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Technical Efficiency Analysis of Agricultural Research and Development in Higher Educational Institutes of Pakistan

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ABSTRACT

The role of education is one of the fundamental factors of any country social and economic development. This epigrammatic present the general idea of the most important investment trends in agricultural research in Higher Education Institutes (HEI) in Pakistan since the early 2003 to 2009, The enhancement in higher education institutes in agriculture research around the world in those days suggests that the higher education institutes in Pakistan also should formulate superior involvement to overall agriculture R&D. Data envelopment Analysis (DEA) instrument is used in order to assess the technical efficiency of 23 HEI of Pakistan. The technical and scale efficiency results suggests the agricultural universities in Pakistan are functioning at a fairly high level of efficiency, although there is room for improvement in several universities by improving the efficiency of those HEI, in order to operate at optimal scale.

Keywords: Higher Education Institutes (HEI), technical efficiency and scale efficiency

INTRODUCTION

The Agriculture sector continues to play a fundamental position in Pakistan's economy. It is the second largest sector, accounting for over 21 percent of GDP, and remains by far the largest employer, absorbing 45 percent of the country's total labor force. Nearly 62 percent of the country's population resides in rural areas, and is directly or indirectly linked with agriculture for their livelihood (GOP, 2011). Pakistan being an agricultural developing country has to produce more output in all obedience of agriculture. By way of required revolutionize in the structure of the agricultural investment. The food price and economic crisis in 2008 have had a severe impact

on majority of people in Pakistan. The solution to long-term food security lies in augmenting investment in agriculture research and development. There is no doubt about that socio economic status, poverty, political instability, terrorism, macro and microeconomic policies breakdown and gigantic drop in foreign direct investment play a critical constancy in lowering Pakistan economic growth. But above all the role of education is one of the fundamental factors of any country social and economic development. Later than the independence of Pakistan in 1947, there was about 10% literacy rate. Miscellaneous Government set several targets during their tenure to hoist the literacy rate; current Government also set a target about 85% literacy rates till 2015. We can't disregard the significant role of education towards escorting economic growth, various studies like [afzal et al. (2010); Martin and Barro (1995); Barro and Martin (1997); Barro (1991)] gives us an idea about the positive correlation in between education and economic growth. Growth theories by [Romer (1986); Romer (1987); Lucas (1988); Barro (1990)] provided the central idea about the relationship and Lucas (1988) in their endogenous growth models presented a fundamental initiative regarding role of education in the economic growth, and then various other studies by [Nili and Nafisi (2003); Gadiri and Dargahi (2003); Emadzadeh et al.(2000)] also estimate the consequences of education towards economic growth, and that found positive and significant association between them.

(Laghari 2012) "identified the various challenges in Pakistan education and research network include access to higher education enrollment and equity, quality and standard of education, faculty, and research, and significance of research in universities building it plays vital role in the building of Economies, Communities and Leadership. According to him education enrollment of Turkey, Malaysia, China, Indonesia and India is ten times more than Pakistan's"[1].

In this regard higher education institutes (HEI) role is quite noteworthy in determining agriculture sector of Pakistan multidimensional through further research and investment in diverse fields of agriculture. Being a agricultural country development in agriculture sector result in reducing poverty, upgrading in socioeconomic status of 62% of people that living in rural area and as well as development of whole of nation also. More enrollment rates in higher education institutes related to agriculture research and development result in promoting efficient labor, human capital, magnetize investment and transforming more advancement in agriculture sector and economic growth. Subsequently, it also shows the way to earn more foreign exchange.

Objectives of the Study

- To estimate technical efficiency of HEI towards agricultural research and development production in Pakistan.
- To estimate returns to scale in HEI in Agricultural R&D.

LITERATURE REVIEW

The enhancement in higher education institutes in agriculture research around the world in those days suggests that the higher education institutes in Pakistan also should formulate superior involvement to overall agriculture R&D. One key element of this literature narrates to the compilation and study of data. Various studies [Anderson (1991); Roseboom et al. (1991), Evenson (2003), Peterson and Perrault (1998); Fischer and Byerlee (2002) Fuglie Pray (2001), coelli and Rao (2003)] examined the role of public investment in agriculture R&D as well as the performance of agriculture research institutes and share of private sector in agriculture R&D. Further studies of [Avkiran (2001); Johnes (2006); Johnes and Yu (2008); Kuah et al. (2011); Bougnol et al. (2006); Flegg et al. (2004)] evaluated the contribution of Higher education institutes towards investment and interventions in R&D.

