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WILLINGNESS TO PAY BY THE FARMERS FOR SAFER USE OF PESTICIDES

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ABSTRACT

This study attempted to investigate the determinants of indirect health cost of pesticide use by farmers. For the purpose willingness to pay for safer pesticides is taken as indirect health cost of pesticide use. The ordered probit model has been employed on primary data collected from Tehsil Bahawalpur in Pakistan. The results revealed that health impairment index, farmer's literacy status, number of dosage of pesticides, farmer's age, use of safety measures, farmer's perception about symptom and working hours have positive impact while number of doses of insecticides, farm size and use of pesticide according to the recommended dose have a negative impact on the willingness to pay for safer pesticides. Highest ratio of the farmers (38 percent) is willing to pay over and above 20% premium for safer use of pesticides to avoid health cost of pesticides. It means that farmers are bearing a high health cost by use of pesticides.

Contribution/ Originality: This empirical work based on primary data contributes to the literature on environmental and health economics, the significance of elimination or at least reducing the adverse effects of pesticide use in cotton growers. The farmers are willing to pay for replacing the pesticides dangerous to health, use of better safety measures and training for use of pesticides.

1. INTRODUCTION

Synthetic pesticides have played a significant role in restricting massive damage to crops. The safety of crops would not have been possible without pesticides (Damalas and Eleftherohorinos, 2011). On the other hand environmental damages and health impairments are also caused by the massive use of pesticides (Maroni *et al.*, 2006). In the last forty years, there is enormous increase in the use of pesticides in Pakistan. Furthermore, the farmers particularly the cotton-growers use pesticides indiscriminately (Khan, 2005). It is also documented that use of pesticides in Pakistan has caused many fold increment in pest population by the development of pest's resistance against pesticides. This massive and indiscriminate use of pesticides results into bearing of enormous health cost by the farmers.

The economic valuation of health costs by use of pesticides is complex due to the market and non-market health-cost. Market components of health cost include illness cost, loss in yield productivity and loss of working days, etc. and non-market components include cost of illness, etc. It is not easy in a model to combine both market and non-market components of pesticide related health cost, so majority of the studies focused on market components of pesticide related health cost. Ajayi (2000) analyzed the cost of treatment and cost of working days lost for Cote d Ivoire. Rola and Pingali (1993) used simply the production losses for Philippines. For Garming and Waibel (2006) assessed the cost of chronic sickness. Although some studies have attempted to estimate the health cost by including market and non-market components (Khan and Damalas, 2015) but a comprehensive analysis is needed by combined market and non-market health cost of pesticides use and ultimately agricultural policy formation. For the assessment of non-market cost contingent valuation approach is prevalent in literature (Khan and Damalas, 2015). In this approach, respondents are offered a hypothetical market, in which they are invited to show their willingness to pay for existing or potential environmental conditions not reflected in any real market. The monetary values obtained in this way are thought to be contingent upon the nature of the constructed market, and the commodity described in the survey scenario. The answers offered a direct way to trace the demand curve for an environmental good that could not otherwise be seen from the market data (Garming and Waibel, 2006).

An individual's preferences provide the appropriate foundations to make decisions about changes in well-being or loss of health effects. Using individual preferences, willingness to pay is a suitable measure for estimating the pesticide health effects. According to Carson (2000) the cost benefit analysis or to find out farmer's willingness to pay economically for a proposed change in a commodity, contingent valuation approach is most appropriate technique. To keep the individual constant at its initial level of utility the changes in utility are measured in monetary terms. The similar law is used in case of non-market commodities and services "that is the highest quantity of income that a consumer/individual is willing to forgo to gain or loss the access to the relevant commodity or service" (Lipton *et al.*, 1995).

The analysis of current study is based on contingent valuation approach to measure the health cost of pesticide use by farmers. By estimating the willingness to pay the policy may be framed to eliminate the health effect of pesticides through financing from the farmers[1]. The core objective of the study is to assess the determinants of farmer's willingness to pay to remain safe by use of pesticides.

