

EMPIRICAL ANALYSIS OF LIVESTOCK PRODUCTIVITY THROUGH IMPROVED BREEDING IN PUNJAB, PAKISTAN

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ABSTRACT

In Pakistan, the productivity of the livestock sector is lower than its capacity due to lack of breeds with high productive potential, nutrition deficiency and poor disease control facilities. This study explores the potential of the livestock sector to move towards more productive breeds of cattle. Primary data were collected from 340 livestock farmers of Punjab Province through stratified random sampling technique. Endogenous Switching Regression (ESR) is employed to identify factors influencing the farmer's decision to adopt superior/exotic breeds of buffaloes and cows and impact of adoption on the gross margins. The results of adoption equation reveal that farmer's decision to adopt exotic breed depends positively on the proximity of his house to livestock market, years of schooling, operational land, access to hired labour and contact with extension agents. Results also show that different socio-economic factors have differential impact on the gross margins of both adopters and non-adopters. There is need of policy reforms to eliminate the constraints of shifting towards high productive breeds.

Keywords: Improved Livestock Breed, Constraints and Impact Analysis, Endogenous Switching Regression (ESR), Punjab-Pakistan.

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INTRODUCTION

The livestock sector performs a key role in rural settings of Pakistan as livelihoods of small and landless farmers depend largely on this sector. For instance, more than 8 million families of Pakistan are involved in raising livestock (Anonymous, 2019). In Punjab province, which is the main producer of dairy products, more than 40 percent of the total household income comes from dairy. Most of farm families are involved in livestock sector as small ruminants and large animals contribute to the food basket of household (Ashfaq *et al.*, 2014).

Given the vital importance of the livestock sector for economic, social, and rural development of Pakistan, it requires a good deal of attention in the national policy framework. Unfortunately, the importance of livestock has neither been fully realized nor reflected in agricultural or economic policy of the country. Besides other limiting factors, the productivity of livestock sector also depends on genetic potential of livestock heads. It is well known that some world-famous breeds of cattle and buffaloes are in Pakistan. The buffalo breeds of Nili-Ravi, Aza Kheli and Kundi are also popular for their high milk production. Nili Ravi is the best buffalo breed in world and is famous as Black Gold of Pakistan (Iqbal *et al.*, 2015). The main dairy cattle breeds in the country are Sahiwal and Red Sindhi which are internationally recognized breeds. Other than well-defined cattle breeds, there are many mixed and crossbred cattle in this country.

Besides our local and crossbred breeds, exotic breeds which are imported from Australia, America and Sweden are also the important part of dairy sector in Pakistan. These breeds are famous for high milk production and breeding efficiency. However, they require great care. Holstein Friesian, Jersey and Friesian X Sahiwal are some common breeds in Pakistan (Khan *et al.*, 2008).

Although Pakistan is endowed with rich cattle genetic diversity and resources. However, efficient utilization and management of these resources are lacking due to the lack of awareness and institutional weaknesses. In addition to this, improvement in tangible breed and its utilization is limited. Only a limited number of genetic improvement programs could get traction in government policy because these programs traditionally take long to complete, and due to political reasons, local governments in Pakistan are generally interested in programs which yield quick and tangible results (Afzal and Naqvi, 2004).

Several previous empirical studies have focused on different aspects of livestock productivity, health and genetic potential like: animal health and dairy productivity (Hall *et al.*, 2004; Rushton, 2013), acceptance of breeding and production practices and future of dairy industry (Oltenucu and Algers, 2005), sustainable diets and genetic diversity of animals (Hoffmann and Baumung, 2013), levels of protein consumption and production of milk (Habib *et al.*, 2019), factors affecting livestock productivity (Lamy *et al.*,

2012), livestock diseases (Modisane, 2009; Otufale and Adekoya, 2012). However, there is limited literature on the impact analysis of genetic potential on the productivity of livestock by considering the selection bias due to observable and unobservable factors. Failure to distinguish between the causal effects of breed adoption and unobservable heterogeneity may lead to biased estimates and misleading policy implications. Based on the existing research gap and within this backdrop, the present study has focused on exploring the impact of adopting productive animal breeds on productivity and identifying the key constraints of adoption by taking into consideration of endogeneity and selectivity bias.