Johnes (2006) apply Data envelopment analysis (DEA) to 2547 Economics graduates from UK Universities in 1993 in order to assess teaching efficiency. Each individual's efficiency is decomposed into two components: one attributable to the university at which the student studied and the other attributable to the student himself. The results suggest that efficiencies derived from DEAs performed at an aggregate level are misleading because it includes both institution and individual components. Johnes and Yu (2008) examine the relative efficiency in the production of research of 109 Chinese regular universities in 2003 and 2004. Output variables measure the impact and productivity of research; input variables reflect staff, students, capital and resources. Mean efficiency is just over 90% when all input and output variables are included in the model, and this falls to just over 80% when student-related input variables are excluded from the model. The rankings of the universities across models and time periods are highly significantly correlated. Kuah et al. (2011) examine the relative teaching and research efficiencies of universities. The model was tested using a hypothetical example and its use and implications in university performance measurement were described. The application of DEA enables academics to identify deficient activities in their universities and take appropriate actions for improvement.

Bougnol et al. (2006) evaluate two classification and ranking schemes concerning universities; one from a published report, "Top American Research Universities" by the University of Florida's The Center and the other using DEA. This suggests that DEA is a suitable tool for these types of studies. Johnes (2006) study the possibility of measuring efficiency in the context of higher education. The paper ends with an application of DEA to a data set of more than 100 Health education institutions in England using data for the year 2000/01. Technical and scale efficiency are high on average in the English higher education sector.

[1] Dr. Javed Laghari is Chairman of HEC, this statement he given in a press release at the Institute of Strategic Studies Islamabad (ISSI) organized a Public talk on 27th July 2011.

Flegg et al. (2004) study the technical efficiency (TE) of 45 British universities in the period 1981 to 1993. To show the causes of variations in efficiency, TE is decomposed into pure technical, congestion and scale efficiency. The analysis of the study shows that there was a substantial rise in the weighted geometric mean TE score during the study period, although this rise was most noticeable between 1988 and 1991. Avkiran (2001) apply data envelopment analysis (DEA) to scrutinize the relative efficiency of Australian universities. In this regard he develops three models, namely, overall performance, performance on delivery of educational services, and performance on fee-paying enrolments. The finding explains that university sector was performing well on technical and scale efficiency but the gap of improving performance on fee-paying enrolments exist. Abbott and Doucouliagos (2003) use non-parametric techniques to estimate technical and scale efficiency of individual Australian universities. The finding expresses that in spite of the output input mix, Australian universities as whole recorded high levels of efficiency relative to each other. Results of the previous studies suggests that overall mean research efficiency is higher in educations universities is higher and performing quite well in R&D.

DATA AND METHODOLOGY

This epigrammatic present the general idea of the most important investment trends in agricultural research in Higher Education Institutes (HEI) in Pakistan since the early 2003 to 2009, description of a latest set of data developed all the way through a comprehensive survey.

The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (Greene, 1993). The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a firm's actual production point lies on the frontier it is perfectly efficient. If it lies below the frontier then it is technically inefficient, with the ratio of the actual to potential production defining the level of efficiency of the individual firm (Farrell, 1957).

In present study we utilized data envelopment analysis (DEA) approach to measure the technical efficiency of HEI related to agricultural R&D. DEA (data envelopment analysis) which is non-parametric approach involve linear programming and does not impose any functional form restrictions, as DEA is a non-parametric approach, so works under the assumption of no random shocks in the data set. In this paper we applied the Data Envelopment Analysis (DEA) instrument in order to assess the technical efficiency of 23 HEI[2] of Pakistan.

