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Investigating the Health Cost and Productivity Loss of Farm Animals Due to Exposure to Pesticides: Evidence from Swat, Pakistan

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Abstract: *This paper investigates the health costs and milk productivity losses of farm animals due to pesticide exposure and its impact on farm owners' profits. This is accomplished using survey data collected from farm owners in Pakistan's Swat district. For analysis, multiple linear and tobit regressions are utilized. The study finds that the farm owners' experience, the number of lactating buffaloes, pesticide-induced milk losses, disease-induced health costs, and milk losses due to consumption of toxic plants and wastewater significantly affect profits. Specifically, an increase in farm experience by one year leads to a monthly increase in farm profit by Rs. 820.04. Likewise, adding an additional buffalo increases monthly profit by Rs. 535.04. Finally, the monthly loss in milk productivity due to pesticides stands at Rs. 9.71. Farm owners can greatly benefit by improving animal feed along with the know-how of the consequences of grazing animals on pesticide-affected fields.*

Key Words: Health Cost, Milk Productivity, Pesticides, Livestock, Tobit regression

JEL Classification:

Introduction

The world's population needs food to survive. To address the growing nutritional needs, food production increased by two to three folds between 1960 and 2000. To meet the ever-increasing food demand, various approaches are used. Among these, the use of pesticides to control pests and increase crop yield has been at the centre of the agricultural industry. While pesticides increase food production, they can also damage the ecosystem (Evenson & Gollin, 2003). Pesticides are used to control or eliminate pests – animals or plants detrimental to human concerns. The use of pesticides raises the quantity and quantity of agricultural output (Cooper & Dobson, 2007; Gianessi & Reigner, 2007). However, pesticide use also involves several negative externalities, such as harmful effects on humans, birds, honeybees, fish, and animals. These concerns are reinforced by the fact that about two billion people are engaged in the agriculture industry, and most of them are exposed to pesticides while protecting their crops and livestock. It is pertinent to mention that pesticide sales increased by a factor of 20 to 30 between 1960 and 1990, adding to the growing concerns over their potential

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(negative) environmental impacts (Oerke, 2006).

The negative impacts of pesticides can take several facets, such as the monetary losses incurred upon individual economic agents, the society as a whole, or the governments concerned. Specifically, these losses include health costs, environmental costs, regulatory costs, and protection costs. Health costs are the expenses borne by farmers or citizens who get sick upon pesticide exposure. Environmental costs are the costs stemming from environmental degradation. Regulatory costs include the expenditure on removing harmful pesticide particles from the affected environment. Finally, the protection costs are the costs involved in protecting the environment as well as flora and fauna from the harmful impacts of pesticides. Despite the diverse nature of the costs, pesticide use continues to increase due to its beneficial impact on crop yields.

Pesticides are applied on crops, fruits, and vegetables to kill, deter, or incapacitate pests in order to protect the plants and obtain a yield of good quality and quantity. Apart from these beneficial results, pesticides also exert a considerable strain on human health, the environment, and the ecosystem. Exposure to pesticides involves the risk of carcinogenic effects in the long term, while in the short term, these can cause several ailments such as diarrhoea, headache, skin and eye irritation, vomiting, dizziness, etc. These risks are reinforced by the fact that most applicators lack the required education, skills, and experience to determine the right quantity and method required for the optimal application of pesticides on crops and fruits. Moreover, in most cases, they also do not wear protective gear while spraying the pesticides, increasing the risk of illness and consequently bearing considerable medical expenses. As a result, they apply staggering amounts of pesticides whereby the excess quantity spills into air, soil, and water, thereby contaminating the ecosystem.

The excessive use of pesticides exerts numerous indirect costs as well. For instance, in addition to direct health costs, pesticide-borne diseases can also cause wage loss and reduce leisure time. Likewise, the contaminated water sources require extensive monitoring, testing, and purification, involving considerable man-hours and costs. Moreover, contaminated food products, when found with sellers, are penalized and discarded by the local authorities, resulting in serious losses for businesses. In addition, pesticide exposure and consumption can also inflict considerable costs upon cattle owners when their livestock falls ill or dies after grazing on contaminated grass or feed. While the impact of pesticide use on humans and the environment has extensively been investigated, fewer studies have analyzed the health costs and productivity losses of animals due to pesticide exposures.