MATERIALS AND METHODS

This study is basically primary data based. Three districts (Sahiwal, Jhang, and Sargodha) from Punjab province were selected based on the highest total

population of buffaloes and cattle in Punjab (PBS, 2006). A total of 340 livestock farmers were selected by multistage random technique. The district Sahiwal has 2 tehsils, district Jhang has 4 tehsils, and district Sargodha has 7 tehsils. To account for the geographical variations, all tehsils from districts of Sahiwal and Jhang were selected, while 4 out of 7 tehsils were randomly selected from district Sargodha. After the selection of tehsils, 3 villages were randomly selected from each tehsil of district Sargodha and Jhang, while 5 villages were randomly selected from each tehsil of district Sahiwal. The reason for selecting more villages from district Sahiwal was the division of such a large district into two tehsils only. A list of all of the livestock farmers in a selected village was prepared, and 10 farmers were selected from each village by systematic random sampling. The location of the sampling districts in Punjab province is given in Figure 1.

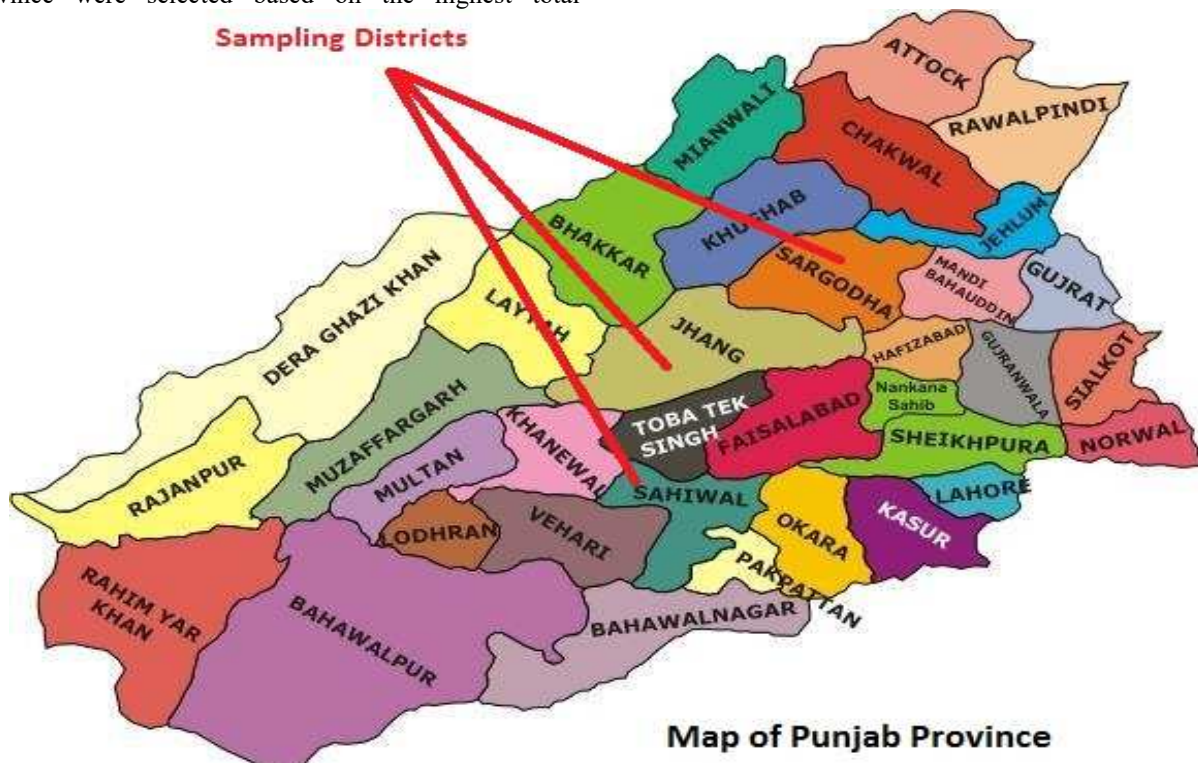


Figure 1. Map of Punjab province and the sampling districts

Livestock farmers were categorized as small, medium, or large farmers based on their possession of adult buffaloes and cattle. Farmers having 1-3 adult animals were categorized as small, 4-6 as medium and those having more than 6 adult animals were categorized as large farmers. The categorization of farmers in such a way is also found in Moaen and Babar (2006) and Ashfaq *et al.* (2014).

The socioeconomic characteristics of farmers such as age, livestock farming experience, education, and family size etc., are provided in Table 1.

Livestock farms were selected by proportionate random sampling technique as most of farmers are small (about 55 percent) in the study area. It implies that farming community in these districts consists of small, subsistence farmers. It is also worth noting that many farmers, in the small farm category, were landless.

The animal inventory of farmers is presented in Table 3. Overall, farmers possessed more buffaloes (2.31 buffaloes per farm) than adult cows (1.78 cows per farm). The other animals are included for more context. Another interesting result is the possession of very few bulls by all type of farms. Low possession of bulls is because farmer consider it non-productive as its role to produce bullocks for work has been replaces by mechanization over the years.

