield of all farmers was 5.29 MT ha^{-1}. The higher level of yield among farmers can be expected considering that the surveyed provinces were the favorable areas for rice production. In terms of area cultivated for rice production, the average farm size was 1.71 has. The relatively larger proportion of farmers (70.8%) having an area below the mean is an indication of the low farm size of many farmers.

In terms of institutional factors that characterize the rice farming activities, 46.7% were members of farmer cooperatives and association. Seventy one percent (71.3%) of them were either owner or amortizing owners of the farm they cultivate. Majority of the farmers finance their farming from their own capital, the remaining used borrowed capitals from various sources like informal lenders, relatives, cooperatives and banks.

TABLE I. Summary descriptive statistics of independent variables used in the willingness to dry model.

VARIABLE	N	MEAN	STD DEV	MIN	MAX	BELOW MEAN (%)
Rice farming experience (yr)	216	27.66	13.30	2.00	65.00	49.07
Household size	216	4.01	1.66	1.00	10.00	66.20
Yield (MT ha^{-1})	216	5.29	1.25	2.19	9.17	50.46
Farm size (ha)	216	1.71	1.83	0.20	15.00	70.83
Dried paddy price (Php kg^{-1})	214	18.21	2.02	14.00	25.00	62.62
Price gap (Php kg^{-1})	214	3.47	0.69	1.75	6.00	44.39
Farm distance to market (km)	216	4.80	3.82	0.10	17.00	53.24

FREQUENCY	COUNT	PERCENT (%)
Female	37	17.13
Male	179	82.87
FCA member	101	46.76
Owner/amortizing owner of land	154	71.3
Borrow production capital	72	33.64
Sell paddy fresh	160	74.42

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During the survey period, the average prices of dried paddy received by farmers was PhP18.21 kg^{-1}, spread over a range from PhP14-25 kg^{-1}. Majority of the farmers (62.6%) received lower than the average price. The average price difference between dry and fresh paddy was PhP3.47 kg^{-1}, spread over PhP1.75 to PhP6.00. About forty percent (44.4%) received lower than the mean price gap. Distance from the farm to market was used as proxy to distance from the farm to drying facilities. The average distance of the farms from the market is 4.8 km, of which, 53% lies below the mean value. Majority of the farmers (77.62%) sold their paddy immediately upon harvest.

Factors affecting farmer's decision to dry

The Logit model results explaining farmers' willingness to dry or sell his paddy as fresh is presented in Table II. Overall, the likelihood ratio statistics of 104.63 which is significant at α=1%, indicates that the explanatory variables jointly explain the farmers' willingness to dry their produce.

The likelihood of farmers drying their produce decreases when the farmer is female compared to male. That is, keeping all other factors constant, the odds of drying paddy is about 73.6 percent lower for females compared to males at α=5% level of significance. This is plausible considering that large volume of paddy for drying is basically done by men. Likewise, the odds of farmers deciding to dry decreased by 61.6 percent when the capital is borrowed as compared to when farmers owned the capital they used in rice production. This effect is significant at α=5%. This result can be explained by the fact that when the capital is borrowed, expectedly this is earning interest. Any delays in payment would mean penalty or added interest. Drying the paddy and waiting for higher prices to capture the benefits of drying and storage may not be enough to offset the added incurred interest due to penalty.

Yield increased the farmers' likelihood of deciding to dry their paddy. A metric ton increase in the farmers' yield increased the odds of deciding to dry by 42.6% at α=10% level of significance. The difference between the dried and fresh price, better known as price gap, has a positive effect in the farmer's decision to dry. The larger the price gap, the more likely the farmers will dry their produce. In terms of marginal effect, a PhP1.00 increase in the price gap will increase the odds of drying by 74.3 percent at α=10% level of significance. This result is analogous with the theory of demand and supply, which states that the higher is the price the higher is the willingness of the supplier of that good. Similar to the case of dried paddy, the higher is the likelihood of the farmers to dry their paddy to obtain higher price and profit. Moreover, the larger is the price gap, the higher is the incentives received by the farmers, which encourage them to do drying.

The price of dried paddy is also an incentive barometer. In like the manner in which the price gap positively affects the likelihood of drying paddy, the higher is the price of dried paddy the higher is the likelihood of farmers to do drying. A PhP1.00 increase in the price of dried paddy increase the odds of farmers drying their paddy by 27.8 percent at α=5% level of significance, keeping all other factors constant. Selling the paddy dried significantly increase the odds of doing drying by more than 53 fold (53X) compared to selling it fresh at α=1% level of significance. The aforementioned results highlighted the importance of incentives or payoff in influencing the decision of the farmers to dry their paddy rather than sell it fresh. The incentives in the form of higher prices for the paddy and large price margins are the driving force to positively influence farmers' decision to dry their paddy. The higher is the perceived incentives, the higher is the likelihood that the farmers will dry their produce. This is similar to the findings claimed by Sunding and Zilberman (2000).