The following input and output variables are used in the DEA analysis:

Input Variables

- The number of Ph.D. staff;
- The number of MS/M.Phil. staff
- The number of MSC/BS staff; and
- The number of admin staff
- The number of technical staff

Output Variables

- The number of Ph.D. graduates
- The number of MS/MPhil graduates
- The number of BS graduate.

The present study uses a single-step methodology. In the first step, data envelopment analysis (DEA) is used to model efficiencies as an explicit function of discretionary variables. The methodology is specified below.

"Assuming we have data on *K* inputs and *M* outputs of N years, x_i is an input vector for the i^{th} farm and y_i is an output vector for the i^{th} year. The K x N input matrix, *X*, and M x N output matrix, *Y*, represent the data of all HEI institions N. For each institute, we obtained a measure of the ratio of all

[2] List of 23 institutes provided in appendix

outputs over all inputs, such as $u/y_i/v/x_i$, where u is an M * 1 vector of output weights and v is K * 1 vector of input weights. To select optimal weights we solve the mathematical programming problem as specified by Coelli, *et al* (1998)". Firstly,

$\max_{u,v} (u/y_i/v/x_i)$ (1.1)

subject to

$$u/y_j/v/x_j \leq 1,\ j= 1,2,\ldots\ldots N,$$
$$u,\ v \geq 0$$

$\max_{u,v} (u/y_i/v/x_i)$ (1.2)

Subject to

$$V/x_i = 1$$
$$u/y_j/v/x_j \leq 1,\ j= 1,2,\ldots\ldots N,$$
$$u,\ v \geq 0$$

Secondly,

$\text{Min}_{\theta}, \lambda\ \theta,$ (1.3)

$$-y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$\lambda \geq 0$$

Where, θ = is a scalar, Restriction: $\theta \leq 1$, λ = is a Nx1 vector of constants

Coelli, *et al* (1998) "suggest that a constant returns to scale DEA model is only appropriate when all firms are operating at an optimal scale, this is not possible in agriculture due to many constraints such as imperfect competition and financial constraints, etc. Bankers, *et al.* (1984) modifies the constant returns to scale DEA model into a variable returns to scale model by adding convexity constraints". Variable Returns to Scale (VRS) DEA model is also found in detail in the studies; Ferrier, D. and Lovell C, A. K., (1990), and Sharma et. al., 1999. Following Coelli, *et al* (1998), an input-oriented variable returns to scale DEA model will be used to estimate technical efficiency. Here, the objective is to determine the relative efficiency for each year. Efficiency is measured by the ratio of inputs to outputs as follows:

$\text{Min}_{\theta}, \lambda\ \theta,$ (1.4)

Subject to

$$\boldsymbol{-y_i + Y\lambda \geq 0}$$
$$\boldsymbol{x_i - X\lambda \geq 0}$$
$$\boldsymbol{N1/\lambda = 1}$$
$$\boldsymbol{\lambda \geq 0}$$

Where, N1/ λ = 1 represents a convexity constraint which ensures that an inefficient HEI is only benchmarked against institute of a similar size. *Y* represents the output matrix for N year. θ represents the total technical efficiency of the ith HEI. λ represents N x 1 constants. *X* represents the input matrix for N year HEI.

While in variable return to scale Data Envelopment Analysis we use the term pure technical efficiency because it is free from scale effects. DEA more flexible in case of variable return to scale and CRS and VRS carried out on the same data set. The ratio between CRS and VRS technical efficiency scores is called scale efficiency. A decision making unit is called scale efficient if VRS and CRS, technical efficiency score are equal.

RESULT AND DISCUSSION

Descriptive Analysis

Descriptive analysis for input and output variables of HEI are presented in Table.1 (see Appendix). Descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS in year 2003 was about 17%, 10.1% and 10%, respectively. Percentage change in in case of PhDs, MS

and MSC. Staff was about11.8%, 10.9% and 15%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 2.9%, 10.4% and 11.9%, respectively.

In year 2004 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS was about 12.8%, 14.5% and 11.1%, respectively. Percentage change in case of PhDs, MS and MSC Staff was about 12.2%, 11.7% and 11%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 3.7%, 11% and 14.2%, respectively. In year 2005 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS was about 11.3%, 11% and 12.8%, respectively. The percentage changes in case of PhDs, MS and MSC. Staff was about 13%, 12.2% and 12.3%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 4.4%, 16.5% and 13.2%, respectively.