This study investigates the health costs and productivity losses of domestic animals caused by feeding on pesticide-infested grass using the case of buffaloes in the Swat district of Khyber Pakhtunkhwa (KP) province of Pakistan. Swat, located in the North of KP, has a favourable climate for growing fruits and vegetables. Therefore, a large number of fruit orchards are spread across the entire district. To optimally use the orchard land, owners cultivate Trifolium Resupinatum grass (locally known as *Shaftal*) and barley under the fruit trees. Barely is largely used as a cash crop, while Shaftal serves as a source of green fodder for domestic animals. The orchard owners routinely spray pesticides on the fruit trees to protect them from pests. This exposes the grass cultivated under these trees to the effects of pesticides. When fed to the buffaloes, this grass can cause illness and milk reduction, inflicting considerable costs upon the owners in the form of medical expenditure as reduced earnings due to milk losses. The issue of excessive pesticide use is widespread in Swat since owners spray their orchards several times a year. This can potentially cause various short- and long-term problems for humans, animals, and the surrounding environment. Despite staggering monetary costs, there is a paucity of studies investigating the impacts of excessive pesticide use. This study attempts to fill this void by investing in the short-term effects (losses) of pesticide use in Swat. Specifically, it investigates milk losses and health costs in buffaloes caused by excessive pesticide use and the effects of these losses on the profit of farm owners in Swat.

Literature Review

Pesticides, Human Health, and Estimated Costs

Pesticides play an important role in improving the quality and quantity of agricultural produce. However, if the quantity of the pesticide used exceeds the recommended amount, it runs the risk of contaminating water, soil, milk, food items, meat, and above all, posing threats to human and animal health. This can aptly be gauged by the staggering number of human pesticide poisonings. For instance, Pimentel & Burgess (2014) estimated that over 26 million instances of non-fatal pesticide occurred across the globe as a consequence of pesticide use. Of these, hospitalization was needed in about 3 million cases along with 220,000 fatalities and nearly 750,000 cases of chronic illness annually. The excessive use of pesticides adversely affects the well-being and welfare of people. Pesticide exposure can reduce the productivity of individuals and can also exert considerable medical costs. In addition, pesticide use also has several public health impacts. Specifically, these include chronic diseases that underlie short and long-term effects. Of particular interest are the long-term impacts that include neurological and cognitive effects such as reproductive and respiratory disorders, language problems, learning impairment, memory loss, and cancer etc (Hart & Pimentel, 2002).

Several scholars have measured the health costs of pesticide use in monetary terms. Prominent among these is Pimentel & Burgess (2014) who estimated the health cost of pesticide use and categorized these into hospitalization costs resulting from poisoning, outpatient poisoning treatment costs, costs of work lost due to poisoning, and costs of cancer and fatalities resulting from pesticide use. They found that a fatality costs about $3.75 million per human, based on the standard set by the US Environmental protection agency (EPA). Likewise, Maumbe & Swinton (2002) estimated the health costs of pesticide use among smallholder cotton growers in Zimbabwe. For this, they collected data from 280 cotton farmers in two districts (Sanyati and Chipinge) who used pesticides, became ill, and recovered from their illness in two and four days respectively. They found that the pesticide-borne illnesses resulted in an annual loss of a mean of 180 Zimbawean dollars in Sanyati and about 316 Zaimbawean dollars in Chipinge. It is noteworthy to mention that they only determined the cost of acute symptoms of pesticides and excluded the chronic side effects and diseases from their study.

The staggering health costs indicate that pesticide use needs to be properly managed and controlled. Failing to do so runs the risk of worse health effects and treatment costs. Illiteracy plays a particularly important role in the improper application of pesticides. This situation is reinforced if the farmer is not aware that exposure to pesticides causes serious and chronic problems for humans and other creatures. The improper use of pesticides is particularly salient in developing countries where the pesticide applicators have a complex mix of issues such as expensive protective equipment, the limited availability of such equipment, and the lack of health facilities and health insurance policies (Antle & Pingali, 1994).

