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Impact of Agricultural Extension Services on Technology Adoption and Crops Yield: Empirical Evidence from Pakistan

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Abstract

The present study was carried out in the rice-wheat area of Pakistani Punjab. The data for the study was collected from three main districts of central Punjab Province i.e. Gujranwala, Sheikhupura and Hafizabad. In total 234 farmers were interviewed. The impact of agricultural extension services was estimated on adoption of new improved technologies and crop yields. The propensity score matching approach for impact evaluation was employed in the current study to correct for potential sample selection biasedness that may arise due to systematic differences between the farmers having benefited from agricultural extension services and not benefited from agricultural extension services. The empirical results indicate that agricultural extension services play a significant role in adoption of improved agricultural technologies like laser leveling, rice and wheat varieties. The farmers having benefitted from agricultural extension services were also getting higher rice and wheat yields. The results also indicates that mostly the large farmers are getting benefits from agricultural extension services and small scale farmers have less access to agricultural extension services.

Keywords: Agricultural extension, technology adoption, propensity score matching, Punjab, Pakistan

Introduction

Agricultural extension is a mode by which the latest information is communicated to the farming community. The effective extension services can help in the adoption of new agricultural technologies which can leads to higher crop yields and more household incomes (Khan *et al*., 2006).In addition the agricultural extension services can help in reducing poverty levels and ensure household food security especially among small and resource poor farmers.

In Pakistan since independence the extension work has been in progress but this is fact that in developing countries the farmers do not have access to sufficient agricultural information (Luqman *et al*., 2005). The extension agents have mostly contact with large farmers and small and marginalized farmers normally receive less information (Sofranko *et al*., 1988). However some researchers argue that this is due to fact that large farmers are more educated and have clear understanding

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regarding adoption of new innovative techniques (Owens *et al*., 2003).

In Pakistan the agricultural extension services can help the meet the food needs of increasing population. The purpose of the agricultural extension services are to support farmers in the good decision making regarding adoption of new agricultural technologies and also regarding adoption of improved management practices (Subedi and Garforth, 1996).

The past researchers have mostly found that agricultural extension services were not quite adequate to educate the farmers effectively i.e. Rogers 1987; Prinsley *et al*., 1994. A recent study revealed that three fourth of the Asian farmers have no contact with the agricultural extension services (Maalouf *et al*., 1991). A number of reasons can be advocated for the poor agricultural extension services like few financial resource, lack of trained staff, inadequate planning etc. (Antholt, 1994). Mostly public extension services have consistently failed to deal with the site-specific needs and problems of the farmers (Ahmad, 1999). The same is true in the case of Pakistan (Ahmad *et al*., 2000; Sofranko *et al*., 1988).

The objective of the current paper is to study the impact of agricultural extension services on adoption of new agricultural technology like laser leveling and rice and wheat varieties and also on the rice and wheat crops yield. Information regarding new technologies i.e. laser leveling, rice and wheat varieties and rice and wheat yields was collected from both categories of farmers having benefitted from agricultural extension services and not benefitted from agricultural extension services. The rest of the paper is organized as follows. In section 2 conceptual framework and empirical model is presented. In section 3 data and description of variables are described. In section 4 empirical results are discussed and paper finally concludes with some policy recommendations.

Conceptual framework

In the current study it is assumed that farmers contact with extension agents for acquiring advice and information regarding adoption of new technologies and crop production technology etc. The information farmers acquire from the extension agents helps them in increasing crop yields which in turn can results in increased household income and reduced poverty levels. Hence, farmers get information from the extension agents to have higher utility levels. The farmers' utility function can be stated in the simple form as follows:

$$U = U(\Omega, \Psi, X, \Phi) \quad \text{.............} \quad (1)$$

In the above equation *U* indicates the utility function, while Ω indicates the visit of the extension agents to the farmers and value of Ω is 0 in case of no extension staff visit and value increases as the frequency of visits increases, Ψ indicates the wealth status of the household like number of acres owned by the farmer, X indicates the farmers personal characteristics and Φ indicates a binary relationship 1 if farmer himself visit extension office and 0 otherwise.

