A comparative study on agricultural production efficiency between China and Pakistan using Data Envelopment Analysis (DEA)

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Abstract

Agricultural production is the base of economic growth and development and the key factor of poverty and food hunger eradication in the world. The most populous countries in the world as China and Pakistan, trying to improve agricultural productivity to reduce poverty and hunger. The aim of the study is to compare the agricultural production efficiency of China and Pakistan using Data Envelopment Analysis (DEA). For the evaluation of comprehensive overall efficiency (technical*scale efficiency) of both countries, agricultural production million tons used as output obtained by using the combination of inputs as agricultural land million hectares, agricultural labor million workers, agricultural tractors millions and agricultural fertilizer million tons during 1978 to 2016. Empirical result shows that during 1978 to 2016 agricultural production efficiency of China relatively occurs at the technically efficient level and the scale efficiency is quite less efficient; however agricultural production efficiency of Pakistan is moderately efficient during 1978 to 2016 only 5 times overall efficiency level occurs, similarly the scale efficiency of Pakistan also gains 5 times efficient value. The comparative results indicate the overall agricultural production efficiency of China is greater than Pakistan; although agricultural production of Pakistan increasing but China have efficient agricultural production because it strongly depends on technology therefore for more efficient agricultural production; Pakistan need to apply new agricultural technology.

Keywords: Agricultural production, China, Efficiency, Pakistan

1. Introduction

Agriculture is worldwide a vital determinant of the livelihoods of small land holding farmers and rural communities. Agricultural growth throughout global history has been the progenitor of broad based economic growth and development, it is key factor for alleviation and eradication of rural poverty and main source of food hunger eradication; stable growth of agriculture is a vital work in the world (Li. X, Zhang. Y, Liang. L, 2017; FAO, 2002).

Introduction of green revolution considerably enhanced the agricultural production through adoption of improved agriculture seed varieties, appropriate use of irrigation system and application of pesticides, chemical fertilizers and new machineries which boosted the agricultural production due to which cereal production of Asia increased outstanding as 3.57 percent annually in 1965 to 1982 (Hazell, 2009; Rosegrant and Hazell 2000). Agriculture sector is an important sector of China and Pakistan; it played a central role to eradicate poverty and cut huger of both economies.

It is considered as the lifeline of economy of Pakistan which contributes about 19.5 percent of the gross domestic product, and about 42.3 percent of labor force involves in this sector and is a raw material of several products. Since last six decades the annual agricultural GDP growth of Pakistan were about 3.46 percent, which has been sustained by technological progress as introduction of high yielding varieties of cotton, grains with the support of public investment in irrigation, agricultural research, extension services and infrastructure development (Ali, 2005; GOP, 2016; PBS, 2008; Madhur, G. Yu, B. 2015; Bhutto, A. W; Bazmi, A. A. 2007).

Wheat, sugarcane, cotton, rice and maize are the major crops of Pakistan which contributing about 23.85 percent of the value added in overall agricultural GDP and 4.66 percent of overall GDP; agriculture production of Pakistan has been growing very fast due to adoption of high yielding seed verities and application of modern technologies (Khan, 2011; GOP 2016). Figure one and two shows area and production of major crop (grain crops, cotton and sugarcane crop) in Pakistan and China.

The agriculture production of both countries increasing time by time but the production of China as compared to Pakistan increasing very fast due to agricultural policies such as seed subsidy policy, tax reduction policy, farm machinery purchase subsidy policy and market oriented policy (Thirtle, C, Piesse. J, 2007; Heady, 2011; Galeale *et al*. 2005; Yang *et al*. 2008; Yu and Jensen 2010).

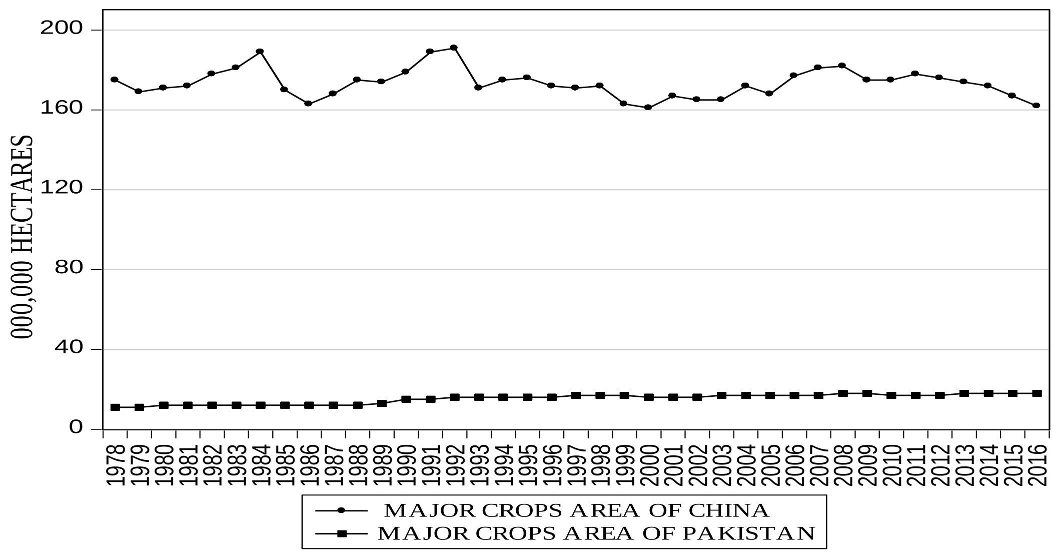

Figure 1: Major crops as Grain crops, Cotton, and Sugarcane crops area of China and Pakistan