Pesticide Use and the Contamination of Water, Milk, and Food

The use of pesticides can also contaminate water, milk, and food. The pesticide-contaminated ground and surface water goes through canals and is spread widely by rainwater. The most common pesticides found in water are atrazine, alachlor, and aldicarb (Pimentel & Burgess, 2014). The contaminated water spreads diseases and exerts considerable monetary costs. For instance, WellOwner (2003) estimated that pesticides contaminated about 16 million water wells in the US, exerting an annual monitoring cost of approximately $17.70 billion. However, cleaning the groundwater and removal of pesticides costs an additional $2 billion. In 1982, it was estimated that, if all consumable water is to be cleaned up before human use, it will cost about $500 annually (Pimentel & Burgess, 2014). Such costs are salient in the case of other countries as well. For instance, the Chinese national census of pollution sources in 2010 found that although industry used to be a major source of water contamination, agriculture has increasingly been proving to be a major factor of water pollution. This was evident from the detection of particles like Organochlorine, Organophosphorus and Phyrithiod in the water. Following this, the issue of safe and clean drinking water issue received much attention in China in 2010. This was because about 298 million Chinese people lacked access to safe and clean water (Yu et al., 2015). To treat, clean, and improve the quality of water by removing residue, the Chinese government started a program as early as 1980 (Zhang, 2012; Zhang and Xu, 2016). Despite this, cases of water and food pollution remain a recurring phenomenon. This is evident from an incident in Hawaii where milk worth $8.5 million needed to be disposed of due to pesticide contamination (Pimentel, 2005).

Several other studies also found the spilling over of pesticides into food, specifically milk. Specifically, these studies found that Organo-chlorine pesticides (OCPs), Organo-Phospores pesticides (OPPs), and Pyrethroids pesticides were above the standard of the World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO) (Elkassas, 2016). Likewise, a study in Faisalabad, Pakistan showed that 40% of milk samples were contaminated and contained endosulphane, chlorpyrifos, and cypermethrin. The measured amount of residue was 0.26, 0.072 and 0.085 µg/mL (Muhammad et al., 2012).

Pesticide Use, Domestic Animal Poisoning, and the Corresponding Costs

Pesticide use can inflict considerable losses on the breeders of domestic animals due to adverse effects on animal health. For instance, Pimentel (2005) estimated that in the US, the total monetary loss of animal production due to pesticide use reached a staggering $4.19 billion which represents 20% of the overall animal production. Further, the measured illness cost of the animal was $21.30 million and animal death-related loss stood at $8.8 million, as reported to various laboratories and diagnostic veterinary centres across the country. It is pertinent to mention that the percentage of animal illness and death-related costs were 0.5% and 0.04% respectively.

Pesticide Use and Honeybee Productivity Losses

Excessive pesticide affects the honeybees and consequently, honey production. The estimated losses in honey production due to pesticide poisoning were approximately $27 million yearly in the US. Due to pesticides, the honeybees get poisoned and consequently, a lot of them are killed, which directly leads to a reduction in honey production. This usually forces the beekeepers to move the bee colonies away from pesticide-affected areas, thus inflicting more costs. Other costs include crop losses due to the lack of pollination by the bees. For instance, Pimentel (2005) mentioned that a typical colony of one million honeybees in the US was rented for $55 per colony for pollination. The author further mentioned the several types of losses caused by pesticide use. These included the losses due to the death of the members of the honeybee colonies that cumulated upto $13.3 million per year, loss of potential honey production that stood at $27 million per year, bee rental losses for pollination about $8 million per year, and pollination around $210 million per year.

The multi-faceted losses inflicted by pesticides compel governments to allocate considerable for controlling pesticide-induced hazards. For instance, the US government approximately spent $10 million to register and train pesticide applicators. Another $400 million were spent to monitor and check the residue in different fruits, vegetable, milk, water, meat, and a variety of other contaminated products. Thus, the overall environmental cost of pesticides cumulated around $470 million per year. According to the United States Environmental Protection Agency, about 2 to 3 million tons of pesticides are used in the US annually. For this amount of pesticide, around $40 billion are spent annually across the country (Popp et al., 2013). Of the total pesticide use across the globe, India accounts for 4%, Europe accounts for about 45%, the US consumes up to 25%, while the rest is used by the remainder world (Yadav et al., 2015).

