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Technological Gap Analyses of Mena and Southern African Countries' Agricultural Productivity

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Abstract **– The technical gap analysis of countries' agricultural productivity was analyzed and the discussions of the study were divided into two regions of Middle East and North African (MENA), and Southern Africa (SA) Countries based on their geographical location. Data Envelopment Analysis (DEA) model was used to analyse Panel data of input-output data from 10 MENA and 10 SA regions from 1991 to 2010. The descriptive statistics was calculated for the pooled data, MENA and Southern African regions. The best performing countries were identified after treating each of the twenty (20) countries included in the observation in different year as individual distinct decision making unit. Tunisia had 59 peer counts in 2003, Jordan had 34 peer counts in 1996, Egypt had 38 peer counts in year 2002, Libya had 27 peer counts in 2003 while Tunisia accounts for the highest number of best performance of 81 counts in 1991 for MENA countries. Swaziland, Mauritius, Malawi, Namibia and Mozambique dictate the way for landlocked countries between 1991 and 2010 respectively. The mean technical efficiency for the MENA, Southern African Region and the pooled data were 0.712, 0.854 and 0.738 respectively while their respective regional frontiers were 0.836, 0.967 and 0.870. The technological gap ratio for the pooled data for the period of time under study was 0.848 but that of MENA and southern African region were 0.852 and 0.883 respectively for the same period. The difference in the regional and metafrontier showed that regional constraints are a subset of that of metafrontier production function. The study suggests transference of technology, as well as diffusion of technical know-how should be encouraged between MENA and SA countries.**

Keywords **– Technological Gap, Efficiency, Frontier and Agricultural Productivity.**

I. Introduction

Agriculture has continued to play a dominant role in the provision of food, raw material for industries.Agriculture is the main source of income for 90 percent of the rural population in Africa. Agriculture is the main source of livelihood for many people and national income for most developing countries. If there is smooth development practice of agriculture, imports are reduced and export increases considerably. This help to reduce countries unfavorable balance of payments as well as saving foreign exchange. This amount may be well used to import other essential inputs, machinery, raw-materials and other infrastructure that is helpful for the support of country's economic development, cannot be overemphasized. Development in agriculture may also increase savings, if there is surplus quantity, it may be invested further in the agriculture sector to develop the sector. Agriculture plays an important role in the economy of most of the countries in the Middle East and North Africa (MENA) region and Southern African (SA) African countries as a whole. Despite the fact that MENA most land is desert (water scarce) and dry region in the world, many countries in the region, highly depend on agriculture. MENA agricultural sector contribution to the overall economy varies significantly among countries in the region, ranging, for example, from about 3.2 percent in Saudi Arabia to 13.4 percent in Egypt (Parinaz, Javad, Zainab. 2013).

Agricultural productivity growth is crucial because it is an essential source of overall growth in an economy. That is why productivity differences among countries, and mainly between developed and underdeveloped ones, emerged as a central issue of development economics (Mounir and Mohamed, 2009). Productivity growth in agriculture has been the major interest of economists in the world for so long. MENA countries' agriculture is quite a diverse sector whose contribution to economic development is important considering the stage of development in which the countries of the region are. Its contribution to GDP is relatively diverse ranging from a high of more than 20% for Syria and Morocco to a low of less than 6% for Jordan and Libya in MENA region can not be overlooked (Parinaz, Javad, Zainab. 2013). According to the FAO (2005), On average, about 65% of the labour force in Africa is employed in agriculture, yet about 32% of GDP is accountable to agriculture, showing relatively low productivity (World Bank, 2013). Africa's rural population, therefore, has been unable to move out of poverty principally because of inability to transform their basic economic activity of agriculture to high productivity levels. Due to its contribution to the economy, the agriculture sector's poor performance is one of the major reasons to low development on the African continent and even counties in the Middle East. It's important to take cognizance of agriculture in improving the economies of the developing countries thereby improve the welfare of the rural poor through the sustained improvements and development in agricultural productivity.