Note. Grain crops includes Wheat, Rice, Maize, Barley, Millet and Sorghum

Source: Data were obtained from, China statistical year book various, Economic survey of Pakistan various issues, Pakistan statistical bureau and Food and Agriculture Organization

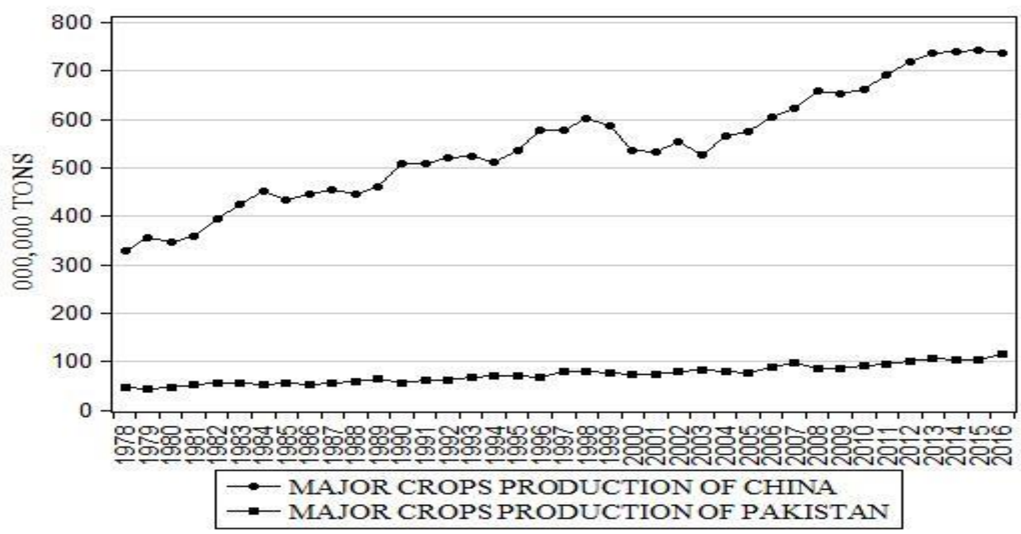

Figure 2: Major crops as grain crops, cotton, and sugarcane production of China Pakistan

Note. Grain crops includes wheat, rice, maize, barley, millet and sorghum

Source: Data were obtained from, China statistical year book (various years), Economic survey of Pakistan (various issues), Pakistan statistical bureau and Food and Agriculture Organization

Development of Chinese agriculture sector started from its economic reform; it plays a vital role in economic growth from central planning to dynamic market sector; the agricultural production improves by household responsibility system and state purchase agricultural marketing system; production of grain increased from 304.8 million tons to 407.3 million tons in 1979 to 1984, about 7.7 percent agricultural production grows annually due to agricultural technology progress enhancing rural infra structure and improved agricultural research (Mao and Koo 1997; State Statistical Bureau 2000; Huang 1998).

However agricultural growth was slow down the production declines from 512.3 million tons to 430.7 million tons during 1998 to 2003 (Fan *et al* 2004; Ma and Fang 2013). For the improvement of agricultural production efficiency and enhancement of grain production government of China provide subsidies to farmers which includes grain subsides, comprehensive inputs subsidies, high quality seed subsidy and machinery subsidies and close down the agricultural tax due to which the grain output has increased up to 601.9 million tons which shoes the grain subsidies and close down of taxes has impact to improve grain output (Liu *et al* 2015). Stable agricultural output growth of China has mainly driven by increasing inputs and technology innovations; due to which agricultural production has improved to cut hunger and reduce the poverty (Li, 2013).

Although limited land shifts of agricultural labor to non agricultural sector, the agricultural production continuously increased (Madhur. B, 2015). Stable growth in agriculture and grain production is not an aim of China to fulfill domestic demand of food but also playing important role in world grain market due to which China has achieved the healthy development (Piessse and Thirtle 2009; Heady 2011; Li. X, Zhang. Y, Liang. L, 2017) The most populous countries of World; China and Pakistan as the World`s first populous and six populous countries trying to improve the agricultural productivity to reduce poverty and widespread hunger and achieve standard of living, agricultural growth rate of both countries are different, although agricultural sector of both countries growing very fast but the growth rate of China consistently high, the production of food crops grow faster than the population growth rate (Madhur, 2015; Ali, 2005).

The present study aims to compare the agricultural production efficiency of China and Pakistan, focusing major crop production as grain production, cotton production, and sugarcane production; research attempts to estimate production efficiency it is hope that the results of present study will be helpful to understand how agricultural production efficiency of both countries changed by time; the investment in agricultural research and resources for agricultural growth.

The rest of the paper is organized as follows. In the subsequent section description of literature review about production efficiency. Section three briefly description of study area. Section four presents methodology and empirical model proposed. Section five presents the results of agricultural production efficiency of China Pakistan comparison. Section six is main conclusion

2. Literature Review

2.1. Production efficiency

Umetsu *et al* (2003) examined the regional difference in total factor productivity, technology and efficiency change in rice sector of Philippine for the post-green era. Results show the gain of production growth was due to introduction of modern seed verities rice seed however decline in growth was due to growing modern rice verities in lowland agricultural system. Investment in infrastructure development, education, increasing the adoption of tractors and favorable agro climatic environmental condition are main concerned the production growth.

