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DOLIQUIDITY CONSTRAINTS INFLUENCE THE TECHNICAL EFFICIENCY OF WHEAT GROWERS? EVIDENCE FROM PUNJAB, PAKISTAN

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ABSTRACT

This article examined the influence of liquidity constraints on technical efficiency of wheat growers in Punjab province of Pakistan. We designed a theoretical model that identifies the possible reasons of liquidity constraints embodied by credit quantity rationing, transaction cost rationing and households risk reluctance behaviour. Primary data was collected from 518 wheat growers from five districts of Punjab. Based on direct elicitation method we categorized wheat growers into liquidity constrained wheat growers (LCWG) and liquidity unconstrained wheat growers (LUWG). We then, employed stochastic frontier analysis (SFA) approach to estimate the technical efficiency of wheat growers. The results indicate that mean technical efficiency difference between LCWG and LUWG was 9 percent. In the second stage of analysis, our inefficiency effects model disclosed that, technical efficiency of both groups of growers were influenced by education level, family size, sowing time, access to extension services, off-farm income and savings of the household head. In addition, credit size had significant positive effect, while interest rates on principal amount had significant negative effect on technical efficiency of both groups of growers.

Keywords: asymmetric information, risk rationing, non-price rationing, SFA, wheat, Pakistan.

INTRODUCTION

Ensuring adequate availability of financial resources, strong linkages between rural households and financial institutions are considered as substantial components of rural development strategy (Dicken, 2007; Zhao and Barry, 2014). Indeed, in recent years capital demands of farming communities are gaining more importance in response to growing farm needs, price risk and financial rationing in farming sector, while financial institutions are reluctant to finance because of alleged uncertainties (Arshad *et al.*, 2016). Therefore, most farmers have had to depend heavily on the private lenders or the meager savings they can generate from internal sources. The theory of production and finance suggests that if financially rationed farm households have improved access to credit, the production efficiency could be enhanced and agriculture sector would contribute substantially in developing economies. Thus, we empirically analyzed the nexus between liquidity constraints and technical efficiency considering the fact that technical efficiency affects farm household's ability to produce maximum output by using the optimal level of inputs.

The available analytical evidence (Feder *et al.*, 1990; Hassan and Ahmad, 2005; Alene and Hassan, 2006; Bashir *et al.*, 2010; Bashir and Mehmood, 2010; Islam *et al.*, 2011; Taubadel and Saldias, 2012among others) suggests that financial needs besides agglomeration of externalities could affect the performance of farm households in multiple ways and its negative repercussion ultimately influence the farm production. Meanwhile, rural financial markets in developing countries especially in Asia are characterized as highly fragmented and this apparent failure stems from the information asymmetry, conditional contracting impediments and problem of incentive compatibility, which in turn creates the limited outreach and operational sustainability of rural financial institutions (Blancard *et al.,* 2006). Though the global financial analysts are focusing on sustainable development agenda by introducing subsidized rural credit programs, the significant impact of their policies on farming communities have been limited so far (Meyer and Nagarajan, 2000).

Like other developing countries, the financial situation of the farm households and the financial market operations are somewhat similar in rural Pakistan. Majority of the farmers are insecure against idiosyncratic financial shocks and face extreme finance shortages. The recent proliferation in rural financial market of Pakistan indicates high imperfection that is often associated with information asymmetry, credit quantity rationing, control monitoring, ratios of non-performing portfolios (NPPs), and particularly the influence of private lenders etc., **[1]**. Additionally, the borrowers are systematically trapped into several types of legal and non-legal agreements based on their net-worth, size of loan, and the allied documentations for loan acquisition (Mehmood *et* *al.*,2012; Bashir and Azeem, 2010). Even in a single economy, greater diversity of agreements, stiff terms and conditions seem unjustifiable. Hence, these limitations have created rigorous lending environment for farm households and have adverse effects on production efficiency.

Pakistan's agricultural sector is a corner stone of the national economy with abundant rural labor capital. Wheat is a leading food crop that contributes up to10.3 percent in agricultural value addition and 2.2 percent into national GDP (GOP, 2016). In production terms, Pakistan is also placed at sixth position across the worldand contributes 3.5 percent into the world's wheat production (Zulfiqar and Hussain, 2014). Despite the remarkable contribution of wheat crop in national GDP, its production is declining each year (Khan, 2015). The yield of wheat crop is 32 percent of its potential, ranking the country on 59th position across the globe in terms of average yield per unit of land (Zulfiqar and Hussain, 2014). The SDPI (2003) documented that, 61 percent of the country's total population is lying below the food security line. The prevailing food insecurity situation may worsen in future due to rapid decline in agricultural production, financial constraints and price hike of agricultural inputs. To this end, it is imperative to reduce the demand-supply gap in efforts to lower the financial burden on farm households that could only be dealt with adequate policies and legislations.

Existing limited literature on credit constraints and technical efficiency conducted in Pakistan reveals various shortcomings. To date, few studies have mainly focused on external credit constraints embodied by financial institutions, while neglecting the influence of household internal credit constraints (Ayaz *et al.*, 2010). In addition, prior studies have overlooked the effect of off-farm earning, technological package and the role of multiple factors associated with the financial institutions (Akram *et al.*, 2013). Therefore, we addressed these gaps and analyzed the household technical efficiency considering internal and external liquidity constraints. Adhering to the methods utilized by Komicha and Ohlmer (2007); Cabrera *et al.* (2010) we employed inefficiency effects model to determine the effects of explanatory variables on technical efficiency. Our diagnostic research adds to spars in exiting literature and may have broader implications from the policy perspective. In addition, our work could provide appropriate guidelines to relevant policy discourse analysts and could persuade the financial institutions to offer their services in the targeted rural areas of our study. Considering the problem in hand we mainly addressed following two questions based on the primary dataset collected in 2016;

a) Do liquidity constraints influence the technical efficiency of wheat growers?

b) Does credit availability affect the technical efficiency of wheat growers?