2. METHODOLOGY

In health economics one of the most commonly used approach for the assessment of non-market commodities and services is contingent valuation approach. Individual's health is primarily private commodity that is estimated by household theory. To measure the change in the supply of non-market commodity in contingent valuation approach the individual's constant utility is taken as base by applying the compensated demand function of Hicks. For the assessment of pesticide associated health outcomes suitable measure is compensating variation which show the utility level without change. The utility of a farmer (U_0) can be expressed as the sum of health (H_0) and sum of income (I_0).

$$Uo = Io + Ho \dots\dots\dots\dots\dots\dots\dots..(1)$$

Where U_0 = initial utility level of farmer, I_0 = initial income of the farmer and H_0 = initial health status of the farmer. Suppose health supply increase to H_1 by taking income constant at I_0 i.e. by using a new or developed pest control technique (I_0=I_1). Farmer goes up to the higher level of utility U_1.

$$U1 = Io = I1 = H1 \dots\dots\dots.\dots..(2)$$

[1] It has been used in the literature for willingness to pay for clean water Rodríguez-Tapia, Revollo-Fernández and Morales-Novelo (2017) willingness to pay for features of pesticides related to environment Gallardo and Wang (2013) and willingness to pay for health risk reduction from pesticides use Wang, Jin, He, Gong and Tian (2018).

Improvement in health is represented by given up amount of income by the farmer that he is willing to pay to accept to remain at its initial utility level with improved health status.

$$Uo = Io - F(WTP) + H1 \ldots\ldots\ldots\ldots (3)$$

The willingness to pay is a function of attributes, characteristics of the consumer (farmer) and other factors consider affecting the choice. In this study we analyze the factors affecting farmer's willingness to pay for safer pesticides. They are household socioeconomic characteristics, health related variables, pesticides and risk related variables, farm characteristics and farmer's perception.

The functional form of the model is as:

WTP = f (HIINDEX, INCOME, LIT, EDU, AGE, FSIZE, DOSEP, DOSEI, PERCEPT, DOSER, SAFETY, WHOUR) ……… (4)

Table 1. Operational definitions of variables for willingness to pay model

Variables	Definitions
Dependent Variable	
Willingness to pay (WTP)	Willingness to pay is a categorical variable, 1= not willing to pay, 2=willing to pay up to 5%, 3=willing to pay 6 to 10%, 4=willing to pay 11 to 20%, 5=willing to pay more than 20% premium for safer pesticides.
Independent variables	
Health impairment index (HIINDEX)	Health impairment index ranged zero to fourteen is a continuous variable.[2]
Farmer's income (INCOME)	Farmer's income is a continuous variable, taken as a farmer's six months income earned in rupees.
Farmer's literacy status (LIT)	Literacy status is a dummy variable, 1=literate, 0=illiterate.
Farmer's education (EDU)	The number of completed years of education as a continuous variable.
Farmer's age (AGE)	Age is a continuous variable, taken as number of completed years.
Farm size (FSIZE)	Farm size is a continuous variable, taken as number of acres of land.
Number of doses of pesticides used (DOSEP)	Number of doses of pesticides used per acre as a continuous variable (It includes herbicides, fungicides and others excluding insecticides)
Number of doses of insecticides used (DOSEI)	Number of doses of insecticides used per acre as a continuous variable
Farmer's perception about symptom (PERCEPT)	Farmer's perception about the symptom as ordered variable: 0=not sure, 1=sure, 2=very sure, 3=completely sure.
Use of pesticides according to the recommended dose (DOSER)	Use of pesticide according to recommended dose is a dummy variable: 1=yes, 0=no
Use of safety measures during pesticides use (SAFETY)	Use of safety measure is a dummy variable: 1=yes, 0=no
Working hours spent by a farmer on pesticide use (WHOUR)	Number of daily hours a person works on a farm and remained exposed to pesticides as continuous variable.

[2]We have calculated health impairment index through additive method by taking fourteen symptoms of diseases (eye irritation, fever, headache, convulsion, dizziness, shortness of breath, vomiting, skin irritation, nervous diseases, blood pressure, tiredness, urinary diseases, digestive diseases, and other diseases) caused by the use of pesticides. All these health impairments are taken as 1=yes, 0=no. The high value of index shows high health impairment and the low value shows low health impairment.

