EFFICIENCY AND PRODUCTIVITY ANALYSIS OF PAKISTAN'S FARM SECTOR: A META-ANALYSIS*

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ABSTRACT:- Farm production and efficiency have always been a primary research question for researchers and agricultural organizations of Pakistan. Meta-analysis in present study provides the statistical efficiency analysis as well as statistical information regarding methodological, regional and crop specific influences on farm sector of Pakistan. The data rely on the published research papers on efficiency analysis of Pakistan's farm sector from 1971 to 2014. Three models separately estimated included methodological model, crop specific model and provincial model. These models incorporated the impact of methodological variables, crop specific variables and regional variables impact on Mean Technical Efficiency Scores (MTES), such as parametric, non-parametric techniques, functional forms, data types, production technology dummies and variable size parameter. The analysis revealed the overall technical efficiency of Pakistan's farm sector as 73%. The results from meta-analysis clearly indicated that farm sector in Pakistan is way behind its optimum potential level. Hence there is sufficient room for improvement. To this end, government should be well-designed to evaluate the misdirected growth policies in farm sector of Pakistan.

Key Words: Mean Technical Efficiency Scores; Stochastic Frontier Analysis; Data Envelopment Analysis; Pakistan.

INTRODUCTION

The role of agriculture sector in Pakistan has been far-reaching and its growing value in this century can't be ignored. Pakistan is blessed with best suitable weather environment that helps in attainment of high agricultural production. The world food demand is rising due to rapid intensification in population. For the period of 68 years of independence, and inspite of adopting green revolution including new high yielding seed varieties, introduction of chemical / commercial fertilizers at large scale level and plant protection know-how, Pakistan is still unable to feed its population adequately. The increasing trend in population ultimately leads to the shortages of food, fiber and industrial crops that hamper the overall process of economic growth. Low productivity of farm produce on one hand and yield variation on other hand is a vast hindrance in Pakistan. These trends in farm produces automatically resulted in price fluctuations that can push the developing fragment of population underneath the poverty line.

By higher agricultural production, the country can save foreign exchange by tumbling imports as well

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facilitate to execute the increasing demand for processed food in the country. Furthermore, export of agricultural products instead of raw material can raise the foreign exchange earnings.

In developing countries, efficiency augmentation in farm sector is imperative for overall economic development. Meta-analysis enables to examine the effect of specific factors of previous studies, quantitatively and empirically (Alston et al., 2000). In the present study, meta-analysis serves to enumerate the review in statistical perspective and captures the technical efficiency performance for the entire farm sector during 1971-2014.

The first study on meta-analysis of farm sector is organized by Thaim et al. (2001), and evaluated 34 farm studies on farm sector of developing countries. Bravo-Ureta et al. (2007) conducted an extended analysis by the use of 167 farm level studies on developed and developing countries. Later Lopez and Bravo-Ureta (2008) used the meta analysis for dairy sector in English and Spanish countries. This meta-analysis included 65 parametric and non-parametric published frontier studies. Kolawale (2009) examined precisely Nigerian agricultural sector's efficiency performance from 1999 to 2009, by taking 64 published research articles.

According to Kolawale (2009), the studies by Thiam et al. (2001) and Bravo-Ureta et al. (2007) on farm efficiency meta-analysis have particular flaws. These studies integrated the sample of developed and developing countries as a single population and set the average technical efficiency as a conjoint benchmark. Meta-analysis on the overall technical efficiency performance of farm sector, specifically in single country gives more broader and meaningful picture. In the present study, farm efficiency meta-analysis is carried out for Pakistan that is consistent with the objectives of this study.

No study has been conducted the meta-analysis on farm sector efficiency of Pakistan. Instead of taking into account other developed and developing countries, this study explicitly focused on Pakistan's agricultural sector and grasp only those observations that belong to Pakistan's farm sector. Hence, the analysis is helpful in summing up the attributes of farm efficiency in Pakistan.

The objectives of present study include the overall technical efficiency of Pakistan's agricultural sector from 1971 to 2014; the methodological concerns such as sample size, parametric and non-parametric analysis, functional forms (constant or flexible) and variable size on efficiency levels and the difference in farm efficiency levels at province wise in Pakistan. Finally, it captures the discrepancy in efficiency level according to the crops, like major crops, horticulture crops and dairy farms.