Aggregate productivity can be defined as the amount of output that can be obtained from given levels of input in a sector or an economy. Therefore, increases in productivity occur when output from a given level of inputs increases. This phenomenon is principally attributed to improvements in the technical efficiency with which the inputs are used and innovations in technology that allow more output to be produced. Total Factor Product (TFP) indices can entrap also the effects of improved infrastructure such as irrigation, roads and electricity, as well as technology in the form of research and development. Total factor productivity (TFP) as a measure of overall productivity has been gaining recognition and acceptance not only for its theoretical relevance but also for its practicality among policy makers and economic analysts. The ability to create, acquire and adapt new technologies is a critical requirement for competing successfully in the global marketplace. It is also a well-documented fact that the African continent has not kept pace with technological advancement. Africa's technological gap could be the source of its increasing economic deterioration because other developing regions are constantly upgrading their own technological capabilities, and the global marketplace has become increasingly liberalized and competitive (Mounir and Mohamed, 2009).

The term technology means “application of knowledge and tools accurately for achieving the envies goals and economic objectives”. Technological gap as a concept is the difference between the potential technology that can be applied compared to the actual amount of technology been applied.

The use of a common production frontier to evaluate the level of efficiency of agricultural sector of countries is now a public practice (Fulginiti and Perrin, 1998; Nkamleu 2004). While production efficiencies of countries measured with respect to a given frontier are comparable, this is not usually the case among countries that function under different technologies. Such constraint arise when comparison of countries from different regions are involved. Battese and Rao (2002) suggest an approach to inquire efficiency of firms in different regions that may not have the same technology. Using the attempt, the productivity of the agricultural sector in a given region, and their technical gap, may be assessing relative to a metaproduction frontier. In improving the total factor productivity of the agricultural sector, the technological level and/or technical efficiency is/are to be improved leaving the policymakers to decide on which course to pursue either to strategise towards technological change (where there is technological gap) or strategize in improving the farmers efficiency when it is dawn on them that output can still be increased without requiring additional input or new technology (Nkamleu*et.al.,* 2006).

II. Statement of the Problem

Agricultural productivity is heterogeneous regionally, differences in productivity performance vary from continents to continents, region to region, country to country, and on farm to farm basis, regions tend to present significant biophysical constraints under which farmers operate. Also agriculture is characterized by a number of special features that distinguish it from other sectors, such as the sector’s role in producing food and meeting basic survival needs; its context and site-specific nature that makes uniform strategies and solutions ineffective; the vulnerability of the sector to being directly affected by climate change compared with most other sectors; its adaptation needs and mitigation potential, mainly through sequestration; and, finally, its complex links to food security, trade and broader land-use and forestry policies.

Weak agricultural technology has many negative impacts on the productivity. Thus for higher productivity it is necessary to follow this definition. In developing countries, farmers mostly use the old traditional ways of cultivation which is why their productivity is low. Which is why if the new techniques of production is not followed and keep owning to the old traditional ways of cultivation, our production process will remain slow, and this is one of the reasons of low agricultural output.

Global economic and financial turbulence, repeated food crises, the deepening impact of climate change, and growing awareness that current model of agricultural dependent economic development are unsustainable, all this concerns attract consideration of the fact that agricultural productivity is of great importance for the sustenance of world populace both in food security improvement and in serving as the live line for many manufacturing industries, this thesis therefore try to phantom out through meta-frontier and technological gap, the analysis of MENA and Southern African countries’ agricultural productivity differences which is a menace much touted by many researchers but under-studied.

A relevant question for agricultural policymakers is whether to pursue a strategy directed towards technological change or a strategy towards efficiency change (Nkamleu, 2004). That is why efficiency differences among countries, and mainly between Middle East and North African (MENA) and Southern African (SA) countries emerged as a central issue of development economics. Therefore, this research was seen as an initial step towards understanding the efficiency of the agriculture sectors in these countries.

Thus the following research questions were answered while considering the problem of technological gap analysis of Mena and SA; Agricultural productivity (1991-2010):

1. What are the descriptive statistics of my chosen data?
2. What is the countries’ peer counts production efficiency?
3. What are the meta-frontiers in relation to agricultural productivity in Mena and Southern African countries?
4. What are the technological gap ratios of the Regions?