Milk Productivity Loss and the Corresponding Costs

Several factors can influence milk production and livestock productivity. These include green and dry fodder, breed, season, quality and quantity of concentrate, management conditions, proper care and labouring, disease, time conception, and vaccination, among others.

The differences in the aforementioned factors/conditions affect livestock productivity and corresponding costs across the regions. For instance, the estimated per year per animal fixed plus variable cost in district Peshawar of the Khyber Pakhtunkhwa province of Pakistan for rural subsistence (1-3 milk animals) was Rs. 59226.83 and their per year lactation worth or milk production was Rs.58220.63. Similarly, the semi-commercial dairy (4-10 milk animals) cost for a single animal was Rs. 87875.25, and their per year milk production worth was Rs.91823.60. If the dairy farm is fully commercial then the cost of the single animal was Rs.95630.27 and their milk production worth was Rs.107004. It is argued that the farmer's profit would increase by providing small loans to the farmer, who in turn, would feed quality food and undertake adequate care of the farm animals (Qadir et al., 2016).

Likewise, in the D.I Khan district of the Khyber Pakhtunkhwa province of Pakistan, the per buffalo milk production and corresponding costs were measured using the Cobb Douglas production function. The costs included dry fodder, green fodder, medicine and vaccination, concentrates, hired labour, permanent labour, and miscellaneous costs. The total estimated costs for these inputs were Rs.14015.20 per buffalo and the net revenue per buffalo was Rs.9809.21. The concentrate and labour were found to contribute significantly while the rest of the factors were marginally important (Sajjad et al., 2011). In another study, Thornton (2010) measured milk production on average and large-sized farms in Bangladesh. The annual production of milk from single buffalo was found to be 1600 kg/year. They further found that increasing farm size increases milk production and also minimizes costs.

Environmental Factors and Milk Production

Products obtained from livestock such as milk, meat, eggs, wool, etc. play a very important role in the agriculture sector, particularly in the developing world. This is evident from the fact that about 30% of the earth's surface is occupied by livestock. Moreover, this sector employs about 1.3 billion people employed on some 600 million farms across the globe (Thornton, 2010). The global climate has several zones such as the Alpine (winter with lots of snowfall), continental (long hot summer), temperate (extremely cold season), dry (a very long dry season which contains several years), and tropical (sometimes extreme rain while other time dryness). These climatic zones have a considerable impact on livestock output (Lamy et al., 2012). For instance, a study was conducted in the Kasur district of Pakistan's Punjab province to detect the factors causing variation in the milk yield of farm animals. The study found that seasons significantly affect milk yield. Specifically, the milk yield was low in the hot and humid seasons compared to the autumn and spring seasons (Javed et al., 2004). Another study examined the factors affecting market milk supply and farm profitability in the Chittagong district of Bangladesh. The study found that a large number of milking cows, experience in dairy farming, age of household head, and large investment in dairy farming led to high profit for the farm owner (Barua et al., 2017). The milk yield and lactation length were most importantly affected by environmental factors such as the season of calving and year of calving. Both of these factors had a significant effect on milk production in the Bahadurnagar district of Pakistan's Punjab province as well. The milk yield was high in the winter season compared to the summer season (Bajwa et al., 2004).

Methodology

Study Region, Sample Size, and Data Collection

For this study, a survey is conducted in the Swat district of the Khyber Pakhtunkhwa province of Pakistan. Swat houses a population of 21, 37,000 individuals. It grows a variety of crops that include wheat, maize, and a diverse range of fruits and vegetables. The land of Swat is highly fertile where the total cropped area is about 180,586 hectares. Out of this, the total irrigated land area is about 84,918 hectares. Moreover, the per thousand rural population head in livestock is 2998 and approximately 2% of the labour force are working with livestock (Pakistan Poverty Alleviation, 2015).