In year 2006 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS it was about 13.8%, 11.5% and 12.9%, respectively. The percentage changes in case of PhDs, MS and MSC Staff was about 13.9%, 13.8% and 13.8%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 13.5%, 12.5% and 13.1%, respectively. In year 2007 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS was about 19%, 23.7% and 14.6% respectively. The percentage changes in case of PhDs, MS and MSC. Staff was about15.1%, 14.7% and 15.7%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 6.3%, 15.5% and 16.6%, respectively. In year 2008 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS was about 11.3%, 10.5% and 22%, respectively. The percentage changes in case of PhDs, MS and MSC Staff was about16.5%, 17.7% and 15.6%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 72.7%, 26.1% and 17.7%, respectively.

In year 2009 descriptive statistics of enrolled students shows that percentage change in PhDs, MS, and MSC/BS was about 14.8%, 18.6% and 16.7%, respectively. The percentage changes in case of PhDs, MS and MSC. Staff was about 17.5%, 18.9% and 16.3%, respectively. In case of graduated students of PhDs, MS and MSc/BS the percentage change was about 6.4%, 8.1% and 13.2%, respectively. There is a significant difference between the percentages of all the variables, precisely, the input and output variables are all higher, on average, for HEIs from 2003-2009. The descriptive analysis shows the increasing trend with each passing year in agricultural research and development.

Empirical Analysis

The result of the study shows that Pakistan HEI related to Agriculture R&D is overall, technical and scale efficient. The use of DEA to universities technical efficiency analysis has largely focused on the efficiencies of university departments related to agriculture research and development. Through literature review it should be quite that for scholastic application there is no definite research work that assistance us for the selection of input and outputs.

Table 4.1

On Average Technical efficiency of HEC Institutes in Agriculture (R&D) from (2003-09)			
Year	**CRSTE**	**VRSTE**	**SE**
2003	0.899	0.978	0.922
2004	0.932	0.971	0.957
2005	0.926	0.987	0.938
2006	0.955	0.972	0.978
2007	0.966	0.984	0.981
2008	0.876	0.975	0.901
2009	0.901	0.921	0.974

A swift of the efficiency scores for all HEI is presented in Table 4.1. Results show that there was a fewer amount of deviation of efficiency scores from the best practice frontier. The mean variable return to scale technical efficiency (VRSTS) score of HEI in year 2003 scores was about 0.978. The average VRSTE score suggests that the average inputs for the HEI could be possibly reduced by 2.2% without upsetting the level of outputs. On the other hand the overall scale efficiency of HEI in year 2003 was about 0.92 that depicts that HEI scale efficiency was less than unity, so HEI were not scale efficient in year 2003

An analysis of VRSTE in year 2004 revealed that the mean technical efficiency in year 2004 was about 0.97. So on average there was possibility to reduced inputs about 3% in HEI without affecting the output. On average the scale efficiency in year 2004 was about 0.95, so under the assumption of variable return to scale the HEI could save on average 5% of their inputs if they operate on optimal scale.

The result of the study shows that in year 2005 the mean technical efficiency of HEI was about 0.987. On average there was possibility to reduced inputs about 1.3% in HEI without affecting the output. . The scale efficiency in year 2005 was about 0.93, so there is possibility to save about 7% of input in HEI, and operate at optimal scale.

The mean variable return to scale technical efficiency (VRSTS) score of HEI in year 2006 scores was about 0.972. The average VRSTE score suggests that the average inputs for the HEI could be possibly reduced by 2.8% without upsetting the level of outputs. On the other hand the overall scale efficiency of HEI in year 2006 was about 0.978 that depicts that HEI scale efficiency was less than unity, so HEI were not scale efficient in year 2006.

The mean variable return to scale technical efficiency (VRSTS) score of HEI in year 2007 scores was about 0.984. The average VRSTE score suggests that the average inputs for the HEI could be possibly reduced by 1.6% without disturbing the level of outputs. On the other hand the overall scale efficiency of HEI in year 2006 was about 0.981 that describes that HEI scale efficiency was less than unity, so HEI were not scale efficient in year 2007.