There were provincial differences in the likelihood of the decision of the farmers to dry their paddy using any available drying technology. Relative to the base province which is Tarlac, Pangasinan and Isabela had lower likelihood of drying their paddy. In particular, the odds of the decision to dry the produce is reduced by 71.9 percent relative to Tarlac. This is significant at α=5%. Isabela, likewise had 56.4 percent lower odds of deciding to dry paddy relative to Tarlac but the differential effect was not significant.

TABLE III. Logistic regression results for the farmer's decision to dry paddy.

VARIABLE	CLASSIFICATION	DF	ESTI-MATE	ODDS RATIO	WALD CHI^2	95% WALD CONFIDENCE LIMITS	
Socio-economic factors							
Sex	Female	1	-1.331	0.264	6.16**	0.090	0.760
	Male	0	0.000	1.000			
Yield (MT (ha^{-1})		1	0.355	1.426	3.57*	0.987	2.061
Institutional factors							
Source of capital	Borrowed	1	-0.956	0.384	5.44**	0.172	0.859
	Owned	0	0.000	1.000			
Market and related factors							
Price gap (Php kg^{-1})		1	0.556	1.743	3.39*	0.966	3.146
Dried paddy price (Php kg^{-1})		1	0.253	1.287	5.36**	1.039	1.594
Form sold	Dry	1	3.995	54.331	20.23***	9.528	309.789
	Fresh	0	0.000	1.000			
Province							
P1=1, 0 Otherwise	Isabela	1	-1.270	0.281	5.99**	0.102	0.777
P1=2, 0 Otherwise	Pangasinan	1	-0.830	0.436	1.32	0.106	1.796
	Tarlac	0	0.000	1.000			
Constant		1	0.857	2.445	0.12		
Likelihood Ratio Chi^2	104.63		-2Log L	170.58	Prob >Chi^2		<0.001

Note: Abridged output showing variables that are significant to drying adoption
*, **, ***significant at 90%, 95% and 99% level of significance

Farmer's drying facility preference

Sundrying, may it be on the road side or multi-purpose drying pavement (MPDP) is still the most used by the farmers. The combined percentage of sun drying was more than 95 percent, of which the roadside dying accounted for about two-thirds of the share. The mechanical dryer like flatbed dryer (FBD) was used by less than five percent of the respondents. In terms of purpose of drying, 38.5 percent of the respondents mentioned they were drying for home consumption only (Table III). These findings were also observed by Salvador et al. (2018) who reported that sundrying is practiced by 97% of the farmers. The facility share were 57.1 percent in road side, 42.9 percent in MPDP and none in FBD. Majority of the respondents

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(58.2%) mentioned they were drying both for home consumption and market. Of this, 66 percent is dried on the road side, 29 percent on MPDP and about 5 percent in FBD. There were three percent who reported to be drying for market only, of which 57 percent dried on the roadside and almost 43 percent using FBD. What is so striking in this result is that despite the government efforts to promote mechanical dryers, less than five percent (4.23%) of the respondents dried using mechanical dryers.

TABLE IIIII. Farmer's reason for drying and drying facility preference.

Purpose Of Drying	Drying Facilities			
Frequency Row Pct Col Pct	Concrete roadside	MPDP	FBD	Total
Home consumption	47	35	0	82
	57.32	42.68	0.00	38.50
	35.34	49.30	0.00	
Home consumption and market	82	36	6	124
	66.13	29.03	4.84	58.22
	61.65	50.70	66.67	
Market only	4	0	3	7
	57.14	0.00	42.86	3.29
	3.01	0.00	33.33	
Total	133	71	9	213
Percent	62.44	33.33	4.23	100.00

Willingness to pay for drying technology

Table IV shows that among the 216 respondent farmers, about 76 percent were willing to pay for the use of the MPDP, considering the incidental expenses associated with drying. The percent of farmers willing to pay for the use of the FBD (64%) was slightly lower than those of the MPDP. The lowest positive response for the use of the technology was registered for the recirculating continuous flow batch dryer (RCBD), where only 30.4 percent of the respondents are willing to pay for its use.

TABLE IVV. Farmers willingness to pay for the drying technology.