To undertake the current study, a survey was conducted using questionnaires in Swat. A total of 121 buffalo farm owners were surveyed between June 1st and June 30th, 2018. Specifically, the study was conducted in two villages of Swat, namely Shamak and Takhtaband of tehsils Khwazakhela and Saidu Sharif, respectively.

Variables of the Study

The dependent variable of the study is farm profit, which is simply what's left after deducting total revenue from the total cost, as shown below.

Profit (π) = Total Revenue – Total Cost

While revenue is computed by multiplying the price and quantity of the milk sold during the study including the monetary value of the dung sold for cooking purposes. Similarly, the total cost is computed by adding up out-of-pocket expenditure on green fodder, dry fodder, vitamins etc. during the thirty days study period.

On the other hand, explanatory variables of the study include animal illness cost and milk loss. In addition, the control variables include the age of the respondent, education of the respondent, dairy farming experience, and the total number of milk-producing buffaloes.

Analytical Techniques

The main analytical techniques used in this study are multiple linear regression and tobit regression.

Multiple Linear Regression

Multiple linear regression is a model where one dependent variable is linearly related to several explanatory variables. The generic form of multiple linear regression is given below.

$$Y = f(X_1, X_2, \dots X_n) \quad \dots\dots (1)$$

Where Y is the dependent variable and X_1, X_2, … X_n are the predictors or explanatory variables. Similarly, the econometric form of the multiple linear regression is written as follows.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots \beta_n X_n + \mu \quad \dots\dots (2)$$

Where Y is the dependent variable, X_1 up to X_n are independent variables, β_0 is the intercept while β_1 till β_n are coefficients of the explanatory variables.

Tobit Regression

Tobit model is considered an optimal choice when censoring data. Tobit model, in its simplest specification, takes the following form.

$$Y_t^0 = X_t + U_t \qquad U_t \sim \mathrm{NID}(0, \sigma^2) \quad \dots\dots (3)$$

$$Y_t = Y_t^0 \ \ if\ Y_t^0 > 0,\ Y_t = 0\ otherwise \quad \dots\dots (4)$$

Where y^0_t is a latent variable that is observable upon taking a positive value. Conversely, it is censored when its corresponding value is negative. In order to allow for censoring from the above rather than below or both below and above, the model is modified. The log-likelihood function for the Tobit model is somewhat unusual but nevertheless, not a difficult task to derive.

Pr(y¬t = 0) = Pr(y0¬t ¬≤ 0) = Pr (yt β + ut ≤ 0)

Pr (ut/ ó2 ≤ - Χt β/ ó2) = Φ(-Χt β/ ó2)

Hence, there is a positive probability that Y_t= 0, the contribution to the log-likelihood function made by observation with $Y_t = 0$ is not the log of density, but the log of that positive probability. If Y_t is positive then density exists and the contribution to the loglikelihood is its logarithm log [1/ ó2Φ {(Y_t − Χt β/ ó2). This is a contribution of the loglikelihood function of the classical normal linear regression model without any censoring.

Compared to tobit regression, the multiple regression model simply postulates that all observations of the explanatory variables are regressed over the dependent variable. Conversely, the tobit model involves censoring zero below the values of the dependent variable. By employing the tobit specification, the standard errors minimizes and one of the variables becomes statistically significant at one per cent instead of ten per cent.

Profitability Function Incorporating Health Cost and Milk Loss Arising from Pesticide Exposure

In economic terms, profit refers to the net result of subtracting costs from revenue. In the context of the present study, revenue is obtained by adding the amount of money obtained by selling milk and buffalo dung during the study period. Likewise, the total cost is the summation of money spent on green fodder, dry fodder, concentrate fodder and labour cost. Costs further include certain indirect costs, i.e. the amount of money spend on buffalo health care when it falls ill due to pesticide exposure. Another indirect cost is incurred in the form of milk loss when animals fall ill due to weather, pesticide exposure, consuming contaminated water, and certain diseases like mastitis, and foot and mouth disease primarily.