2.1. Empirical Model

Willingness to pay (WTP) is a multiple response variable that has inherent order or rank so the ordered probit model is appropriate which can be expressed as:

$$WTP* = X'\beta + \varepsilon \; \dots\dots\dots\dots (4)$$

Where WTP* is the latent or unobserved willingness to pay, X is a vector of variables considered to effect willingness to pay, β is a vector of parameters showing the association between willingness to pay and variables in X and ε is an independently and identically distributed error term with mean zero and variance one. The probability of WTP being in one of J finite categories can be shown as:

$$Pr(WTP \; = \; j-1) = \; \Phi(\alpha j - X'\beta) - \Phi(\alpha j - 1 - X'\beta)\forall j \epsilon J \dots\dots.(5)$$

Where Φ (.) is a cumulative density function (CDF), which estimates the probability of WTP. The ordered probit model allows for calculation of predicted probabilities for each WTP category and marginal effects. When calculated at the means of the data, predicted probabilities indicate the chance of the average farmer being willing to pay a premium falling in each of the categorical premium levels. For the analysis of WTP we have used the following function:

$WTP^* = \beta_0 + \beta_1$ HIINDEX + β_2 INCOME + β_4 EDU + β_5 AGE + β_6 FIZE + β_7 DOSEP + β_8 DOSEI + β_9 PERCEPT + β_{10} DOSER + β_{11} SAFETY + β_{12} WHOUR + ε …….. (6)

In the equation No.6 WTP* is the latent or unobserved willingness to pay. WTP is the estimated score of ordered probit model and is linear function of all independent variables.

2.2. Sampling and Data Collection

Data has been collected through a well-designed and comprehensive questionnaire in 2014, by face to face interviews from farmers in Tehsil Bahawalpur. The cotton belt of Pakistan that is the area which produces major part of the cotton production in the country passes through Tehsil Bahawalpur. So the area may be a good case study. Similarly major part of the pesticides used in agriculture absorbs cotton production. It signifies the geographic area of research for the topic. The non-probability sampling technique is used and a sample size of 203 observations was collected from farmers who were directly exposed to pesticides. Only those farmers were included in the sample who were owners of the farm and also work on farm. The survey was conducted during the period when pesticides were applied on cotton.

3. RESULT AND DISCUSSION

The percentage of willingness to pay in different categories has been shown in table 2.

Table-2. Distribution of Willingness to Pay Responses (%)

Willingness to pay for safer pesticide category	
Not willing to pay	25.12
Willing to pay 1-5% premium	15.76
Willing to pay 6-10% premium	7.88
Willing to pay 11-20% premium	12.81
Willing to pay over and above 20% premium	38.42
Total	100

The results show that highest percentage of the farmers (38.42 percent) is willing to pay more than 20% premium. It indicates that farmers perceive a high cost of health due to pesticide use.

The results of ordered probit model are given in table 3 and the marginal effects and predicted probabilities for willingness to pay in different categories are shown in table 4. The upper panel of table 4 shows the predicted probabilities and the lower panel shows the marginal effects. The predicted probabilities show the average likelihood of farmer's willingness to pay for safer pesticide use.

Table-3. Estimated Coefficients of Ordered Probit Model for Willingness to Pay

Variables	Estimated coefficients	P>|z|
HIINDEX	.135624	0.014**
INCOME	7.09e-08	0.834
LIT	.9591117	0.000*
EDU	-.0617347	0.157
AGE	.0202769	0.008*
FSIZE	-.0499286	0.055**
DOSEP	.4008564	0.000*
DOSEI	-.3937413	0.000*
PERCEPT	.5350727	0.000*
DOSER	-1.530242	0.090***
SAFETY	.4082784	0.030**
WHOUR	.0529096	0.083***
Number of obs = 203 **Pseudo R^2 = 0.3179**	**LR $chi^2(12)$ = 189.62** **Log likelihood = -203.44794**	**Prob > chi^2 = 0.0000***

*, ** and *** indicates 1, 5 and 10 percent level of significance respectively.