The mean variable return to scale technical efficiency (VRSTS) score of HEI in year 2008 scores was about 0.975. The average VRSTE score suggests that the average inputs for the HEI could be possibly reduced by 2.5% without distressing the level of outputs. On the other hand the overall scale efficiency of HEI in year 2008 was about 0.901 that portrays that HEI scale efficiency was less than unity, so HEI were not scale efficient in year 2008.

The mean variable return to scale technical efficiency (VRSTS) score of HEI in year 2009 scores was about 0.921. The average VRSTE score suggests that the average inputs for the HEI could be possibly reduced by 8% without troubling the level of outputs. On the other hand the overall scale efficiency of HEI in year 2009 was about 0.974 that represents that HEI scale efficiency was less than unity, so HEI were not scale efficient in year 2009.

Table 4.2

Return to scale of HEI from 2003-2009														
	2003		**2004**		**2005**		**2006**		**2007**		**2008**		**2009**	
	%	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**
CRS	82.6	19	78.2	18	73.9	17	82.6	19	86.9	20	65.2	15	86.9	20
IRS	8.70	3	13.04	3	17.3	4	4.35	1	8.70	2	17.3	4	0.00	0
DRS	4.35	1	8.70	2	8.70	2	13.0	3	4.35	1	17.3	4	13.0	3
Total	100	23	100	23	100	23	100	23	100	23	100	23	100	23

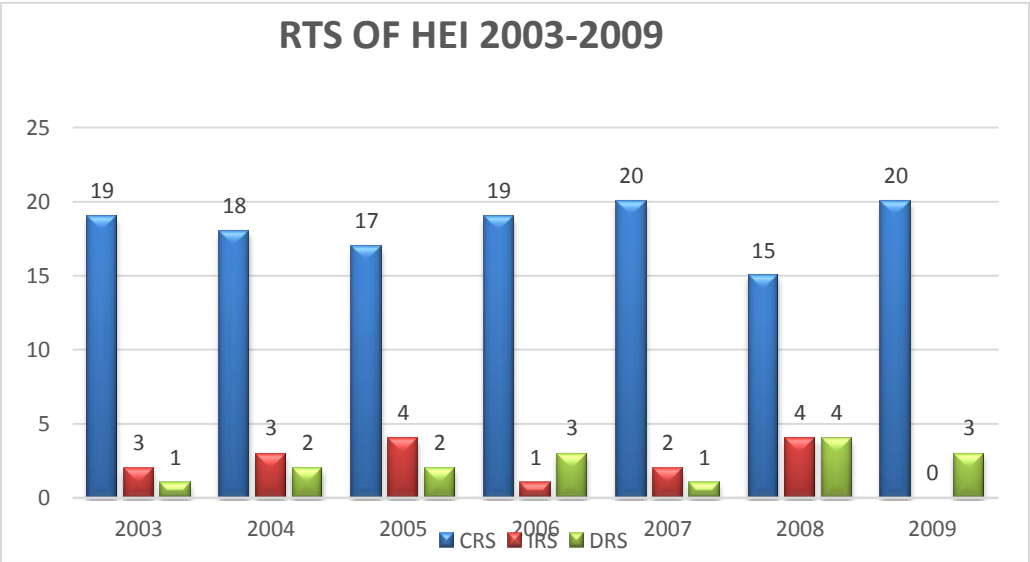

Figure.1

A VRS model disintegrates efficiency scores into pure and scale efficiency score. In order to examine whether the inefficiencies were because of increasing returns to scale (IRTS) or decreasing returns to scale (DRS), the VRS DEA model was run. The results designate that in year 2003, out of 23 HEI 19 (82.6%) were operating at Constant Return to Scale (CRS) in other words in 2003 19 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 3 (8.7%) of institute operating at Increasing Return to Scale (IRS) and 1(4.35%) institute working at Decreasing Return to Scale (DRS)[3].