The profit function of this study is computed using the multiple linear regression model. In this model, profit is the dependent variable which is explained by a variety of factors such as disease-inducted health cost, health cost incurred due to pesticide exposure, number of lactating buffaloes, milk loss due to pesticide and disease, milk loss due to low-quality food, toxic plant and wastewater, respondent's age, education, and experience etc. The empirical model is shown below.

$$\pi = \beta_0 + \beta_1 Age + \beta_2 Edu + \beta_3 Exp + \beta_4 NLB + \beta_5 MLdp + \beta_6 MLdd + \beta_7 MLdlqf + \beta_8 MLdtpww + \beta_9 HCdp + \beta_{10} HCdd + \varepsilon_t \ldots\ (5)$$

Where *Age* is the age of the respondent, *Edu* is the respondents' education, and *Exp* refers to experience. In addition, *NLB* refers to the number of lactating buffaloes, *MLdp* is the milk loss due to pesticide use, *MLdd* stands for milk loss due to disease, *MLdlqf* is milk loss due to low-quality food, *MLdtpww* is milk loss due to toxic plant and wastewater, *HCdd* is health cost due disease. Moreover, HCdp refers to the health cost due to excessive pesticide use. Finally, ε_t is the error term, which captures the unexplained variation in the dependent variable.

Results and Discussion

Descriptive Statistics

The descriptive statistics are reported in Table 1 below.

Table1

Descriptive Statistics.

Variable	Mean	Median	Minimum	Maximum	Std. Dev	C.V.
Profit	13894	11237	-73163	80380	24946	1.795
Age	3.801	4.000	1.00	8	1.873	0.492
Edu	1.818	1.000	1.00	5.00	1.087	0.598

Variable	Mean	Median	Minimum	Maximum	Std. Dev	C.V.
Exp	13.19	11.00	2.00	35.0	9.132	0.691
NLB	3.396	3.000	0.00	10	1.753	0.516
MLdp	774.3	560.0	0.00	2566	796.0	1.028
MLdd	263.1	230.0	0.00	1200	254	0.968
MLdlqf	75.72	0.000	0.00	450	126	1.665
MLdtpww	31.96	0.000	0.00	210	61	1.925
HCdp	219.9	190.0	0.00	700	201	0.916
HCdd	641.3	700.0	0.00	1750	541	0.844

Source: Authors' Computation.

In Table 1, it can be seen that the farm owner's average monthly profit stands at Rs. 13,894. Similarly, the average experience of the farm owner is about 13.9 years. Upon illness of the farm animal (buffalo) as a result of consuming pesticide-affected grass exposure and diseases, the farm owner experiences a monthly financial loss of Rs. 774.3 and Rs. 263.1 respectively. This happens as a result of the decrease in milk production. However, the farm owners spend/lose about Rs. 219 on treatment and Rs. 641 on health costs.

Correlation Matrix

The results of the correlation analysis are reported in Table 2.

Table 2

Correlation Results.

	Profit	Age	Edu	Exp	NLB	MLdp	MLdd	MLlqf	MLtpww	HCdp	HCdd
Profit	1										
Age	0.061	1									
Edu	0.045	-0.488	1								
Exp	0.492	0.303	-0.13	1							
NLB	0.522	-0.024	-0.00	0.25	1						
MLdp	-0.60	0.034	-0.08	-0.22	-0.308	1					
MLdd	0.112	0.050	0.038	0.063	0.0281	0.137	1				
MLlqf	0.356	0.097	-0.03	0.301	0.559	-0.21	0.335	1			
MLt	0.309	0.025	0.009	0.184	0.685	-0.21	0.346	0.547	1		
HCdp	0.307	0.110	-0.11	0.256	0.516	-0.19	0.324	0.330	0.353	1	
HCdd	-0.55	0.073	-0.07	-0.12	-0.147	0.41	-0.05	-0.047	-0.115	-0.07	1

Source: Authors' Computation.

In Table 2, it can be seen that profit is positively correlated with the respondents' age, education, experience, and the number of lactating buffaloes. However, among these variables, experience and the number of lactating buffaloes depict a stronger association while the rest exhibit relatively weaker relationships. On the other hand, profit is negatively correlated with milk loss and pesticide-induced health costs. Age is positively correlated with most variables except education and the number of lactating buffaloes where the correlation is negative. Furthermore, education is inversely correlated with most variables, indicating that educated individuals are more likely to have the skills to avoid losses and increase farm profitability.