The remainder of our paper is structured as follows: next section explains the use of direct elicitation method, possible reasons of liquidity constraints under non-price rationing mechanism and lays out the theoretical model to identify the liquidity constrained and unconstrained farm households [2]. Section 3, first illustrates the data collection procedure, followed by the discussion of how we used SFA approach and inefficiency effects model. In section 4, we present maximum likelihood estimates of production function and ranges of technical efficiency of both LUWG and LCWG at household level. Later, this section explains the determinants of technical efficiency of categorized groups of wheat growers. The final section draws conclusion and suggests important policy implications.

Empirical identification of liquidity constraints: The concept of credit constraints and its possible reasons (quantity rationing, transaction cost rationing and risk rationing), have enormously been debated by the economists (Boucher *et al.*,2008; Flestcher *et al.*, 2008; Leslie *et al.*, 2014). However, we considered the general concept of liquidity constraints and clarified liquidity constraints rather than credit constraints as a practical matter. The situation of liquidity constraints arises, when farm households do not have adequate amount of internal funds and productive assets, while lenders disburse insufficient loan amount for production inputs (even when borrowers are willing to pay incompatible interest rates) or reject applications. This particular situation arises in imperfect financial market or when there is failure in one of the market conditions as price mechanism flops to retain the market equilibrium. Further, our identification of liquidity constraint was under the mechanism of non-price rationing. Conversely, we hypothesized liquidity unconstrained farm households having enough cash and productive assets for the farm inputs and can easily fulfill the production requirements to attain optimal or higher level on the frontier.

Prior to our survey we designed a coherent theoretical model for clear identification of liquidity constrained and unconstrained farm households. The respondents were classified into two categories; the general respondents and the borrowers. In the first step, the general respondents were considered the ones who did or did not face the liquidity constraints. In the second step, those respondents who did not face liquidity constraints were excluded from the dataset (they had zero external loan demand), while those who faced liquidity constraints were proceeded further and classified into two categories: (i) respondents who entered into the financial market but their applications were rejected after considering several reasons, and (ii) those who did not enter into the financial market because of risk reluctance behavior or several other reasons (See figure 1). Previous studies (Flestcher *et al.*, 2008; Zhao *et al.*, 2014), categorized some particular situations such as transaction cost rationing and risk rationing occur because of non-interest monetary and household risk reluctance behavior. In a similar study by Boucher *et al.* (2008) reported on both cases of transaction and risk rationing being expensive for the households' business activities.

Likewise, we classified borrowers into two categories:(i) respondents who applied for loan and received adequate amount and, (ii) respondents who participated in credit programs but received insufficient amount (situation of quantity rationing), or received sufficient amount but diverted it to other purposes than agriculture. The situation of quantity rationing usually arises due to moral hazards or information asymmetries (Zhao and Barry, 2014), while the mis-utilization of agricultural loans in rural Pakistan is a common practice that results in liquidity constraint and loan delinquency. However, in our theoretical model we categorized this particular situation into liquidity constraint side.

In the final step, we identified three categories of liquidity constraints that are: applied but rejected, did not apply, and, applied and received insufficient amount or used the loan for other purposes. Conversely, the respondents who received sufficient loan amount and appropriately utilized it on farm activities were considered as liquidity unconstrained farm households. Similarly, considering the multiple manifestations of credit constraint the study by Zhao *et al.* (2014) in rural China, categorized the households into supply-side (financial institution side), and demand-side (households side) credit constraints under non-price rationing mechanism.