It is assumed that farmers utility level is affected if there is problem in either way contact i.e. either extension staff do not visit the farmer or farmer himself do not visit the extension staff. Based on this farmer utility level can be quantified as follows:

The farmers' utility level is maximum when the extension staff visit the farmers and farmer also visit the extension staff as presented in equation 2.

$$U_{\max} = U(\Omega, \Psi, X, \Phi) \quad \text{...........} \quad (2)$$

The utility level is medium when one of the contact levels are missing i.e. either extension staff don't visit the farmer as presented in equation 3 or farmer don't visit the extension staff as presented in equation 4.

$$U_{med} = U(\Psi, X, \Phi) \quad .... \quad (3)$$

$$U_{med} = U(\Omega, \Psi, X) \quad .... \quad (4)$$

The farmers utility level is minimum when both the contacts are missing i.e. extension staff do not visit the farmer and farmers also do not visit the extension staff as represented in equation 5.

$$U_{\min} = U(\Psi, X) \quad .... \quad (5)$$

The empirical analysis was carried out by employing the propensity score matching approach to correct for potential sample selection biasedness that may arise due to systematic differences between the participants and non participants.

Propensity Score Matching Approach

The propensity score matching is new technique as defined by Rosenbaum and Rubin (1983) as the conditional probability of receiving a treatment given pre-treatment characteristics:

$$p(Z) \equiv \Pr\{D = 1 \mid Z\} = E\{D \mid Z\} \quad (6)$$

Where D={0,1} is the indicator of exposure to treatment and Z is the vector of pre-treatment characteristics. If the exposure to treatment is random within cells defined by Z, it is also random within cells defined by the values of the mono-dimensional variable p (Z). As a result, given a population of units denoted by *i*, if the propensity score $p(Z_i)$ is known the Average effect of Treatment on the Treated (ATT), which is most prominent evaluation parameter and explicitly focuses on the effects on those for whom the programme is actually intended and can be given as

$$\begin{aligned}\tau &\equiv E\{Y_{1i} - Y_{0i} \mid D_i = 1\} \\ &= E\{E\{Y_{1i} - Y_{0i} \mid D_i = 1, p(Z_i)\}\} \\ &= E\{E\{Y_{1i} \mid D_i = 1, p(Z_i)\} - E\{Y_{0i} \mid \\ &D_i = 0, p(Z_i)\} \mid D_i = 1\}\end{aligned}$$

(7)

where the outer expectation is over the distribution of $(p(Z_i) \mid D_i = 1)$ and Y_{1i} and Y_{0i} are the potential outcomes in the two counterfactual situations of treatment and non treatment respectively.

The expected outcome of the average treatment effect for the treated are defined as the difference in the expected outcome values with and without treatment.

As pointed out by Heckman (1997) that the average treatment effect for the treated (ATT) may not be of relevance for the policy makers because it includes the effect on persons for whom the programme was never intended. For example, if a programme is specifically targeted at individuals with low family income, there is little interest in the effect of such a programme for a millionaire.

The propensity score matching rest on two assumptions i.e. unconfoundedness assumption and common support condition. The unconfoundedness assumption states that once the observable factors are controlled for technology adoption is random and uncorrelated with the outcome variables and the common support assumption states that matching can only be performed over the common support region.

Data and description of variables

A detailed questionnaire was developed for data collection in rice-wheat area of Pakistani Punjab. The relevance of questionnaire with field level situation was observed and some deficiencies were identified. The questionnaire was finalized after incorporating the comments. For impact assessment relevant socio-economic, human, natural resource/ biological and institutional indicators were included in the study. A detailed survey was carried out during the month of December 2004 to determine the impact of different labour categories on rice-wheat crops yield and household income.