The primary variable of interest in this study is pesticide-induced milk loss (MLdp). This variable is negatively correlated with profit, experience, and education. Likewise, disease-induced health costs (HCdd) are also inversely correlated with all other variables except age.

Variance Inflation Factor (VIF)

To check for multicollinearity, the variance Inflation factor (VIF) technique is utilized. The results are reported in Table 3.

Table 3

Variance Inflation Factor (VIF).

	Age	Edu	Exp	NLB	MLdp	MLdd	MLdlqf	MLdtp -ww	HCdp	HCdd
Auxiliary R^2 value	0.32	0.25	0.22	0.60	0.32	0.27	0.42	0.52	0.33	0.20
VIF value	1.47	1.33	1.28	2.5	1.47	1.36	1.72	1.92	1.49	1.25

Source: Authors' Computation

In Table 3, it can be seen that the VIF values of all variables are less than 5, indicating the lack of the multicollinearity problem.

Tolerance

Tolerance is defined as the inverse of the Variance Inflation Factor (VIF). The results of tolerance are given in Table 4.

Table 4

Tolerance.

	Age	Edu	Exp	NLB	MLdp	MLdd	MLdlqf	MLdtp -ww	HCdp	HCdd
VIF value	1.47	1.33	1.28	2.5	1.47	1.36	1.72	1.92	1.49	1.25
T value	0.68	0.75	0.78	0.40	0.68	0.73	0.58	0.48	0.77	0.80

Source: Authors' Computation.

Table 4 shows the tolerance values (T value) of all variables are greater than 0.2, indicating the lack of the multicollinearity problem.

Heterscedasticity Test

This study used Breusch Pagan test for the detection of heteroscedasticity. Under this test, the dependent variable is the square of the residual while the remaining variables are treated as explanatory variables. Regressing the square of residual and multiplying the R^2 value of this auxiliary regression by the total number of observations (N) yields the value of the LM test statistic. To test the null hypothesis of heteroscedasticity, the LM value is compared with the value of the chi-square. If;

$$LM > \chi 2(\alpha, k);$$

Then the null hypothesis stands rejected. For this study, the R^2 equals 0.12, N is 121, α is 0.05, and k, i.e. the total number of parameters, is 11. Using these values, we find;

$LM=N.R^2$; therefore

$LM=121\times0.12 = 14.52$; and

$\chi^2(\alpha, k)$ so;

$\chi^2(0.05,11)$ = chisq.inv.rt (0.05, 11) = 19.67

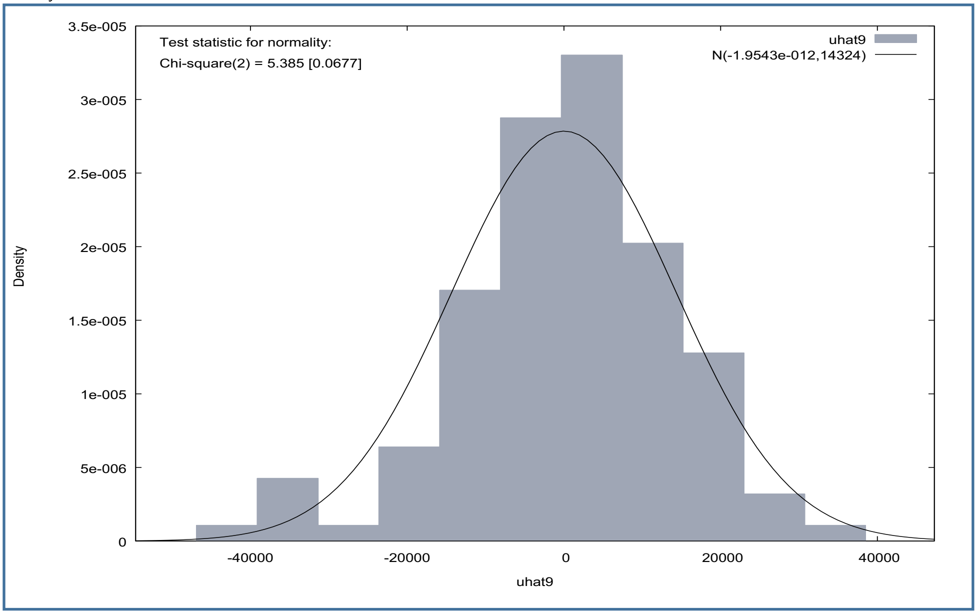
The above computation indicates the lack of the heteroscedasticity problem in the results. This finding is complemented by the results of the Koenker Robust and White tests, yielding p-values of 0.118132 and 0.098507, indicating the lack of the heteroscedasticity problem.