MATERIALS AND METHOD

Meta-analysis requires imperative deliberation and systematic examination of pertinent literature. According to Sterne (2009), Meta-analysis provides an opportunity to researchers to do unified analysis on numerous comparable studies.

Current search executed the data of published articles from numerous national and international journals including The Lahore Journal of Economics, Agriculture Science Journal, Bangladesh Journal of Agriculture Economics, Agricultural Research Journal, Pakistan Journal of Applied Economics, Agricultural Sciences, Food Science Agriculture, Agricultural Economics, Sarhad Journal of Agriculture, Pakistan Journal of Social Science etc. All published articles encircled grain crops, cash crops, horticulture crops and dairy farms. These research studies have estimated efficiency analysis like estimation of technical, allocative and economic efficiency and the comparative efficiency analysis. Accordingly, out of 43 articles during 1971-2014, the total number of observations are 71 in existent data analysis.

According to Greene (2002), efficiency score are double censored between 0 and 1, hence Two Limit Tobit model for meta-analysis should be appropriate for Meta regression. Previous studies such as Thiam et al. (2001) and Bravo-Ureta et al. (2007) used Two Limit Tobit model and Kolawale (2009) accounted the truncated regression model for meta-analysis. McDonald (2008) pointed out that the efficiency scores in actual are constructed and based on fractional data instead of censoring method. Due to this reason, selecting the Tobit Model for meta-analysis leads to unreliable estimators. Comparatively, the procedure of Ordinary Least Square (OLS) technique is more acceptable for fractional data as compared with Tobit regression. However, Kolawale (2009) articulated that OLS technique is inadequate for meta-analysis due to probability mass as the efficiency score ranges between 0 and 1. Truncated regression delivered inordinate explanation to the coefficients in which OLS procedure is frequently deficient.

Subsequently the existing contradictions on the model choice for meta-analysis, present study takes into account all three techniques that include two limit Tobit, truncated and Ordinary Least Square (OLS) regression. The results from all techniques can lead to better comprehension. Later, the best results out of these techniques are reported from the truncated regression model.

The selected variables for Meta-Analysis are similar to the earlier studies by Thiam et al. (2001) and Bravo-Ureta et al. (2007). All three models contain same independent variables including parametric technique, cross-sectional data, time series data, variable size, primal model, provinces dummies and crops dummies.

The first model is methodological model and explanation of variables in this model is as follows:

$$Y_{it} = \beta_0 + \sum_{i=l}^{7} \sum_{t=l}^{T} \beta_{it} D_{it} + \beta_7 Var_{it} \qquad (1)$$

The dependent variable is Mean Technical Efficiency Score (MTES) as testified by earlier studies. To see the impact of parametric and non-parametric frontier models on the average efficiency of previous studies, the frontier models are divided into two categories, (1) parametric models (2) non-parametric models. The dummy D_{1para} specifies that if the study selected the parametric technique than it holds the value equal to one and zero otherwise. Here non-parametric variable is the base category. To gauge the impact of data type on average efficiency scores, the variable is divided into three categories, (1) cross-sectional (2) time series (3) panel. With this reference, D_{2Cross} is the dummy which is equal to one if data of the specified study is cross sectional and zero otherwise. Similarly, D_{3Time} is a dummy variable for time series bearing value 1, and zero otherwise. At this juncture base category is panel data.

The functional form variable is divided into three categories (1) Cobb-Douglas (2) Translog (3) Other functional forms. D_{4Cobb} bears the value 1 if the specified study used Cobb-Douglas functional form, and zero otherwise. D_{Trans} dummy refers to the study that selected the Translog functional form bearing value 1 and zero otherwise. The base category is other functional forms that include non-parametric studies as well. The impact of technology variable on average efficacy is measured by primal and dual technology used as dummy variables, where D_{prim} holds value 1 if study employed primal variable and zero otherwise. Here base category is dual technology. The next variable used in this study is the variable size (VAR), which is computed by dividing the total number of variables by total number of observations used by the specific study.