The data and description of variables is presented in table 1. The data was collected from 3 important districts of rice wheat area like Gujranwala, Sheikhupura and Hafizabad. About 46 percent farmers were interviewed from Gujranwala district, 22 percent were interviewed from Sheikhupura district and 32 percent were interviewed from Hafizabad district. In total 234 farmers were interviewed. As the table 1 indicates only 27 percent farmers have benefited from agricultural extension services and vice versa.

Table 1: Data and description of variables

Variable	Description	Mean	Std. Dev
Extension Contact	1 if farmer have contact with extension services, 0 otherwise	0.273	0.442
District1 Gujranwala	1 if farmer belongs to Gujranwala district, 0 otherwise	0.457	0.499
District 2 Sheikhupura	1 if farmer belongs to Sheikhupura district, 0 otherwise	0.222	0.416
District 3 Hafizabad	1 if farmer belongs to Hafizabad district, 0 otherwise	0.320	0.474
Market distance	Distance of market in kilometers	6.897	5.417
Bank distance	Distance of bank in kilometers	28.94	33.34
Road distance	Distance of road in kilometers	1.786	5.797
Age	Age of farmer in number of years	44.918	14.604
Experience	Experience of farmer in number of years	24.008	13.408
Education	Education of farmer in number of years	6.171	4.895
Caste	1 if farmer belongs to scheduled caste, 0 otherwise	0.418	0.494
Settler	1 if farmer is settler, 0 if migrant	0.598	0.491
Family size	Total number of family members in the household	6.568	4.340
Refrigerator	1 if household owns a refrigerator, 0 otherwise	0.482	0.500
Tractor	1 if household owns a tractor, 0 otherwise	0.358	0.506
Bicycle	1 if household owns a bicycle, 0 otherwise	0.615	0.487
Motorcycle	1 if household owns a motorcycle, 0 otherwise	0.299	0.458
Zt drill	1 if household owns a Zt drill, 0 otherwise	0.081	0.273
Car	1 if household owns a car, 0 otherwise	0.085	0.280
Tube well	1 if household owns a tube well, 0 otherwise	0.282	0.478
Radio	1 if household owns a radio, 0 otherwise	0.299	0.458
TV	1 if household owns a TV, 0 otherwise	0.619	0.486
Washing machine	1 if household owns a washing machine, 0 otherwise	0.581	0.494
Credit (dummy)	1 if household have access to credit facility, 0 otherwise	0.764	0.434

Rice area (acres)	Area under rice in acres	18.36	25.205
Rice yield (maunds)	Yield of rice in maunds	32.00	7.942
Rice price (rupees)	Price of rice in rupees	465.62	97.858
Wheat area (acres)	Area under wheat in acres	15.925	24.631
Wheat yield (maunds)	Yield of wheat in maunds	27.384	12.60
Wheat price (rupees)	Price of wheat in rupees	310.72	107.41
Income	Income from nonfarm labour in rupees	18888	47491

Source: Authors' own calculations

The mean distance to the market was about 7 kilometres from the household. The mean distance to the bank was about 29 kilometres. The mean road distance was about 2 kilometres. The mean age of the farmers was about 45 year and the mean experience was about 24 years. The mean education level was about 6 years of schooling. As the caste system is also quite strong in the study area and information about caste was also collected. Approximately 42 percent of the farmers belonged to scheduled caste and the rest belonged to non-scheduled caste. About 60 percent of the farmers were settlers and the rest were migrant. The average family size was about 7 persons per household. Information regarding a number of household assets was also collected. About 48 percent of the households have own refrigerator and 36 percent of the households have own tractor. About 62 percent of the households have own bicycle. The 30 percent of the households have own motorcycle. Only 8 percent of the households have own zero tillage drill. About 9 percent of the households have own car. About 28 percent of the households have own tube well. About 30 percent of the households have own radio. Similarly 62 percent of the households have own TV. About 58 percent of the households have own washing machine.

About 76 percent of the households have availed credit facility. The area under rice was about 18 acres and average rice yield was 32 maunds[i]. The mean rice price was 465 rupees. The area under wheat was about 16 acres per households. The average wheat yield was 27 maunds per household. The average wheat price was rupees 310. The average household income was about rupees 18888.

