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Women Participation: A Productivity Strategy in Rice Production

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Abstract: Agriculture is an important engine for economic growth and a vigorous driver of poverty reduction in developing countries. In Pakistan, rice production is one of the most essential sectors. However, it has been underperforming, largely because of low women's participation, which is often a crucial resource in agriculture and the rural economy. Unfortunately, previous studies have seldom recognized and emphasized the role of women in triggering agricultural and rural development. We address this research gap using 300 farm households' survey data forms collected from Pakistan farmers by applying the stochastic frontier analysis. The results indicate that women's participation is associated with higher labor/land ratio, land productivity, and finally improved technical efficiency. Precisely, women's participation increased technical efficiency (TE) by 47.3%. Interestingly, in view of previous studies, this evidence is not sporadic. Overall, our study provides some evidence to promote women's participation in rice production, as such empowerment of women holds great potential to enhance agricultural production, which is consistent with the aim of sustainable development goals (SDGs).

Keywords: women's participation; technical efficiency; Pakistan; rice production; women empowerment

1. Introduction

Historically, worldwide, women in rural areas have played important roles and have made a remarkable contribution in rice farming [1,2]. In actual fact, their role in farming is influenced by several interrelated socioeconomic (including ethnicity, class, religion, and age), environmental, and political factors which are identified as “gender roles” [3,4]. For instance, traditionally, women have undertaken roles such as sowing, transplanting, weeding, and crop processing while males have been responsible for land preparation, ploughing, irrigation, and field leveling [5]. However, these roles change over time because they are dynamic [6]. Thus, in some cases, women's participation could be completely restricted or limited. Women's participation in farm households in Pakistan is a case in point.

The Food and Agriculture Organization (FAO) opine that women are the backbone of the rural economy in the developing world given the key role they play in contributing towards food security. Particularly, they are responsible for about 60% to 80% of food production in developing countries and are the main custodians of knowledge regarding crop varieties [7]. To support this, there is empirical evidence that women have a decisive role in ensuring food security and preserving local

agro-biodiversity [2,8]. Unfortunately, in Pakistan, their contribution is rarely considered and valued in development plans [9,10]. Consequently, they have limited access to productive resources (land, funding, new practices, technological advancements, market opportunities, and infrastructure) [11]. In fact, various social barriers and constraints stand in their way and this has significantly affected the number of women participating in agriculture within a household in Pakistan [12]. In rice production which is mostly labor intense, such a scenario is most likely to affect production and technical efficiency (maximum obtainable production output from a given set of inputs and existing production technology). This is true because the participation rate for women is 18.93%, however, women comprise 42% of the total family labor in Pakistan. In addition, a number of men are migrating to urban areas. Thus, women's labor fulfills the labor demand gap in rice production. Given that rural women are responsible for the use of diverse natural resources and integrated farm management to meet the daily household needs (family nutrition, food security and child care), their participation in rice production could be significant [13].

The reasoning is that rice production is mainly constrained by labor, while women's participation increases the labor supply of the family which facilitates the relaxation of the labor input within a family, in the sense, more female labor supply in the family means that males can work in off-farm sectors without deteriorating farm management, and therefore women's participation gives farmers more freedom to optimize the level of inputs, particularly the labor/land ratio, increase land productivity, and finally contribute to poverty and hunger reduction in Pakistan [14,15]. Otherwise, if females are not allowed to participate in agriculture and males find a part-time job in the off-farm sector, agriculture is not well managed. Therefore, we expect that families with women's participation in agriculture should have higher technical efficiency than those without any women's participation.

Rice is a strategic and major staple crop of Pakistan, which contributes 0.7 percent to the GDP [16]. It is the second major source of foreign exchange earnings and holds great potential to contribute towards food security, hunger reduction, and poverty alleviation [17]. However, production systems adopted in most parts of Pakistan are labor intense, and thus greatly affect productivity in food production [18]. In view of this, could women's participation in households influence technical efficiency?

While there is a dearth of information regarding women's participation in agriculture, few scholars have abstractly highlighted the roles that women play in agriculture in Pakistan. For instance Khan, Sajjad, Hameed, Khan, and Jan [12] investigated the role of women in agricultural activities in the Peshawar district and found that women were actively involved. In another study, Amir et al. [19] determined the involvement of rural women in agricultural activities and revealed that most activities were dominated by husbands with the remarkable contribution of wives. Lastly, in a more related study, Begum and Yasmeen [20] conducted research on the contribution of Pakistani women in agriculture with a focus on productivity and constraints. The conclusion was that Pakistan has to encourage the engagement of women in agriculture to satisfy the food demands of an increasing population, and at the same time remain competitive globally. However, one major weakness of these studies is that they fail to explicitly state and empirically provide evidence that women's participation influences productivity. In addition, the lack of crop focus makes their finding more general which is inconsistent with the principles of policy formulation.

Therefore, to begin filling this research gap, we examine whether women's participation influences technical efficiency and also probe the possible underlining mechanism. The results of the study, when fully utilized, could assist policymakers to prepare plans on how to boost women's participation, which could potentially trigger rural and agricultural development [21].