Nili-Ravi is considered a superior breed of buffalo and is recognized internationally. It is more productive, and more expensive. Kundi is another good breed of buffalo. However, the Kundi buffaloes are not usually present in Punjab (Khan *et al.*, 2007). Reference to previous empirical study (Khan *et al.*, 2007), Nili and Ravi as separate breeds and Nile-Ravi is considered as mixed breed while no crossing is reported between Kundi and Nili-Ravi. The Nili-Ravi breed was about one third of total adult buffalo populations on the farms (about 34 percent), while the Kundi breed was about one percent of the total adult buffaloes in the Faisalabad. The rest of the buffalo population consisted of 'mixed'. Table 4 also indicates such a wide gap of population for two breeds. Farmers of the study area attribute such a wide gap to challenges in rearing exotic breed in terms of their acclimatization to Punjab's environment, poor carriage capacity and unavailability of pedigree bulls.

The breed diversity of cattle at livestock farms was higher than buffaloes. There were all types of breeds ranging from indigenous to crosses of exotic breeds. However, about 60 percent of farmers had indigenous breeds at their farms which are less productive than exotic breeds, such as Jersey, Friesian, and crosses of these breeds. About 30 percent of the cattle population was described as 'non-descriptive' breed which is an issue to be addressed. The population of pure exotic breeds e.g. Holstein-Friesian, and Jersey was only 20 percent at livestock farms. The population of exotic cross breeds was about 20 percent.

Farmers were using both natural breeding and artificial insemination for breeding purposes (Table 6). However, natural breeding was found more prevalent in buffaloes, and the practice of artificial insemination was more prevalent for cows. This might be due to easy availability of buffalo sires in the villages. Also, it was revealed during the field survey that farmers were not much concerned about breed selection for buffaloes. In case of buffaloes, only about 30 percent of farmers were using artificial insemination as a breeding source. In the case of cattle, artificial insemination was being done by above 80 percent of farmers. However, one notable point is that the large farmers usually went for expensive semen, and a wide range of semen quality was being provided at various prices.

Definition of Variables and Descriptive Statistics: The dependent variables used in this study is the adoption of exotic breed and gross margins. The explanatory variables include level of education, household size, labor, water frequency, extension services, operational land, off-farm income, distance of household from livestock market and locational dummies. The definitions and sample statistics of the variables used in the analysis are given in Table 7.

Estimation of Gross Margins of Livestock Farmers: The gross margins are calculated by using the following traditional formula:

$$\text{Gross Margins} = \text{Total Revenue} - \text{Total Variable Cost} \quad (1)$$

Empirical Specification: We employed endogenous switching (ESR) model in this study in order to account for selection bias. ESR is the extension of Heckman selection model with the exception that Heckman method assumes outcome function would differ only by unobservable factors between the adopters and non-adopters. ESR is a parametric approach and accounts for selection bias caused by observable and unobservable factors, influencing outcome. The underlying model has two separate regimes for adopters and non-adopters. Inverse mill ratio is calculated to control for selection bias and plugged into the outcome equations.

In this study, farmers have two choices: to adopt exotic breeds or to adopt indigenous breeds (not to adopt exotic breeds). They weigh their choices on the basis of utility. The binary choice decision based on the utility from adoption or no adoption can be specified as:

$$B_i^* = \alpha X_i + \mu_i \quad (2)$$

$$B_i^* = 1 \quad \text{if } U^*(\pi) > 0$$

$$B_i^* = 0 \quad \text{if } U^*(\pi) \leq 0$$

Here B_i^* depends on a vector of variables X_i and error term μ_i which is assumed to have zero mean and equal variance. The error term is composed of measurement errors and unobserved factors. This model assumes two regimes: 1, to adopt and 2, not to adopt. α is the vector of parameters to be estimated.

The outcome equations can be formulated as:

$$Y_1 = \beta_1 Z_i + \gamma_1 B_{1i} + \varepsilon_{1i} \quad (3a)$$

$$Y_2 = \beta_2 Z_i + \gamma_2 B_{2i} + \varepsilon_{2i} \quad (3b)$$

Here Y_1 and Y_2 represent gross margins for adopters and non-adopters respectively. Z_i represents a vector of individual, household and locational characteristics of respondent i . β_1 , β_2 , γ_1 and γ_2 are parameters to be estimated and ε_1 and ε_2 are the error terms. B_1 and B_2 represent the adoption decision of the farmer i to adopt and not to adopt respectively. For the ESR model to be correctly specified, Z contains the same variables as B plus at least one suitable instrument that is correlated with the adoption decision but uncorrelated with the outcome.