According to McDonald (2008), due to data generating factor in mean efficiency scores, it is hardly probable that $E = (\omega_i / X_i)$ executed normally. Therefore, after the estimation of equation 1, normality of residual from this equation 1 is tested. The result of residual and rejected the hypothesis of normality at P = 0.26879. McDonald (2008) and Kolawale (2009) suggested that if non-normality is identified, and most of the explanatory variables in the model are based on dummy variable than it is appropriate to apply Box-Cox transformation on mean efficiency scores that has been extensively used in literature. Hence, following McDonald (2008) and Kolawale (2009). This study employed the Cox-Box transformation to overcome the issue of non-normality. The estimated result of Cox-Box regression provided the θ value of 2.43. The null hypothesis is θ=1which is rejected as P=0.000.

$$MTES_{transi} = AMTES^{2.43} - 1/2.43 \qquad (2)$$

Using equation 2, the MTES was re-generated and the truncated regression is re-estimated.

To perceive the influence of crops on average efficiency scores, the crops specific dummies introduced in second model.

$$Y_{it} = \gamma_0 + \sum_{i=l}^{8} \sum_{t=l}^{T} \gamma_{it} D_{it} + \gamma_8 Var_{it} \qquad (3)$$

All crops are divided into three categories, (1) major crops (2) horticulture crops (3) livestock. The dummy variable of horticulture crops, D_{horti} = 1 if the study undertakes the horticulture crop and zero otherwise. The variable of livestock, D_{lives} = 1 if value study analyzed the livestock farms and zero otherwise. Here the reference category is major crops. In the second model, normality assumption is not rejected at P = 0.0004, therefore, Cox-Box transformation is not applied on the second model.

To measure the provincial impact on the efficiency level of farm sector, provisional dummies introduced in third model.

$$Y_{it} = \alpha_0 + \sum_{i=l}^{8} \sum_{t=l}^{T} \alpha_{it} D_{it} + \alpha_8 D_{8trans} \quad (4)$$

The provinces are divided into three categories such as Punjab, Sindh and KPK, Balochistan region is dropped because no farm efficiency study up till now has been commenced there. The dummy variable of Punjab province, D_{pun} = 1 if study undertakes in Punjab province and zero otherwise. The dummy variable of Sindh province, D_{Sin} = 1, when a study is embarked on Sindh and zero otherwise. Similarly, the dummy variable for Khyber Pakhtunkhwa province, D_{Kpk} = 1, if the study is undertake in KPK province and otherwise zero. Here, Punjab province used as reference category and will be omitted while estimating the model. In third model, normality assumption is rejected again at P = (0.0038). As a result, Cox-Box regression all over again used to sort out the normality problem.

$$MTES_{transi} = AMTES^{2.63} - 1/2.63 \quad (5)$$

The estimated result of Cox-Box regression provided the θ = 2.63. The null hypothesis is θ=1which is rejected as P = 0.000. The 2.6.5 equation is re-estimated after re-generation of METS.

RESULTS AND DISCUSSION

The data are expedient for general idea about particular studies conducted for efficiency analysis of Pakistan's farm sector. It stretches information on number of observation, year of data collection and publication, product, average efficiency score of each study and overall average efficiency of Pakistan's farm sector. The overall average efficiency of Pakistan's farm sector is approximately 73%. This score depicts that the farm sector of Pakistan from 1971 to 2014 is constantly producing 27% a reduced amount farm output from its definite potential.

Overall 43 research articles are designated in this study, out of which 39 studies employed stochastic frontier technique, one study applied deterministic method and rest of the four studies used DEA technique (Table 1). Most of the studies on farm efficiency analysis of Pakistan comprehensively bank on parametric approaches, cross-sectional data, Cobb-Douglas functional form and primal illustration of the proficiency. The average mean efficiency score in parametric and non-parametric models is about 74% and 69%, respectively. This result indicates that in contrast to parametric models average mean efficiency scores are higher than the non-parametric models. This result is in line with

Table 1. Methodological features of studies on efficiency of Pakistan's farm sector