The present study contributes to the literature in the following ways: First, the study emphasizes the role of women's participation in rice production. As "women's" specialized labor is provided, it helps to augment rice production. Secondly, through acknowledgement of the association of technical efficiency and women's participation, the study intuitively puts forward the potential hidden talents of rural women and proposes their potential for proper harnessing to attain improved productivity.

The remainder of the paper is structured as follows: Section 2 presents the materials and methods, Section 3 provides the empirical results and discussion, and Section 4 closes with the conclusions and policy recommendations.

2. Materials and Methods

2.1. Data and Study Site

The study was conducted in two districts (Gujranwala and Shaikupura) of Punjab province in Pakistan from June to September 2019 and districts are highlighted in lower part of the Figure 1. The districts have a long history regarding rice production, as they are located in a province which is known and famous for massive rice production in the country [22]. Generally, the province hosts households that produce the best quality of rice such as basmati rice which has eventually contributed to the export earnings and GDP of Pakistan [22,23]. The climatic conditions in the region are ideal for agriculture and to a large extent influence the success of agriculture in the province.

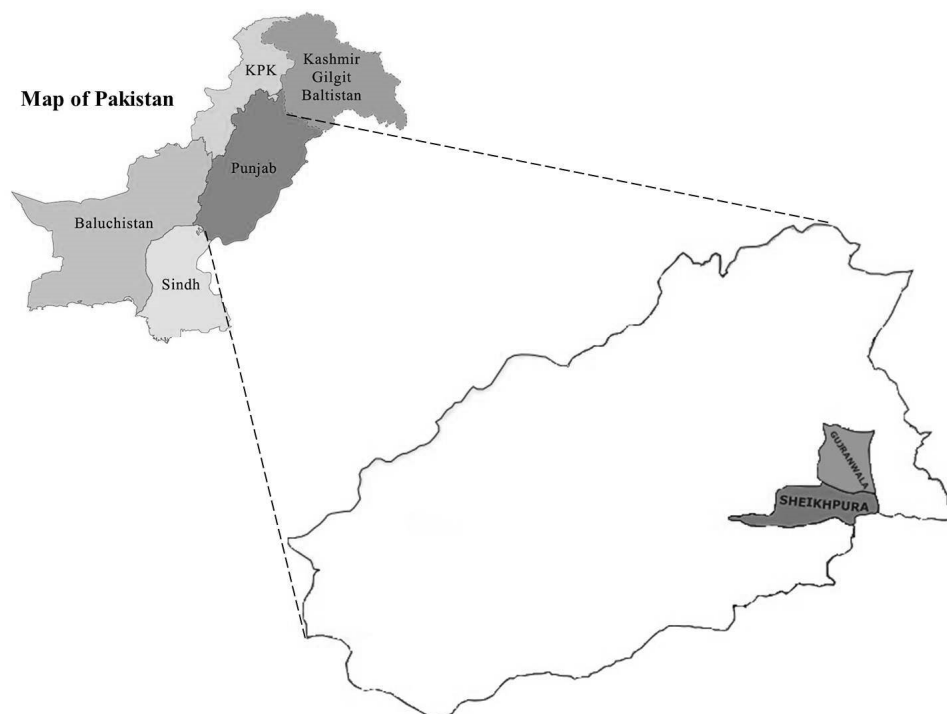


Figure 1. Map of the Pakistan showing study area in Punjab Province.

A multistage sampling procedure was employed to collect the cross-sectional data used in this study. A summary of the sampling approach is presented in Figure 2. First, the province was purposively selected and then a zone, Lahore (basically a rice zone within a rice producing region), was randomly chosen. Then, two districts were selected before randomly choosing two tehsils (subdivision of a district as specified by the government). Thereafter, union councils (which are subdivisions of tehsils from which villages are formed) were selected and a village from the union council was chosen. Finally, 25 rice farmers were randomly selected from each selected village using a list of farmers from the Ministry of Agriculture. Fortunately, all farmers consented to participate in the study.

A pretested and structured questionnaire was administered by well-trained enumerators. The instrument focused on input-output data and women's participation. Particularly, data on the number of hours spent in rice production per day, fertilizer, seed, land, pesticides and machine hours used were collected. In addition, socioeconomic, technical, and institutional data was also collected to enable smooth estimation of determinants of women's participation and technical inefficiency. Apart from administering the questionnaire and structured interview with key informants, focus group

discussions were also conducted. This form of triangulation helped in enriching the reliability of collected data [24,25]. Altogether, data from 300 farmers were collected (2 districts $\times$ 2 tehsils $\times$ 3 union councils $\times$ 1 village $\times$ 25 farmers).