Finally, the error terms are assumed to have a trivariate normal distribution, with zero mean and non-singular covariance matrix expressed as:

$$\text{cov}(\mu_i, \varepsilon_1, \varepsilon_2) = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\mu} \\ \sigma_{12} & \sigma_2^2 & \sigma_{2\mu} \\ \sigma_{1\mu} & \sigma_{2\mu} & \sigma^2 \end{bmatrix} \tag{4}$$

Where,

$$\sigma_1^2 = \text{var}(\varepsilon_1); \sigma_2^2 = \text{var}(\varepsilon_2); \sigma^2 = \text{var}(\mu_i); \sigma_{12} = \text{cov}(\varepsilon_1, \varepsilon_2); \sigma_{1\mu} = \text{cov}(\varepsilon_1, \mu_i); \sigma_{2\mu} = \text{cov}(\varepsilon_2, \mu_i);$$

σ^2 corresponds to the variance of the error term in the adoption equation and σ_1^2, σ_2^2 represent the variance of the error terms in the outcome equations.

According to Maddala (1983), when there are unobservable factors associated with selection bias, the important implication of the error structure is that as the error term (μ_i) of the adoption equation (2) is correlated with the error terms ($\varepsilon_1, \varepsilon_2$) of the outcome functions (3a) and (3b), the expected values of $\varepsilon_{1i}, \varepsilon_{2i}$ conditional on the sample selection are non-zero, giving rise to selection bias. To solve this problem, we estimated inverse mills ratio (also called non-selection hazard) as under:

$$E(\varepsilon_{1i} | B_i = 1) = E(\varepsilon_{1i} | \mu_i > -X_i'\alpha) = \sigma_{1\mu} \left[\frac{\phi(X_i'\alpha / \sigma)}{\Phi(X_i'\alpha / \sigma)} \right] \equiv \alpha_{1\mu} \lambda_1 \tag{5a}$$

$$E(\varepsilon_{2i} | B_i = 0) = E(\varepsilon_{2i} | \mu_i \leq -X_i'\alpha) = \sigma_{2\mu} \left[\frac{-\phi(X_i'\alpha / \sigma)}{1 - \Phi(X_i'\alpha / \sigma)} \right] \equiv \alpha_{2\mu} \lambda_2 \tag{5b}$$

where φ and Φ represent probability density and cumulative distribution functions of the standard normal distribution respectively. The ratio of φ and Φ evaluated at $\alpha X_i'$, as represented by λ_1 and λ_2 in equations (5a) and (5b) are inverse mills ratio (IMR) which denote selection bias terms.

Two stage method have been used to estimate ESR in previous studies () whereas the underlying study employs a single stage Full-Information Maximum Likelihood (FIML) method proposed by Lokshin and Sajaia (2004). The model estimates determinants of adoption and impact of adoption on adopters and nonadopters simultaneously thus minimizing the calculation error. The functional form is described as:

$$\ln B_i = \sum_{i=1}^N \left\{ \begin{array}{l} B_i w_i \left[\ln F \left(\frac{X_i'\alpha + \rho_{1\mu}(Y_{1i} - Z_{1i}'\beta / \alpha_1)}{\sqrt{1 - \rho_{1\mu}^2}} \right) + \ln(f((Y_{1i} - Z_{1i}'\beta) / \alpha_1)) \right] \\ + (1 - B_i) w_i \left[\frac{\ln(1 - F(X_i'\alpha + \rho_{2\mu}(Y_{2i} - Z_{2i}'\beta) / \gamma_2))}{\sqrt{1 - \rho_{2\mu}^2}} \right] \\ + \ln(f((Y_{2i} - Z_{2i}'\beta) / \gamma_2)) \end{array} \right\} \tag{6}$$

The signs of the correlation coefficients $\rho_{1\mu}$ and $\rho_{2\mu}$ describe important economic explanations. In case, the signs of $\rho_{1\mu}$ and $\rho_{2\mu}$ are alternate, the farmers tend to adopt exotic breeds on the basis of their comparative advantage. Additionally, it also underlines that adopters have above average returns from adoption and nonadopters have above-average returns from non-adoption. On contrary, if the coefficients have the similar signs, it is the evidence of hierarchical sorting: whether they decide to adopt or not, adopters have above average returns, but they are better off adopting, whereas nonadopters have below-average returns in either case, but they are better off not adopting.

RESULTS AND DISCUSSION

The average variable costs and the gross margins per animal are provided in Table 8. Overall, the gross margins per animal are Rs. 24,515. Surprisingly, the gross margins of small farmers are higher than the large farmers. This is due to a variety of reasons. One is the higher revenues earned by small farmers selling of animals. This could be due to more animals sold by small farmers in the survey year to fulfill any urgent cash needs. Secondly, small farmers have a low percentage of unproductive (dry) animals at their farms. These gross margins are calculated by dividing the costs and revenues by ‘total number of adult animals’, not counting whether some of those adult animals could also be dry for some period of survey year. The large farmers had 21 percent dry adult animals at their farms as compared to small farmers having only 6 percent dry adult animals. Because the small farmers are more likely to be cash starved, therefore, they probably could not afford having a dry animal for longer periods. They either sell it or replace it with milking animal.