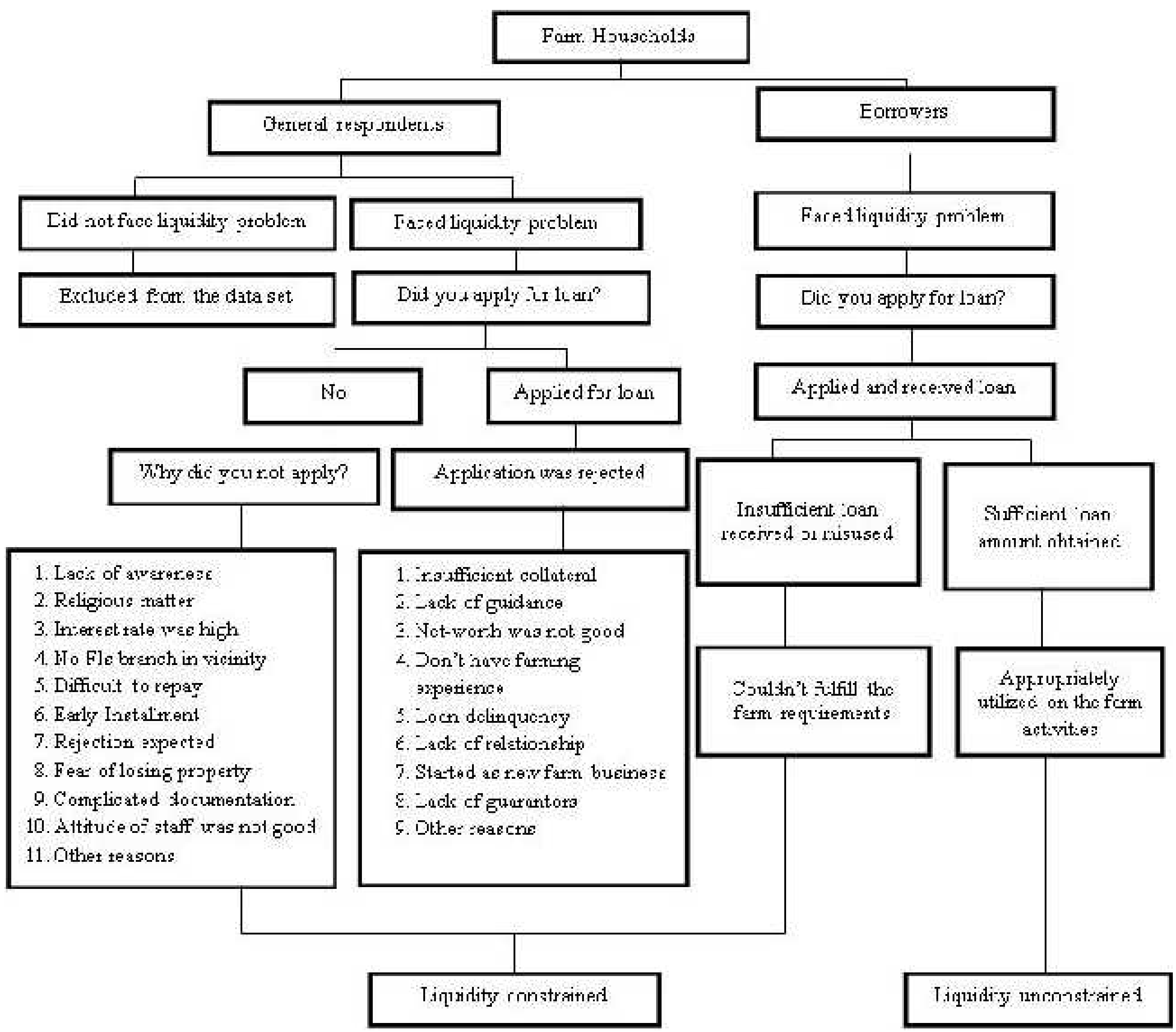

Figure 1.Theoretical model of liquidity constrained and unconstrained farm households.

MATERIALS AND METHODS

Survey design and data collection: This study was conducted in Punjab province of Pakistan, considering its big share of agriculture in the national GDP(approximately 60 percent). Furthermore, the selection of wheat crop in our study was based on two reasons: first, wheat is a leading food (grain) crop in Pakistan; second, wheat contributes 10.3 percent to the value added in agriculture (as stated above) and 2.2 percent in to national GDP (GOP, 2016). Simple random sampling technique was used in the five selected districts namely; Gujrat, Sheikhupura Faisalabad, Sahiwal, and Bahawalpur. Direct elicitation method was employed for data collection to ask the liquidity rationing status of farm households. The studies conducted by Barham *et al.* (1996); Gilligan *et al.* (2005); Flestcher *et al.* (2008)among others, acknowledge the reliability of this method in identifying the credit rationing status of the households.

Considering the multiple manifestations of liquidity constraints, we systematically categorized the respondents into liquidity constrained and liquidity unconstrained under mixed farming system of Punjab. The farm households, who had not applied for loan neither faced the problem of liquidity constraint, were excluded from the dataset because they had zero loan demand from external sources. Subsequently, in LUWG group we included those households who applied for loans, received sufficient amount and used for farm interventions. In order to target the respondents who availed cash finance facility [3], we obtained a list of borrowers from financial institutions. A total of 518 wheat growers were interviewed to collect the desired information. Finally, based on our theoretical model we identified 167 wheat growers as liquidity unconstrained and 351 as liquidity constrained.