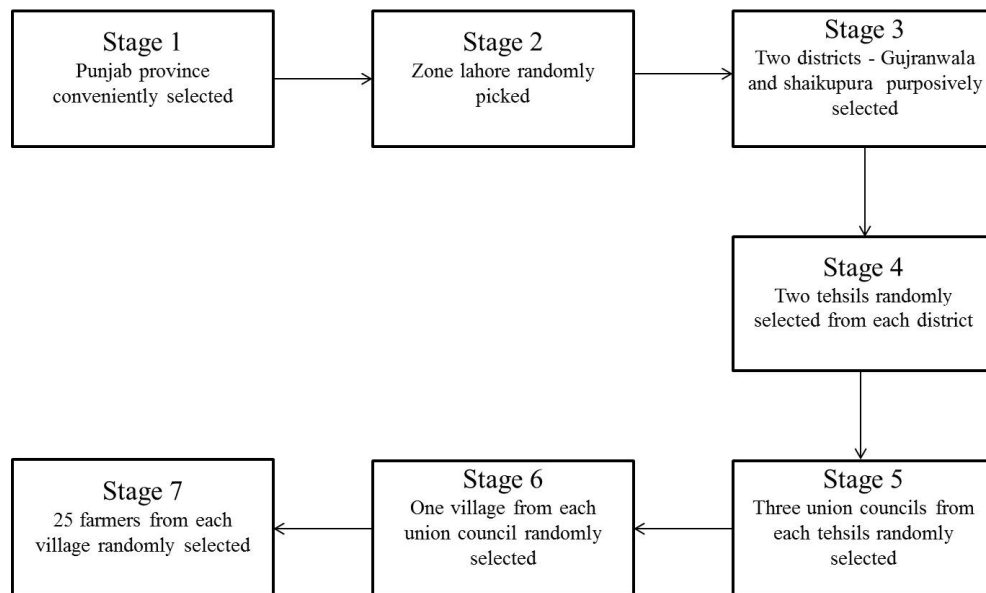


Figure 2. Multistage sampling procedure.

2.2. Measurement of Key Variables

Women's participation was our key explanatory variable. It was captured through a dummy. On the basis of the discourse by Khan, Sajjad, Hameed, Khan, and Jan [12] who reported, in Pakistan, that the contribution made by women in agriculture is determined by the percentage of time spent in performing the activities, we considered a household to have women's participation if at least one woman worked half a man day (which is 4 hours per day because a man day is 8 hours as indicated by Qadri and Jahan [26]) during the survey year. Accordingly, "1" represented a household with women's participation and "0" otherwise. In the interest of robust estimates, women's participation was also captured through the share of women's agricultural labor input (the percentage of labor hours from the total labor hours used in production).

The primary outcome variable was technical efficiency (TE) similar to the approach by Mwalupaso et al. [27]. The procedure for deriving the TE scores is well elaborated in the empirical strategy and analytical framework section. As specified by Battese and Coelli [28] and Koopmans [29], the TE scores range was zero to one.

2.3. Theoretical Underpinning and Conceptual Framework

The study is underpinned by two theories of cultural modernity, that is, the human development perspective and the production theory. In summary, through changes in existential constraints, the human development perspective at its core connects social modernization to emancipative values. In fact, the theory accentuates changes in contemporary societies, particularly, those favorable for women's empowerment. In this way, greater equality between genders is established through a link between cultural modernity and people because rising emancipative values often triggers increased women's empowerment in society [30,31]. This suggests that women would, then, participate in decision making and production in regard to agricultural development. In spite of the relative disadvantages regarding physical ability, the participation of women allows them to take responsibilities in a household which can influence agricultural production. In addition, considering that women seldom engage in off-farm employment, the empowerment of women who participate in agriculture

assures increased time spent on labor and intensifying cultivation [32]. Thus, the most likely outcome would be similar to the effect of labor force feminization which significantly improves the technical efficiency of grain production [33].

The second theory, the production theory, is more related to our study. This theory is concerned with deriving output from the conversion of inputs [34–36]. Fundamentally, the theory exhibits the link between input and output changes, and discloses that there is a maximum obtainable output from a fixed set of inputs under a given available technology [37–39].

With respect to these theories, we postulate that women’s participation in rice production is a form of women’s empowerment [40,41]. It also provides additional labor in essential farming activities and contributes essential skills [42] that could be pivotal for increasing rice productivity. However, women’s participation could be influenced by socioeconomic, institutional, and technical factors. For instance, a farming experience in a household could favor or hinder women’s participation and the same goes for religion and skills training. In the conceptual framework presented in Figure 3, women participating in rice production is viewed as an important input in production that is determined by various factors. Because Koopmans [29] proposed that determinants of production can be recognized, by means of the production function, the impact of women’s participation in rice production can be evaluated. Considering the significant roles that women play in agriculture, it is expected that the maximum rice output from a specified set of inputs can be obtained for households that adopt women’s participation. Ultimately, given that women’s participation implies increasing labor supply in the family and relaxing constraint of agricultural labor, farmers can find a more optimal set of inputs, and therefore we expect improved technical efficiency in rice production.