Chavas (2005) investigated the farm household efficiency: evidence from the Gambia. Efficiency analysis conducted at farm level and household level. Econometric analysis indicates technical efficiency is fairly high due to access on technology of most the farm households, modest results of scale efficiency was found and allocative inefficiency by contrast is found to be important for most of the farm households. Allocative inefficiency caused by limitation in markets for financial capital and nonfarm employment. Armagan *et al.* (2010) estimated efficiency and total factor productivity of crop production at NUTS1 level in Turkey: Malmquist index approach. NUTS (The Nomenclature of Territorial units for Statistics) regions in Turkey were selected as decision making units; to estimate the efficiency and total factor productivity changes during 1994 to 2003 the Data Envelopment Analysis (DEA) and Malmquist productivity index were used.

Results reveals there has been decrease in technical efficiency and total factor productivity in regions excludes Western Marmara, the Aegean, the Mediterranean and the East Balcksea Region. The decrease in agricultural production efficiency caused by real price level remained same and the real price of inputs increased regardless the decreasing population economically active in agricultural sector, and the difficulty experienced in integration of the latest technology to the agricultural sector. Lotfi et al (2012) declared the patterns of agricultural development must be optimize constantly and the cash crops efficiency must grow high, particularly the comprehensive growth by the food centered to food and cash crops. Tan and Floros (2012) stated that the high production in traditional agricultural system gain by the use modern technology. Chang *et al* (2014) argued that for high yield of crops the technology is very important factor, adoption of new quality seed and use modern methods of agricultural activity promotes production level. King *et al* (2016) proposed factors of agricultural production system. For enhancement of agricultural production, systematical use of soil, fertilizer, plant nutrition and improved agricultural technology are distinct factors.

Khan. F, Salim. R, Bloch. H. (2014) Nonparametric estimates productivity and efficiency change in Australian Broadacre Agriculture. The empirical results show there is slower growth of total factor productivity due to slower growth in technological progress which is main driver of declining trend of productivity growth. Liu *et at* (2015) analysis the productivity and efficiency change in China`s rice production during new farm subsidy years. Study explores the rice production growth of China, little contributed by technical efficiency changes technical. Farm subsidy on rice farms efficiency has not significant. Improved and upgraded technology may help rice farmers for better rice production. Li. X, Zhang. Y, Liang. L. (2017) analysis the agricultural production input/output efficiency and special disparity in China. Study results indicate the agricultural production inputs has technical efficiency but there is lack of scale efficiency and there has large disparity in east, center and western regions. Ullah, A, Khan. D, Zheng. S. (2017) examine the technical efficiency of peach growers: evidence from Khyber Pathunkhwa, Pakistan. Study results suggested that technical efficiency of peach farmers can be improved by appreciate use of inputs and proper management to avoid production process errors and problem.

3. Study Area

Study aims to compare the agricultural production efficiency between China and Pakistan; According to geography and different climatic conditions; China is the world`s largest country, it classified into four agro ecological zones as arid zone, semi-arid zone, semi-humid zone and humid zone (Figure 3).

Figure 3: represents Agro-ecological zones of China
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Arid zone is located west and northwest side of China, agriculture comprises of irrigated cotton, and grain, vegetables and fruits, and livestock domestication have dominancy in this zone. Semi-arid zone is located in central China and the main irrigated crops of this zone are wheat, maize and cotton, this region also consist of rained cropping system. Semi-humid zone having both floods and droughts, it includes northeast side of the country, however this zone is potentially fertile, it has short growing season and the major crops of this zone are wheat, maize and soybean and rice, it also comprises north plain and its neighbor area. This area is longer growing seasonal area then northeast and the irrigated crops are grown as wheat, maize, and rice. The humid zone consist of south and southwest side of the country. It has tropical monsoon climate and consist whole year round cropping as wheat, rice, maize however rice is the main dominant crops on other grain crops (Wang *et al.*, 1999; FAO, 2011).

Agriculture sector consider as the backbone of Pakistan, it is divided into ten agro-ecological zones on the basis of climate, land use and water availability (Figure 4).

