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Instability of Textile Production in Pakistan: Stochastic Frontier Model Approach

INAYATULLAH KHAN
PhD scholar, Department of Economics, Gomal University, D. I. Khan – Pakistan.
Email: inayat66@gmail.com

Prof. Dr. MOHAMMAD AFZAL
Department of Economics, Preston University, Islamabad – Pakistan.
Email: profafzal@gmail.com

Abstract

Textile industry is the largest industry of Pakistan and like other industries it is facing not only high and escalating cost of electricity and gas but also lack of market access. This study has computed production uncertainty (PU) due to technical inefficiency (TIE) of textile exporting and manufacturing (TEM) firms in Pakistan. We has obtained data from annual reports of 98 companies for the year 2017-18. We has applied stochastic production frontier approach with half normal distribution of ui. PU with confidence bounds had been computed. Inefficiencies (ui/εi) were statistically significant at 5 % level of significance. The mean PU was 0.0045. The computed scores of PU of TEM firms in Pakistan during 2017-18 showed that maximum numbers of firms had their PU score low and close to minimum PU score and very few firms had high PU score and close to maximum PU score.

Keywords: *Textile Manufacturing Firms, Production Uncertainty, Technical Inefficiency, Confidence Bounds, MLE Technique, Cobb-Douglas Production Function.*

Introduction

Textile industry is the largest industry of Pakistan and like other industries it is facing not only the high and escalating cost of electricity and gas but also lack of market access. This adversely impacts the textile exporters' ability to meet their commitments. The production uncertainty (PU) also influences the ability of the firms to accept orders from abroad. Enterprises must understand and identify sources of PU and respond accordingly to remain competitive with other firms in the textile exports.

Production uncertainty may be due to different factors and sources. Based on production inefficiency, Bera and Sharma (1999), for the first time, introduced the concept of PU due to technical inefficiency (TIE) and presented analytical expression for measuring firm specific PU by stochastic frontier function. The purpose of the paper is to compute PU of textiles exporting and manufacturing (TEM) firms in Pakistan. Empirical research on PU and its effects on the performance of firms had not received much interest from researchers and the literature was limited on this subject matter. Other studies had not addressed the issue in this perspective.

Owners of firms are worried about utilizing their resources optimally to ensure maximum profit as well as high quality of their products so that they could compete successfully with rival firms. The competitiveness of a firm is the ability to compete with the best practiced firm. It is expected that textile manufacturing firms in Pakistan will use their resources of production efficiently and will move towards technologically efficient production frontier to reduce production cost in an optimum way and will improve the quality of products to compete with the firms in the domestic and international textile markets.

The textile industry of Pakistan has shown progress due to easily available local raw material and labour force, simple manufacturing process and government's incentives. It has performed well not only in production but also in export over the last six decades. More recently it has been progressing and has increasing foreign demand.

For many countries, particularly, for some developing countries, like Pakistan the trade openness has brought a sea-change in the way their economy works. It has changed the global trade pattern. It has enhanced the competition among textiles and clothing exporters. China's entrance into WTO (World Trade Organization) has increased its exports.

Firms are required to succeed in changing their basic structure to work in new situations. That requires firms to increase their production capacity and to reduce their production cost in an optimum way. The share of manufactured items in exports of developing countries in the world was 20.4 percent in 1992. It had been increased from 29.4 percent in 2000 to 39 percent in 2009. This trend is expected to continue if these countries increase their manufacturing production capacity. Then manufacturing activities will be transferred to developing countries to reduce production costs (UNIDO[1] 2011, 153).

The paper has followed the following structure. Section II highlights the significance of Pakistan's textile industry. Section III provides brief review of studies. Section IV concisely discusses the methodology and data. Empirical results are given in section V. Lastly section VI carries the conclusions with future research suggestions. References have been given at the end.

Pakistan Textile Industry

Pakistan is desperately dependent on cotton textile and clothing for industrial base and exports that account for almost 60% of the total exports. Textile industry of Pakistan uses local cotton as basic raw material. Pakistan is the fifth largest producer and importer and third largest consumer of cotton in the world (The PACRA (Pakistan Credit Rating Agency Limited) 2020, 7-9).

Textile industry of Pakistan is a labor-intensive industry. The clothing sector provides jobs to unskilled labour. Pakistan is the sixth country in the world regarding population and has the low cost of labor force. According to Hamid, Nabi and Zafar (2014) textile and garments is the largest component of manufacturing sector that accounts for almost 50% of Pakistan's exports and due to expected future changes in the international trade, this sector has the potential to play an important role in increasing Pakistan's exports. Garments manufacturing is the least energy and capital intensive industrial activity that has attempted to overcome their difficulties.