On the costs side, the major cost components were fodder and concentrate costs. The labor cost for large farmers was 4 times that of the small farmers. However, the total variable cost per animals was almost same for small and large farmers.

The Potential of Livestock Sector in Shifting toward High Producing Breeds and Key Constraints regarding this Shift:

One of the objectives of this study was to explore the potential of livestock farmers to shift toward high milk producing breeds, and to identify the key constraints in breeding and adopting of exotic breeds. The data on milk productivity of exotic/superior breeds shows promising results. The comparison of milk productivities of various buffalo and cattle breeds is provided in Tables 9 and Table 10. Two facts about milk productivity can be spotted easily by looking at these two tables. First, milk productivity increases as we move across farm sizes, from small to large farmers (except for some cases in cattle). Secondly, the productivity of

superior/exotic breeds is significantly higher than that of other breeds.

Similarly, the average productivity of exotic and exotic cross breeds of cattle is higher than that of indigenous breeds (Table 10). Our productivity results showed that the superior breeds of animals perform better, even in the existing conditions of undernourishment, disease, and poor breeding practices.

Factors affecting the Adoption of Exotic Breeds of Animals, and Gross Margins of Adopters & Non-adopters:

To introduce the policy reforms to improve the genetic potential at farms, it is necessary to understand the behavior of adopters and non-adopters of exotic breeds of animals. In order to analyze the driving forces behind the farmers' decision to adopt an exotic breed of buffalo and/or cow, we employed an ESR, as it provides the advantage of controlling for observable and unobservable selection bias. FIML estimates of ESR for equation (6) are provided in Table 11. The third column of Table 11 presents the estimated coefficients of the adoption equation on exotic breed, whereas the last two columns of the Table 11 present the impact of different factors on gross margins of adopters and non-adopters respectively. The empirical results of probability of exotic breed adoption show that the education of the household head significantly increases the probability of choosing better breeds and making better decisions (Huffman, 2001). Educated farmers are likely to have more access to literature provided by different extension agencies on the benefits and managements of superior animal breeds. Thus, education is a powerful source that leads farmers to opt for exotic breeds of buffaloes and cows.

Another important factor that drives farmers' decision to choose exotic breeds is their ability to afford permanent labor for livestock. Farmers belonging to households endowed with valuable physical capital, such as landholdings, are more likely to choose an exotic breed of buffalo and cow. The results show that farmers having more operational landholdings are more likely to adopt better breeds. This could also be an indicator of affluence. Thus, affluent farmers are more likely to adopt exotic breeds. It is observed that exotic animals require extra care, better food and sufficient space. The coefficients of the variables representing labor and operational land are positive and statistically different from zero, implying that farmers endowed with labor and operational land holding are more likely to adopt exotic animal breeds.

The variable representing the visits of extension workers also shows positive sign and is statistically significant, indicating that availability of dairy extension services also play an important role in farmers' decision to adopt exotic breeds of animals. The empirical results suggest that farmers, where livestock extension workers

pay visits have a significantly higher probability of having exotic breeds. Thus, improving the livestock extension services could also be an important factor toward improving genetic potential at farms. The coefficient of off-farm income is positive, indicating that off-income tends to adopt exotic breed, but this variable is not significantly different from zero.

The results of the second part of FIML endogenous switching regression model which represents outcome equation both for adopters and non-adopters are presented in last two columns of Tables 10. Identification of the model requires at least one variable which is present in the adoption equation but does not enter into the gross margin equation. Distance of farmers from livestock market is used as the identifying instrument. It is evident from the results that distance of farmers' residence from livestock market significantly impacts their decision to choose an exotic breed, but it may not affect the outcome indicating no direct effect of distance on the gross margin of breeds. The farmers located closely to the livestock markets are more likely to adopt an exotic breed, and vice versa, probably due to the fact that market is imperfect, and farmers are reluctant to trade good breeds there.

The non-significance of covariance terms in the case of gross margins of adopters and non-adopters, in the lower panel of the table, shows the absence of endogenous switching in both cases, indicating that there is no self-selection due to unobservable factors. Also results show that the covariance terms have alternate signs with > 0 and < 0 , which indicates that adoption of high yield breed is based on its comparative advantage. It shows that farmers, who adopted have above average returns from adoption and those who choose not to adopt have above-average returns from non-adoption.