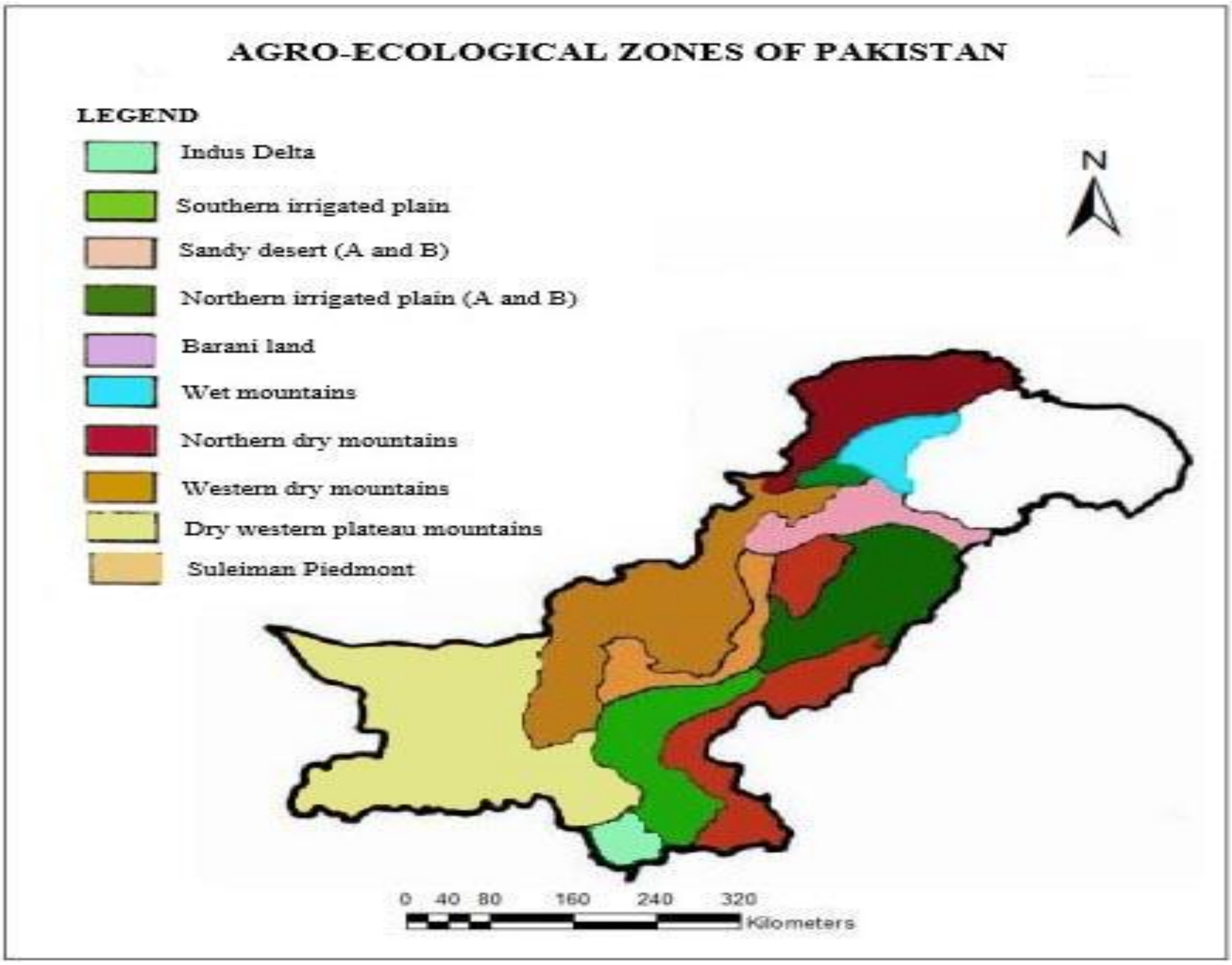

Figure 4: Agro-ecological zones of Pakistan
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Zone one is called is Indus Delta, this zone climate is arid and tropical marine, the soil of this zone are clay and silt where major crops grown as rice, sugarcane cane, banana and pulses. Zone two is irrigated plain of southern are also called as lower Indus plain. In this zone the climatic condition is arid and subtropical, mostly soil is sandy loam and silt major crops grown as cotton, wheat, rice and gram. Zones three A and three B are sandy desert area, where the soil is sandy and loamy fine sand, these zone mostly consist of grazing. Zone four

A and four B are the irrigated plain of northern areas where the soils are sandy loam, clay-loam and loamy, in these zones mostly irrigated crops as rice, wheat, maize, sugarcane, oil seeds and orchard are grown. Zone five consist of barani or rainfed land.

Main crops are wheat, millet, oil seed and pulses. Zone six is the northern wet mountain area of the country, the soil condition is silt loam and silt clay, most of the area consist forestry however a small part have rainfed agriculture. Zone seven is northern dry mountains of country which have valley soil are and deep clayey and most of the area used for grazing. Zone eight is western dry mountainous consist of hills with deep slops, most of the area have grazing land but some part have wheat and fruits. Zone nine is dry western plateau mountains. Mostly land grown grazing, melons, fruits and vegetables and wheat in those area where availability of water. Zone ten is plains of Suleiman range the climate is hot and arid, irrigation comes from hills flood and major crop grown are wheat, millet and gram (FAO, 2004, PARC, 1980)

4. Methodology and Empirical Model Proposed

4.1. Data Envelopment Analysis (DEA) Model

Data envelopment analysis (DEA) was proposed by Charnes, Cooper and Rhodes in 1978 which assumed constant return to scale (CRS), while the assumption of CRS is suitable for decision making units (DMUs) which operates at an optimal scale. In 1984 Bankler, Charnes and Cooper had explore an extension of CRS DEA to interpret Variable Return to Scale (VRS); DEA model are both either the input oriented or the output oriented model. Earlier explained as to reduce input at greatest level expended efficiency in the condition of output remains constant, however latter evaluation is to increasing output efficiency in the condition where the input resource remains constant (Coelli 1996). In this study we evaluate the agricultural production efficiency of China and Pakistan; for agricultural production efficiency inputs are easier control.

Therefore we used VRS input-oriented DEA in paper to analyses the agricultural production efficiency.