Table 1: Growth in Capacity

	Spindles (Millions)	Rotors	Looms (Mill Sector)	Shuttle less	Power looms	Looms Total
2014-15	13.180	185,387	7,934	28,500	375,000	411,434
2015-16	13.414	187,259	8,188	28,500	375,000	411,688
2016-17	13.414	198,801	9,084	28,500	375,000	412,584
2017-18	13.410	198,801	9,084	28,500	375,000	412,584

Source: GOP, Textile Commissioner Organization (2017-18, 2)

[1]UNIDO (United Nation Industrial Development Organization)

Textile exports account for almost 60% of total exports. As Pakistan has been endowed with cotton production and cheap labor, she has a comparative advantage vis-à-vis her competitors in textile exports. Approximately $6.4 billion has been invested in the Textile industry of Pakistan during the 1999-2007 [GOP (Govt. of Pakistan) 2007-08, 39]. The numbers of spindles, rotors and looms has increased significantly since independence but these remained approximately the same for last two years (Table 1).

Table 2: Textile Exports of Pakistan (US$ Millions)

	Cotton & Cotton Textiles	Synthetic Textiles	Wool & Woolen Textiles	Total Textiles Exports	Total Pakistan's Exports	% age of Textiles Exports
2014-15	13139	330.743	119.448	13589	23885	56.90
2015-16	12168	287.793	97.68	12553	20802	60.34
2016-17	12205	187.587	78.506	12529	20478	61.35
2017-18	13220	309.681	75.852	13606	23222	58.59

Source: GOP (2018-19, 38)

Textile sector has inherent potential for the longest domestic production chain. It starts from ginning to spinning, knitting/weaving, dyeing and finishing, made ups and garments. At each operational stage, it has in-built high value addition potential. The percentage share of textiles in total exports of Pakistan had been remained vulnerable (Table 2). The yarn and cloth production in Pakistan has increased slightly for last few years as shown in Table 3.

Table 3: Growth in Production

	Yarn Production (Millions Kgs)	Cloth Production: (Millions Square Meters)		
		Mill Sector	Non-Mill Sector	Total
2014-15	3,369.7	1,036.9	8,089.6	9,126.5
2015-16	3,397.3	1,039.1	8,120.1	9,159.2
2016-17	3,428.1	1,043.3	8,126.4	9,169.7
2017-18	3,430.1	1,043.7	8,127.2	9,170.9

Source: GOP, Textile Commissioner Organization (2017-18, 2)

The textile sector specially the clothing sector has also significance in Pakistan's economy because this is the second largest sector which is suitable for women and provides considerable job opportunities outside the house. The cotton textile industry has played a crucial role in the progress of Pakistan's economy.

Table 4: Major Exports of Pakistan (% Share)

	Cotton Manufacture	Leather & Leather Manufacture	Rice	Sub-Total of Three Items	Other Items	Total
2014-15	54.5	4.8	8.5	67.8	32.2	100
2015-16	55	4.9	8.8	68.7	31.3	100
2016-17	59.4	4.5	7.9	71.8	28.2	100
2017-18	56.9	4.6	8.8	70.3	29.7	100

Source: GOP (2018-19, 127)

Exports basket of Pakistan contains few items. The bifurcation of the items in Table 4 shows that export in the few items is the major factor for lower export earnings. The three categories of exports has accounted for 70.3 percent of total exports during 2017-18.

Table 5: Significance of Textile Industry

	2015-16	2016-17	2017-18
% in Total exports	60.34	61.35	58.59
% in Manufacturing	46	46	46
% in Industrial employment	40	40	40
Machinery Imports [b] (US$ Million)	461.51	556.83	545.11

Source: a. GOP (various issues)
b. GOP, Textile Commissioner Organization (2017-18)

Table 5 indicated the significance of textile industry in Pakistan's economy. Textile sector of Pakistan is one of the major contributors to exports as shown in first row of the Table .It has played vital role in earning foreign exchange and jobs in the economy for the last more than six decades. It provides employment to 40 % of industrial labour force. It is expected, textile sector will continue to play a significant role in the growth of Pakistan's economy as there is no other sector that has the same potential to benefit it.

Review of Literature

Review of stochastic frontier (SF) literature revealed that the researchers had taken much interest in estimating TE and factors which affect the TIE of a firm. But analyzing the behavior of other measures of E (u_i / ε_i) in comparison with observational error had remained neglected in empirical research. Jondrow, Lovel, Materov and Schmidt (1982) suggested E [u_i/ε_i] as a measure of firm specific TIE. Bera and Sharma (1999) introduced the concept of PU due to TIE and presented analytical expression to estimate it by SF function with inefficiency term (u_i) distributed as half normal, truncated normal and exponential. They derived the analytical expressions for confidence intervals for inefficiency. They also illustrated their concepts using the model and data set of the U.S. electric utility industry.

Koirala and Koshal (2004) followed the approach of Bera and Sharma (1999) to find firm level PU for carpet industry of Nepal using the CMI (Census of Manufacturing Industries) data for 1992, 1997 separately and also for combined data. Production function was applied to find firm level PU by the standard error of TE. Although they did not give firm level value of PU in their paper but in Table 3 on page 363, they had written 32.46 and 17.56 as the average PU for 1992 and 1997 data respectively. They also found average PU = 257.13 for the combined data. These results were ambiguous as TE had range in a (0, 1) interval. Therefore, mean, variance and the standard error of it couldnot exceed one. How average PU had so big value, was questionable?