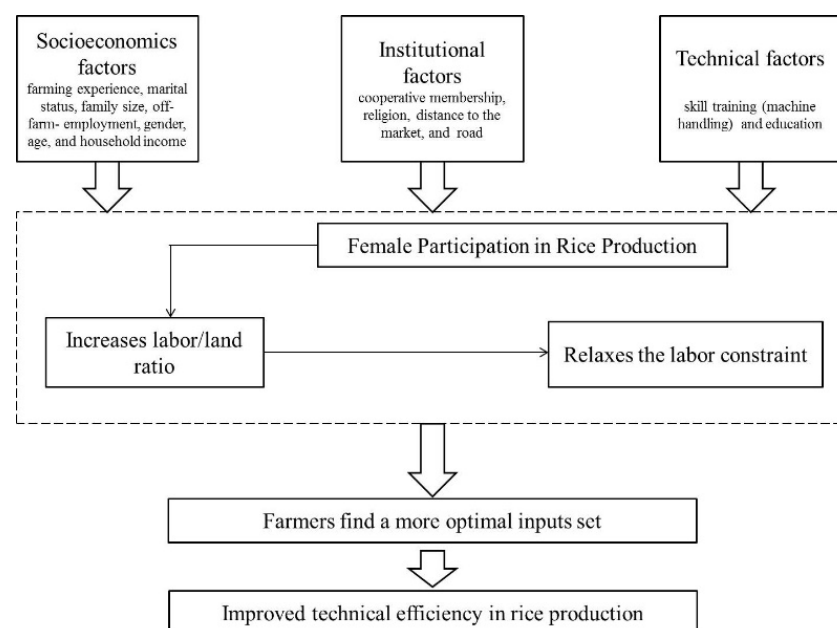


Figure 3. Conceptual framework.

2.4. Empirical Strategy

To adequately evaluate the association of women’s participation in farm households with technical efficiency, stochastic frontier analysis (SFA) was employed. In the interest of robust estimates, we imposed a region of common support through “one-to-one nearest neighbor matching without replacement” using propensity score matching (PSM). Because every household where women participate was matched with a household with nonparticipation, biases emanating from observed variables were mitigated [27,43].

2.4.1. Stochastic Frontier Analysis

For productivity analyses, various techniques are available [36,38]. In this study, the popular approach, technical efficiency (TE), was adopted. To do so, a one-step SFA was applied using maximum likelihood estimation (MLE) as proposed by Wang and Schmidt [44] and Kumbhakar and Lovell [45].

Formulated by Aigner, Lovell and Schmidt [37], the SFA is generally specified as:

$$Y_i = f(x_i, \beta) \exp(v_i) \exp(-u_i), \quad (1)$$

where Y_i is the output of the i -th farmer; x_i is a vector of the inputs; β is a vector of parameters to be estimated; and $V_i \sim N(0, \delta_v^2)$ and $U_i \sim N^+[f(\mu, \alpha), \delta_u^2]$ are the random error and the inefficiency term, respectively.

In this context, TE is specified as:

$$TE_i = \frac{y_i}{y_i^*} = \frac{f(x_i, \beta) \exp(v_i - u_i)}{f(x_i, \beta) \exp(v_i)} = \exp(-u_i) \quad (2)$$

where $y_i = f(x_i, \beta) \exp(v_i - u_i)$ is the observed production with inefficiency and $y_i^* = f(x_i, \beta) \exp(v_i)$ is the maximum output at given input set (perfect technical efficiency).

Following the above presented SFA framework, various production functions have been advanced [46]. Among various production functions, the translog production function and the Cobb–Douglas (CD) production function are widely used in the current literature [47–49]. In particular, the CD function is the first-order approximation of any unknown production function [50], and the translog production function is the second-order approximation of any unknown production function [51]. The CD function assumes the elasticity of substitution between inputs is constant, while the translog function is more flexible but has more unknown parameters to be estimated. Through application of the likelihood ratio (LR) test as guided by Belotti et al. [52], selection of the function which is well suited for the data is achieved by means of hypothesis testing. We conduct the model specification test by comparing the translog function and the Cobb–Douglas function using the formula in Equation (3). As the test is statistical insignificant (0.745), we cannot reject the null hypothesis, which indicates that the CD production function can represent the data well. The LR test general form is given as follows:

$$LR = -2[\ln\{L(H_A)\} - \ln\{L(H_0)\}] \quad (3)$$

where $L(H_0)$ and $L(H_A)$ are the values of the likelihood function under the null and alternative hypotheses, respectively.

Thus, in our case the test is in favor of the CD production function, which was, then, applied in the estimation:

$$\ln Y_i = \beta_0 + \beta_i \sum_{i=1}^4 \ln X_i + v_i - u_i, \quad (4)$$

$$u_i = \alpha_0 + \alpha_1 \text{female participation}_i + \sum \alpha_i d_i + z_i \quad (5)$$

where Y_i is the rice output; X_i is a vector of the four classical inputs (land, fertilizer, seeds, and labor); $\beta_0, \alpha_0, \alpha_1, \alpha_i$ and β_i are parameters to be estimated; d_i is a vector of other determinants (which includes characteristics of family (household income, member of cooperative, family size, size of cultivated land, distance from the market center and also from the main road) and household head (gender, farming experience, marital status, education, off-farm employment status, and age)) of technical inefficiency other than women's participation; u_i is a non-negative inefficiency component that follows a truncated-normal distribution; and v_i is a random error following a normal distribution for the production function; while z_i is a random error for the inefficiency model.