The results of the second part of FIML-ESR shows that the coefficient of education of household head is positive, indicating that level of education tends to exert positive effect on the gross margins of both adopters and non-adopters. Thus, education appears to have a key factor of production as it is linked with better livestock management and economic approaches which is in line with the human capital theory (Kousar and Abdulai, 2015; Kousar *et al.*, 2018; Kousar *et al.*, 2019).

The composition of households, such as household size, seems to have negative impact on the gross margins of both the adopters and non-adopters. This could be due to a high proportion of expenditures being diverted toward the increased requirements of domestic expenditures, leaving less budget to spend on the management of animals. However, this impact of was not significant in both cases. Similarly, the watering frequency of dairy animals seems to have a positive impact on gross margins. This could be due to increased milk productivity with increased water frequency. As noted by Etgen and Reaves, 1982 and; Ali *et al.*, 2015,

dairy animals watered more frequently or freely produce more milk, therefore, increased watering frequency or free access to water for dairy animals could be helpful in increasing gross margins via increased milk productivity.

Coefficient of hired labour is positive and significant in the case of adopters, implying that exotic breed needs extra care. Access to livestock extension services from various agencies has a significant positive effect on the gross margins of both the adopters and non-adopters. Farmers, who have access to livestock extension services, are more likely to obtain higher gross margins. This could be the positive impact of extension services on the adoption of better livestock management practices, as well as exotic breeds, as discussed previously.

Operational landholdings, which also includes rented in shared in land besides owned land, seems to have a positive and significant impact on the gross margins of both the adopters and non-adopters. This is perhaps due to better feeding practices with increased fodder cultivation on plenty of land.

Constraints related to Improved Breeding and Adoption of Exotic Breeds: To investigate reasons for low genetic potential at farms, farmers were asked to list the constraints toward the adoption of exotic breeds and improving their breeding practices. The results of this constraint analysis are presented as percent scores (Table 12). The average percent score of constraints faced by all farmers was 4.35. The constraints having a score of above 5 were designated as severe constraints, while the constraints which had a percent score above or equal to the average score, but below 5, were designated as moderate constraints.

Overall, there were 13 constraints faced by farmers in the severe and moderate category. Out of those 13 constraints, 6 were common across all three levels of farmer. The severe constraints reported by all farmers were the unavailability of pedigree bulls in their herds, high price of exotic breeds, the extra care required for exotic breeds, and the high nutrition/feed cost of exotic breeds. Apart from these constraints, the other severe constraints reported by small farmers were the high expenses to maintain pedigree bulls in their herds, and the high price of artificial insemination. However, the percent scores for these constraints on medium and large farmers were moderate. Large farmers also reported that they did not adopt exotic breeds because they were highly vulnerable to diseases, their drought tolerance was low, they involved high risk, and the price of milk was low which means that return on the expensive animals was not enough. These were reported as severe constraints. Most of these constraints were also reported by medium farmers. However, these constraints had moderate scores for small farmers.

The moderate level constraints reported by all farmers were the unavailability of pedigree bulls in the entire area, and the availability of exotic breeds. Farmers reported that they could not cross breed their animals with superior bulls because, these bulls were not available, even in the nearby villages, and one of the constraints in purchasing the exotic breeds of animals was the issue of their availability. Farmers reported that it was difficult to find a good animal because the markets were far away, and, in some cases, the owners were not willing to sell their animals.

Table 1. Socioeconomic Characteristics of Livestock Farmers.

General Information	Farm Category			
	Small	Medium	Large	Overall
Age (Years)	40.92	41.28	40.63	40.97
Livestock Farming Experience (Years)	23.43	23.38	23.46	23.42
Schooling (Years)	5.87	7.77	9.22	6.96
Family Size (No.)				
Adult Male	2.72	3.59	3.70	3.12
Adult Female	2.51	3.29	3.22	2.84
Children	2.33	2.76	3.10	2.58
Total	7.56	9.63	10.02	8.54
Family Type (%)				
Nuclear	42.5	18.3	15.0	75.8
Joint	4.2	5.8	13.3	23.3
Extended	0.00	0.8	0.00	0.8

Table 2. Number of Farms in the Sample.

Farm Category	Frequency	Percent
Small	190	55.9
Medium	90	26.5
Large	60	17.6
Total	340	100.0

Table 3. Buffaloes and Cattle Inventory.

Animals	Farm Category			Overall
	Small	Medium	Large	
Buffaloes				
Adult	0.98	2.91	5.62	2.31
Heifer	0.49	1.04	2.47	0.99
Bulls	0.04	0.14	0.47	0.14
Calves	0.62	1.79	3.18	1.38
Cattle				
Adult	0.83	1.80	4.78	1.78
Heifer	0.39	0.61	1.20	0.59
Bulls	0.19	0.67	0.38	0.35
Oxen	0.08	0.07	0.28	0.11
Calves	0.59	1.09	2.97	1.14

Table 4. Diversity of Buffalo Breeds at Livestock Farms.