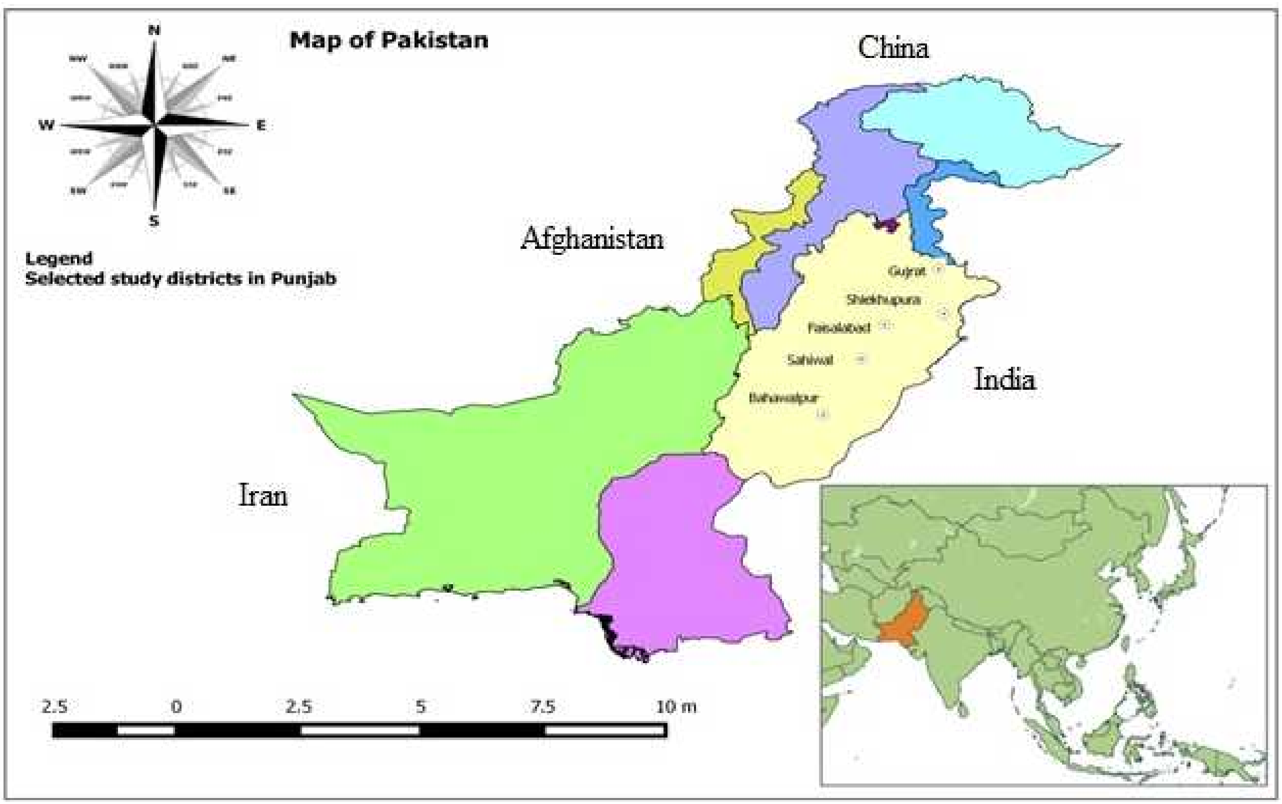

Figure 2: Selected study districts in Punjab, Pakistan

Data description: Empirically, we considered that technical efficiency of wheat growers is disaggregated into six inputs. The output variable y_i is considered as the total wheat yield for i^{th} wheat grower on acre-1basis(analysed in maunds i.e., 40 kilograms) [4]. Subsequently, the input variables: operating land$x_1$represents the total land area cultivated under wheat crop analysed in acres (1 hectare = 2.47acres);seed rate x_2 indicates the quantity of wheat seed used on acre-1(analysed in kilograms); family labourx_3 shows the average number (No.) of family labour (equivalent to adult male) in a cropping season; fertilizer application $x_4$represents the quantity of fertilizer that are, DAP (Di-ammonium phosphate), urea, potash etc., applied on acre-

^{1} (analysed in kilograms); plant protection measures x_5 indicates the total number of pesticides, weedicides, etc.,applicationin a cropping season (analysed in number);irrigation application x_6 represents the number of irrigation application in a cropping season (analysed in number). The descriptive statistics of output and all inputs variables used in the technical efficiency analysis are presented in table 1.

Table 1. Descriptive statistics of output and inputs variables used in SFA analysis

Variables	LUWG N (167)	LCWG N (351)	Full sample N (518)	t-ratios
Yield	41.760	38.208	39.353	6.564^{***}
(Maunds acre^{-1})	(5.162)	(7.401)	(6.957)	
Operating land	9.89	6.076	7.306	11.361^{***}
(Acres)	(5.01)	(4.207)	(4.822)	
Seed rate	44.509	42.102	42.878	2.902^{**}
(Kilograms acre^{-1})	(5.980)	(5.010)	(5.454)	
Family labour	2.167	2.313	2.266	-3.672^{***}
(Average no. of adultmale)	(0.997)	(0.964)	(0.976)	
Fertilizer application	195.14	162.69	173.15	10.564^{***}
(Kilograms acre^{-1})	(35.831)	(33.53)	(37.471)	
Plant protection measures	1.682	1.712	1.702	-0.373
(No. of application season^{-1})	(0.828)	(0.789)	(0.801)	
Irrigation application	5.958	5.849	5.884	0.660
(No. of application season^{-1})	(1.153)	(1.117)	(1.129)	

Notes: Standard deviations are given in parentheses.
Significant degree at $^{*}p < 0.10$, $^{**}p < 0.05$ and $^{***}p < 0.01$.

Table 2 summarizes the determinants of technical efficiency of wheat growers. The variable z_1 represents the age of the householdhead in years; z_2 shows education level of the household head (years of schooling); household size z_3 represents total family members of the household; z_4 is a dummy variable that represents certified seed (if used certified seed then 1, otherwise 0); z_5 is a dummy for sowing time (if timely sowed wheat seed then 1, otherwise 0);z_6 is a dummy for drill sowing (if seed planted with drill method then 1, otherwise 0);z_7 represents lined watercourse considered as dummy (if the watercourse near to the farm was lined then 1, otherwise 0); z_8 is a dummy for owned tube-well (if owned then 1, otherwise 0);z_9 is a dummy for extension services (if received extension services then 1, otherwise 0);z_1 is a dummy for livestock (if owned then 1, otherwise 0);z_1 is a dummy for off-farm income (if the farm household had off-farm earning then 1, otherwise 0); z_1 represents yearly savings of the household head (estimated in 1000 Pak rupees);z_1 shows interest rates charged on the principal amount (estimated in percentage)[5]; z_1 indicates the distance to nearest formal financial source (estimated in kilometer); z_1 is the size of loan (estimated in 1000 Pak rupees); z_1 is a dummy representing credit availability.