Normality Test

To test for normality, the study uses the Jarque Bera test, which shows a p-value of 0.278626. This indicates the normality of the residuals. This can also be viewed in Figure 1.

Figure 1

Normality Test.



Source: *Authors.*

Multiple and Tobit Regressions

The results of the multiple and tobit regressions are presented in Table 5.

Table 5

Multiple and Tobit Regressions.

Variables	Multiple Linear Regression	Tobit Regression
Constant	-766.93	1352.14
	(0.90)	(0.8045)
Age	555.44	–125.76
	(0.51)	(0.8608)
Edu	1177.84	–54.23
	(0.39)	(0.9624)
Exp	820.04	918.67
	(1.75e-06 ***)	(1.72e-012 ***)
NLB	5354.04	5882.24
	(1.70e-05 ***)	(2.19e-09 ***)
MLdp	-9.71	–10.24
	(4.24e-06 ***)	(1.34e-07 ***)
MLdd	5.06	8.83
	(0.40)	(0.0866 *)
MLdlqf	7.89	2.28
	(0.55)	(0.8280)
MLdtpww	-56.71	–66.23
	(0.0688 *)	(0.0070 ***)
HCdp	-4.25	–8.28

Variables	Multiple Linear Regression	Tobit Regression
	(0.59)	(0.1966)
HCdd	-16.06	−14.35
	(3.42e-08 ***)	(3.72e-010 ***)

*P-values in parenthesis, Significance at 1% is shown by ***, at 5% by **, and at 10% by **
Source: Authors' computation

Table 5 shows the relationship between profit (the dependent variable) and several explanatory variables in multiple and tobit regression specifications. A multiple regression model is utilized to find out the drivers of profit. However, some of the surveyed farms run into losses, hence their profits assume negative values. Given this, the Tobit model is also utilised for comparing the coefficients and their corresponding p-values once the negative profit values are censored.

In Table 5, it can be seen that experience and number of lactating buffaloes depict statistically significant positive relationships with profit. This indicates that an increase in experience and the number of buffaloes leads to a corresponding increase in profit. Conversely, milk loss due to pesticides, milk loss due to consuming toxic plants and wastewater and health cost due to disease exhibit statistically significant negative relationships with the dependent variable. This indicates that milk loss and health costs drastically reduce farm profits. These relationships hold across both models.

Conclusion and Recommendation

This study aimed to assess the pesticide-induced profit losses and monetary costs borne by buffalo farm owners using survey data collected in the Swat district of the Khyber Pakhtunkhwa province of Pakistan. The study finds that milk losses due to pesticide exposures, health costs due to disease, and health costs due to pesticide considerably reduces the profits of the farm owners in the study area. In addition to these key findings, several other observations need discussion.

First, the buffalo keepers and pesticide applicators exhibit significant deficiencies in terms of the required knowledge and skills. Specifically, they lack the know-how of determining the right quantity of the required pesticide. Likewise, buffalo keepers are deficient when it comes to determining the right type and quantity of feed to enhance milk productivity and avoid health costs. Given this, the study recommends governments strictly regulate pesticide sales and application. Moreover, government organizations also need to inform and train the farmers about the proper use of pesticides and their potential hazardous impacts. In addition, the health staff also need to be trained for proper mitigation of pesticide-affected humans and animals. Likewise, livestock officials must inform animal keepers about the right quality and quantity of animal feed along with the negative consequences of grazing animals on pesticides affected grass lands.

For further research, the study suggests exploring the health costs and wage losses of pesticide applicators due to pesticide exposure.

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