Table-4 Predicted Probabilities and Marginal Effects for Willingness to Pay

	WTP (No willingness)	WTP (up to 5%)	WTP (6-10%)	WTP (11-20%)	WTP (more than 20 %)
Predicted probabilities					
C	.083537	.2255663	.17786743	.24203355	.27099571
Marginal Effects					
HIINDEX	-.0208311 (0.021)**	-.0269557 (0.021)**	-.0062905 (0.118)	.0091513 (0.071)***	.044926 (0.015)**
INCOME	-1.09e-08 (0.834)	-1.41e-08 (0.834)	-3.29e-094 (0.836)	.78e-09 (0.834)	2.35e-08 (0.834)
LIT	-.1516822 (0.000)*	-.1763947 (0.000)*	-.0401707 (0.000)*	.0576469 (0.018)**	.3106007 (0.000)*
EDU	.0090919 (0.168)	.0124791 (0.167)	.0030397 (0.241)	-.0042543 (0.214)	-.0203564 (0.159)
AGE	-.0031144 (0.014)**	-.0040301 (0.015)**	-.0009405 (0.108)***	.0013682 (0.055)**	.0067168 (0.010)**
FSIZE	.0076687 (0.066)**	.0099235 (0.065)***	.0023158 (0.171)	-.0033689 (0.117)	-.016539 (0.058)**
DOSEP	-.0615693 (0.001)*	-.0796716 (0.002)*	-.0185924 (0.075)***	.0270479 (0.030)**	.1327854 (0.000)*
DOSEI	.0604764 (0.001)*	.0782574 (0.002)*	.0182624 (0.079)***	-.0265678 (0.034)**	-.1304285 (0.000)*
PERCEPT	-.0821841 (0.000)*	-.1063475 (0.000)*	-.0248176 (0.046)**	.0361042 (0.025)**	.1772451 (0.000)*
DOSER	.0839921 (0.000)*	.2084152 (0.000)*	.1397446 (0.044)**	.1191864 (0.363)	-.5513383 (0.021)**
SAFETY	-.0645787 (0.042)**	-.0797163 (0.038)**	-.0174409 (0.125)	.0284768 (0.104)***	.1332592 (0.026)**
WHOUR	-.0081266 (0.098)***	-.010516 (0.097)***	-.002454 (0.172)	.0035701 (0.152)	.0175265 (0.085)***

*, ** and *** indicates 1, 5 and 10 percent level of significance respectively.

3.1. Health Impairment index

Theoretically it is assumed that health effects of pesticide use results into increased willingness to pay for avoiding these effects. The ordered probit results have shown positive impact of health impairment index on willingness to pay. The results of the marginal effects show that health impairments negatively influence first three categories of willingness to pay (1= not willing to pay, 2= willing to pay 1-5 percent, 3= willing to pay 6-10 percent premium) and positively influence the fourth and fifth category (4= willing to pay 11-20 percent, 5= willing to pay more than 20 percent). An incremental increase in health impairment leads to pay higher premium for safer use of pesticide. The results are analogous to theoretical expectations and are supported by a number of studies (Ajayi, 2000; Garming and Waibel, 2009; Khan, 2009).

3.2. Education of the Farmers

Education of the farmer was captured in the analysis by two variables, i.e. literacy status of the farmer as binary variable and the years of education of the farmer as continuous variable. The results of regression analysis have shown that literacy status of the farmer has positive impact on the likelihood of willingness to pay. According to marginal effects education has negative marginal effect for first three categories of willingness to pay and positive effects for fourth and fifth category of willingness to pay. It explained that literate farmers have more knowledge and information about pesticides risk and symptom. They are more conscious about their health as compared to illiterate farmers and are more likely to pay higher premium for safer pesticide use. The results are supported by Khan (2009) and Muhammad *et al.* (2015). Wang *et al.* (2018) demonstrated that with higher education, the better people understand the consequences of pesticide use on health and the need to reduce the health risks. Therefore, the educated will be more willing to pay the premium than the illiterate. The years of schooling has no significant impact on willingness to pay in regression analysis as well as marginal effects. The explanation may be that there is lesser variation in years of education of the farmers as majority of the farmers in the economy are comparatively having lesser years of completed education.

3.3. Farmer's Age

Farmer's age has shown positive impact on willingness to pay in the regression. According to marginal effects age has negative marginal effect for first three categories of willingness to pay and positive marginal effect for fourth and fifth category of willingness to pay. Farmer's age was taken as proxy for farmer's experience and awareness. Experienced farmers have long history of pesticide use and exposure to hazards of pesticide use. They are more willing to pay for safer pesticide use (Ajayi, 2000; Cranfield and Magnusson, 2003; Garming and Waibel, 2009; Khan, 2009; Muhammad *et al.*, 2015).

3.4. Farm Size

Contrary to theoretical expectations the regression analysis has shown that farm size has negative impact on willingness to pay. According to marginal effects the farm size has positive effect for first three categories of willingness to pay and negative effects for last two categories of willingness to pay. Such type of relationship may be explained as large land holders use appropriate quantity of pesticides with adequate safety measures (Khan, 2005). They experience less negative effects of pesticide use that is why they are less likely to have willingness to pay the premium. The results are supported by Garming and Waibel (2009) however Khan (2009) has concluded that large family size holders are more likely to pay the premium.