Empirical results

The empirical results regarding determinants of farmers contact with agricultural extension services are presented in table 2. The dependent variable is dummy i.e. 1 if farmer have benefitted from extension services and 0 otherwise. The road access coefficient is positive and significant at 1 percent level of significance, indicating that more the road access, more the chances that farmers will be benefitted from extension services and vice versa. The age coefficient is positive, although non-significant indicating that mostly the experienced farmers are benefited from agricultural extension services. The caste system is also quite strong in the study area, the caste was included as dummy variable, 1 if farmer belonged to a scheduled caste and 0 otherwise. The caste coefficient indicates that scheduled caste farmers are more benefitted from extension services and vice versa. The education coefficient is positive and significant at 1 percent level of significance indicating that more the education levels of the farmers more are the chances that farmers will be benefited from extension services and vice versa. The family size coefficient is negative and non-significant. The land holding coefficient is positive and significant at 1 percent level of significance indicating that more the land holding more the chances that farmers will be benefitted from extension services. From this finding this can also be interpreted that extension personnel mostly visit the large land holders. A number of household assets were also included in the model. The bicycle ownership is positive and significant at 10 percent level of significance. The TV ownership is positive and significant at 1 percent level of significance. The tube well ownership is positive and significant at 1 percent level of significance. The tractor ownership is positive and non-significant. The car ownership is negative and non-significant. The radio ownership is positive and non-significant. The credit ownership is negative and non-significant. The district dummies were also included in the model to capture the regional variation. The value of pseudo R^2 is 0.300 indicating that 30 percent variation in the dependent variable is due to independent variables. The *LR* χ^2 is significant at 1 percent level of significance, indicating the robustness of the variables included in the model.

Table 2: Propensity score matching estimates (Probit estimates)

Variable	Coefficient	t-values
Road access	0.403***	3.10
Age	0.0243	1.47
Caste	0.322	1.18
Education	0.073***	2.47
Family size	-0.0002	-0.01
Organization membership	0.436	1.48
Landholding	0.016**	2.17
Bicycle	0.468*	1.85
TV	0.032***	2.94
Tube well	0.541***	1.99
Tractor	0.260	1.32
Car	-0.314	-0.67
Radio	0.063	0.25
Credit	-0.051	-0.18
District dummies		
Gujranwala	-1.167***	-3.38
Sheikhupura	-0.706	-1.63
Constant	-1.186	-0.86
Number of Observations	234	
Pseudo R^2	0.300	
LR χ^2	82.41	
Prob> χ^2	0.000	

Note: The results are significantly different from zero at ***, **, * at 1, 5 and 10% levels respectively.

The propensity score matching results for average treatment affect for the treated (ATT) are presented in table 3. A large number of different matching algorithms were employed for the empirical analysis i.e. Nearest Neighbour Matching (NNM), Mahalanobis Metric Matching (MMM), Radius Matching (RM) and Kernel Matching (KM) were employed in the current analysis[ii]. The outcome variables are new technologies like laser leveling, wheat and rice varieties and yields of rice and wheat crops. The laser leveler is a new technology introduced in the rice-wheat area of Pakistani Punjab. The laser leveler helps to improve the soil texture, structure and aeration of soil. In addition laser leveler also helps in water saving as the soil structure is improved. The rice and wheat varieties are the improved varieties adopted by the farmers.

Table 3: ATT results for adoption of new technologies and rice and wheat crops yield