Type	No. of cases	No .of studies	Min. TE	Max. TE	Avg. TE
Approach					
SFA	65	39	0.11	0.96	0.74
Deterministic	1	1	0.84	0.84	0.84
DEA	6	4	0.40	0.87	0.69
Data					
Cross-Sectional	41	65	0.11	0.96	0.73
Time	1	2	0.87	0.89	0.88
Panel	4	4	0.57	0.78	0.68
Functional Form					
Cobb-Douglas	51	31	0.62	0.96	0.79
Translog	12	8	0.11	0.94	0.73
Others	8	5	0.40	0.87	0.71
Technology Illustration					
Primal	59	35	0.36	0.96	0.77
Dual	12	8	0.11	0.89	0.57

Bravo-Ureta et al. (2007).

A stimulating dissimilarity is found in data type and mean average efficiency scores. Bravo-Ureta et al. (2007) indicated that panel data display higher efficiency scores than cross-sectional data. In contrast, present study found 73% cross-sectional mean average efficiency score that is higher than panel data 68% efficiency scores. Nevertheless, time series mean average efficiency scores was 88% which is significantly higher than cross sectional and panel data efficiency scores in Pakistan.

Concerning the consequences of functional form application, an attention-grabbing configuration is detected. The efficiency scores resulting in Cobb-Douglas and Translog functional forms, mean average efficiency scores are found 79% and 73%, respectively. A total 31 studies preferred Cobb-Douglas functional form, 8 preferred Translog model and 5 opted for other functional forms. The studies in developed and developing world that employed Translog functional form reported higher efficiency scores than that of Cobb-Douglas functional form. This is contrary to the case in Pakistan where the studies that preferred Cobb-Douglas functional form produced higher mean technical efficiency scores than Translog functional form. This result is fairly in contradiction to the earlier studies. In technology illustration, a total of 35 studies employed primal technology and 8 applied dual one. Results produced 77% and 59% mean average efficiency scores of primal and dual technologies, respectively. Consequently, the efficiency scores of primal technology are higher than the dual approach. These results are consistent with Bravo-Ureta et al. (2007).

The province wise factual figures, like number of studies, number of cases, minimum, maximum and average mean technical efficiency scores in Pakistan were noted (Table 2). About 32 studies and 52 cases were conducted in Punjab province. Not even a single study yet, has been conducted on farm efficiency analysis in Balochistan province.

Exclusive substantial mean average farm efficiency discrepancy was found across Punjab and other provinces of Pakistan. Crop wise number of studies, cases and average mean efficiency scores revealed that maximum average mean efficiency score of 83% is achieved in maize crop in Pakistan (Table 3). Maize is followed narrowly by rice and dairy with 82%, while 81% for cotton. Whereas the lowest scores of 67% and 68% are found in wheat and horticulture crops, respectively.

To estimate the deviation in mean average technical efficiency of Pakistan's farm sector, three models have been used. The methodological, crops specific and provisional models are estimated to evaluate the impact of methodological variables, province specific variables and crops specific variables on farm efficiency scores of Pakistan.

Table 2. Mean efficiency of Pakistan's farm sector by Province

Province	No. of cases	No .of studies	Min. TE	Max. TE	Avg. TE
Punjab	52	32	0.40	0.96	0.78
Sindh	5	3	0.36	0.83	0.62
KPK	13	9	0.11	0.89	0.63
Gilgit-Baltistan	1	1	0.81	0.81	0.81
Balochistan	Nil	Nil	Nil	Nil	Nil

Table 3. Crop wise mean efficiency of Pakistan farm sector

Crops	No. of cases	No .of studies	Min. TE	Max. TE	Avg. TE
Wheat	18	11	0.24	0.93	0.67
Cotton	10	6	0.76	0.93	0.81
Maize	4	3	0.68	0.94	0.83
Rice	3	3	0.72	0.91	0.82
Sugarcane	1	1	0.77	0.77	0.77
Horticulture	11	6	0.35	0.84	0.68
Aggregate crops	19	10	0.11	0.91	0.71
Dairy	6	4	0.70	0.96	0.82

D_{1para} used to capture the influence of parametric models on MTES. The result of D_{para} in methodological model indicates that parametric models yield -0.0650 lower Mean Technical Efficiency Score (MTES) compared to non-parametric models. But it is insignificant (Table 4). This result is in line with Bravo-Ureta et al. (2007). The best probable ground for higher efficiency scores of non-parametric models as compared to parametric models is that Non-parametric models fundamentally and statistically are based on indexes that are equal to 100% and result in higher efficiency scores (Kumbhakar and Lovell, 2000).