There are n DMUs for a given time period, and Xi and Yr are the input and output vectors for the given DMU with m inputs and s output respectively.

$$X_j = (X_{1j}, X_{2j}, \ldots, X_{mj})^T,\ Y_j = (Y_{ij}, Y_{2j}, \ldots, Y_{mj})^T \quad j = 1, 2, 3, \ldots, n \qquad (1)$$

While Xij (i=1,2,3,…,m) is the ith input variable of jth DMU; Yrj (j=1,2,3,…s) is rth variable output of jth DMU. The VRS input oriented DEA is given as fallows (Wang, et al, 2012**)**

$$\begin{cases} \min \theta = VD_2 \\ s.t \sum_{j=1}^{n} X_j Y_j \le \theta X_D \\ \sum_{j=1}^{n} Y_j \lambda_j \ge 1 \\ \sum_{j=1}^{n} \lambda_1 = 1 \\ \lambda_j \ge 0, i = 1,2,3,\ldots,n \end{cases} \quad (2)$$

In equation number 2, the value of efficiency of each DMU represented by θ and the $0 \le \theta \le 1$, i.e $\theta = 1$ indicates the technical efficiency of DMU and $\theta < 1$showing technically inefficient of the DMU.

4.2. Data

In this study we used data from various issues of China statistical year book, economic survey of Pakistan and various publications Pakistan statistical bureau, for the period of 1978 to 2016. The agricultural production in million tons were used as output obtained by combination of inputs as agricultural land million hectares, agricultural labor used million persons, number tractors used for agriculture in millions and fertilizer million used tons. The summery statistics for the variable used to analyze the agricultural production efficiency of China and Pakistan. In these variables there is high variability across sample, subsequently all the variables of both countries have high standard deviation in relation to its mean.

Table 1: Summery statistics

China	Units	Minimum	Maximum	Mean	Std. Dev.
Agricultural Production	Tons (Millions)	328	744	544	116
Agricultural Land	Hectares (Millions)	160	191	173	7.41
Agricultural labor	Workers (millions)	215	391	318	46
Agricultural Tractors	Numbers (Millions)	1.93	23.17	12.12	7.10
Agricultural fertilizer	Tons (Millions)	8.84	60.23	36.50	16.34
Pakistan	**Units**	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
Agricultural Production	Tons (Millions)	44.82	115	73.75	18.81
Agricultural Land	Hectares (Millions)	11.06	18.06	15.25	2.36
Agricultural labor	Workers (millions)	12.38	24.73	17.46	4.17
Agricultural Tractors	Numbers (Millions)	0.075	0.53	0.317	0.14
Agricultural fertilizer	Tons (Millions)	0.88	4.36	2.61	1.07

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The average agricultural production of China is 544 million tons. Average agricultural land is 173 million hectares, agricultural workers are 318 million, number of agricultural tractors are 12.12 and average fertilizers used for agricultural production in China is 36.50 million tons. While in Pakistan the average agricultural production is 73.75 million tons, average agricultural land is 15.25 million hectares, on an average agricultural workers are 17.46 million, average number of agricultural tractors is 0.317 million and the average agricultural fertilizers used in Pakistan is 1.07 million tons (Table 01).

5. Empirical Results

5.1. Agricultural production efficiency

The analysis of efficiency obtained by using DEA, the results of agricultural production efficiency of China shown in table 02. The results reveals in 1978 and 1979 agricultural production relatively efficient; overall all efficiency, pure efficiency and scale efficiency all are 1. Similarly during 1983, 1984, 1985, 1986, 1996, 2015 and 2016 the agricultural production is efficient; the value 1 appears in overall efficiency, pure technical efficiency and scale efficiency; from 1978 to 2016 the agricultural production in such nine years is comparatively favorable, without insufficient production or input dissolution.

Agricultural production efficiency of remaining years is comparatively inefficient representing the agricultural production not reached at best point of production while optimization level of agricultural production inputs could be applied. While the results of pure technical efficiency reveals during 1978, 1979, 1983, 1984, 1985, 1986, 1987, 1990, 1996, 1998, 1999, 2002, 2013, 2015 and 2016 the value appear 1 which enlightens such years the agricultural production affectivity optimizing; the progress of agricultural production strongly depend on agricultural technology which sustained the agricultural production, however the remaining years the pure technical efficiency of agricultural production is less than 1 indicating the weaker dependency of agricultural production on technology but mostly depends on natural resource inputs. Similarly results of scale efficiency shown from table 1 reveals during 1978, 1979, 1982, 1983, 1984, 1985, 1986, 1996, 2015 and 2016 showing 1 value means unchanged return to scale of such period; the agricultural production inputs of such years achieving the best combination and the years of 1980, 1981, 1988, 1989, 1993, 1994, 1995, 1997, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2006, 2007, 2009, 2010 reveals increasing return to scale; the agricultural production gains at optimum level is increasing greater than the input used, therefore increasing of agricultural output continuously acquiring by increasing agricultural production inputs.

Finally during 1987, 1990, 1991, 1992, 1998, 2008, 2011, 2012, 2013 and 2014 the scale efficiency of is less than 1 showing decreasing return to scale explained as the output agricultural is increasing less than its use increasing inputs. Means increasing use of agricultural inputs results not optimized production of output so that for acquiring more return to scale, it is important to increase the production technical efficiency of agriculture. For analysis of inputs dimensions we used input orientated DEA, it mainly concern to combination inputs used to analyses efficiency of output. Theoretically the combination of inputs increase the output production in China results shown in table 2.