Category	Matching Algorithms	Outcome	ATT	t-value	Caliper Critical level of hidden bias	Number of treated	Number of Control
Adoption of New Technologies							
	NNM	Laser Leveler	1.32***	3.15	1.25-1.30	80	144
	MMM	Laser Leveler	1.45***	2.79	1.15-1.20	72	136
	RM	Laser Leveler	1.02***	2.80	1.45-1.50	65	133
	KM	Laser Leveler	1.61***	2.42	1.05-1.10	63	149
	NNM	Wheat Varieties	-0.67	-1.41	_	67	110
	MMM	Wheat Varieties	0.32	0.86	_	77	125
	RM	Wheat Varieties	0.82	1.37	_	61	122
	KM	Wheat Varieties	-0.49	-1.21	_	40	132
	NNM	Rice Varieties	0.62	1.09	_	66	151
	MMM	Rice Varieties	0.58	1.03	_	52	140
	RM	Rice Varieties	0.85*	1.72	1.25-1.30	57	149
	KM	Rice Varieties	0.43	0.90	_	52	170
Impact on Crop Yields							
	NNM	Rice Yield	0.08	1.21	_	48	155
	MMM	Rice Yield	0.23*	1.86	1.50-1.55	31	146
	RM	Rice Yield	0.11	1.23	_	46	152
	KM	Rice Yield	0.18*	1.69	1.25-1.30	43	167
	NNM	Wheat Yield	0.25*	1.73	1.15-1.20	52	142
	MMM	Wheat Yield	0.34**	2.24	1.40-1.45	39	131
	RM	Wheat Yield	0.22*	1.91	1.35-1.40	45	166
	KM	Wheat Yield	0.16*	1.66	1.20-1.25	49	157

Note: NNM stands for Nearest Neighbour matching, MMM stands for Mahalanobis Metric Matching, RM stands for Radius Matching and KM stands for Kernel Matching while ATT stands for Average Treatment Affect for the Treated.

The impact of agricultural extension services on adoption of laser leveling technology is positive and significant at 1 percent level of significance in all the four matching algorithms i.e. NNM, MMM, RM and KM. The empirical results for adoption of improved wheat varieties are non-significant in all the four matching algorithms indicating that agricultural extension services needs to be improved regarding adoption of improved wheat varieties. The results regarding extension role in adoption of improved rice varieties are positive although significant only in case of RM. The impact of agricultural extension services on rice yield are positive, although significant only in case of MMM and KM. The extension services impact on wheat yields are positive and significant in all the four matching algorithms i.e. NNM, MMM, RM and KM. The overall empirical results indicate that farmers having contact with agricultural extension services are more likely to adopt new improved agricultural technologies.

The critical levels of hidden bias are also reported in table 3. The critical level of hidden bias are only reported for the significant results as the hidden bias for the non-significant results are meaningless. The critical level of hidden bias varies from lowest of 1.05 to a maximum of 1.50. The value of 1.50 indicates that farmers having extension contact and not having extension contact differs in their odds of technology adoption up to 50 percent level. The presence of hidden bias does not indicates that results are misleading, this only indicates the level up to which the farmers benefitting from extension services and not benefitting from extension services differs. The number of treated and number of control are also reported in the table.

In case of applying propensity score matching approach the main objective is to balance the covariates before and after matching and for that a large number of balancing tests are employed like value of R^2 before and after matching and the joint significance of covariates before and after matching. The critical level of hidden bias before and after matching. The results regarding covariates balancing are presented in table 4. The median absolute bias before matching is quite high in all the four different matching algorithms. Before matching the median absolute bias is in the range of 18.21-26.41. After matching the median absolute bias is quite low and is in the range of 7.30- 13.72. The percentage bias reduction is in the range of 40.06 percent to 70.46 percent hence indicating that after matching considerable amount of bias has been reduced. The value of R^2 is another indicator of covariate balancing. The value of R^2 is quite high before matching and is quite low after matching indicating that after matching the participants and non-participants are very similar to each other.