The results of the study reveals that in year 2004, out of 23 HEI 18 (78.2%) were operating at Constant Return to Scale (CRS) in other words in 2004, 18 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 3 (13.4%) of institutes operating at Increasing Return to Scale (IRS) and 2 (8.70%) institutes working at Decreasing Return to Scale(DRS).

The results of year 2005 shows that, out of 23 HEI 17 (73.9%) were operating at Constant Return to Scale (CRS) in other words in 2005, 17 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 4 (17.3%) of institutes operating at Increasing Return to Scale (IRS) and 2 (8.70%) institutes working at Decreasing Return to Scale(DRS).

The results of return to scale of year 2006 shows that, out of 23 HEI 19 (82.6%) were operating at Constant Return to Scale (CRS) in other words in 2006,19 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 1 (4.35%) of institute operating at Increasing Return to Scale (IRS) and 3 (13.04%) institutes working at Decreasing Return to Scale (DRS).

The results of year 2007 reveals that, out of 23 HEI 20 (86.9%) were operating at Constant Return to Scale (CRS) in other words in 2007, 20 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 2 (8.7.%) institutes operating at Increasing Return to Scale (IRS) and 1 (4.35%) institutes working at Decreasing Return to Scale (DRS).

The results of return to scale of year 2008 shows that, out of 23 HEI 15 (65.2%) were operating at Constant Return to Scale (CRS) in other words in 2008, 15 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 4 (17.3%) of institute operating at Increasing Return to Scale (IRS) and 4 (17.3%) institutes working at Decreasing Return to Scale(DRS).

The results of year 2009 reveals that, out of 23 HEI 20 (86.9%) were operating at Constant Return to Scale (CRS) in other words in 2009, 20 HEI were scale efficient. The result of the study further discloses that out of 23 HEI 0 (0.00. %) institutes operating at Increasing Return to Scale (IRS) and 3 (13.04%) institutes working at Decreasing Return to Scale (DRS).

So the results of the study reveals that in case of IRS institutes an equivalent escalation in all inputs is result in more than a proportionate increase in outputs. So in order to upsurge the scale of operation there is need to increase in the demand as well. Those institutes operating at DRS, it means that that a percentage increase in all inputs is followed by less than a percentage change in outputs. So there is need to improve the efficiency of those HEI, in order to operate at optimal scale.

CONCLUSION

In this present study we have assess the efficiency of HEI that are functioning on agricultural research and development. Educational institute played a very important role in providing human capital and more advances techniques in agricultural sector through research and development. Pakistan being an agricultural developing country has to produce more output in all obedience of agriculture. By way of required revolutionize in the structure of the agricultural investment. The food price and economic crisis in 2008 have had a severe impact on majority of people in Pakistan. The solution to long-term food security lies in augmenting investment in agriculture research and development. DEA was used to estimate the technical and scale efficiency for the universities engaged agricultural research and Development. The technical and scale efficiency results suggests the agricultural universities in Pakistan are functioning at a fairly high level of efficiency, although there is room for improvement in several universities by improving the efficiency of those HEI, in order to operate at optimal scale.