III. Literature Review

Even as the developing world was quickly embracing new technologies, some studies showed decreasing productivity. If the deterioration in productivity is confirmed, it is a reason for concern since not only a large section of their population is dependent on agriculture in these countries but also their agricultural products are a main source of exports and foreign exchange. Efficiency performance of selected countries using various institutional and economic variables. They indicated that life expectancy and trade intensity play a positive role on increasing efficiency.

Headey et al (2005) estimated the impact of different environmental variables on agricultural TFP growth rates using different parametric method. They pointed out that number of agricultural scientist per thousand workers; agricultural expenditure as percentage of With a glance at global agricultural production, Alston, Babcock and Pardey (2010) showed decrease in global yield growth rates for wheat, corn, soybeans and rice over period 1990-2007 for middle and high income countries.

Ajetomobi (2008) in an attempt to estimate Total Factor Productivity (TFP) of Agricultural Commodities in Economic Community of West African States (ECOWAS): 1961 – 2005 considered rice, cotton and millet. Astronomical growth was evidenced in the TFP of all the selected crops with rice showing impressive result after an outstanding performance of rice considering the TFP in ECOWAS and pre-ECOWAS sub-period, rice and millet hard more impressive TFP in ECOWAS period (1979-2005) but larger TFP for cotton in pre-ECOWAS period. In both periods, there is the sustenance of productivity growth of rice and cotton through technological progress while the efficient use of inputs sustained the productivity growth in millet.

Fuglie (2010) found decrease in global yield growth rates while his results indicate decreasing TFP growth rates in developing economies. On average, agricultural TFP growth rate has decreased from 2.30 percent over the 1990s to 1.90 percent over the 2000s. The studies which have estimated agricultural TFP in the countries of interest are few.

Belloumi and Matoussi, (2009) calculated TFP growth rate for 16 countries in Middle East and North Africa (including Iran, Iraq, Turkey and Syria) and encountered increasing agricultural productivity for the group. Lau and Yotopoulos (1989) found in their study a decrease in agricultural productivity for LDCs in the 1970s but an increase in the 1960, using translog production function.

Trueblood (1996) estimated a traditional Cobb-Douglas production function and applied the nonparametric methodology to calculate a Malmquist index using panel data covering 117 countries and 31 years. The study also showed negative productivity growth in a significant number of developing countries.

Fulginiti and Perrin (1997, 1998 and 1999) confirm the results obtained earlier byKawagoe and Hayami (1985) and Lau and Yotopoulos (1989) and Kawagoe et al. (1985). They estimated agricultural productivity by using an output-based Malmquist Index over the period 1961-1985. Their results showed negative productivity growth for some of the 18 countries in their study. They also mentioned that those that tax agricultural had the most negative rates of productivity change. Agricultural efficiency change indices and productivity indices have been estimated using nonparametric Malmquist indices for 70 developed and developing countries in the period 1961 – 1993 by Arnade (1998). Some of the developing countries in this sample presented negative rates of technical change.

Coelli and Rao (2003) calculated growth in agricultural productivity in 93 countries. Results indicated a growth rate of 2.1% in Total Factor Productivity, with efficiency change and technical change equal to 0.9% and 1.2% per year, respectively. Pfeiffer (2003) estimated agricultural productivity growth using a translog production function frontier and a nonparametric Malmquist productivity index in the Andean region (Bolivia, Colombia, Ecuador, Peru and Venezuela) for the period 1972-2000 and found that productivity growth is positive and increasing over the time for this period. More directly relevant to the countries in this study.

Shahabinejad and Akbari (2010) analyzed agricultural productivity growth in the "Developing Eight" (Bangladesh, Egypt, Indonesia, Iran, Malaysia, Nigeria, Pakistan and Turkey) over the period 1993 - 2007 using data envelopment analysis (DEA). Their results showed Total Factor Productivity was positive and that technical change is the main source of this growth. They estimated an average technical change 1.5% and a negative average efficiency change (-0.4%) for this region. Results also indicated all countries have improved technology more than efficiency in this period. Declining productivity seems to be observed in countries suffering from wars such as Iran and Iraq during 1970-2000 (Belloumi and Matoussi, 2009).