Table 2: Analysis of input oriented DEA for agricultural production efficiency of China

Agricultural production efficiency of China				
Year	**Overall Efficiency**	**Pure technical efficiency**	**Scale Efficiency**	**Results**
1978	1.000	1.000	1.000	Unchanged return to scale
1979	1.000	1.000	1.000	Unchanged return to scale
1980	0.937	0.988	0.948	Increasing return to scale
1981	0.943	0.979	0.963	Increasing return to scale
1982	0.990	0.990	1.000	Unchanged return to scale
1983	1.000	1.000	1.000	Unchanged return to scale
1984	1.000	1.000	1.000	Unchanged return to scale
1985	1.000	1.000	1.000	Unchanged return to scale
1986	1.000	1.000	1.000	Unchanged return to scale
1987	0.994	1.000	0.994	Decreasing return to scale
1988	0.937	0.941	0.995	Increasing return to scale
1989	0.929	0.939	0.989	Increasing return to scale
1990	0.974	1.000	0.974	Decreasing return to scale
1991	0.920	0.942	0.977	Decreasing return to scale
1992	0.922	0.953	0.968	Decreasing return to scale
1993	0.977	0.978	0.999	Increasing return to scale
1994	0.920	0.940	0.979	Increasing return to scale
1995	0.942	0.956	0.985	Increasing return to scale
1996	1.000	1.000	1.000	Unchanged return to scale
1997	0.979	0.985	0.995	Increasing return to scale
1998	0.997	1.000	0.997	Decreasing return to scale
1999	0.993	1.000	0.993	Increasing return to scale
2000	0.904	0.996	0.908	Increasing return to scale
2001	0.875	0.962	0.909	Increasing return to scale
2002	0.916	1.000	0.916	Increasing return to scale
2003	0.850	0.972	0.874	Increasing return to scale
2004	0.871	0.933	0.933	Increasing return to scale
2005	0.882	0.954	0.925	Increasing return to scale
2006	0.883	0.913	0.968	Increasing return to scale
2007	0.885	0.897	0.986	Increasing return to scale
2008	0.919	0.926	0.992	Decreasing return to scale
2009	0.908	0.922	0.985	Increasing return to scale

2010	0.909	0.923	0.985	Increasing return to scale
2011	0.928	0.933	0.995	Decreasing return to scale
2012	0.957	0.970	0.987	Decreasing return to scale
2013	0.979	1.000	0.980	Decreasing return to scale
2014	0.985	0.992	0.993	Decreasing return to scale
2015	1.000	1.000	1.000	Unchanged return to scale
2016	1.000	1.000	1.000	Unchanged return to scale

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Similarly input oriented DEA is used to analysis agricultural production efficiency of Pakistan, the results shows that during 1978, 1981, 1982, 1997 and 2016 there is efficiency of agricultural production; in such years the results of overall all efficiency, pure technical efficiency and scale efficiency are 1; this implies that the agricultural production in such five years is consistently efficient; however the agricultural production efficiency of other years is relatively inefficient which showing the agricultural production efficiency not reached at best fit point of efficient production at optimized level input used.

The results of pure technical efficiency indicates in 1978, 1981, 1982, 1988, 1989, 1991, 1997, 1998, 2012 and 2016 enlightens 1 value which shows in such years agricultural production efficiency optimizing and the strong dependency agricultural production on agricultural technology; however in remaining years the pure technical efficiency value is less than 1 which indicating agricultural production depend on natural resource inputs and weakly depends on agricultural technology.

The results of scale efficiency shown 1 value during 1978, 1981, 1982, 1997 and 2016 which reveals unchanged return to scale; in such years the agricultural production inputs achieving optimum level of production, while during 1979, 1980, 1983, 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1996, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010 and 2011 the scale efficiency reveals the increasing return to scale which means the agricultural production increasing greater than increasing inputs used; and during 1994, 1998, 2012, 2013 and 2014 the scale efficiency shows the decreasing return to scale; the agricultural production in increasing but not greater than increasing inputs used, so the use of increasing inputs not giving optimum level of outputs.

Therefor input oriented DEA results of Pakistan shows from 1978 to 2016 the agricultural production efficiency of some years is efficient but increasing majority of years is increasing return to scale and some years the agricultural production efficiency at decreasing return to scale by the increasing combination of production inputs table 3.

Table 3: Agricultural production efficiency of Pakistan the mean value of efficiency

Agricultural production efficiency of Pakistan				
Year	**Overall Efficiency**	**Pure Technical Efficiency**	**Scale Efficiency**	**Results**
1978	1.000	1.000	1.000	Unchanged return to scale
1979	0.924	0.996	0.928	Increasing return to scale
1980	0.926	0.974	0.951	Increasing return to scale
1981	1.000	1.000	1.000	Unchanged return to scale
1982	1.000	1.000	1.000	Unchanged return to scale
1983	0.972	0.977	0.995	Increasing return to scale
1984	0.917	0.949	0.967	Increasing return to scale
1985	0.921	0.977	0.943	Increasing return to scale
1986	0.863	0.955	0.904	Increasing return to scale
1987	0.870	0.948	0.917	Increasing return to scale
1988	0.949	1.000	0.949	Increasing return to scale
1989	0.975	1.000	0.975	Increasing return to scale
1990	0.813	0.872	0.933	Increasing return to scale
1991	0.946	1.000	0.946	Increasing return to scale
1992	0.857	0.944	0.908	Increasing return to scale
1993	0.936	0.972	0.963	Increasing return to scale
1994	0.949	0.959	0.990	Decreasing return to scale
1995	0.924	0.978	0.945	Increasing return to scale
1996	0.868	0.927	0.936	Increasing return to scale
1997	1.000	1.000	1.000	Unchanged return to scale
1998	0.976	1.000	0.976	Decreasing return to scale
1999	0.885	0.901	0.983	Increasing return to scale
2000	0.837	0.863	0.969	Increasing return to scale
2001	0.856	0.881	0.971	Increasing return to scale
2002	0.964	0.987	0.977	Increasing return to scale
2003	0.959	0.970	0.988	Increasing return to scale
2004	0.879	0.912	0.963	Increasing return to scale
2005	0.839	0.880	0.953	Increasing return to scale
2006	0.898	0.920	0.976	Increasing return to scale
2007	0.965	0.966	0.999	Increasing return to scale
2008	0.832	0.856	0.973	Increasing return to scale
2009	0.752	0.815	0.922	Increasing return to scale
2010	0.855	0.904	0.947	Increasing return to scale
2011	0.892	0.917	0.972	Increasing return to scale
2012	0.997	1.000	0.997	Decreasing return to scale
2013	0.980	1.000	0.980	Decreasing return to scale
2014	0.954	0.993	0.961	Decreasing return to scale
2015	0.930	0.933	0.997	Decreasing return to scale
2016	1.000	1.000	1.000	Unchanged return to scale

