Ind. Jn. of Agri.Econ.
Vol.62, No.3, July-Sept. 2007

SUBJECT III
RISK MANAGEMENT IN AGRICULTURE/RURAL SECTOR

Reducing the Risk in Livestock Production: Factors Influencing the Adoption of Vaccination Against Bovine Diseases

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I

INTRODUCTION

Livestock is an important source of livelihood for farmers in India. As per the latest livestock census, India possessed 185 million cattle, 98 million buffaloes, 124 million goats and 61 million sheep (Government of India, 2003) and produced 97 million tonnes of milk, 2.3 million tonnes of meat and 44.9 million kg of wool in 2004-05 (Government of India, 2006). The livestock functions as a source of regular income, movable asset of high liquidity and a cushion on which the farmers can fall upon at times of climatic vagaries like drought when the crop sector fails. They are also a source of draught power for farm operations and energy for household purpose. Since livestock is distributed more equitably than land, they help in reducing the rural income inequality. The contribution of livestock sector in Indian agricultural economy is on increase that it accounted for 13.8 per cent of agricultural gross domestic product (GDP) in 1980-81 and increased to nearly 25 per cent in 2004-05 (Government of India, 2006). However, livestock production in India faces major threat in the form of diseases, which affect the production by increased animal mortality, loss of milk and meat, loss due to reproductive failures and general debility. Livestock in India are affected by almost all diseases known to mankind and Government spends a lion's share of the public funds available to the livestock sector on curative veterinary care. However, no quantitative estimates has been made on the extent of loss to the nation because of diseases, but it could be reckoned that nearly Rs 50 billion is lost due to diseases accounting for almost 10 per cent of the value of the entire livestock sector in 1991 (Chawla *et al.*, 2004). Noticeable success in alleviating some diseases like rinderpest has been achieved due to the concerted

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The authors thank the authorities of NATP for funding the project "Livestock-Crop Production System Analysis for Sustainable Production". Special thanks are due to PI of the project Raj Vir Singh, Head, Department of Dairy Economics and Management, National Dairy Research Institute, Karnal. The service rendered by U.C. Pant, Research Associate is duly acknowledged.

efforts towards vaccination, but, on the other hand the incidence of foot and mouth disease (FMD), black quarter (BQ) and haemorrhagic septicaemia (HS) has increased in recent years (Birthal, 2002), of which FMD being the most prevalent one. The emergence of the disease can be prevented to a great extent by vaccinating the animals. Vaccination acts as an insulation against the risk of livestock loss due to diseases. The population at risk in the country is about 420 million and vaccinations are just 25 million, barely 5 per cent of the animals at risk (Chawla *et al.*, 2004).

Vaccination of the productive animal has been identified as an important intervention point in augmenting livestock production in India. However, the spread of the immunisation programme largely depends on the macro level policy environment (Gauri and Khaleghian, 2002). The quality of a country's institutions and its level of development are also strongly related to immunisation rate coverage and vaccine adoption. At the micro-level, the adoption of the vaccination can be correlated with various psycho-personal characters and socio-economic background of the farmers. The attitude of the farmers towards risk affects the adoption of vaccination technology (Goswami *et al.*, 2001). Understanding the factors that affect the adoption of vaccination can help in formulation of policies towards further spread of the technology and reduce the livestock loss. In this context, the present paper investigates the factors influencing adoption of vaccination against bovine diseases.

II

DATA AND MODEL

The data for the present study was carved out from a larger study titled "Livestock-Crop-Production System Analysis for Sustainable Production in Rajasthan" funded by National Agricultural Technology Programme (NATP) of Indian Council of Agricultural Research. Initial field level survey was undertaken to identify the major livestock-crop production systems prevalent in Rajasthan by collecting data from all the nine agro-climatic sub-zones of the state using multistage random sampling. These are: Jodhpur from arid Western Zone, Hanumangarh from irrigated North Western Plain Zone, Jhunjhunu from transitional Plain of Inland Drainage Zone, Jalore from transitional Plain of Luni Basin Zone, Jaipur from Semi-Arid Eastern Plain Zone, Alwar from Flood Prone Eastern Plain Zone, Bhilwara from Sub-Humid Southern Plain Zone, Banswara from Humid Southern Plain Zone and Sawai-Madhopur from Humid South Eastern Plain Zone. Subsequently, one district from each sub-zone was selected randomly. Further, one tehsil from each of the selected district was randomly selected and a cluster of 3-4 villages from each tehsil was selected for collection of information from farmers who were keeping livestock (a total of 5,818 households) to identify the major production systems. In the second stage a total of 150 farmers from each district was identified based on probability proportion to size of production systems in each district. The present study uses data collected from 998 farmers who were keeping bovines.