The inclusion of credit availability (dummy variable), might raise different questions because of its indirect effect on output and technical efficiency of the farm household. However, its inclusion in our analysis was due to the fact that: firstly, credit significantly affects the distribution of resources by overcoming the binding constraints of liquidity and to purchase the farm inputs more optimally; secondly, it helps farm households to acquire improved technologies, and thirdly, the availability of credit can be helpful for productive use of fixed inputs (Carter, 1989).

Table 2.Descriptive statistics of explanatory variables used in inefficiency effects model

Variables	LUWG N (167)	LCWG N (351)	Full sample N (518)	t-ratios
Age of household head (Years)	39.874 (9.544)	42.199 (10.248)	41.449 (10.076)	-4.146^{***}
Education of household head(Years)	7.371 (4.237)	5.715 (4.381)	6.249 (4.400)	2.692^{**}
Household family size (Numbers)	7.862 (3.207)	6.683 (2.651)	7.063 (2.892)	6.751^{***}
Certified seed (Yes=1)	0.467 (0.500)	0.356 (0.479)	0.391 (0.488)	1.084
Sowing time (Yes=1)	0.610 (0.489)	0.632 (0.482)	0.627 (0 .483)	0.404
Drill sowing (Yes=1)	0.269 (0.445)	0.196 (0.397)	0.220 (0.414)	1.673^{**}
Lined water course (Yes=1)	0.329 (0.471)	0.370 (0.483)	0.357 (0.479)	-0.419
Owned tube-well (Yes=1)	0.532 (0.500)	0.313 (0.464)	0.384 (0.486)	2.933^{**}
Extension services (Yes=1)	0.431 (0.496)	0.470 (0.499)	0.457 (0.498)	-1.850^{**}
Livestock holding (Yes=1)	0.377 (0.486)	0.219 (0.414)	0.270 (0.444)	3.365^{**}
Off-farm income (Yes=1)	0.215 (0.412)	0.145 (0.352)	0.168 (0.374)	1.676
Household savings (1000 Pak Rupees)	126.82 (537.23)	62.23 (264.5)	83.057 (375.43)	0.501
Interest rates (Percentage)	12.245 (1.705)	2.416 (5.294)	5.584 (6.407)	19.857^{***}
Distance to lenders (Kilometers)	10.497 (6.227)	12.115 (7.156)	11.593 (6.906)	-4.966^{***}
Credit size (1000 Pak Rupees)	704.185 (408.57)	166.581 (681.06)	339.90 (656.40)	5.369^{***}
Credit availability (Yes=1)	-	-	0.426 (0.495)	-

Notes: Standard deviations are given in parentheses.
Significant degree at $^{*}p< 0.10$, $^{**}p< 0.05$ and $^{***}p< 0.01$.

Econometric estimation:

Stochastic frontier analysis: In the first stage of analysis, we used stochastic frontier approach developed by Aigner *et al.* (1977), to estimate the technical efficiency of wheat growers. The approach is mainly based on the econometric specification of production frontier and has widely been adopted in technical efficiency studies (Tipi *et al.*, 2009; Cabrera *et al.*, 2010), among others. The general form of SFA model using primary dataset is given under:

$$y_i = f(x_i; \beta)\exp(v_i - u_i) \quad [1]$$

In equation [1], y_i symbolizes the observed output of i^{th} wheat grower, whereas x_i represents observed functionof inputs or explanatory variables, β is a set of technological parameters, while $f(x_i; \beta)$, indicates the production frontier of the model. The random variation in output is denoted by (v_i), that is, symmetric random error and considered to be independently distributed as $N(0, \sigma_v^2)$, while (u_i),is a set of variable (non-negative random) linked with the inefficiency of wheat growers in production having mean (u), variance σ_μ^2, (that is, $|\ N\ (u, \sigma_u^2|$), and considered to have a half-normal distribution (Kumbhakar and Lovell, 2000).The variance parameters of this model can be presented as $\sigma^2 = \sigma_v^2 + \sigma_\mu^2$; $\lambda = \sigma_\mu^2/\sigma^2$ and $0 \leq \lambda \leq 1$. Given the distributional assumptions of both variance (v_i) and (u_i) we derived the estimates of u_i, from its conditional expectation, by putting the standard integrals.

$$E(u_i|\varepsilon_i) = \mu_i^* + \sigma_i^* \left[\frac{\phi(-u_i/\sigma_{i,}^*)}{1-\Phi(-u_i/\sigma_{i,}^*)}\right] \text{...........} [2]$$

In equation [2], $u_i^* = (u\sigma_v^2 + \varepsilon_i\sigma_\mu^2)/(\sigma_v^2 + \sigma_\mu^2)$, $\sigma_v^{*2} \equiv \sigma_v^2\sigma_u^2/(\sigma_v^2 + \sigma_u^2)$ and Φ (.) and ϕ (.) indicate cumulative distribution and probability density functions. From equation [1], we obtained the values of both (v_i) and $(u_i)$by replacing the estimates of $\varepsilon_i\sigma_\varepsilon$ and l. That is,considered as output oriented technical efficiency (TE_i) of i^{th} wheat grower, given the level of inputs it can be defined as the ratio of observed output to maximum achievable output represented by $\exp(-v_i)$ explained as under:

$$TE_i = \frac{y_i}{f(x_i;\beta)e \quad (v_i)} \exp\{-(u_i|\varepsilon_i)\} \text{..........} [3]$$

$$TI_i = 1 - TE_i$$

The distribution of (u_i),in equation [3] limits the estimated technical efficiency of wheat grower in between 0 and 1. Therefore, the efficiency scores of different groups of wheat growers in our analysis were defined as $1 - \exp\{(-u_i|\varepsilon_i)\}$ and considered as a dependent variable while estimating inefficiency effects models (LUWG, LCWG and full sample). To estimate the technical efficiency of wheat growers the general form of SFA model is given under:

$$\ln Y_i = \beta_0 + \sum_{k=i}^{6} \beta_{il} \ln x_{il} + v_i - u_i \text{..........} [4]$$

Where y_i indicates the accumulated value of output of i^{th} wheat grower which were estimated in maunds and x_{ij} are the inputs variables, that are, operating land, seed rate, family labor, fertilizer application, plant protection measures and irrigation application (as mentioned above);the β_s are the coefficients of explanatory variables that have to be estimated and (v_i) and $(u_i)$are alreadyexplainedin equation [1].