Bandyopadhyay and Das (2006) have also tried to evaluate PU by assuming a SF model whose error components (statistical noise v_i and inefficiency term u_i) are jointly distributed as truncated bivariate - normal. They derived the analytical expressions for the firm level E (u_i / ε_i) and PU and their confidence intervals, but they imposed the condition that the distribution of ε_i should be negatively skewed.

Duong (2016) examined technical efficiency of Foreign Direct Investment (FDI) firms in the Vietnamese manufacturing sector and used stochastic production frontier model and concluded that the average level of technical efficiency of FDI firms was about 60% that was higher than that of domestic firms. The study also reported correlation between technical efficiency of FDI firms and other factors.

This brief review of existing literature shows that the researchers have not given much attention to an interesting and significant area of PU. So, this study will add a humble contribution to the literature on firm level production uncertainty.

Methodology and Data

We followed Bera and Sharma (1999) approach to measure production uncertainty of TEM firms in Pakistan. We also computed the confidence intervals for inefficiency ui/ε_i of each firm and have used the hypothesis tests for the significance of ui/ε_i. Bera and Sharma (1999) suggested that PU due to TIE at the firm level could be measured empirically by the standard error of the TIE term u_i on the given entire compose error term ε_i of the firm. The SF model introduced by Aigner , Lovell and Schmidt (1977) and Meeusen and Broeck (1977) independently is given by the following expression:

$$OP_i = f(X_i, b) + \varepsilon_i$$

Where "OP_i" represents output, "X_i" shows the vector of non-stochastic inputs and "ε_i" denotes the stochastic error term of the ith firm. "f" denotes the production function and "b" represents the vector of parameters to be estimated. For production function, they assume the error term ε_i as:

$$\boldsymbol{\varepsilon_i} = v_i - u_i \quad , (i=1, 2, 3 \ldots. \; N)$$

The v_i and the u_i are independent component of ε_i and the v_i is normally distributed random error having zero mean and σ_v^2 variance ($v_i \sim N\,[0, \sigma_v^2]$). The v_i shows effects on production due to external factors which are outside the control of the firm (e.g. climate, natural disasters, luck and measurement error). They have also assumed that the u_i is one-sided ($u_i \geq 0$) and a firm specific which measures deviation from the best practiced frontier due to internal factors. It represents TIE effects which are behavior factors and can be controlled by a firm. It reflects the managerial capability.
Here we have assumed that the u_i had a half-normal distribution ($u_i \sim N(0, \sigma_u^2)$).

Bera and Sharma (1999) had defined probability density function (p.d.f) of u_i as

$$k(u_i) = \frac{2}{\sqrt{2\pi}} \frac{1}{\sigma_u} \exp\left\{-\frac{{u_i}^2}{2\sigma_u^2}\right\} \quad , ui > 0$$

And the p.d.f of u_i / $\boldsymbol{\varepsilon_i}$ as

$$f\left(\frac{u_i}{\varepsilon i}\right) = \frac{1}{\{1-\emptyset(r_i)\}} \frac{1}{\sqrt{2\pi}} \frac{1}{\sigma^*} \exp\left\{-\frac{(u_i-\mu_i^*)^2}{2\sigma^*}\right\}, ui \geq 0 \qquad \text{(a)}$$

Here $\mu_i^* = -\varepsilon_i\sigma_u^2/\sigma^2$, $\sigma_*^2 = \sigma_u^2\,\sigma_v^2/\sigma^2$
$\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $r_i = -\mu_i^*/\sigma^*$

They extended the idea of Jondrow *et al.* (1982), that the E (u_i/ε_i) is the expression for TIE and could be derived from equation (a). The values of E (u_i/ε_i) for each firm could be predicted by following expression.

$$E\,[u_i/\varepsilon_i] = \mu_i^* + \sigma_* h\,(r_i) \qquad (1)$$

And $h(\mathrm{ri}) = \frac{\Phi(\mathrm{ri})}{1-\phi(\mathrm{ri})}$, where Φ (.) represents the cumulative distribution function (c.d.f) and ϕ(.) denotes the probability distribution function (p.d.f) of a standard normal random variable.

The conditional variance of the inefficiency term u_i conditional on the specified whole combine error term ε_i is Var [ui /εi]. They defined variance of (u_i/ε_i) as under:

$$\text{Var}\ [u_i/\varepsilon_i] = \sigma_*^2\ \{1+ r_i\ h\ (r_i) - h^2\ (r_i)\}$$

For empirical research purpose and conducting hypothesis tests, they have proposed PU due to TIE, as the standard errors of firm level E (u_i/ε_i) estimates. The values of PU for each firm according to their definition could be estimated by the following equation.

$$PU_i = \sqrt{\text{Variance}\ [ui/\varepsilon i]} = \sqrt{\sigma_*^2\ \{1+ r_i\ h\ (r_i) - h^2\ (r_i)\}} \qquad (2)$$

When a firm has a higher level of PU then there is larger space for improvement in production of that firm.