2.4.2. Towards Explaining Underlining Mechanism

Liu, Xu, Zheng, and Hua [32] explicitly contended that women's participation improved the land/labor ratio which culminated in augmented land productivity. Therefore, given that matching has been achieved by means of PSM as indicated above, we investigated whether land productivity and land/labor ratio were different between the households with women's participation and those without women's participation. Since the characteristics are comparable, the difference (average treatment effect on the treated (ATT)) in productivity and ratio is due to women's participation status of the household, and accordingly, in favor of households with women's participation, this suggests the pathway in which women's participation impacts on technical efficiency.

We also calculated how much rice production could be increased on average if a household with nonparticipation adopted women's participation in rice production. Then, we estimated the associated income growth and poverty reduction attributable to the production increase.

3. Empirical Results and Discussion

3.1. Descriptive Statistics

Table 1 presents summary statistics of households in the study area. We employed t-tests to ascertain the differences between the characteristics, which need to be addressed in further estimations. First, we observe significant differences in characteristics between households with and without women's participation. Particularly, the cultivated land, and the amount of fertilizer and seed used was more for nonparticipating households. Either this suggests that they have higher income (used as capital) or that they aim for higher production than their counterparts. On the one hand, the income difference was insignificant, but the rice output was in favor of households with women's participation. This finding hints the possibility of poor resource allocation in households without women's participation that is highly essential for improved technical efficiency [23,53].

On the other hand, family size, cooperative membership status, education and age of household head, off-farm employment, machine hours used, and distance to the road were significantly different between the two groups. It is not surprising that households without women's participation are more inclined to off-farm participation because they are more educated, have relatively larger households, and live further away from the main road. Usually, because most households are resource poor in most rural settings, off-farm employment is preferred which gravely affects farm management [54]. This explains why so much input is used yet the output is relatively inconsistent. In addition, despite higher households being members of cooperatives, generally, the subscription levels for both groups were low. On the basis of the premise that cooperatives are information machines for improved agricultural productivity [55,56], some potential to increase output on account of membership is not maximized in the households.

Regarding households with women's participation, the relative higher output is plausible considering that more machine hours are used during production. Considering that women's participation denotes additional labor, it is expected that fewer machine hours would be used because a machine is a substitute for labor. However, in Pakistan, the unconventional methods of rice production [22] are utilized which require more machine time for weeding. Thus, it is unlikely that even with additional labor, machine hours would be reduced. According to Hunt [57], machinery is an important factor for increased agricultural production as it greatly compliments the work of a farmer.

The differences in characteristics exposed between the two groups suggest that biases in estimation are expected if these differences are not addressed. Hence, matching was done, and bias was reduced, as can be seen from Figure 4. Clearly, before matching the difference is evident, but significantly minimal after matching.

Table 1. Summary statistics.

Variable	Description	Pooled N = 300	Women's Participation N = 168	Without Women's Participation N = 132
<i>Output</i>				
Rice output	Rice output in kg	21580 (700.75)	14404.76 (553.28)	30712.12 *** (955.92)
<i>Classical inputs</i>				
Land	Cultivated land for rice in acres	10.79 (0.35)	7.20 (0.28)	15.36 *** (0.44)
Fertilizer	Fertilizer used in kg	150.62 (1.40)	140.03 (1.29)	164.09 *** (2.24)
Labor	Labor hours used in production	672.84 (3.82)	667.50 (5.91)	679.64 (4.27)
Seeds	Rice seeds used in kg	96.54 (3.95)	51.40 (2.22)	154.00 *** (5.32)
<i>Explanatory Variable</i>				
Income	The household income per annum in Pakistani currency (PK.Rs)	17136.68 (1195.71)	16934.54 (1816.26)	17393.94 (1436.44)
Member of Cooperative	Membership of a household to a cooperative (1 if a member)	0.23 (0.02)	0.20 (0.03)	0.28 * (0.04)
Family Size	Number of members in a household	4.70 (0.10)	4.54 (0.13)	4.89 * (0.15)
Market Distance	The distance from the market in kilometers	23.93 (0.40)	23.68 (0.50)	24.24 (0.63)
Distance to road	The distance from the house to the main road in kilometers	22.95 (0.35)	22.39 (0.43)	23.67 * (0.58)
Gender	Sex of the household head (01 if women)	0.45 (0.03)	0.45 (0.04)	0.44 (0.04)
Farming Experience	Number of years of farming experience	18.62 (0.50)	18.79 (0.64)	18.40 (0.78)
Marital status	Marital status of household head (1 if married)	0.88 (0.02)	0.89 (0.02)	0.86 (0.03)
Education	Number of years of schooling for the household head	7.24 (0.18)	6.93 (0.24)	7.63 * (0.27)
Off-farm employment	Engagement of household in off-farm employment (1 if engaged in employment)	0.58 (0.03)	0.51 (0.04)	0.67 *** (0.04)
Age	Age of the household head	42.36 (0.55)	43.20 (0.74)	41.30 * (0.80)
Machine	Number of machine hours used	10.78 (0.01)	10.84 (0.01)	10.69 *** (0.02)

Note: Figures in parenthesis are standard errors of the means. *** $p < 0.01$ and * $p < 0.1$.