Fulginiti and Perrin (1998) indicated productivity losses for Pakistan and productivity gains for Turkey during the period 1961-1985 while other literature has shown positive TFP growth rate (0.28%) for Pakistan during 1965-2005 (Ahmed,1987). The countries of interest in this study have individually been the subject of a few studies. Considering Pakistan, Chaudhry (2009) estimated an increasing TFP, 1.75%, over period 1985-2005.

Evenson and Pray (1991) calculated an increasing TFP growth rate 1.07% for 1965-1985. Other studies by Kemal et al (2002), Ali (2004) and Ahmad et al. (2008) indicate that agricultural TFP in Pakistan has grown at an annual average rate of 0.37%, 2.17% and 0.28% around the period 1965-2001, respectively. These studies gives a recommendation on some policies like increasing the area under cultivation and fertilizer at cheaper prices for the farmers can increase TFP growth in the agriculture sector of Pakistan. Moreover, agricultural TFP macro determinants indicated that policies which improve human capital, enhance credit resources in agriculture, facilitate openness of agricultural economy would improve productivity of Pakistan's agriculture (Ali et al., 2006; Riazuddin, 2006). A study on the determinants of Total Factor Productivity in Iran in the period 1959-2007 showed that 1% change in skilled human capital leads to 30% increase in Total Factor Productivity and one percent change in physical capital leads to a 55% increase in Total Factor Productivity in the agricultural sector, Khani and Y -azdani, (2012).

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IV. Methodology

Study Area

The study areas are Middle East and North Africa (MENA) region and Southern African (SA) region.

Middle East and North Africa (MENA):

MENA which many people prefer to call WANA (West Asia and North Africa) or the less common NAWA (North Africa-West Asia) due to the geographic ambiguity and Eurocentric of the term Middle East is a region that covers different countries and territories in the Middle East and North Africa, it covers an extensive region extending from Morocco ($33^{0}32$’N, $7^{0}35$’E) to Iran ($35^{0}41$’N, $51^{0}25$’E), including all Middle Eastern and Maghreb countries. These countries include Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Yemen, Libya, Morocco, Palestine, Israel, Qatar, Saudi Arabia, Syria, Tunisia, United Arab Emirate, and Omen. And sometimes also include Afghanistan, Armenia, Azerbaijan, Cyprus, Djibouti, Georgia, Mauritania, Pakistan, Somalia, Sudan and Turkey.

MENA came into the Arab spring with multiple strengths including young and educated population, strong resources, and economic resiliencethat helped it weather the 2008 /2009 global financial crisis. The region population accounts about six percent (6%) of the total world population with 381million and the vast majority living in the middle income countries.

The region has vast reserves of petroleum and natural gas that make it a vital source of global economic stability, MENA is the most water scarce and dry region in the world, countries in the Mediterranean Sea are highly dependent on agriculture. Annually, the region exceeds its supply of water from rainfall and river flows, depleting ground water resources. According to UNDP (2009), the availability of water and subsequent agricultural production are expected to diminish.

Fig. 1. Map of MENA region (The shaded portion)
Source: Wikipedia 2017.

Southern African Region:

The countries include Angola, Botswana, Tanzania, Seychelles, Mauritius, Democratic Republic of the Congo, Madagascar, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia and Zimbabwe according to Southern African Development Community (SADC). The Southern region occupies an area of 554,919 km^2 with a population of 277 million people as an estimate (FAO 2003). Sometimes, the two major islands (Madagascar and Mauritius) are regarded as part of the South African countries. There are two major classifications for countries in Southern Africa: The United Nations classification and that of Southern African Development Community (SADC). There are several countries in Southern Africa just like in every other African region. Such countries include Botswana, Lesotho, Namibia, Swaziland and South Africa. These countries constitute the geographic mapping of South African countries according to the United Nations. A lot of people often think that South Africa has other countries within it, but that is not true, South Africa is the main hub among the Southern African countries. South Africa is just one country at the Southern part of Africa.