Model

Research on the process of adoption of new technology and factors determining it mainly followed two distinct trends. On the one hand, some studies mainly concentrated on exploring the adoption paths, growth rates, ceiling levels and potential of further expansion. On the other hand, numerous cross-sectional micro level studies have focused on the effects of various firm and/or institution-specific factors on the individual's adoption behaviour. The first approach follows the notion that the process of imitation and the speed of adoption are influenced by the profitability and other economic considerations alone. The second approach required identification of various dimensions of heterogeneity in the population that is relevant for the adoption of the specific technology and incorporates them in the adoption study (Bhattacharyya *et al.*, 1997). Our study uses the cross sectional data to explain the factors that determine the adoption of the vaccination technology as an insulating mechanism against the risk of livestock loss due to the diseases and hence uses the second approach.

Logit or probit models are generally used to predict the effects of change in the independent variables on the probability of belonging to a group or category when the dependent variables are dichotomous. To generate the dependent variable, the farmers have been classified into two groups, who vaccinate their livestock and who do not and used logit model as specified below.

$P_i = \frac{1}{1+e^{-Zi}}$, where P_i is the probability that a farmer is an adopter.

$1\text{-}P_i = 1 - \frac{1}{1+e^{-Zi}}$ = The probability that a farmer is not an adopter

The Odd's ratio = $\left(\frac{P_i}{1-P_i}\right) = e^{Zi}$

Taking logarithm on both sides,

$\ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \alpha + \sum_{i=1}^{n} \beta_i X_i + e_i$ where X is the vector of the independent variable and β_i' s, the coefficients to be estimated.

Model Specification

In our model, we are guided by three sets of factors as regressors, the human endowment, production endowment and agro-climatic and institutional endowment. The human endowment factors enable the potential adopters to understand and decode the information and thereby help the diffusion of the new technology. Moreover, the risk assessment and bearing behaviour of the farmers are affected by the individual and psychological attributes of the farmer. The production endowment affects the choice and/or desirability of a particular technology. The risk bearing capacity of the farmer also depends on the production environment, say in the form of the capital endowment of the farmer. The climatic variations, the development of the location with respect to the availability of facilities likes veterinary clinics, accessibility to these facilities and other supply conditions contributes to adoption. These factors vary widely across a large geographical area and therefore, we have included geographical variables to capture this effect. Three variables are included in the model to exclusively capture human endowment of the farmer, viz., literacy status of the farmer, size of the family and presence of crossbred cattle. It is hypothesised that the literate farmers will be more forthcoming in the adoption of new technologies compared to illiterate farmers. The family size of the farmers acts as a proxy for the potential household labour supply as well as the household demand for nutrition, for example milk. For the predominantly vegetarian population of India, milk is a source of protein. In that sense, size of the family may affect the odds of adoption of vaccination positively. On the other hand, the larger the family size, the higher the chance of getting diversified income portfolio (off-farm income). It is expected that the farmers with source of off-farm income in addition to their farm income tended to be less risk averse (Sharma and Kumar, 2000) and this may affect the decision to vaccination negatively. The dummy variable for the presence of the crossbred cattle was included in the analysis to capture the attitude of the farmers towards the technology (technology receptiveness). Attitude has been defined as the degree of farmers' positive or negative feelings towards an innovation. The production endowment of the farmer is captured by three factors, viz., the size of operational holding, total number of bovines and present value of fixed assets employed in livestock production. The operational holding acts as a source of wealth of the farmers and therefore his risk bearing ability. The quantum of the fixed assets of the households in livestock production indicates the capacity of the farmers to adopt new technology as well as the seriousness with which the farmers undertake dairy farming. The effect of the geographic and institutional interventions was captured by using dummy variables for the agro-climates. We had nine agro-climatic sub-zones, and therefore eight dummies were used in the analysis, Semi-Arid Eastern Plain Zone (Jaipur) forming the base dummy. This zone was selected as it was medium in terms of rainfall and temperature analysed through the mean and standard deviation across the sub-zones. The independent variables were the dummy variable for literacy of head of the household, family size, dummy variables for presence of crossbred cattle (1 if present and 0 otherwise), size of operational holding (in hectare), present value of fixed assets in livestock (in Rs.), size of bovine holding and dummy variables for agro-climates. Further, to determine the impact of vaccination on milk production, regression analyses were conducted with the average milk production per lactating buffalo/cattle as the dependent variable and present value of assets employed (as proxy for extent of capital use) and dummy variable for vaccination as independent variables.