Inefficiency effects model: Battese and Coelli (1995) further extended the work of Aigner *et al.* (1977) and introduced the concept of inefficiency effects of the households or the firms in stochastic frontier analysis. Therefore, in the second stage of our analysis, we used inefficiency effects model to estimate the effects of explanatory variables on technical efficiency of categorized groups of wheat growers. We employed inefficiency effects model using maximum likelihood estimation method.

$$IE_i = \delta Z_i + \eta_i \text{..........} [5]$$

In equation [5], IE_i indicates inefficiency scores, while Z_i is a vector of selected variables affecting inefficiency of the categorized groups of wheat growers and η_i is a random error term in dataset, that is supposedto be normally and independently be distributed with zero mean and variance σ_η^2 .

RESULTS AND DISCUSSION

Maximum likelihood estimates of production frontier: The results indicate that, the coefficients of operating land variables for both LUWG and LCWG were 0.023 and 0.076 respectively (See table 3). These numbers explain that, 1 percent increase in the unit of operating land results to an estimated increase in wheat yield of 0.02 percent for LUWG and 0.065 percent for LCWG. These findings are backed by an earlier study of Hassan and Ahmad (2005). The variables of seed rate showed highest input effect on production and the estimated elasticities were 0.500 for LUWG and 0.369 for LCWG. One possible explanation is that, in the surveyed areas most farmers were using good quality seed that significantly and positively affected wheat yield.The coefficient of the family labour for LCWG was estimated 0.034 and significant at 5 percent level. The values of the coefficients of fertilizer application for LUWG and LCWG were 0.099 and 0.115 respectively. The values of the coefficients for the plant protection measures variables for both LUWG and LCWG were 0.075 and 0.047 respectively. The coefficient of the irrigation application for LUWG was estimated as 0.050 and significant at 5 percent level, while the same coefficient was non-significant in case of LCWG.

However, the scale elasticity, that is, the sum of all output elasticities in our models, revealed the existence of decreasing returns to scale (DRS). In general terms, DRS explain that, for the sample of wheat growers, there was no proportional relationship between the farm inputs and the level of output produced. This finding could be because the farm households in the surveyed areas may not be able to spend more optimally or failed to adopt improved technology. Though we avoid overestimation by classifying the farm households as financially rationed or not but in all cases we analyzed DRS. A recent study by Sheng *et al.* (2015) suggested that, farm households efficiency can be enhanced by adoption of improved technologies and capacity building, rather than expanding their scale.

Table 3. Maximum likelihood estimates of production frontier.

Variables	LUWG N (167)	LCWG N (351)	Full Sample N (518)
Intercept	0.481	0.594	0.689
	(0.060)***	(0.080)***	(0.056)***
Ln Operating land	0.023	0.076	0.072
	(0.008)**	(0.009)***	(0.007)***
Ln Seed rate	0.500	0.369	0.431
	(0.043)***	(0 .055)**	(0.039)**
Ln Family labor	0.008	0.034	0.034
	(0.007)	(0.009)***	(0.009)**
Ln Fertilizer application	0.099	0.115	0.049
	(0.025)***	(0.034)**	(0.007)*
Ln Plant protection measures	0.075	0.047	0.042
	(0.013)**	(0.014)**	(0.009)***
Ln Irrigation application	0.050	0.049	0.020
	(0.020)**	(0.030)	(0.012)
Ln σ^2	-9.023	-6.795	-6.999
	(0.157)***	(0.095)***	(0.085)***

Notes: The values in parenthesis indicate standard errors. Significant degree at $^{*}p< 0.10$, $^{**}p< 0.05$ and $^{***}p< 0.01$.
Variance parameters

Liquidity unconstrained: Log likelihood = 475, Wald $_{\chi}2$ = 1593, $\lambda = \sigma_\mu/\sigma_\upsilon$ = 1.218, σ^2=0.0006

Liquidity constrained: Log likelihood = 658, Wald $_{\chi}2$ = 618, $\lambda = \sigma_\mu/\sigma_\upsilon$ = 0.112, σ^2= 0.0019

Full sample: Log likelihood = 1026, Wald $_{\chi}2$ = 1223, $\lambda = \sigma_\mu/\sigma_\upsilon$ =0.008, σ^2= 0.001

Range of technical efficiency: The results in table 4 indicate that, technical efficiency varies widely among sample farm households as mean technical efficiency for LUWG was 89.8 percent and for LCWG was 80.7 percent. The difference in average technical efficiency of both LUWG and LCWG was 9.10 percent, which indicates a significant efficiency gap. Therefore, in both cases, an average wheat grower in the surveyed areas could, in principle, increase its wheat yield 10.2 percent for LUWG and 19.3 percent for LCWG, utilizing their exiting level of input resources.The results further indicate that, approximately 74.84 percent of LUWG and 25.63 percent of LCWG achieved technical efficiency levels of more than 85 percent. In a similar experiment, conducted by Komicha and Ohlmer (2007) in Ethiopia, reported that credit constrained farm households had technical efficiency scores 12 percent less than credit non-constrained farm households.