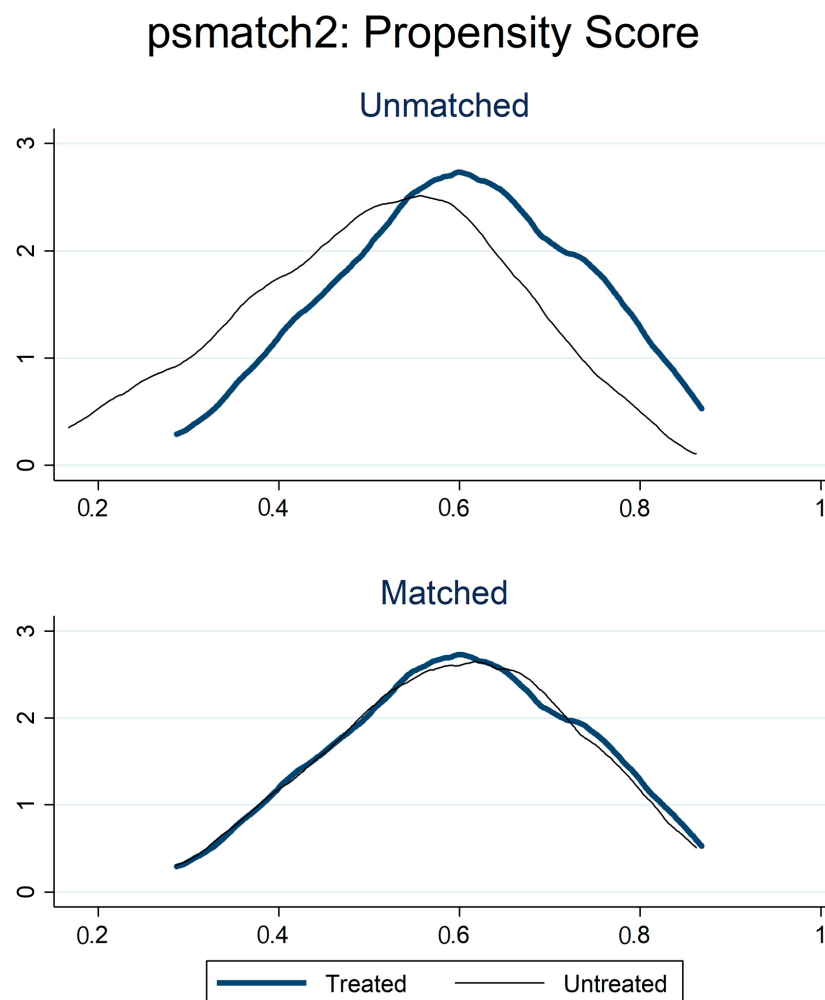


Figure 4. Density before and after matching.

3.2. Association between Women's Participation and Technical Efficiency

Consistent with the empirical strategy, the subsequent model (SFA) is based on a matched sample for robust and consistent estimates. This is essential as it controls the potential endogeneity that could exist on account of self-selection [58]. In addition, while it would have been ideal to estimate for each respective group for more specific policy implication, the estimations were not consistent with the rice production reality in Pakistan. Thus, by making the two groups comparable, we hold the view that, to a very large extent, the results presented hold important policy implications in their current form [27,43].

Table 2 presents the SFA estimations. The deterministic part is on the left-hand side while the inefficiency function is on the right. Among the classic inputs, labor and seed are significant and the former is the most important factor. This implies that an additional labor unit is more likely to increase output more than other inputs. However, this finding must not be generalized as it is unique to the study areas and specific areas with similar characteristics and also, the sum of the coefficients adds up to 0.982, and is not statistically different from 1, suggesting a constant return to scale.

The bottom part of Table 2, discloses that technical efficiency is worthy of discussion as the value of lambda is significantly greater than zero. This means that the variation in output between households is partly due to technical inefficiency [28]. In view of this, we find that women's participation, farming experience, marital status, and machine hours used are significant determinants of technical efficiency. Precisely, women's participation increased TE by 47.3%. Given the revelation by Khan, Sajjad, Hameed,

Khan, and Jan [12] that most women in participating families of Pakistan work along with men on the farm, this finding is plausible. Particularly, they perform almost all on-farm operations except ploughing in hilly areas, arid zones, and tribal belts [12]. Qadri and Jahan [26] also disclosed that women in participating households spend a substantial amount of time performing agricultural activities, i.e., about 39.34% to 50.42% per man day. Therefore, the positive impact of women's participation on technical efficiency is justified, households in which women participate are more efficient than those without participation. Since the rice production process involves decisions concerning daily management and factor allocation, the plausible explanation is that women's participation enhances everyday production processes, as well as operational control [32]. Even in instances where males assume non-agricultural employment, production could not be inconvenienced as additional labor (women) would still be available for rice production. Using the share of women's labor as a robust check, we found similar and consistent results (Appendix A Table A1), implying that changing the women's participation variable does not introduce any bias in the estimation.