3.5. Number of Doses of Pesticide

The variable of number of pesticides used includes herbicides and fungicides, etc. According to the theoretical expectations number of doses of pesticides used should increase the willingness to pay. The regression results have shown positive impact of number of doses of pesticides used on willingness to pay. According to marginal effects number of doses of pesticides used has negative effect for first three categories and positive effects for last two categories of willingness to pay. As the number of doses of pesticides used increases the pesticides exposure and risk increases which leads to more likely for the farmers for willing to pay higher premium for safer pesticides use. The results are supported by Ajayi (2000) and Rola and Pingali (1993).

3.6. Number of Doses of Insecticide

The use of insecticides has been separated from pesticides on the basis that insecticides are particularly used for cotton crop. Contrary to theoretical expectations number of doses of insecticide has negative impact on willingness to pay. According to marginal effects number of doses of insecticide has positive marginal effects for first three categories of willingness to pay and negative marginal effects for fourth and fifth category of willingness to pay. This relationship may be explained by the phenomenon that farmers are spending huge expenditures to purchase insecticides to secure their crops from pests and there is no alternative or safer pesticides use available to protect their crops. They are not willing to further increase the cost by paying for safer pesticides use. The results are supported by Ajayi (2000) and Rola and Pingali (1993).

3.7. Farmer's Perception about Symptom

The ordered probit model has shown that farmer's perception about symptoms positively impacts the willingness to pay. According to marginal effects farmer's perception about symptom occurrence has negative effect for first three categories and positive marginal effects for fourth and fifth category of willingness to pay. The results are according to the expectations as farmers have perception about negative health effects of pesticide use, they are more likely to pay higher premium for safer pesticides use (Ajayi, 2000; Garming and Waibel, 2009; Khan, 2009). Wang *et al.* (2018) indicated that farmers' risk perceptions has been found positive which imply that respondents with a higher risk perception would have a higher probability to be willing to pay for reducing their health risks associated with pesticide use. Khan and Damalas (2015) also argue that farmers who perceive pesticides as a health risk are more willing to pay for a premium relative to those who do not perceive pesticides as a health risk

3.8. Use of Pesticide According to Recommended Dose

Under the theoretical expectations use of pesticide according to recommended dose should have negative impact on willingness to pay. Ordered probit results have shown negative effect of use of pesticides according to recommended dose on willingness to pay. According to the marginal effects use of pesticide according to recommended dose has positive marginal effects for first four categories of willingness to pay and negative effect for fifth category. The use of pesticides according to recommended dose represents the awareness of the farmer regarding pesticide practices. It may be assumed that they are also familiar with the negative health effects of pesticides. So they are likely to pay higher premium for safe use of pesticides.

3.9. Use of Safety Measures

The ordered probit regression has shown positive impact of use of safety measures on willingness to pay. According to the marginal effects utilization of safety measures during pesticides use has negative marginal effects for first two categories of willingness to pay and positive marginal effects for last two categories of willing to pay. The explanation may be that these farmers are much conscious about the negative impacts of pesticides on health and are willing to pay higher cost for safer pesticides use.

3.10. Working Hours

The results have shown that daily working hours of farmers on the farm have positive impact on willingness to pay. According to the marginal effects working hours spent by the farmers on use of pesticides has negative marginal effects for first two categories of willingness to pay and positive marginal effects for last categories of willingness to pay. As farmer spends more time on farm and remains exposed to pesticides and ultimately is willing to pay higher premium for safer pesticides use (Ajayi, 2000).

4. CONCLUSION AND POLICY RECOMMENDATIONS

This study evaluated the indirect heath costs of pesticides use in the form of farmer's willingness to pay for safer pesticides. The results express that majority of the farmers are willing to pay higher premium for safer use of pesticides to avoid health cost caused by pesticide use. It explains that farmers are bearing high health cost by use of pesticides.

The results expressed that health impairment index, age of the farmer, farmer's education, number of doses of pesticide used, farmer perception about symptoms, use of pesticide according to recommended dose and working hours enhance the farmer's willingness to pay for safer pesticides. All these results express that farmers are bearing an indirect health cost of pesticides use. It may be diminished by use of appropriate measures. It is proposed that scientists should focus on research for alternative pest control methods which are less harmful to the human health. Seminars and workshops should be conducted to provide the sufficient information to farmers to increase their knowledge about how the negative effects of pesticides can be avoided by adopting safety measures

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