Table 4. Methodological Models

Variables	Para-meters	Coef. (S.E)	Z-state	P-Value
Parametric	β_1	-0.0650 (0.0485)	1.34	0.18
Cross	β_2	0.0966 (0.4496)	2.15	0.032
Time	β_3	0.2270 (0.0347)	6.54	0
Cobb	β_4	0.8198 (0.4757)	1.72	0.085
Translog	β_5	0.02 (0.0796)	0.31	0.775
Primal	β_6	0.0223 (0.0552)	0.4	0.686
Var. size	β_7	1.11249 (0.7423)	1.5	0.134
Constant	β_0	0.05215 (0.7753)	0.67	0.501
Chi Square	χ^2	66.91 (0.0000)		

P-value of χ^2 represents in parenthesis

To see the impact of functional form on MTES, The Cobb Douglas and Translog functional form dummy variables are considered for estimation. In all models the functional form results reflect the diverse trends. The omitted category is other functional forms. The DCobb variable in methodological and provincial model shows that Cobb-Douglas functional form attained 0.8198 and 0.1040 units higher MTES compared to other functional forms, respectively. But in Crop specific model, it shows negative but insignificant impact on MTES. The Translog functional form in all models shows that translog functional form acquired higher MTES compared to other functional forms. But it is statistically insignificant. Hence, it emulates the fact that the translog functional form effect on MTES is rather undistinguishable. Consequently, as compared to the other functional forms Cobb Douglas and Translog functional forms yield higher efficiency score. According to Greene (2002) and Thiam et al. (2001) there is no coherent justi-fication following these results. This result is in line with Ahmad and Bravo-Ureta (1996), Resti (2000) Thiam (2003) and Lopez and Bravo-Ureta (2008).

To see the impact of data type D_{cross} dummy variable and for time series data, D_{time} dummy variable is introduced in all three models. The omitted category is panel data variable. The D_{cross} dummy shows positive and significant effect on MTES in methodological and provincial models. Hence, the cross sectional data compared to panel data bring about 0.0966 and 0.1181 units higher MTES, respectively. In crop specific model, D_{cross} dummy shows negative but insignificant impact on MTES. In all models, the time series data variable dummies are positive and highly significant and reflect that time series data compared to panel data resulted in higher MTES. The results of study designates that apart from crop specific model , cross-sectional and time series data yielded higher MTES as compared to panel data, which is the reference category.

To see the influence of primal and dual technology on MTES, D_{prim} dummy variable used in all three models. Except from crop specific model (positive and significant), primal technology shows negative and insignificant impact on methodological and provincial models. These results are consistent with Bravo-Ureta et al. (2007).

Variable size estimate contend with the ratio and used to examine the impact on all three models dimensionality. The result of study shows positive but insignificant impact of variable size on MTES. In non-parametric models and variable size, Bravo-Ureta et al. (2007) found positive association. As number of variables increase, it resulted in higher efficiency scores. According to Chavas et al. (2005) it would be expected that model dimensionality and technical efficiency scores shows positive association. This result is similar to Thomas and Tauer (1994) and Chavas et al. (2005) and Lopez and Bravo-Ureta (2008).

Crop specific model is estimated to investigate that either crops MTES fluctuate or remain stable for horticulture, livestock and major crops production in Pakistan.

The result of D_{horti} dummy variable reveals that horticultural crops have -0.4158 units lower but insignificant MTES estimates, compared to major crops MTES which is the reference category (Table 5). The result of $D_{livestock}$ dummy variable shows the 0.1193 units higher MTES compared to major crops. Hence, the livestock sector is performing better than major crops of Pakistan. Numerous issues of economics surveys also show that the livestock sector performance in Pakistan outpasses the horticulture and major crops. According to Government of Pakistan (2014), livestock sector shares 55.9% of the value added in agricultural sector, against the share of 37.6 % by all crops.