Confidence Bounds for (u_i/ε_i) and Hypothesis Testing

From the conditional mean E (u_i/ε_i) and variance Var (u_i/ε_i), Bera and Sharma (1999) suggested $(1-\alpha)$ 100% confidence interval for the inefficiency u_i/ε_i.

The lower confidence bound for ith firm (LCB_i) for inefficiency (u_i/ε_i) was simplified as:

$$LCB_i = \mu_i^* + \Phi^{-1}[\alpha/2 + (1-\alpha/2)\ \Phi\ (r_i)]\ \sigma^* \qquad (3)$$

And the upper confidence bound (UCB_i) for ith firm for inefficiency (u_i/ε_i) was calculated by the formula:

$$UCB_i = \mu_i^* + \Phi^{-1}[1 - \alpha/2\{1-\Phi\ (r_i)\}]\ \sigma^* \qquad (4)$$

To conduct hypotheses tests for the significance of the E (u_i/ε_i) at firm level, Bera and Sharma (1999) have suggested the procedure for researchers as under:

If the null hypothesis is:

H_O: E $[u_i/\varepsilon_i] = 0$

And alternative hypothesis for one sided test is:

Ha: E $[u_i/\varepsilon_i] > 0$

Then one should use E $[u_i/\varepsilon_i] / \sqrt{\text{Var}\ [ui/\varepsilon i]}$ = E (u_i/ε_i) / (PU_i) and compare it for accepting or rejecting the null hypothesis with only the upper critical value defined as:

$$\int_{cu}^{\infty} f(wi)\,dwi = \alpha \qquad (5)$$

Here $$Wi = \frac{ui - E\ [ui/\varepsilon i]}{\sqrt{\text{Var}\ [ui/\varepsilon i]}}$$

The test for the significance of ith firm inefficiency to accept or reject the null hypothesis was performed by comparing the value E (u_i/ε_i) / (PU_i) with $\alpha = 0.05$.

Data

Availability of necessary and relevant data of Pakistan's textile manufacturing firms, due to some limitations, is the crux of problem. In this study, we had tried to obtain a consistent dataset. The data used in this study had been collected from the annual reports of 98 TEM firms for the year 2017-18. The names of these firms are available with the author that can be provided on request. Some of the annual reports had been downloaded from Karachi stock exchange and the websites of the companies and the others were copied from Lahore stock exchange personally. The monetary values of all variables used in the model were reported in thousands rupee (Pakistan's currency unit) terms.

We could not find information about labor force employed from all firms' reports. Thus, in the empirical model, we had used all variables in terms of thousands rupees (we had used wages, salaries and other benefits of labor instead of the total number of employees or hours). Battese and Corra (1977); Pitt and Lee (1981); Salim (2006); Singh, Pramatma and Singh (2007); Sasidaran and Shanmugam (2008); Goplan and Shanmugam (2010); Sheikh and Ahmed (2011) had also used cost of labor in their econometric production models. This allows the researcher to control for heterogeneity in labor quality across firms and also avoid inputs heterogeneity. Data of those TEM firms in Pakistan that had exported their products during the year 2017-18 were used.

Empirical Model

A standard log-linear Cobb-Douglas SF output specification with the half-normal distribution to estimate parameters of different input variables for TEM firms in Pakistan has been assumed as under:

$$\ln OPF_i = b_0 + b_1 \ln OFA_i + b_2 \ln RM_i + b_3 \ln EC_i + b_4 \ln SW_i + V_i + U_i \quad (6)$$

Here, the character "i" on the lower case is a symbol for individual firm1, 2, 3, ….., 98

ln = natural logarithm
b_0 = constant term
b_i = Parameter of explanatory variables, subscript i denotes 1, 2, 3,4
OPF = Output of the firm = Net Sale – distribution cost + Change in finished goods + Change in work in process – Purchase for resale during the year
OFA = Net value of Operating Fixed Assets of the firm during the year
RM = Total amount spent on "Raw & packing material + Stores and spares + Chemical & dyes" consumed + Processing /stitching /weaving /knitting charges etc. during the year
EC = Total amount spent on Fuel and power and water charges during the year
SW = Total amount of Salaries, wages, and other benefits of workers during the year
V = Random error
U = TIE

The SF output model given in equation 6 was estimated by Maximum Likelihood estimation (MLE) technique. The half-normal distribution of u_i had been selected. As for truncated normal distribution of u_i, the data was not converged, i.e. the software STATA had not shown the results.

The likelihood function had been parameterized in terms of $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\lambda = (\sigma_u / \sigma_v) \geq 0$ and estimation had been shown in Table 6.

Production Uncertainty Analysis

The estimated parameters of the variables along with standard errors, z - scores, p - values and 95 % confidence intervals for technical efficiency are presented in Table 6.