Table 4. Efficiency estimates of liquidity constrained, liquidity unconstrained and full sample size.

Efficiency range	LUWG (N=167)		LCWG (N=351)		Full Sample (N=518)	
	Numbers	Percentage	Numbers	Percentage	Numbers	Percentage
< 80 %	19	11.377	186	52.991	205	39.575
81-85 %	23	13.772	75	21.367	98	18.918
86-90 %	34	20.359	22	6.267	56	10.810
91-95%	49	29.34	45	12.820	94	18.146
> 95%	42	25.149	23	6.552	65	12.548
Total	167	100	351	100	518	100
Mean	0.898	89.8	0.807	80.7	0.835	83.5
Std. Dev.	0.072	-	0.089	-	0.094	-

Technical inefficiency effects estimate: The determinants of technical inefficiency effects are explained in table 5. Following Cabrera *et al.* (2010) we interpreted the results of estimated parameters with respect to technical efficiency. That is, a negative effect on farm household technical inefficiency has a positive effect on technical efficiency (See eq. [3]). This explanation method is a common practice in the existing literature that facilitates the comparison with other studies.

The estimated parameters indicate that age of the household head (as an indicative of farming experience) had significant but negative effect on LUWG. The negative sign shows that, older farmers in the surveyed areas were technically less efficient compared to their younger counterparts. The coefficients of education of the household head for both groups were significant and positive while the effect seemed more profound in LUWG. Komicha and Ohlmer (2007) reported that, education is a vital component of human capital, which enhances managerial performance and particularly awareness about loan acquisition. The coefficients of the household size for both LUWG and LCWG were significant and positive. These findings indicate that technical efficiency increases with increase in the household size.

The coefficients of certified seed for both LUWG and LCWG were positive and significant, suggesting a positive effect on wheat yield. The result shows that, the growers who sowed in time attained higher production. These findings are in line with the analytical work of Musaba and Bwacha (2014).The variable of drill sowing for LCWG was significant at 10 percentlevel, but had positive effect on technical efficiency of wheat growers.In addition, the coefficient of owned tube-well for LUWG was negative and non-significant, while for LCWG was significant at 10 percent level. In rural areas of Pakistan there are severe electricity crises and it's expensive to afford diesel/petrol cost. Therefore, most farmers in rural areas depend on canal irrigations. We therefore, cannot assume that, LUWG group of growers who owned tube-wells were technically less efficient than those who did not.

The production and dissemination of latest knowledge is essential to validate the efficiency at farm level and to make the agriculture sector multifunctional (Labarthe, 2009).In our analyses, the coefficients of extension services for both LUWG and LCWG were significant and positive, suggesting satisfactory performance of Punjab's agriculture extension department. Similarly, the provision of traction and manure for livestock farming in rural Pakistan has substantially increased the farmer performance and decreased the total costs of production. The coefficient was significant and positive for LUWG which indicates that, the farm households who held livestock were technically more efficient compared to others.

Diversification of income sources among farm households is a norm related to pull or push factors (Escobal, 2001).However, in rural Pakistan diversified source of income is generally limited because of credit constraints, geographic characteristics and lack of technical expertise(Reardon *et al.*, 2000).In our analyses, the coefficients of off-farm income for both LUWG and LCWG groups were significant and positive which indicate that those farm households who had diversified source of income other than crop production were technically more efficient. These findings are similar to the study of Tipi *et al.* (2009). The coefficients of the household savings for both LUWG and LCWG were significant and positive, which indicate that the households who had higher savings rates were technically more efficient.

In the last step, the analyses of our key variables were associated with financial institutions. The variable distance to lenders was significant for LCWG, while non-significant for LUWG. De Young *et al.* (2008) reported that, financial institutions' proximity and relationship with the farm borrowers had strong implications for both side of business activities. The variable of credit size showed significant and positive effect on both LUWG and LCWG. The effect of credit size can be seen in two ways. Firstly, with an increase in credit amount, the farm households can easily adopt improved technologies and can rationally allocate their resources. Secondly, the volume of loan can reduce per unit transaction cost.In fact, while disbursement of loan some costs are fixed (e.g., third party evaluation, mortgage charges, lawyer fees etc.), regardless of the credit amount. In addition, the interest rates on principal amount had significant negative effect on technical efficiency of both LUWG and LCWG. Mehmood *et al.* (2012) documented that financial institutions in rural Pakistan charged higher interest rates that often resulted in loan delinquency.

In summary, the parameter estimates of full sample were somewhat similar to those of LUWG and LCWG (See table 5). However, the main purpose to analyse full sample size was to estimate the effect of credit availability on technical efficiency of the growers. Following Komicha and Ohlmer (2007); Cabrera *et al.* (2010); Bashir *et al.* (2010); Bashir and Mehmood (2010) among others, we analysed credit availability as dummy variable (As stated above). The inclusion of credit availability (dummy) indicates its impact on technical efficiency, while the liquidity constraint status was assessed by direct elicitation approach. Overall, the result indicates that, credit availability had significant positive impact on technical efficiency of wheat growers. The findings of our analysis are in line with the study by Ayaz (2010) while in contrast to the hypothesis of financial analysts, who claimed that financial market in rural Pakistan is not contributing substantially in boosting the livelihoods of rural poor. However, there is dire need to reduce the risk reluctance mechanisms at the households level by providing subsidize insurance premiums as suggested by Arshad *et al.* (2015).