Farmer Category	Buffalo Breeds (%)			Overall
	Nili Ravi	Kundi*	Non-descriptive/mixed	
Small	27	2	71	100
Medium	39	0	61	100
Large	36	0	64	100
Overall	34	1	65	100

*Kundi is not the common breed in study area but 2 kundi reported here was gift received by farmer.

**Based on adult animal.

Table 5. Diversity of Cattle Breeds at Livestock Farms (Percent).

Cattle Breed Type	Farm Category			Overall
	Small	Medium	Large	
Indigenous Breeds				
Sahiwal	26	25	26	25
Cholistani	1	3	2	2
Achai	0	0	1	0.33
Dhanni	1	3	0	2
Sahiwal x Cholistani	1	0	0	1
Non-descriptive	34	31	23	30
Total	65	62	52	61
Exotic Breeds				
Holstein-Friesian	9	13	27	15
Jersey	5	7	5	6
Total	14	20	31	20
Cross with Exotic Breeds				
Friesian x Sahiwal	14	16	14	14
Jersey x Sahiwal	7	3	2	4
Total	21	19	16	18

**Based on adult animals

Table 6. Source of Breeding Service (Percent).

Source	Farm Category			Total
	Small	Medium	Large	
		Buffaloes		
Artificial	27.68	35.44	22.64	29.10
Natural	72.32	64.56	77.36	70.90
		Cattle		
Artificial	84.44	77.61	87.50	83.10
Natural	15.56	22.39	12.50	16.90

Table 7. Variable Names, Definitions and Descriptive Statistics.

Variables Names	Definition of variables	Sample Mean	Standard Deviation
Dependent variables: Adoption of Exotic Breed and Gross Margins			
Explanatory variables			
Education	Years of schooling of the head of the household	5.89	4.54
HHSize	Number of members in a household	5.12	3.20
Labor	1 if farmer has hired permanent labor, 0 otherwise	0.76	0.44
WaterFreq	Number of times, water served to animals in a day	1.02	0.99
Extension	1 if livestock extension worker visits, 0 otherwise	0.83	0.43
OffIncome	Income from sources other than farming (Rs.)	65452.45	5214.21
OperatLand	Area of land used for cultivation (Acres)	12.98	11.92
Distance	Distance of HH from livestock market (Km)	0.66	0.79
Locational Dummies			
Sahiwal	1 if Sahiwal district, 0 otherwise	0.67	0.45
Sargodha	1 if Sargodha district, 0 otherwise	0.85	0.32

Source: Survey data

Table 8. Gross Margins per Animal (Rs.)

Average Cost per Animal	Small Farmers	Medium Farmers	Large Farmers	Overall
Fodder cost	25,724	22,718	23,368	24,513
Concentrate cost	24,297	20,959	22,860	23,160
Labor cost	1,185	3,548	4,756	2,441
Health care cost	2,973	2,481	2,453	2,751
Breeding cost	339	346	415	354
Total Variable cost	54,518	50,051	53,853	53,218
Average Value of Output per Milking Animal per Year (Rupees)				
Milk	50,445	54,955	52,439	51,991
Selling of animals	30,174	21,397	16,677	25,469
Byproduct Revenue	95	385	676	274
Total	80,714	76,737	69,791	77,734
Gross Margin	26,196	26,685	15,938	24,515

Table 9. Productivity of different Buffalo Breeds (Liters).

Farmer Category	Breed Type			Overall
	Nili Ravi	Kundi	Non-descriptive /Mixed	
Small	6.5	5.2	4.7	5.46
Medium	6.9	-	5	5.95
Large	7.8	-	5.2	6.5
Total	7.06	5.2	4.96	5.97

Table 10. Productivity of different Cattle Breeds (Liters).

Breed Type	Farm Category
Indigenous Breeds	
Sahiwal	18.23
Cholistani	11.79
Dhanni	6.67
Sahiwal x Cholistani	12.00
Non-descriptive	4.25
Average	10.59
Exotic Breeds	
Holstein-Friesian	30.14
Jersey	24.16
Average	27.15
Exotic Cross	
Friesian x Sahiwal	25.04
Jersey x Sahiwal	14.50
Average	19.77
Overall	20

Table 11. Full information maximum likelihood estimates of the endogenous switching regression.