Table 6: The Results of Estimated Model (6)

Dependent Variable is OPF (output of a firm) Number of observation = 98

Log likelihood function = 68.8642 Number of iteration = 04

Variables	Estimated parameters	Standard error	z-scores	p-values	95% CI	
Intercept	0.878	0.1879	4.8	0.000	0.4947	1.2987
OFA	0.048	0.0378	1.59	0.102	-0.0123	0 .0778
RM	0.6998	0.0308	24.9	0.000	0.6748	0 .7498
EC	0.0971	0.0250	3.94	0.004	0.0477	0 .1701
SW	0.1623	0.0291	4.81	0.001	0.08817	0.2213
σ_v	0.0895	0.0169	-	-	0.0599	0.13228
σ_u	0.1429	0.0349	-	-	0.0910	0.2299
σ^2	0.0279	0.0080	-	-	0.0134	0.0389
λ	1.5984	0.0498	-	-	1.4937	1.6982

Source: Author computation

L-R test of $\sigma_u = 0$; χ^2 (01) = 2.58, Prob > = χ^2 = 0.054

The software did not show z - scores and p - values of the error terms, $\sigma$and λ. Therefore, these values were not shown in Table 6. The likelihood ratio test of u_i presented the value of 2.58 (significant at 0.05). The results of estimated model in Table 6 showed that all variables had expected sign and $\lambda > 0$ i.e. 1.5984, therefore our model was fitted well. All estimated parameters of dependent variables had expected positive sign and these were significant at 1 % level except OFA (operating fixed asset) which was significant at 10 % level.

Here the value of $\lambda > 0$ i.e. $\lambda \cong 1.60$ and was statistically different from zero. This indicated that the use of SF in regression was acceptable. Therefore, the model used to compute E (u_i/ε_i) and PU of TEM firms in Pakistan for 2017-18 and the specification of distributional assumption were appropriate. Further RM (cost of Raw material) had maximum elasticity of production i.e. 0.6998 than other inputs. SW (Salaries, wages, and other benefits) had the second maximum elasticity of production i.e. 0.162.

To compute PU of TEM firms of Pakistan, first the value of $\hat{\varepsilon}_i$ had been computed as the difference of observed OP_i and fitted OP_i of the estimated model (6). Then, the value of μ_i^*, σ_*^2 and r_i had been obtained by using the value of σ_v, σ_u, and σ^2 from the table and computed ε_i of each firm.

The Φ (r_i) had been calculated by using the Microsoft Excel and ϕ (r_i) had been computed with the help of Z table - normal distribution calculator. Putting these values in equations (2), the values of PU of individual firms had been obtained. The LCB_i and UCB_i for PU of each firm had also been computed by using equations (3) and (4).

Tests had been performed for the significance of i-th firms' inefficiency to accept or reject the null hypothesis by comparing the value E (u_i/ε_i) / (PU_i) with α calculated by equation 5. If the value of E (u_i/ε_i) / (PU_i) of i-th firm was greater than 0.05, then the null hypothesis was rejected and the value of i-th firm's inefficiency was statistically significant.

Table 7: Estimated error ε_i, E (u_i /ε_i), PU_i, 95% CI for u_i/ ε_i
Table 7 (a)

Grade	Firm No	ε_i	E (u_i /ε_i)	PU_i	LCB_i	UCB_i	E (u_i /ε_i) / PU_i
1	95	0.1155	0.0198	0.0037	0.0012	0.1225	5.3514
2	44	0.1137	0.0201	0.0037	0.0012	0.1231	5.4324
3	63	0.108	0.0208	0.0037	0.0012	0.125	5.6216
4	75	0.0962	0.0222	0.0038	0.0013	0.1292	5.8421
5	57	0.0946	0.0223	0.0038	0.0013	0.1298	5.8684
6	5	0.0864	0.0232	0.0038	0.0014	0.1328	6.1053
7	7	0.0847	0.0233	0.0038	0.0014	0.1335	6.1316
8	90	-0.0521	0.0666	0.0038	0.0037	0.1983	17.5263
9	50	-0.0526	0.0669	0.0038	0.0037	0.1986	17.6053
10	81	-0.0541	0.0677	0.0038	0.0037	0.1995	17.8158
11	23	-0.056	0.0687	0.0038	0.0038	0.2006	18.0789
12	66	-0.0626	0.0722	0.0038	0.004	0.2044	19.0000
13	15	-0.0631	0.0724	0.0038	0.0041	0.2047	19.0526
14	91	-0.0645	0.0731	0.0038	0.0041	0.2055	19.2368
15	27	-0.0662	0.074	0.0038	0.0042	0.2065	19.4737
16	35	-0.0665	0.0742	0.0038	0.0042	0.2067	19.5263
17	2	-0.0666	0.0742	0.0038	0.0042	0.2067	19.5263
18	53	-0.0701	0.076	0.0038	0.0044	0.2088	20.0000
19	39	-0.0719	0.077	0.0038	0.0044	0.2099	20.2632
20	98	-0.0732	0.0776	0.0038	0.0045	0.2106	20.4211
21	25	0.0652	0.0254	0.0039	0.0016	0.1411	6.5128
22	56	-0.0377	0.059	0.0039	0.0032	0.1902	15.1282
23	67	-0.0758	0.079	0.0039	0.0046	0.2122	20.2564
24	24	-0.0775	0.0799	0.0039	0.0047	0.2132	20.4872
25	38	-0.0775	0.0799	0.0039	0.0047	0.2132	20.4872
26	71	-0.0788	0.0805	0.0039	0.0048	0.214	20.6410
27	11	-0.0789	0.0806	0.0039	0.0048	0.2141	20.6667
28	62	-0.0802	0.0813	0.0039	0.0048	0.2149	20.8462