Southern Africa is endowed with natural resources like gold, platinum and diamond but just like other countries in Africa, corruption and the bane of colonialism has shaped this region into what it is today. Among all the countries in the Southern Africa, South Africa is the economic super power, the main center of economic activity and development. South Africa’s GDP is more than those of all other countries in this region put together.

Fig. 2. Map of Southern region.
Source: Wikipedia 2017.

V. Source of Data and Sampling Method for Data

The study was based on data exclusively drawn from the FAOSTAT system of statistics (AGROSTAT) used for dissemination of statistics compiled by Food and Agriculture Organization (FAO). A panel data on 10 countries in MENA region and 10 countries in SA countries from 1991 to 2010 were used.

VI. Measurement of Variables

(a) *Output*

The output aggregates that were used here refer to the final output (agricultural output) in different countries exclusively. These aggregates will be constructed using international average prices (expressed in US dollars). The output series are adjusted for price differences across countries, expressed in billions of US dollars. The 2004-2006 base years (in million dollars) is used to cover the study period, 1990-2010, using the FAO production index number series.

(b) *Input*

Labour: This is the economically active population in agriculture, which is defined as all persons engaged in or seeking employment in the operation of a family farm or business, whether as employers, own-account workers, salaried employees or unpaid workers. The economically active population in agriculture includes all persons engaged in economic activities in agriculture, forestry, hunting or fishing. Since we are to examine the agricultural sector productivity for a country, as a whole, it is quite appropriate that the economically active population is used as an aggregate measure of the labour input into the sector.

Land: This variable includes the arable land, land under permanent crops as well as the area under permanent pasture, expressed in millions of hectares. Arable land includes land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market or kitchen gardens and land temporarily fallowed (for less than five years). Land under permanent crops is the land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest which include cocoa, rubber, fruit trees, vines etc. Land under permanent pasture is land that is used permanently (for at least five years) for forage crops, either cultivated or growing wild.

Pesticides: This is the chemical used in preventing pest like rodents and insects, the total amount in litres used throughout the period of reference in both regions will be used as measurement.

Livestock: The livestock input variable that will be used in the study is the sheep-equivalent of five categories of animals. The categories of animals to be considered are buffaloes, cattle, pigs, sheep and goats. Data on numbers of these animals will be converted into sheep equivalents using the following conversion factors: 8.0 for buffalo and cattle; and 1.0 for sheep, goats and pigs.

Fertilizer: This input is quite difficult to measure. The FAO Fertilizer Yearbook provides details of fertilizer production and use in different countries, and the data available involve a large number of fertilizers. It is impossible to consider fertilizer data in such detail. Thus, following other studies (Rao *et.al., 2005;* Nkamleu *et.al., 2006*) on inter-country comparisons of agricultural productivity, the sum of the nitrogen (N), potassium (P_2O_2) and phosphate (K_2O) contained in the commercial fertilizers that were applied as the measure of fertilizer input in this paper. This variable is expressed in thousands of tons.

VII. Data Analysis

The data collected were subjected to both descriptive and inferential statistical analysis and Estimates of the parameters were be carried out through the use of the Data Enveloping Analysis (DEA) model.

VIII. Data Analysis

Estimates of the parameters were carried out through the use of the Data Enveloping Analysis (DEA) model.

DEA is a linear programming methodology that uses data on output and inputs of countries, to construct a piece-wise linear surface over the data point. This frontier surface is constructed by the solution of a sequence of linear programming problem.

The procedure is easily introduced via the ratio form (Coelli et al., 1998; Nkamleu, 2004b). For each country we would like to obtain a measure of the ratio of all outputs over all inputs, such as u'yi /v'xi , where 'u' is an m x 1 vector of output weights and 'v' is a k x 1 vector of input weights. Under constant return to scale assumption, the optimal weights are obtained by solving the mathematical programming problem:

$$Max_{u,v}(u'y_i/v'x_i), \quad (1)$$

$$Subject\ to\ \frac{u,'y_j}{v'x_j} \leq 1, \quad j = 1,2\ldots\ldots,N$$

$$u, v \geq 0 \quad (2)$$

This involves finding values for u and v such that the efficiency measure of the i-th farmer is maximized, subject to the constraint that efficiency measures must be less than or equal to one. To avoid having an infinite number of solutions, one imposes the constraint v'x = 1, which provides,