Dependent variable: Adoption of Exotic Breed and Gross Margins		FIML Endogenous Switching Regression		
Variables	Description	Adoption Decision 1/0	Adoption=1 Adopters	Adoption=0 Non-adopters
Education	Years of schooling of HH head	0.033(0.01)**	999(442)	760(3081)
HHSIZE	No. of HH members	-0.007(.01)	-2573(3527)	-1768(2456)
Labor	1 if farmer has hired permanent labor, 0 otherwise	0.772(0.17)**	292993(65397)**	-204356(45554)**
WaterFreq	No. of times providing water to animals in a day	0.029(0.08)	11110(31437)	7606(21899)
Extension	1 if livestock extension worker visits, 0 otherwise	0.188(0.10)**	71734(36860)**	49517(25663)**
OffIncome	Income from sources other than farming (Rs.)	0.000(0.00)	0.06(0.05)	-0.04(0.04)
OperatLand	Acres of land used for cultivation	0.127(0.06)**	48382(21122)**	33832(14717)**
Sahiwal	1 if Sahiwal district, 0 otherwise	-0.036(0.13)	-13759(47503)	9958(33094)
Sargodha	1 if Sargodha district, 0 otherwise	-0.027(0.11)	-10057(41656)	7520(29016)
Distance	Distance of HH from livestock market (Km)	0.000(0.00)**		
Constant		0.022(0.22)	7454(84678)	-6251(58290)
σ_{ei}			379834(1.348)**	264576(0.909)**
ρ_j			0.380(0.234)	-0.840(0.306)

Note: Significance of t-statistics of mean difference is at the *10%, **5% and ***1% levels.

σ_{ei} denotes the square root of the variance of the error terms in the outcome equations, ρ_j denotes correlation coefficient b/w the error term of selection equation and error term of outcome equation.

Table 12. Constraints in Improved Breeding and Adoption of Exotic Breeds (percent score).

Constraints	Farm Category			Overall
	Small	Medium	Large	
Severe Constraints				
Unavailability of pedigree bulls in the herds	5.06	5.16	5.02	5.08

Pedigree bulls are expensive to maintain	5.01	-	-	-
High price of artificial insemination	5.04	-	-	-
High price of exotic breeds	5.17	5.38	5.04	5.20
High vulnerability of exotic breeds	-	-	5.16	-
Exotic breeds demand extra care	5.08	5.25	5.24	5.15
Low drought tolerance of exotic breeds	-	5.08	5.30	5.03
Exotic breeds involve high risk	-	5.01	5.04	-
High nutrition/feed cost of exotic breeds	5.05	5.04	5.06	5.05
Low price of milk--	-	-	5.04	-
Moderate constraints				
Unavailability of pedigree bulls in the whole area	4.72	4.76	4.94	4.77
Pedigree bulls are expensive to maintain	-	4.96	4.96	4.99
High price of cross breeding with pedigree bulls	4.37	4.36	-	4.35
High price of artificial insemination	-	4.96	4.85	4.99
High vulnerability of exotic breeds	4.92	4.96	-	4.97
Low drought tolerance of exotic breeds	4.92	-	-	-
Exotic breeds are not easily available	4.65	4.71	4.81	4.69
Exotic breeds involve high risk	4.94	-	-	4.98
Low price of milk	4.63	4.61	-	4.96
Livestock market does not exist	-	-	4.51	-

Conclusions and Policy Options: This study aims at identifying the key constraints in the improvement of genetic potential at farms and exploring the potential of traditional livestock sector in shifting toward a high productivity sector. For this purpose, data were collected from 340 livestock farmers from the Punjab, Pakistan.

Study shows that about 70 percent of the adult population of buffaloes is comprised of low genetic potential breed, and about 60 percent of the adult cattle population can be described as indigenous population. Most of the buffaloes are being bred by bulls, while artificial insemination is more prevalent for cattle. Given the present composition of livestock herds, small farmers earn higher gross margins on per animal basis. The empirical results of ESR showed that the education level of farmers, the availability of labor, livestock extension services, operational landholding, and distance from livestock market are the main factors that affect the farmers' decision to adopt an exotic breed of animal. Most of these factors also had a positive impact on the gross margins of adopters of exotic breeds. The severe constraints toward improved breeding/adoption of exotic breeds were the unavailability of pedigree bulls in their herds, the high price of exotic breeds, the extra care required for exotic breeds, and the high nutrition/feed cost of exotic breeds. The moderate level constraints in this regard were the high price of artificial insemination, high prices of cross breeding with pedigree bulls, scarce availability of exotic breeds, and low price of milk.

A solid policy action is required to eliminate the constraints facing this kind of productivity shift. Farmers do not have pedigree bulls of the superior indigenous breeds. Pedigree bulls on a cooperative level could be provided to improve genetic potential. New policy

reforms regarding artificial insemination could be introduced to control prices and ensure quality.

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