[3] See Figure.1

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APPENDIX

Table1

Year	Enrolled Students			UNIVERSITY STAFF						Graduated Students		
	PhDs	MS	MSC/BS	PhDs	MA	MSC	ADMIN	TECHNICIANS	OTHER STAFF	PhDs	MS	MSC/BS
2003												
Sum	2447	8025	18461	834	690	565	463	84	1893	203	5825	15436
Mean	106	349	879.1	36.3	31.4	24.6	21.0	3.8	82.3	8.8	253.3	701.6
SD	241	730	2107.7	57.6	54.7	79.8	38.2	5.6	215.5	24.0	555.8	1934.2
Maximum	1001	2310	9570	208	219	294	170	24	1035	115	2212	8966
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Percentage change	17.0	10.1	10.0	11.8	10.9	15.0	6.2	2.4	9.6	2.9	10.4	11.9
2004												
Sum	1852	11528	20464	864	740	430	899	100	2358	261	6182	18440
Mean	84.2	501.2	930.2	37.6	33.6	18.7	39.1	4.3	102.5	12.4	268.8	801.7
SD	136.9	1036	2305.0	58.3	57.4	64.0	76.6	7.1	224.6	32.6	558.4	2311.7
Maximum	546	3959	10735	231	228	280	329	31	1028	150	2214	11000
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Percentage change	12.8	14.5	11.1	12.2	11.7	11.4	12.0	2.8	12.0	3.7	11.0	14.2
2005												
Sum	1627	8722	23569	919	778	460	919	1349	1411	310	9259	17121
Mean	74.0	379.2	1024.7	41.8	35.4	20.0	40.0	58.7	61.3	13.5	402.6	778.2
SD	116.4	642.1	2571.4	65.4	57.5	68.5	72.2	257.9	104.2	41.4	1003	1973.2
Maximum	494	2178	12191	255	221	300	312	1241	432	200	3877	9000
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Percentage change	11.3	11.0	12.8	13.0	12.3	12.2	12.3	38.2	7.2	4.4	16.5	13.2
2006												
Sum	1988	9094	23832	987	877	519	1046	131	2779	249	7002	16911
Mean	86.4	395.4	1083.3	42.9	39.9	23.6	45.5	5.7	120.8	10.8	304.4	768.7
SD	178.1	747.1	2428.4	68.0	62.4	77.0	81.8	9.2	271.5	31.3	663.2	1824.7
Maximum	738	2912	11050	268	233	320	344	42	1251	150	2730	8000
Minimum	0	1	0	0	0	0	0	0	0	0	0	0
Percentage change	13.8	11.5	12.9	13.9	13.8	13.8	14.0	3.7	14.1	3.5	12.5	13.1
2007												
Sum	2743	18829	27064	1071	932	591	1285	1500	2613	440	8676	21561
Mean	124.7	818.7	1288.8	46.6	42.4	25.7	55.9	65.2	113.6	20.0	377.2	1026.7
SD	238.5	1847.7	2654.4	71.1	63.5	84.1	100.8	280.9	234.7	74.0	801.4	2326.9
Maximum	848	7231	11754	283	229	340	419	1353	978	350	3411	10000
Minimum	0	1	0	0	0	0	0	0	0	0	0	0
Percentage change	19.0	23.7	14.6	15.1	14.7	15.7	17.2	42.4	13.3	6.3	15.5	16.6
2008												
Sum	1637	8357	40638	1171	1126	590	1357	170	3429	5107	14617	22874
Mean	71.2	363.3	1847.2	50.9	51.2	25.7	59.0	7.4	149.1	222.0	635.5	1089.2
SD	119.9	693.3	3504.3	79.5	74.8	84.4	106.7	11.9	320.8	1042	1678	2699.0
Maximum	433	2902	11835	311	259	350	443	54	1446	5000	6293	9932
Minimum	0	0	0	0	0	0	0	0	0	0	3	0
Percentage change	11.3	10.5	22.0	16.5	17.7	15.6	18.2	4.8	17.4	72.7	26.1	17.7
2009												
Sum	2141	14732	30819	1243	1202	615	1504	200	5200	452	4517	17159
Mean	93.1	640.5	1467.6	54.0	54.6	26.7	65.4	8.7	226.1	19.7	196.4	858.0
SD	158.9	1283	2517.1	82.4	80.4	87.3	107.5	13.0	427.1	62.4	329.9	1514.7
Maximum	548	4892	10205	310	259	358	444	56	1461	303	1075	4935
Minimum	0	0	0	0.01	0	0	0	0	0	0	0	0
Percentage change	14.8	18.6	16.7	17.5	18.9	16.3	20.1	5.7	26.4	6.4	8.1	13.2

Source: *self calculation and estimation*

Table2. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2003*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	0.727	0.728	0.999
8	1	1	1
9	1	1	1
10	0.252	1	0.252
11	0.705	1	0.705
12	1	1	1
13	1	1	1
14	0.763	0.763	1
15	1	1	1
16	0.703	1	0.703
17	1	1	1
18	1	1	1
19	1	1	1
20	1	1	1
21	0.539	1	0.539
22	1	1	1
23	1	1	1