$$Max\ \mu, v\ (\mu' y_i), \quad (3)$$

$$Subject\ to\ v'x_i = 1$$
$$\mu'y_j - v'x_j \leq 0, \quad j = 1,2,\ldots\ldots,N$$

$$u, v \geq 0 \quad (4)$$

Where the notation changes from 'u' and 'v' to 'μ' and 'v' reflect the transformation. This form is known as the multiplier form of the linear programming problem (Coelli, 1996). Using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$$Max_{\theta,\lambda}\theta,$$

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

$$\lambda \geq 0 \quad (5)$$

Where θ is a scalar and λ is a Nx1 vector of constants. θ measures the ratio of the observed vector of outputs to the maximum vector that could be achieved, given the input vector. The value of θ obtained will be the efficiency scores for the ith country. The constant returns to scale (CRS) assumption are appropriate when all firms are

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operating at an optimal scale. The use of the variable returns to scale (VRS) specification will permit the calculation of efficiency scores devoid of scale efficiency effects. According to Coelli (1996), the VRS specification has been the most commonly used specification in the 1990's. We also opted for the VRS specification. The linear programming problem under CRS in the equation above can be easily modified to account for VRS by adding the convexity constraint: N1'λ = 1 to equation (3) to give:

$$Max_{\theta,\lambda}\theta, \quad (6)$$

$$Subject\ to\ -y_i + Y\lambda \geq 0$$
$$\theta x_i - X\lambda \geq 0$$
$$N1'\lambda=1$$
$$\lambda \geq 0 \quad (7)$$

Where N1 is an Nx1 vector of one. If we have data on Lk countries, the above linear program is solved Lk times for each year. The metafrontier is constructed using a DEA model based on the pooled data for all the countries in all the regions. Since we have a total of L = ΣkLk countries, we re-run the above linear program model with the inputs and output matrices with data for all countries. Data Envelopment Analysis Computer program (DEAP 2.1) and a multi-stage DEA procedure will be employed to run the models.

IX. Results and Discussion

Mean and Standard Deviation of MENA, Gulf of Guinea and Pooled Data

The results (Table 1) of the descriptive and DEA analysis brought about some interesting outputs.

The descriptive statistics (mean, standard deviation, minimum and maximum) were computed for MENA, Southern African countries and pooled data as presented in table three. There were 200 observations for MENA countries, 200 observations for Southern African countries which sum up to 400 observations considered for the whole of the two regions. The mean Net outputs for MENA Countries, Southern African countries and the pooled data were 3853892.00, 1967625.00 and 2910758.00 respectively in '000 US dollars. The mean values for land (in '000ha), livestock (in '000 dollars), labour ('000 persons), Pesticide (in '000 dollars) and fertilizer (metric tons) were also presented in table 3 below for MENA, Southern African countries and pooled data.

Table I. Mean and Standard Deviation of MENA, Southern African Countries and Pooled Data.

Variables		Mean			
MENA Countries					
Net output ('000 2004-2006 dollars)	200	3853892	4959034	1262.35	2.15x107
Land ('000 ha)	200	33981.11	37461.12	963.3	136698
Livestock ('000 2004-2006 dollar)	200	709584.6	602110.8	65526	2534776
Labour ('000 persons)	200	14770.56	11749.65	904	44488
Pesticide	200	48461.11	51910.08	2000	277032.2
Fertilizer (metric tons)	200	73775.07	145856.2	0	957773
Southern African Countries					
Net output ('000 2004-2006 dollars)	200	1967625	2821143	183666.8	1.26x107
Land ('000 ha)	200	29334.19	27837.94	91	98125
Livestock ('000 2004-2006 dollar)	200	283402	540358.7	16976	2751781
Labour ('000 persons)	200	7238.28	6162.37	601	19535
Pesticides	200	22506.03	41756.51	121.12	285005
Fertilizer (metric tons)	200	31630.92	73557.55	274	759089
Pooled Data					
Net output ('000 2004-2006 dollars)	400	2910758	4138402	1262.35	2.15x107
Land ('000 ha)	400	31657.65	33042.78	91	136698
Livestock ('000 2004-2006 dollar)	400	496493.3	609885.8	16976	2751781
Labour ('000 persons)	400	11004.42	10100.16	601	44488
Pesticides	400	35483.57	48809.16	121.12	285005
Fertilizer (metric tons)	400	52703	117277.8	0	957773