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5.2 Analysis input redundancy on the basis of input indicators

Input oriented DEA is applied to analyses input redundancy on the basis of input indicators of China and Pakistan. Results shows in China during 1980, 1981, 1982, 1988, 1989, 1992, 1993, 1994, 1995, 1997, 2000, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013 and 2014 appears different value of input redundancy, but years of 2012, 2013 and 2014 are at the stage of increasing return to scale which reveals such year could not develop potential of return to scale possibly because of small input scale or further enhancement of technical efficiency, while the production redundancy appears in remaining years because of large production input scale in China table 04. Similarly the results of Pakistan shows during 1979, 1980, 1983, 1984, 1985, 1986, 1987, 1990, 1992, 1993, 1994, 1995, 1996, 1997, 2000. 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014 and 2015 appears different value of input redundancy, however in 1986 and 2011 are at stage of increasing return to scale which shows potential of return to scale not developed possibly because small input scale and the production redundancy appears in remaining years excluding such years because of large production input scale table 04.

Table 4: Input redundancy analysis on the basis of input indicators of China and Pakistan

China					Pakistan			
Year	X_1	X_2	X_3	X_4	X_1	X_2	X_3	X_4
1978	0.000	0.000	0.000	0.000	0.000	0.000	0.0000.000	
1979	0.000	0.000	0.000	0.000	308240.71	0.000	12534.52	160133.00
1980	0.000	0.000	0.000	1015975.13	0.000	0.000	13120.74	20507.91
1981	0.000	1391505.08	0.000	1010528.77	0.000	0.000	0.000	0.000
1982	37479.45	4414569.10	0.000	775154.29	0.000	0.000	0.000	0.000
1983	0.000	0.000	0.000	0.000	4336.93	0.000	22770.36	0.000
1984	0.000	0.000	0.000	0.000	0.000	0.000	27378.72	48009.86
1985	0.000	0.000	0.000	0.000	0.000	0.000	39815.83	05107.68
1986	0.000	0.000	0.000	0.000	0.000	193693.55	13507.99	343565.22
1987	0.000	0.000	0.000	0.000	0.000	0.000	72570.50	472472.68
1988	0.000	0.000	568929.98	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	400034.79	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.000	0.000	0.000	0.000	0.000	45948.82	28535.15
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	131216.46	48757635.98	0.000	0.000	0.000	0.000	12632.75	220471.15
1993	0.000	36567426.36	0.000	0.000	121671.56	0.000	0.000	58631.18
1994	0.000	12040453.81	0.000	2032835.72	805512.84	0.000	0.000	21673.90
1995	0.000	1362628.56	0.000	1626888.16	805512.84	0.000	0.000	21673.90
1996	0.000	0.000	0.000	0.000	122864.00	0.000	0.000	228155.69
1997	0.000	0.000	0.000	400706.71	0.000	0.000	40044.08	3413.84
1998	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.000	0.000	0.000	16832.59	0.000	0.000	5223.45	71705.02
2001	0.000	0.000	0.000	483611.96	0.000	0.000	0.000	339051.51
2002	0.000	0.000	0.000	0.000	0.000	0.000	661.17	28094.23
2003	0.000	0.000	32779.04	0.000	0.000	0.000	16648.81	349991.70
2004	0.000	0.000	0.000	607435.19	0.000	0.000	9496.0	81408.79
2005	0.000	0.000	56223.51	0.000	0.000	0.000	37099.61	747315.64
2006	0.000	0.000	0.000	420572.39	0.000	0.000	54400.65	841023.08
2007	0.000	0.000	0.000	378747.60	0.000	0.000	20048.90	90109.31
2008	0.000	18832011.80	750420.90	0.000	0.000	0.000	11419.39	0.000
2009	0.000	8721279.01	879768.60	0.000	0.000	0.000	38399.56	192349.81
2010	0.000	3279157.41	943580.24	0.000	0.000	433523.57	48515.19	90274.41
2011	0.000	13276997.43	919586.85	0.000	0.000	1853603.56	60272.28	309799.75
2012	1541940.18	3212607.74	625620.30	0.000	0.000	1230771.49	43859.44	128331.02
2013	5674244.73	20161290.65	180137.15	0.000	0.000	0.000	0.000	0.000
2014	3416041.67	5218617.90	21404.43	0.000	645749.02	637819.67	46477.13	0.000

2015	0.000	0.000	0.000	0.000	39027.06	0.000	20759.99	0.000
2016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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5.3. Agricultural production efficiency comparison between China and Pakistan

Agricultural innovation and technology development have critical role in agricultural productivity gains in the world; the policies for agricultural development improve the agricultural production efficiency and strengthen rural areas to ensure the stable growth of agriculture, economic and social development (Stads and Rahija, 2012; Huang and Rozelle, 2010; Li. X, Zhang. Y, Liang. L, 2017).