Table 2. Stochastic frontier analysis (SFA) estimation.

Figure.		Inefficiency Model	
Classical Inputs	Coef (Std.Err)	Explanatory Variables	Coef (Std.Err)
Inlabor	0.469 * (0.248)	Women's participation	−0.473 * (0.278)
Inland	0.081 (0.128)	Member of cooperative	0.122 (0.327)
Inseed	0.238 *** (0.079)	Family size	−0.178 (0.115)
Infertilizer	0.194 (0.184)	Gender	−0.295 (0.276)
Constant	13.694 *** (1.652)	Farming experience	0.044 * (0.025)
		Marital status	−0.886 * (0.519)
		Education	−0.012 (0.050)
		Off-farm employment	−0.291 (0.261)
		Machine	1.926 ** (0.975)
		Constant	−19.301 * (10.577)
Model Diagnostics			
sigma_u	0.998 *** (0.207)	Log likelihood	−177.627
sigma_v	0.116 ** (0.055)	Mean	0.567
lambda	8.573 *** (0.180)	N	264

Note: Figures in parenthesis are standard errors of the coefficients. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Similarly, being married improves technical efficiency of households. According to Blundell et al. [59], the family is a remarkable labor source in rural agricultural communities. Thus, for most households, the use of additional family labor is rational as no wages are paid [60].

Contrary to our expectation, additional machine hours used positively influenced technical efficiency. Since machines ease the effort in the work to be done, this gives a farmer ample time to focus on other farming activities [57]. Although rice production is mostly labor intense, using the latest technology (which seems to be unconventional but is gaining ground) that makes use of tools and machines has been deemed “cleaner”, reducing waste and increasing efficiency [61]. Strikingly, the results are the opposite in our study area, suggesting that the machines are being used inappropriately or the absence of policy support measures.

Lastly, with more years of farming experience, there was increased technical inefficiency. This contradicts most findings [62,63] that have found that as years of experience increase the farm efficiency increase. In fact, Mwalupaso, Wang, Rahman, Alavo, and Tian [27] added that owing to the expected acquisition of dexterity that results from experience, it empowers farmers to make correct decisions and improve their efficiency. Therefore, this finding requires further investigation. However, chances are that the prevalent low cooperative subscription and greater interest in off-farm employment could be the underlining reasons for such an influence.

Regarding the distribution of the technical efficiency scores, it is evident from Figure 5 that households with women's participation generally have a higher mean than their counterparts.

Particularly, households with women's participation had a mean efficiency of 0.640 with a range of 0.040 to 0.956 while the other group's average and range were 0.495 and 0.084 to 0.937, respectively. Our finding is lower than that found by Bakhsh, Ahmad, Hassan, and Gill [63] which is attributable to the failure to address differences in characteristics among the farmers. Such procedure tends to exaggerate the findings [27]. From the average efficiency of the pooled sample, we find that there is potential to increase current output by 43.3% without altering the current level of inputs.

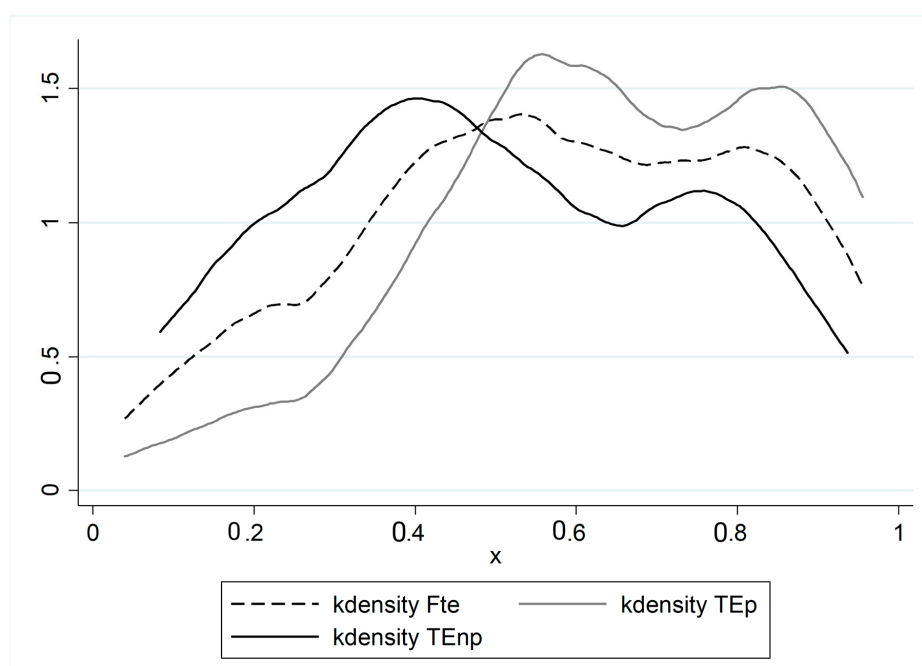


Figure 5. Kernel density distribution. Note: Fte is TE distribution for the pooled sample, TEp is for the sample where women participate, and TEnp is for the sample without participation.