Table 7 (b)

Grade	Firms No	ε_i	$E(u_i/\varepsilon_i)$	PU_i	LCB_i	UCB_i	$E(u_i/\varepsilon_i)/PU_i$
29	59	-0.0846	0.0835	0.0039	0.005	0.2176	21.4103
30	93	-0.0871	0.0848	0.0039	0.0052	0.2191	21.7436
31	42	0.0579	0.0263	0.004	0.0016	0.1441	6.5750
32	74	0.0555	0.0266	0.004	0.0016	0.145	6.6500
33	34	-0.0283	0.0539	0.004	0.003	0.1851	13.4750
34	70	-0.0296	0.0546	0.004	0.003	0.1858	13.6500
35	54	-0.0309	0.0553	0.004	0.003	0.1865	13.8250
36	80	-0.0937	0.0882	0.004	0.0056	0.2231	22.0500
37	8	-0.0951	0.0889	0.004	0.0056	0.224	22.2250
38	65	-0.0964	0.0896	0.004	0.0057	0.2248	22.4000
39	92	-0.0975	0.0901	0.004	0.0058	0.2255	22.5250
40	82	-0.0991	0.091	0.004	0.0059	0.2265	22.7500
41	69	-0.1039	0.0935	0.004	0.0062	0.2295	23.3750
42	72	-0.104	0.0935	0.004	0.0062	0.2296	23.3750
43	10	0.0387	0.0292	0.0041	0.0018	0.1523	7.1220
44	13	-0.0163	0.0473	0.0041	0.0027	0.1788	11.5366
45	37	-0.0175	0.048	0.0041	0.0027	0.1794	11.7073
46	86	-0.0191	0.0488	0.0041	0.0028	0.1802	11.9024
47	30	-0.1055	0.0943	0.0041	0.0063	0.2305	23.0000
48	83	-0.1076	0.0954	0.0041	0.0065	0.2319	23.2683
49	1	-0.1077	0.0954	0.0041	0.0065	0.232	23.2683
50	47	-0.1088	0.096	0.0041	0.0066	0.2327	23.4146
51	6	-0.0097	0.0436	0.0042	0.0026	0.1754	10.3810
52	4	-0.119	0.1013	0.0042	0.0074	0.2392	24.1190
53	52	-0.12	0.1019	0.0042	0.0075	0.2398	24.2619
54	55	-0.1221	0.103	0.0042	0.0077	0.2412	24.5238
55	29	-0.1238	0.1039	0.0042	0.0078	0.2423	24.7381
56	33	0.1554	0.012	0.0043	0.001	0.11	2.7907
57	94	0.0095	0.0354	0.0043	0.0022	0.1658	8.2326

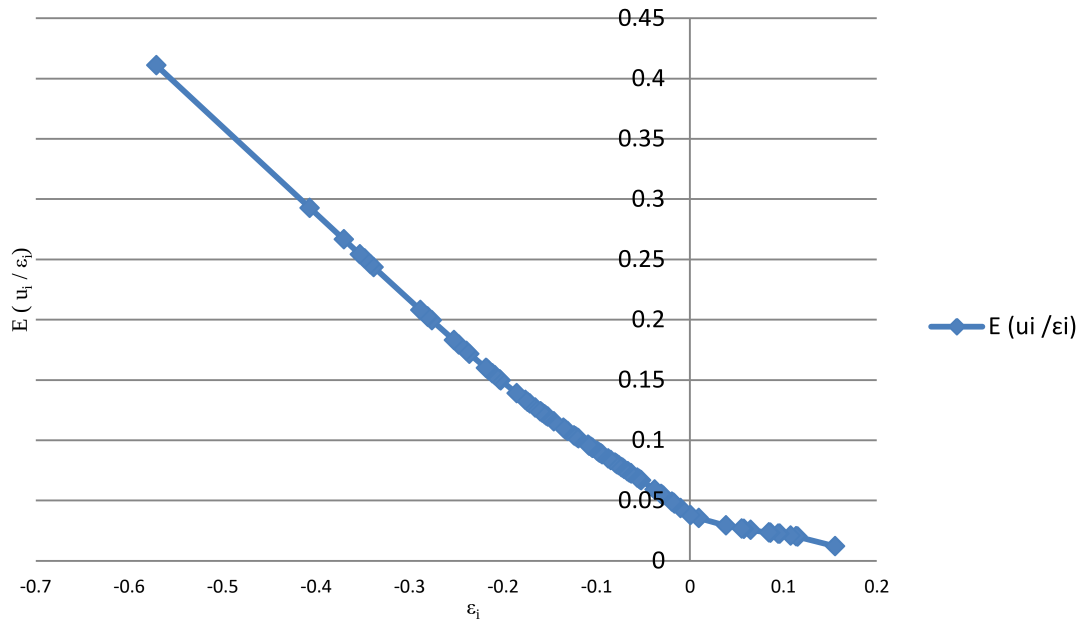
Table 7 (c)