Table3. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2004*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	0.749	1	0.749
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	0.93	1	0.93
11	1	1	1
12	1	1	1
13	1	1	1
14	0.792	0.792	1
15	0.95	1	0.95
16	1	1	1
17	1	1	1
18	1	1	1
19	0.543	1	0.543
20	1	1	1
21	0.465	0.551	0.844
22	1	1	1
23	1	1	1

Source: *self calculation and estimation*

Table4. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2005*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	0.799	1	0.799
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	0.837	1	0.837
10	0.959	0.963	0.996
11	1	1	1
12	1	1	1
13	1	1	1
14	0.694	0.737	0.942
15	1	1	1
16	1	1	1
17	1	1	1
18	1	1	1
19	0.443	1	0.443
20	1	1	1
21	0.557	1	0.557
22	1	1	1
23	1	1	1

Source: *self calculation and estimation*

Table5. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2006*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
13	1	1	1
14	0.831	0.851	0.977
15	0.907	1	0.907
16	0.829	1	0.829
17	1	1	1
18	1	1	1
19	1	1	1
20	1	1	1
21	0.397	0.503	0.789
22	1	1	1
23	1	1	1

Source: *self calculation and estimation*

Table6. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2007*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1

4	0.721	0.734	0.982
5	1	1	1
6	1	1	1
7	0.825	0.902	0.914
8	1	1	1
9	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
13	1	1	1
14	1	1	1
15	1	1	1
16	1	1	1
17	1	1	1
18	1	1	1
19	1	1	1
20	1	1	1
21	0.678	1	0.678
22	1	1	1
23	1	1	1

Source: *self calculation and estimation*

Table7. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2008*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	0.53	1	0.53
8	0.7	1	0.7
9	1	1	1
10	1	1	1
11	0.948	0.951	0.996
12	1	1	1
13	1	1	1
14	0.472	0.481	0.98
15	0.853	1	0.853
16	0.598	1	0.598
17	1	1	1
18	1	1	1
19	0.329	1	0.329
20	1	1	1
21	0.73	1	0.73
22	1	1	1
23	1	1	1

Source: *self calculation and estimation*

Table8. *Technical Efficiency of (HEC) Institutes in Agriculture (R&D) in 2009*

INSTITUTES	CRSTE	VRSTE	SE
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1
7	0.608	0.608	1
8	0.746	0.746	1

9	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
13	1	1	1
14	0.748	0.906	0.826
15	0.856	1	0.856
16	1	1	1
17	1	1	1
18	1	1	1
19	0.574	0.574	1
20	1	1	1
21	0.382	0.533	0.717
22	0.818	0.818	1
23	1	1	1

Source: *self calculation and estimation*

Institutes
Sindh Agriculture University, Tandojam, Pakistan
Pir Mehr Ali Shah Arid Agriculture University Rawalpindi
Gomel University and Faculty of Agriculture
University of Veterinary and Animal Sciences
University of Veterinary and Animal Sciences, Lahore
University of Veterinary and Animal Sciences, Lahore (Department of Livestock Production)
Faculty of Animal Husbandry, University of Agriculture, Faisalabad.
Division of Agriculture and Extension, University of Agriculture, Faisalabad.
Faculty of crop sciences, Department of Food Technology,Pir Mehr Ali Shah University of Arid Agriculture Rawalpindi
Faculty of Agricultural Economics and Rural Sociology, University of Agriculture, Faisalabad.
Faculty of Agricultural Economics and Rural Sociology, University of Agriculture, Faisalabad.
Faculty of Agriculture, University of Agriculture Faisalabad , Jail Road
Faculty of Sciences, University of Agriculture, Faisalabad
Faculty of Veterinary Science, University of Agriculture Faisalabad.
Vice Chancellor Office, University of Agriculture, Faisalabad
Department of Agriculture Sciences,Allama Iqbal open university Islamabad, Pakistan
Faculty of Biological Sciences Quaid-i-Azam University Islamabad
Institute of Environmental and Engineering and Management
PMAS Arid Agriculture University Rawalpindi.
Punjab University Lahore
University of Engineering & Technology, Lahore
Department of Fresh Water Biology and Fisheries, University of Sindh
Institute of Water Resources and Management, Mehran University of Engineering & Technology, Jamshoro