Drying Facilities		Count	Percent
		n=214	(%)
MPDP	No	52	24.30
	Yes	162	75.70
Flatbed (FBD)	No	77	35.98
	Yes	137	64.02
Recirculating (RCBD)	No	149	69.63
	Yes	65	30.37

Amount of WTP for the drying technology

The willingness to pay (WTP) for use of the drying technologies expressed in terms of price per kg paddy is presented in Table V. When zero bids were considered, the average amount of WTP for MPDP was PhP0.27 kg^{-1}, with a standard deviation of PhP0.21 kg^{-1}, ranged from PhP0.0 kg^{-1} to 0.80 kg^{-1}, median value of PhP0.20kg^{-1} and mode of PhP0.00 kg^{-1}. Considering greater than zero bids only, the average WTP is PhP0.36 kg^{-1}, with standard deviation of PhP0.18 kg^{-1}, range from PhP0.15 kg^{-1} to PhP 0.80 kg^{-1}, median and mode of PhP0.40 kg^{-1}.

For FBD, when zero bids are considered, the average WTP was PhP0.42 kg^{-1}, with a standard deviation of PhP0.34 kg^{-1}, a range of PhP0.0 Kg^{-1} to PhP1.25 kg^{-1}, a median value of PhP0.55kg^{-1} and mode of PhP0.00 kg^{-1}. Considering greater than zero bids only, the average WTP is PhP0.65 kg^{-1}, with standard deviation of PhP0.14 kg^{-1}, a range of PhP0.50 kg^{-1} to PhP1.25kg^{-1}, median and mode of PhP0.60 kg^{-1}. This is very much lower than the fee quoted by the FBD service providers. Our on-field elicitation with technology providers suggests that the fee for using the FBD ranged from PhP60.0 $sack^{-1}$ (PhP1.20kg^{-1}) to PhP70.0 $sack^{-1}$ (PhP1.40kg^{-1}). Under such drying fees and considering incidental costs in bringing the paddy to and from the facility, the farmer's computed total drying cost is around PhP76.0 $sack^{-1}$ (PhP1.52kg^{-1}) to PhP81.0 $sack^{-1}$ (PhP1.62kg^{-1}) under the range of fee stated by the service provider of the FBD facility.

For RCBD when zero bids are considered, the average WTP is PhP0.30 kg^{-1}, with a standard deviation of PhP0.48 Kg^{-1}, PhP0.0 Kg^{-1} to PhP1.75 Kg^{-1}, median value of PhP0.0 kg^{-1} and mode of PhP0.00 kg^{-1}. Considering greater than zero bids only, the average WTP is PhP0.99 kg^{-1}, with standard deviation of PhP0.27 kg^{-1}, range from PhP0.75 kg^{-1} to PhP1.75kg^{-1}, median of and PhP0.95kg^{-1} mode of PhP0.75 kg^{-1}. This is much lower than the quoted fees by the owner/service provider of this drying technology, which is at the range of PhP60.00 $sack^{-1}$ (PhP1.20 kg^{-1}) to PhP70.0 $sack^{-1}$ (PhP1.40 kg^{-1}). Under such drying fees and considering incidental costs in bringing the paddy to and from the facility, the farmer's computed total drying cost is around PhP71.0 $sack^{-1}$ (PhP1.42kg^{-1}) to PhP76.0 $sack^{-1}$ (PhP1.52kg^{-1}) under the range of fee stated by the service provider of the RCBD facility.

TABLE V. Amount farmers are willing to pay.

Drying Facility		Willingness To Pay					
	N	Mean	Std Dev	Min	Max	Median	Mode
		PhP kg-1					
MPDP	162	0.36	0.18	0.15	0.80	0.40	0.40
	214	0.27	0.21	0.00	0.80	0.20	0.00
Flatbed (FBD)	137	0.65	0.14	0.50	1.25	0.60	0.60
	214	0.42	0.34	0.00	1.25	0.55	0.00
Recirculating (RCBD)	65	0.99	0.27	0.75	1.75	0.95	0.75
	214	0.30	0.48	0.00	1.75	0.00	0.00

IV. Summary, Conclusion and Recommendation

The farmers' decision to dry or not to dry their marketable surplus was analyzed using logistic regression model. The results revealed that the decision to perform drying, either part or all of their produce, is significantly affected by the farmers' socio-economic and farm characteristics like gender and yield, institutional variables such as source of capital, and price and market related factors like price of dried paddy, price gap and form sold. These factors co-influenced the decision of the farmer to dry paddy.

The general findings from the analyses indicated that farmers' decision to dry is driven mostly by prices which are their barometer of size of incentives. They are willing to adopt the drying technology if the incentives offered by the market is significant enough to increase their income. The market is important because it gives the signal in which farmers use to weigh the benefits and costs of the technology before adoption.

However the drying fees that farmers are willing to pay are way below the existing mechanical drying fees set by the service providers. Service providers should consider possible

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reduction on their existing drying fees vis a vis the amount farmers are willing to pay for the use of these drying technologies. Further studies on determining the significant factors affecting the farmers' willingness to pay and on the amount they are willing to pay needs to be investigated so as to gain insights on encouraging farmers to dry paddy prior to marketing.

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