Grade	Firms No	ε_i	E (u_i /ε_i)	PU_i	LCB_i	UCB_i	E (u_i /ε_i) / PU_i
58	96	0.0006	0.0378	0.0043	0.0024	0.1701	8.7907
59	61	-0.1307	0.1076	0.0043	0.0085	0.2468	25.0233
60	22	-0.133	0.1089	0.0044	0.0088	0.2484	24.7500
61	16	-0.1342	0.1095	0.0044	0.0089	0.2491	24.8864
62	28	-0.1353	0.1101	0.0044	0.009	0.2499	25.0227
63	89	-0.1453	0.1156	0.0045	0.0103	0.2565	25.6889
64	31	-0.1521	0.1194	0.0046	0.0112	0.261	25.9565
65	78	-0.1537	0.1203	0.0046	0.0114	0.2621	26.1522
66	26	-0.1554	0.1213	0.0046	0.0117	0.2633	26.3696
67	45	-0.1579	0.1227	0.0047	0.0121	0.265	26.1064
68	32	-0.1595	0.1236	0.0047	0.0123	0.266	26.2979
69	40	-0.1598	0.1238	0.0047	0.0124	0.2663	26.3404
70	51	-0.1652	0.1269	0.0048	0.0133	0.2699	26.4375
71	97	-0.1711	0.1304	0.0048	0.0144	0.2739	27.1667
72	68	-0.1734	0.1318	0.0049	0.0149	0.2756	26.8980
73	84	-0.176	0.1333	0.0049	0.0154	0.2773	27.2041
74	77	-0.1851	0.1388	0.005	0.0174	0.2836	27.7600
75	87	-0.2022	0.1496	0.0052	0.022	0.2955	28.7692
76	20	-0.2029	0.15	0.0052	0.0222	0.296	28.8462
77	18	-0.2034	0.1503	0.0052	0.0224	0.2964	28.9038
78	14	-0.2035	0.1504	0.0052	0.0224	0.2964	28.9231
79	76	-0.2085	0.1536	0.0052	0.0239	0.2999	29.5385
80	17	-0.2112	0.1553	0.0053	0.0248	0.3018	29.3019
81	49	-0.2153	0.158	0.0053	0.0262	0.3047	29.8113
82	73	-0.2171	0.1592	0.0053	0.0269	0.306	30.0377
83	19	-0.2179	0.1597	0.0053	0.0272	0.3065	30.1321
84	12	-0.2357	0.1715	0.0055	0.0343	0.3191	31.1818
85	9	-0.239	0.1738	0.0055	0.0357	0.3215	31.6000
86	41	-0.2471	0.1793	0.0055	0.0395	0.3272	32.6000
87	43	-0.2523	0.1829	0.0056	0.0421	0.3309	32.6607
88	46	-0.276	0.1993	0.0056	0.0549	0.3478	35.5893
89	3	-0.2799	0.2021	0.0057	0.0572	0.3507	35.4561
90	48	-0.2806	0.2025	0.0057	0.0576	0.3511	35.5263
91	85	-0.2883	0.208	0.0057	0.0623	0.3566	36.4912
92	21	-0.3382	0.2435	0.0058	0.0952	0.3925	41.9828
93	64	-0.3415	0.2459	0.0058	0.0975	0.3949	42.3966
94	58	-0.3479	0.2505	0.0058	0.1019	0.3994	43.1897
95	60	-0.3529	0.2541	0.0058	0.1055	0.4031	43.8103
96	79	-0.3702	0.2665	0.0058	0.1177	0.4155	45.9483
97	88	-0.4065	0.2926	0.0058	0.1436	0.4417	50.4483
98	36	-0.5708	0.4109	0.0058	0.2618	0.5599	70.8448
	Average		0.1080	0.0045			

Source: Author computation (from Table 6)

From the computed LCB_i and UCB_i values and the tests for the null hypothesis performed for E (u_i /ε_i) and PU of each individual firms, it had been found that the values of inefficiencies for each TEM firm were statistically significant at 5 % level of significance, as all the values of E (u_i /ε_i)/ PU_i were greater than 0.05 (Table 7).