III

RESULTS AND DISCUSSION

The farmers were classified into various categories depending on the size of the landholding (Table 1). Out of total 998 farmers, the farmers who possessed operational holding below 2 ha accounted for nearly three-fifth of the total respondents. Overall, only 18 per cent farmers adopted vaccination, clearly indicating the lack of adoption of improved management techniques. This might be due to the lack of awareness or because of the under-valuation of the risk of livestock diseases compared to the cost involved in getting the animal vaccinated. Barring the landless category, we can observe an increase in trend of the percentage of farmers adopting vaccination as we move up the land category.

The table also indicates some of the general characters of the farming households. The average family size was 6.9 and the average literacy of the head of the household was nearly 49 per cent. The average size of operational holding was 3.42 ha. However, the land was poor in terms of the percentage area irrigated. The size of operational holding generally exhibited a positive correlation with the size of livestock holding in terms of Adult Cattle Unit (ACU). The farmers possessed on an average 342 ACU per 100 households. Buffaloes were the major milch animals. The spread of the crossbred cattle was less, consisted of only 5 per 100 households.

The farmers who adopted vaccination were better in terms of the size of operational holding, owned land and fixed assets in livestock enterprise (Table 2). However, the size of the livestock holding was higher in the case of non-adopters than in the case of the adopters possibly because the adopter farmers were undertaking better management of the productive stock, limiting the stock size small size. The literacy rate of the adopters was higher than the non-adopters. The adoption of crossbred cattle was followed by only three per cent of the farmers - 8 per cent by the vaccinated farmers and 2 per cent in case of non-vaccinated farmers. This might be because of the unsuitability of the crossbred cattle for draught purpose and high cost involved in raising them.

Logit regression estimates of the adoption of vaccination are given in Table 3. Among the personal factors, literacy did not bear an important role. Literacy is generally believed to impart significant positive role in technology adoption, but the case may not be true here because of the immediate non-observability of the results of vaccination due to the preventive rather than curative nature of the technology. Other personal variables like the family size did not influence the adoption. The dummy variable for the ownership of crossbred cattle turned out to be a significant variable. This variable was hypothesised to capture the attitude of the farmers towards technology adoption and as such represented the technology receptiveness of the farmers. One another reason might be that, due to the high susceptibility of the crossbred cattle towards diseases, farmers are vaccinating them as compared to local cattle (which are generally tolerant to the diseases). The impact of the capital endowment seemed to be more pronounced than the personal endowment variables.

TABLE 1. IMPORTANT CHARACTERISTICS OF THE FARMERS DISTRIBUTED OVER CATEGORY OF FARMERS

					Livestock holding (No per 100 households)						Land		
Category (1)	Percentage of farmers (2)	Family Size (No.) (3)	Percentage of farmers vaccinated (4)	Literacy (per cent) (5)	Buffalo (6)	Local cattle (7)	CB cattle (8)	Bovines (9)	Small ruminants (10)	ACU (11)	OPH (ha) (12)	Percentage OPH irrigated (13)	Total Assets (Rs.) (14)
Landless	6.52	6.68	10.47	52.30	191	40	06	237	22	233	0.00	-	11923
Marginal	28.28	5.79	8.51	40.78	180	162	00	341	68	305	0.62	62.90	9196
Small	24.67	6.72	16.26	51.22	238	76	06	319	108	329	1.53	56.86	9642
Semi-Medium	18.66	7.52	20.97	46.24	267	99	11	377	76	383	2.95	43.73	10276
Medium	15.45	7.84	30.52	53.25	251	105	8	364	122	393	6.69	19.13	9788
Large	6.42	3.81	39.06	52.31	222	156	3	381	155	425	19.48	7.24	12926
Overall	100	6.90	18.25	49.05	224	112	5	342	90	342	3.42	25.43	10008

Source: Field Survey.

TABLE 2. DISTRIBUTION OF IMPORTANT CHARACTERISTICS BY VACCINATION STATUS

Characteristics	Not Vaccinated		Vaccinated		Overall	
	Mean	SD	Mean	SD	Mean	SD
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Operational holding (ha)	2.89	4.39	5.80	9.27	3.42	5.71
Owned land (ha)	2.86	4.40	5.64	9.24	3.37	5.70
Irrigated operational holding ha)	0.94	1.80	0.52	1.56	0.87	1.77
Fixed assets (Rs.)	9103	11156	14054	25619	10028	14992
ACU (No.)	3.46	4.27	3.26	2.35	3.42	3.99
Literacy (per cent)	47.67		54.94		48.99	
Percentage farmers possessing Crossbred cattle	1.72		8.24		2.90	
Family size (No.)	6.90	3.91	3.87	3.60	6.90	4.02
Size of bovine holding (No.)	3.52	7.36	2.93	2.01	3.41	6.71

Source: Field Survey.