3.3. Mechanism of the Impact of Women's Participation on TE

As established earlier, households with women's participation were associated with improvement in technical efficiency. In support of this, Table 3 presents additional evidence consistent with our hypothesis, i.e., women's participation relaxes the labor constraint because of the significantly higher labor/land ratio than their counterparts. Ultimately, productivity is boosted making the realized output quantity closer to the maximum obtainable quantity. Since matching has already been achieved, the difference (ATT) in mean for the two groups is attributable to women's participation alone. Therefore, evidently women's participation improves both labor/land ratio and productivity, culminating in augmented technical efficiency of rice farmers.

Table 3. Average treatment effect on the treated (ATT) estimates.

Item	Description	Mean		ATT
		Households with women's participation	Households without women's participation	
Land productivity	Rice output per acre in kg/acre	1535.61	814.39	721.21 *** (56.38)
labor/land ratio	Labor hours per acre	94.34	49.82	44.52 *** (3.28)

Notes: *** $p < 0.01$.

3.4. Implication for Policy and Practice

Given that women constitute more than 50% of the world population [20], their involvement in production and management activities could have serious implication for policy and practice, especially in terms of productivity. In addition, based on the fact that the contribution of women accounts for 66% of the total economically active manpower in agriculture in Pakistan, the findings in this study are highly essential.

Interestingly, our findings imply that households without women's participation have the potential to increase their technical efficiency by 47.3% without changing their input level of available technology. Accordingly, women's participation is fundamental to agricultural and rural development. It is a form of women's empowerment, and leads to improvement in the knowledge levels and experience. Thus, by assessing, acknowledging, and emphasizing the important role that women traditionally play in rice production, the practice is likely to improve. Since specific tasks done on farms by men and women could be separated in line with specialization, improved productivity is expected and this could recuperate dynamism in rice production in Pakistan. Therefore, this study answers one of the most important policy questions likely to improve rice production practice, that is, "Does women's participation improve technical efficiency?"

In addition, the difference in rice output per acre is about 721 kg (Table 3) which is worth 93,730 (721 kg $\times$ 130 Rs/kg) Pakistani rupee (Rs), culminating to 710 Rs (93,730/132 households without women's participation) per nonparticipating households. These estimates imply that if households without women's participation considered adoption, they would most likely increase their rice production by 721 kg and augment their household income by 710 Rs (4.29 USD/acre where 1 USD = 165.50 Rs) per household. Ultimately, in view of the poverty severity (relative to the 2 USD/day poverty line) and extreme poverty (1.25 USD/day poverty line), the projected income growth has higher propensity to contribute towards poverty eradication.

4. Conclusions

For a long time, women have been the pillars in rice production globally. However, in Pakistan, participation of women has been low because of social barriers and cultural constraints. The opportunity cost has been low rice productivity, as empirically found in this study which sought to investigate the association of women's participation and technical efficiency. This was not always considered in previous research and this has contributed to the existing limitation in literature, thereby failing to adequately inform policy.

Our results indicate that women's participation is associated with improved technical efficiency. Precisely, a difference in efficiency of about 47.3% is found in favor of households that have women's participation. This implies that these households produce rice output closer to the maximum obtainable than their counterparts. If policy is directed at promoting women's participation, this would culminate in enhancement rice productivity, as well as labor/land ratio which would facilitate technical efficiency improvements. In the long run, women's participation facilitates income growth which has the propensity to contribute towards poverty alleviation consistent with the first goal of SDGs.

Finally, despite the usefulness of the empirical evidence provided in this study, there are a number of limitations. First, use of cross-section data prevents the detection of the association of women's participation over time. Secondly, women's participation was not categorized into different levels of participation which limits the impact on policy formulation. Lastly, time did not permit data collection in a wider area for more inclusive findings. Therefore, to add more value to the subject of women's participation, future studies should take this into account. Overall, regardless of these limitations, the results are substantially important considering the dearth of literature on the contribution of women in agriculture.

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Appendix A

Table A1. SFA estimation using share of women's labor.

Frontier		Inefficiency Model	
Classical Inputs	Coef (Std.Err)	Explanatory Variables	Coef (Std.Err)
Inlabor	0.076 * (0.043)	Share of women's labor	−0.326 *** (0.052)
Inland	0.153 (0.106)	Farming experience	0.104 * (0.055)
Inseed	0.539 *** (0.126)	Marital status	−0.150 ** (0.062)
Infertilizer	0.226 (0.190)	Family size	−0.009 (0.017)
Constant	9.314 *** (2.652)	Member of cooperative	0.011 (0.018)
		Education	−0.040 (0.027)
		Off-farm employment	−0.092 (0.074)
		Gender	−0.157 (0.165)
		Machine	0.639 *** (0.070)
		Constant	−6.069 *** (1.531)
Model Diagnostics			
Log likelihood		−159.761	
Mean		0.597	
Lambda		0.639 *** (0.070)	
N		264	

Note: Figures in parenthesis are standard errors of the coefficients. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

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