Figure 1: Graph of E (u_i /ε_i) against ε_i : 2017 - 18



Source: Author computation (from Table 7)

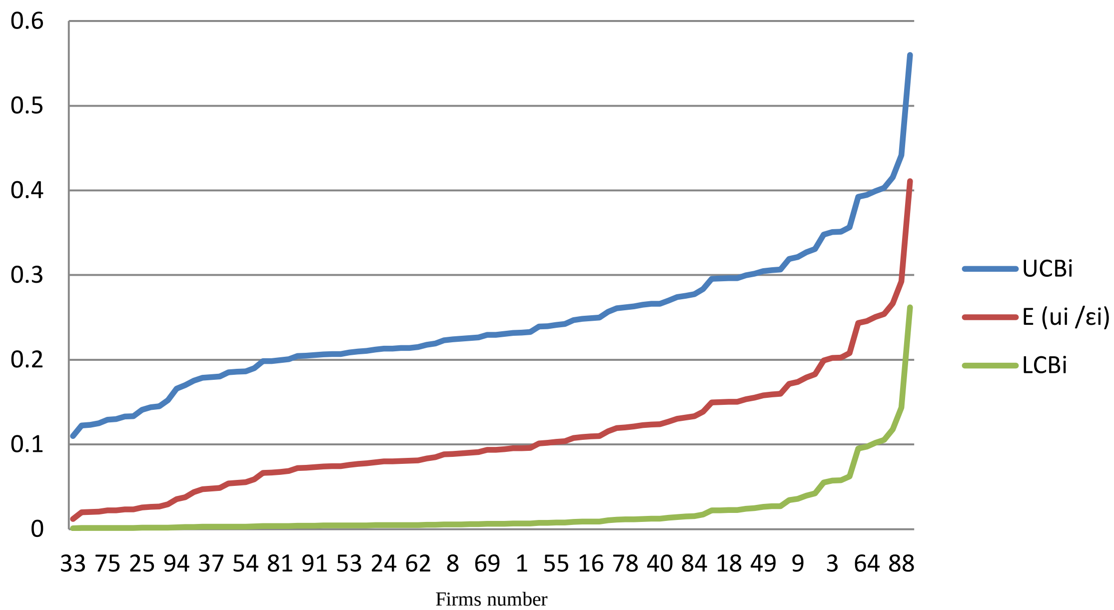
Inefficiencies E (u_i /ε_i) of TEM firms in Pakistan for 2017-18 were between 0.012 and 0.4109 and the mean E (u_i /ε_i) was equal to 0.1080. Therefore, the firms of Pakistan were not achieving 100 percent of production potential during the year. The PU in Pakistan's TEM firms for 2017-18 was between 0.0037 and 0.0058 and the mean PU was equal to 0.0045.

Similarly, the relationship with estimated PU_i and estimated $\boldsymbol{\varepsilon_i}$ of TEM firms is not monotonically decreasing, when $\hat{\boldsymbol{\varepsilon}}_i$ had the value near to zero or greater than zero. When E (u_i /ε_i) was the largest i.e. 0.4109 then PU was the largest i.e. 0.0058. But when E (u_i /ε_i) was smallest then PU had not the smallest value (Table 7).

The graph of estimated E (u_i /ε_i) of TEM firms in Pakistan against estimated $\boldsymbol{\varepsilon_i}$ is shown in Figure 1. It is obvious that when $\hat{\boldsymbol{\varepsilon}}_i$ has negative value then the relationship with E (u_i /ε_i) and $\hat{\boldsymbol{\varepsilon}}_i$ is monotonically decreasing but when $\hat{\boldsymbol{\varepsilon}}_i$ has positive value then the relationship does not hold good for 2017-18 data set.

The scores of E (u_i /ε_i) of Pakistan's TEM firms for the year 2017-18 were depicted in the Figure 2 with confidence intervals. The upper line shows the UCB_i for E (u_i /ε_i) of individual firms , middle line shows E (u_i /ε_i) of the same individual firms while lower line shows the LCB_i of the same individual firms. It is obvious from Figure 2 that when the level of E (u_i /ε_i) is small then the width of CI is small and when the level of E (u_i /ε_i) is high then the width of CI is large.

Figure 2: Confidence Bounds for E (ui / εi): 2017 - 18



Source: Author computation (from Table 7)

Conclusions

This study had estimated risk or variation in firm specific production (due to TIE) of TEM firms in Pakistan for year 2017-18. Bera and Sharma (1999) called it as firm specific production uncertainty (PU). The estimated PU scores remained on average between 0.0037 and 0.0058. And on average mean PU is equal to 0.0045. The computed scores of PU of TEM firms in Pakistan during 2017-18 showed that maximum number of firms had their PU score low and close to minimum PU score and very few firms had high PU score and close to maximum PU score. According to Bera and Sharma (1999), a firm having the lowest PU score is most efficient one. This study had revealed that maximum numbers of firms were working on efficient level and had a little instability and the lowest variation (due to TIE) in their production.

Suggestions for Future Research

Different tracks for future research are proposed as;

First, this study had estimated PU due to TIE by Bera and Sharma (1999) approach. They assumed that the relationship between estimated E (u_i /ε_i) score of a firm and estimated error term ε_i of SF output function and the relationship between estimated PUi and ε_i are monotonically decreasing, but in this study, it had been revealed that when the residual ε_i has positive value then, these relationships does not hold good. Econometricians in future may make efforts to resolve these problems for better results.

Second, this study had used labour cost instead of numbers of labourers or hours of labour in the SF output function. If, one of these is available in future, that should be used for better analysis of output function. Third, in this study, data of Public limited companies had been used. Private companies and small and medium enterprises may also be included in future research to analyze the entire trend of PU of TEM firms in Pakistan, if the relevant data of these companies is available.

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