TABLE 3. LOGIT ESTIMATES OF FACTORS DETERMINING ADOPTION OF VACCINATION

Variables	Coefficient	Standard Error
(1)	(2)	(3)
Constant	-1.464***	0.381
Dummy variable for literacy	0.142	0.207
Family size (No.)	-0.024	0.026
Dummy variable for crossbred cattle	1.10**	0.472
Size of operational holding (ha)	0.030*	0.016
Fixed assets in livestock production (Rs.)	0.001***	0.0001
Size of bovine holding (No.)	-0.025	0.048
Dummy variables for agro-climates		
Arid Western Zone	-0.121	0.454
Irrigated North Western Plain Zone	1.518***	0.332
Transitional Plain of Inland Drainage Zone	0.362	0.367
Transitional Plain of Luni Basin Zone	-2.886***	1.043
Flood Prone Eastern Plain Zone	-1.424***	0.455
Sub-Humid Southern Plain Zone	-1.203***	0.466
Humid Southern Plain Zone	-1.091***	0.418
Humid South-Eastern Plain Zone	-1.489***	0.529
-2Log likelihood	716.27	
N	983	

***, ** and * indicates level significance at 1, 5 and 10 per cent respectively.

The size of the operational holding was significantly and positively affecting the adoption. Similar is the case of the value of the assets, which in fact turned out to be the most significant variable. By adopting vaccination, the farmers realise higher rate of return for the fixed assets.

Other than the human endowment and production endowment variables, the variables indicating the geographical differences in development exhibited significant effect on the pattern of adoption of vaccination. The results indicated that all the agro-climatic sub-zones except the Transitional Plain of Inland Drainage Zone had a significant effect compared to the base sub-zone. The dummy variable representing the Irrigated North-Western Plain Zone was significantly positive possibly due to the availability of larger number of veterinary clinics and the importance farmers attached to better livestock rearing practices. This region is largely irrigated so that larger quantity of fodder is available for livestock production. All the other zones exhibited significant negative signs.

The effect of vaccination on the production of milk was analysed by multiple linear regression separately for buffalo and cattle (Table 4). The present value of the assets utilised in the production process is used as a proxy variable for the extent of capital use. The dummy variable for vaccination was given a value of 1 if the farmers vaccinated the animal and 0, otherwise. The result indicated positive influence of the variable in both the cases, but was significant only in case of cattle. The intercept shift due to vaccination was about 274 kg. This higher intercept shift for the dummy variable might be because of the significant improvement in the yield of crossbred cattle due to the reduction of the risk of diseases and resultant production loss. The intercept shift due to vaccination in case of buffalo was nearly 80 kg, which was not statistically significant. Thus we can conclude that the vaccination could raise the productivity of the bovines by minimising the economic loss arising due the disease which otherwise would have affected them.

TABLE 4. REGRESSION ESTIMATES IMPACT OF VACCINATION OF MILK PRODUCTION

Variables (1)	Buffalo Coefficient (2)	Buffalo SE (3)	Cattle Coefficient (4)	Cattle SE (5)
Constant	1056.04*	36.17	550.46*	34.25
Value of Assets (Rs)	0.007*	0.002	0.003	0.002
Dummy variable for vaccination	79.61	80.20	274.4*	64.82
Adj. R^2	0.03		0.09	
N	518		260	

* Indicates level of significance at 1 per cent.

IV

CONCLUDING REMARKS

The adoption of vaccination is a method to insulate the livestock from the risk of getting affected by debilitating diseases. Rather than the human endowment of the farmer, it is the production endowments available with them that affect the adoption of vaccination. The major determinants were the size of operational holding and present value of the fixed assets for livestock rearing. Also, the farmers were sensitive to the vaccination when they possessed the crossbred cattle. The results also indicated the significance of the regional variables highlighting the differentials in the veterinary care and other institutions engaged in providing the livestock services in spreading the adoption of vaccination. Therefore, it is necessary to give the farmers easy accessibility to livestock services so that the extent of adoption of vaccination can be enhanced and the risk of livestock diseases can be minimised.

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