Figure 5 represents comparative efficiency change of agricultural production in China and Pakistan.

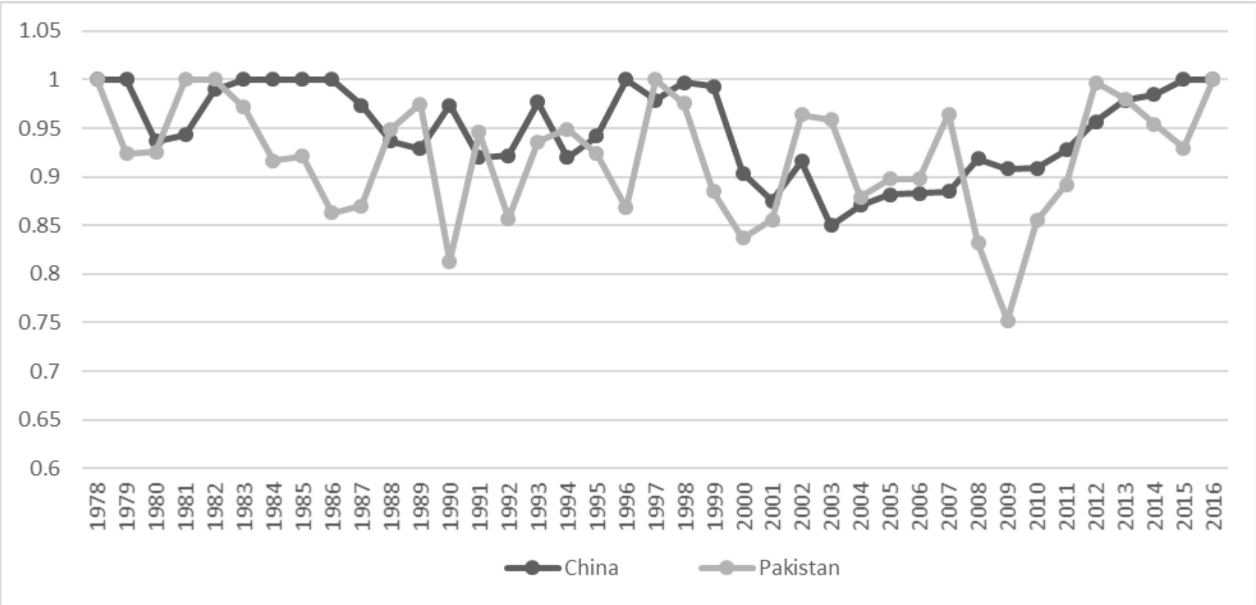

Figure 5: Comparative efficiency change of agricultural production in China and Pakistan.
Authors own work

This section compares the efficiency change of agricultural production in China and Pakistan; result reveals that from 1978 to 2016 Chinese agricultural production comprehensive benefit fluctuated between 0.85 to 1, it gains highest value as 1 given 9 years and lowest value as 0.85 in one year other years are more than 0.85 and near to 1. Similarly agricultural production comprehensive benefit of Pakistan fluctuated from 0.75 to 1 about 5 years agricultural production efficiency gain value 1 and lowest value of agricultural production efficiency as 0.75 other years as between of 0.75 to 1. Overall comparative results shows in China the agricultural production is more efficient then Pakistan, although Pakistan improve agricultural production but China have more comparative advantage over agricultural production table 5.

6. Conclusion

This study investigates the agricultural production efficiency comparison between China and Pakistan over time period of 1978 to 2016. We used DEAP 2.1 to analysis the agricultural production technical efficiency, and scale efficiency of both countries. Result indicates during 1978 to 2016 Chinese agricultural production efficiency score gains 9 times as 1; and the results of pure technical efficiency reveals about 15 years value appears 1 which clarifies such years the agricultural production affectivity optimizing and the progress of agricultural production strongly depends on agricultural technology due to which sustained agricultural production at optimizing level and the results of scale efficiency enlightens during given study period about 10 years value appears as 1 which means in such years the agricultural production inputs achieving the best combination of gaining optimum level of output.

However input-oriented DEA analysis result shows agricultural production efficiency of Pakistan gains 5 times efficient level of production during 1978 to 2916 while the pure efficiency indicates 10 times appears value as 1 during study period and the value of scale efficiency of Pakistan appears 5 times as 1 which means during 1978 to 2016 only 5 years unchanged return to scale appears and the agricultural production inputs achieving optimal level of production output. Comparative results of both countries shows overall production efficiency of China is greater than Pakistan, similarly pure technical efficiency also have greater advantage than Pakistan pure technical efficiency which means Pakistan need more technical improvement to get optimum level of production; Although agricultural production of Pakistan at the rate increasing return to scale it needs more improvement to achieve best production level. Therefore study concludes Chinese agricultural production is more efficient than Pakistan because the agricultural production of China strongly depends on technology; so for more improvement of agricultural production Pakistan need to more of agricultural technology.

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