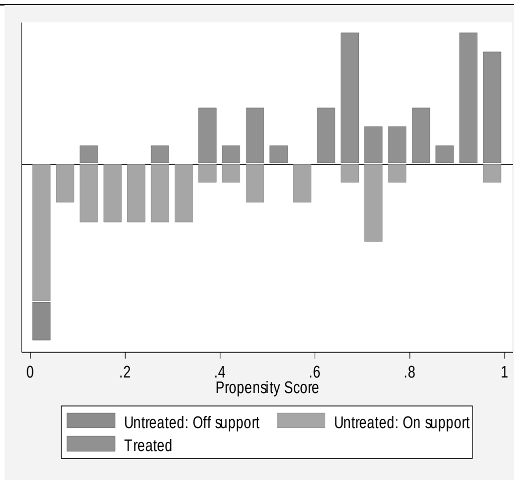
The p-value of joint significance of covariates is quite low before matching indicating that joint significance should always be accepted before matching. The p-value is quite high after matching indicating that joint significance should always be rejected after matching, that after matching the participants and non-participants are not systematically different from each other.

The results regarding indicators of covariates balancing before and after matching are also presented in figure 1. The figure indicates that covariates have been balanced and there are no systematic differences after matching and also highlights the importance of imposition of common support condition[iii].

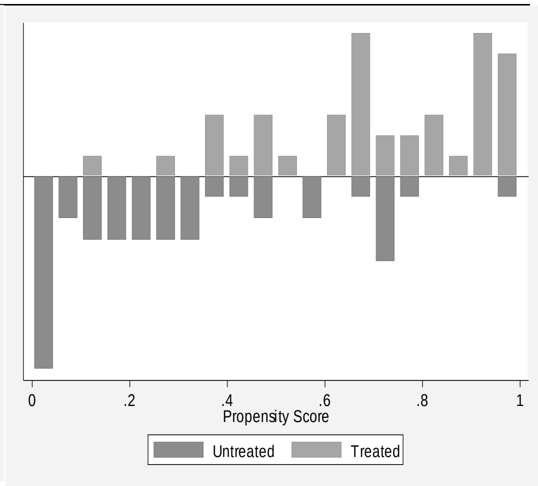
Table 4: Indicators of covariates balancing before and after matching

Matching Algorithm	Outcome	Median absolute bias before matching %	Median absolute bias after matching	% bias reduction	Value of R^2 before matching	Value of R^2 after matching	p-value of joint significance of covariates before matching	p-value of joint significance of covariates after matching
NNM	Laser Leveler	23.63	12.10	48.793	0.310	0.002	0.013	0.981
MMM	Laser Leveler	24.88	9.52	61.736	0.341	0.001	0.015	0.922
RM	Laser Leveler	19.22	7.39	61.550	0.372	0.000	0.011	0.864
KM	Laser Leveler	20.43	11.86	41.948	0.339	0.003	0.017	0.714
NNM	Wheat Varieties	22.54	13.51	40.062	0.412	0.004	0.018	0.651
MMM	Wheat Varieties	25.22	12.67	49.760	0.431	0.006	0.014	0.712
RM	Wheat Varieties	21.79	8.11	62.781	0.322	0.002	0.016	0.533
KM	Wheat Varieties	20.44	10.63	47.994	0.416	0.000	0.012	0.734
NNM	Rice Varieties	21.58	11.54	46.524	0.371	0.001	0.013	0.668
MMM	Rice Varieties	24.55	9.62	60.814	0.460	0.002	0.012	0.712
RM	Rice Varieties	26.41	13.72	48.049	0.381	0.000	0.011	0.910
KM	Rice Varieties	20.50	11.65	43.170	0.353	0.000	0.017	0.814
NNM	Rice Yield	23.92	12.85	46.279	0.442	0.000	0.015	0.477
MMM	Rice Yield	22.53	10.62	52.862	0.536	0.002	0.016	0.365
RM	Rice Yield	20.45	8.22	59.804	0.381	0.001	0.014	0.630
KM	Rice Yield	23.38	9.49	40.590	0.470	0.002	0.015	0.721
NNM	Wheat Yield	22.66	7.41	67.299	0.333	0.003	0.017	0.462
MMM	Wheat Yield	20.73	8.64	58.321	0.541	0.002	0.014	0.511
RM	Wheat Yield	24.72	7.30	70.469	0.462	0.001	0.015	0.422
KM	Wheat Yield	18.21	10.37	43.053	0.382	0.002	0.013	0.569