Table 5. Crop's Specific Model

Variables	Parameters	Coef. (S.E)	Z-state	P-Value
Horticulture	γ_1	-0.4158 (0.0569)	0.73	0.465
Livestock	γ_2	0.1193 (0.0673)	1.77	0.076
Cross	γ_3	0.8007 (0.07934)	1.01	0.313
Time	γ_4	0.3188 (0.0816)	3.9	0
Cobb	γ_5	-0.0017 (0.0706)	0.02	0.980
Translog	γ_6	0.0058 (0.09622)	0.06	0.952
Primal	γ_7	0.1507 (0.06527)	2.31	0.021
Var. Size	γ_8	1.7209 (1.044)	1.65	0.099
Constant	γ_0	0.4802 (0.1159)	4.14	0
Chi Square	χ^2	29.28 (0.0002)		

P-value of χ^2 represents in parenthesis

Provincial model is estimated by adding the provincial dummies to test the provisional impact on MTES in Pakistan.

The base category is the Punjab province. The D_{kpk} dummy variable coefficient shows negative and insignificant parameter. According to the Government of Khyber Pakhtunkhwa (2010), the share of agricultural sector in Khyber Pakhtunkhwa has declined from 8.07 in 2000-01 to 7.13% in 2010-11(Table 6). The major factors are destitute irrigation system and low quality of seed varieties. The D_{sin} dummy variable coefficient displays positively significant result. Hence, Sindh province yielded 0.0902 unit higher MTES compared to reference province Punjab. According to Government of Sindh (2012) Sindh's agricultural economy has the share of 23% in the national GDP. This has been made possible due to technical support provided, subsidies on the available credit, research and development and enhancing of the potential of the farmers. This might be the reason that province Sindh have the greater efficiency scores compared to Punjab.

Table 6. Provincial Model

Variables	Parameters	Coef. (S.E)	Z-state	P-Value
KPK	α_1	-0.0477 (0.0602)	-0.79	0.428
Sindh	α_2	0.0902 (0.0463)	1.95	0.052
Cross	α_3	0.1181 (0.0537)	2.20	0.028
Time	α_4	0.2268 (0.0342)	6.62	0
Cobb	α_5	0.1040 (0.0510)	2.04	0.042
Trans	α_6	0.0312 (0.0784)	0.40	0.690
Primal	α_7	0.0101 (0.0539)	-0.19	0.851
Var. Size	α_8	0.9694 (0.8185)	1.18	0.236
Constant	α_0	0.0401 (0.0906)	-0.44	0.658
Chi Square	χ^2	71.09 (0.0000)		

P-value of χ^2 represents in parenthesis

CONCLUSION

The basic purpose to conduct the meta-analysis in present study was to comprehend and elucidate the ins and outs behind dissimilarities in Mean Technical Efficiency (MTES) of farm sector of Pakistan. To justify this perseverance, the existing section employed 43 available studies that explicitly capture the efficiency analysis of farm sector of Pakistan. The results from descriptive analysis show that overall MTES in Pakistan is about 73% from 1971 to 2014.

Thus, at given level of farm inputs, farm production in Pakistan can be enhanced by about 27% via improvement in the managerial characteristics of farmers. To this end, government should be well-equipped to evaluate the lead astray growth policies in farm sector of Pakistan. It is the prerequisite to magnify the farm sector growth by assembling accessible and up-to-date farm technologies. On the other hand, government should place prime importance on the adoption of new technologies and facilitating the farmers to have sound acquaintance with the advance technologies in advance adoption of new technologies. This can be accomplished by organizing technology related programmes for the farmers. End result may perhaps enable farmers to take full advantage of advanced technologies and attain the best possible level of farm production frontier in Pakistan.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S.No	Author Name	Contribution to the paper
1.	Ms. Hina Fatima	Conceived the idea, Wrote abstract, Methodology, Did SPSS analysis,Conclusion, Data collection, Data entry in SPSS and analysis, Results andDiscussion, Introduction, References
2.	Ms. BushraYasmin	Technical input at every step,

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