Table 5: Parameter estimates of inefficiency effects model.

Variables	LUWG N (167)	LCWG N (351)	Full sample N (518)
Constant	-8.399	-4.390	-4.470
	(1.096)***	(0.624)***	(0.534)***
Household head age	0.0341	0.009	0.0094
	(0.011)**	(0.009)	(0.008)
Householdhead education	-0.130	-0.083	-0.078
	(0.036)***	(0.037)**	(0.033)**
Household family size	-0.097	-0.066	-0.054
	(0.031)**	(0.030)**	(0.025)**
Certified seed	-0.950	-0.736	-0.632
	(0.457)**	(0.360)**	(0.311)**
Sowing time	-1.415	-0.948	-0.841
	(0.467)**	(0.404)**	(0.343)**
Drill sowing	-0.861	-1.23	-0.782
	(0.443)*	(0.405)	(0.312)**
Lined water course	-0.487	-0.642	-0.298
	(0.445)	(0.395)	(0.325)
Owned tube-well	0. 835	-0.749	-0.142
	(0.458)	(0.426)*	(0.376)
Extension services	-1.126	-0.868	-0.832
	(0.419)**	(0.371)**	(0.300)**
Livestock holding	-1.823	-0.563	-0.437
	(0.637)**	(0.363)	(0.311)
Off-farm income	-1.013	-1.180	-1.199
	(0.433)**	(0.507)**	(0.411)**
Household savings	-0.003	-0.002	-0.002
	(0.001)**	(0.0009)**	(0.0008)**
Distance to lenders	0.020	0.038	0.015
	(0.016)	(0.011)**	(0.009)
Credit size	-0.0003	-0.0005	-0.0004
	(0.0001)**	(0.0002)**	(0.0002)*
Interest rates	0.088	0.062	0.142
	(0.044)**	(0.031)**	(0.071)**
Credit availability	-	-	-1.422
			(0.512)**

Notes: The values in parenthesis indicate standard errors.
Significant degree at *p< 0.10, **p< 0.05 and ***p< 0.01.

Conclusions and policy implications: This article analysed the effect of liquidity constraints on technical efficiency of wheat growers using primary data collected from five randomly selected districts of Punjab province of Pakistan. Based on direct elicitation method, we categorized wheat growers into liquidity constrained and liquidity unconstrained. Then, we employed stochastic frontier analysis approach to estimate the technical efficiency of both LUWG and LCWG. The analyses indicate that, mean technical efficiency scores for LUWG and LCWG were 89.8 percent and 80.7 percent, respectively. The mean technical efficiency difference between these two groups was 9.10 percent.This result suggests that, averagewheat growers in the surveyed areas could, in principle, increase their wheat production by 10.2 percent for LUWGand 19.3 percent for LCWG, using their existing level of input resources. In the second stage of analyses, inefficiency effects model revealed that technical efficiency of the both groups of growers were influenced by the farm households education, households size, sowing time, extension services, off-farm income and household head savings. The explanatory variables associated with the financial institutions further indicated that credit size had significant positive and interest rates on principal amount had significant negative effect on technical efficiency.

Another key question of this study was to estimate the effect of credit availability on technical efficiency of the farm households. herefore, we analysed the full sample size and found that credit availability had positive effect on technical efficiency. Though our analyses detected very strong impact of credit availability on the technical efficiency of wheat growers but the question is still unexplained as why the imperfections prevail in rural financial market and why there is not a substantial reduction in poverty across rural farming communities of Pakistan and elsewhere in low income countries.

The insights gained from our analyses led us to infer that, improved access to formal credit may reduce the liquidity rationing situation of the farm households in Pakistan. Our findings suggests that the financial policies of government and private agencies need to be restructured in order to focus on both supply and demand side of credit constraints as a primary instrument. Moreover, social campaigns and relevant innovative efforts may also be taken from the financial institutions side in order to encourage the borrowers to secure loans. An important implication of our study is related to interest rates. The significant and negative effect of interest rates on technical efficiency of the growers suggests that, the State Bank of Pakistan may reduce the KIBOR, closely monitor the interest rates charge by the commercial banks and provide subsidized credit facilities to subsistence and small land holders. At the same time, the government may revise the per acre limit of cash finance each year considering the financial requirements that are, prices of inputs, land rent and market value of wheat crop. The financial institutions may also need to focus on the geographic proximity of their branches to facilitate the farmers in their vicinity, particularly in southern Punjab.

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Notes:

1. Highly imperfect is in the sense that, borrowers are trapped across several legal and non-legal agreements and costly documentations that often involved in rural financial market of Pakistan.
2. Non-price rationing is hypothesized as those farm households who would like to borrow money at the existing interest rates, but financial institutions deny their applications or those households who wouldn't like to borrow because of risk aversion and demand depressions.
3. Cash finance facility usually disburses for the farm running expenditures (e.g., purchase of seed, chemical, pesticide, payment of labour wages, etc.)
4. We used acres and maunds as standard units of measurement based on following reasons: the financial institutions in the surveyed areas disbursed loans on per acre basis, secondly, to target the small farmers and thirdly, in agricultural enterprise acre and maund are standard units of handling farm operations in Pakistan.
5. Most farmers availed loan facility linked with Karachi inter-bank offer rate (KIBOR). Therefore, we calculated KIBOR in addition to the commercial banks markup rate. The rate of 6 months KIBOR in 1st and 2nd quartersof 2016 was 6.34 percent.

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