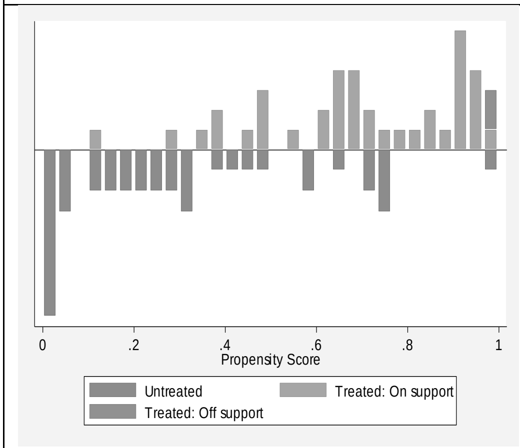
Note: NNM stands for Nearest Neighbour Macthing, MMM stands for Mahalanobis Metric Matching, RM stands for Radius Matching and KM stands for Kernel Matching.



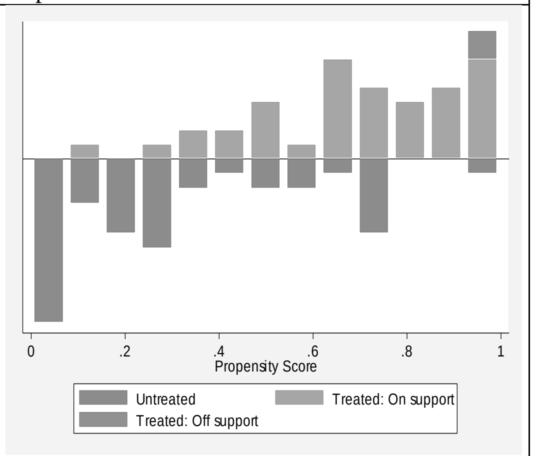
Impact on laser leveler



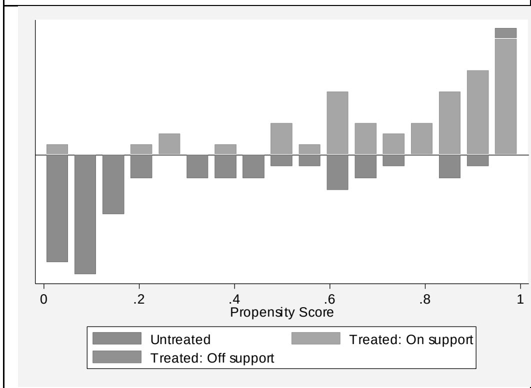
Impact on rice varieties



Impact on wheat varieties



Impact on rice yield



Impact on wheat yield

Figure 1: Indicator of covariates balancing before and after matching

Note: Treated on support indicates the individuals in the participation group who found a suitable match, while treated off support indicates the individual in the participation group who does not found a suitable matching. The untreated on support indicates the individuals in the control group who found a suitable match, while untreated off support indicates the individual in the participation group who were not able to found a suitable match.

Conclusion

The current study has important policy implications. From the empirical results it can be clearly concluded that agricultural extension services in Pakistan play an important role regarding laser leveling technology adoption. Laser leveling being new technology is very important regarding water saving and increasing soil texture and structure. This beneficial aspects of laser leveling technology need to be further explored in future studies. However, the agriculture extension role regarding adoption of improved varieties is not much encouraging especially the wheat varieties. In this particular area the extension services needs to be improved.

The most important and positive impact of agricultural extension services are on the yields of rice and wheat crops in Pakistan. Wheat is an important food crop while rice is an important cash crop in the study area. The increase in the yield of these crops directly can help in increasing the household income and reducing the much needed poverty levels in Pakistan. Overall the agricultural extension are playing important positive role but still a lot of improvement can be made. The probit estimates also indicates that mostly the large farmers currently benefited from agricultural extension services and the extension service to small farmers needs to be provided.

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Notes

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i. One maunds is equal to 40 kgs.
ii. Different matching algorithms were employed to check the robustness of the results.
iii. Matching can only be performed over the region of common support.