Source: Field survey, 2018

X. Peer Counts of MENA and Southern African Countries

The DEA analysis identifies "peers" (best performing countries) for the MENA and Southern African countries. The best performing countries are presented in table II. Each country that makes up the sub-Sahara Africa were treated as a different observation in different years and it is in line with the study of Rao *et al.,* (2003). This infers that Tunisia in 1991, 1993, 1996, and 2003 are peers for the DEA frontier for MENA countries. Most of the countries relate to later years of 2000 to 2010, which depicts that there assumed to be an improvement in agricultural productivity over a particular period of time, then the frontier showed peers from later years. Tunisia dictated the way in the early years (1991) majorly because of the effort of the government in improved agricultural production. It is one of the Arab countries that is sufficient in dairy products and it accounts for up to 16 percent of the countries GDP. Egypt (2002, 2005, 2007 and 2008) appeared as peers for the MENA countries and was indebted to the Nile River and its dependable seasonal flooding. The river's predictability and the fertile soil allowed the Egyptians to build an empire on the basis of great agricultural wealth. Egyptians are credited as being one of the first groups of people to practice agriculture on a large scale. This was possible because of the ingenuity of the Egyptians as they developed basin irrigation. Jordan, Iraq and Libya were also peers for various years.

Also, Swaziland 1991, and 2009 appeared as peers. Swaziland appears as peers for most countries and leading the way for many other countries through various years (153) in 1991. This may be due to the fact that Agriculture was in a boom before a decline in 1994. Mauritius appeared as peers in 1991 which corroborate the finding of Kappel and Pfeiffer (2013) where the Seychelles and Mauritius were way ahead of most of the developing countries and they accordingly display the best performance in the index (i.e Performance Index Africa, PIA). Namibia, Malawi, South Africa and Mozambique also appeared as peers for various years

Table II: Distribution by Peer Counts of MENA and Southern African Countries.

Region	Peer Count	Country	Year
MEENA	81	Tunisia	1991
	18	Tunisia	1993
	34	Jordan	1996
	31	Tunisia	1996
	15	Iraq	1996
	38	Egypt	2002
	27	Libya	2003
	59	Tunisia	2003
	24	Jordan	2004
	27	Egypt	2005
	25	Egypt	2007
	31	Egypt	2008
Southern Africa	78	Mauritius	1991
	34	Namibia	1991
	157	Swaziland	1991
	37	Namibia	1993
	16	Botswana	1998
	24	Malawi	2000
	51	Malawi	2001
	45	Madagascar	2004
	17	South Africa	2009
	47	Swaziland	2009
	30	Mozambique	2010

Source: Field survey, 2018

XI. Technical Efficiency and Technological Gap Ratio

Ten (10) MENA and ten (10) Southern African countries of Africa region were considered for the study. The average regional DEA efficiency, the Metaproduction frontier and the Technological Gap Ratio (TGR) for the 20 years period were presented in table III. The mean technical efficiency for the pooled data was 0.738. This implies that the two regions produce the average of 73.8% of the potential output at the given technology and suggests a huge potentials for improvement in the sector. This is far from the findings of Barnes and Revoredo-Giha (2011) which reported that the average technical efficiency of EU countries was over 0.90 when they carried out a Metafrontier Analysis of Technical Efficiency of Selected European Agriculture. This is slightly greater than the mean technical efficiency (0.728) of the regions (South, West, Central and East Africa) that make up the sub-Sahara Africa by Nkameleu*et al.,* (2006) in their study of Metafrontier Analysis of Technological Gap and Productivity Differences in Africa Agriculture. It is also greater than the 68 percent established by Rao *et al.,* (2003) in the study Metafrontier function for the Study of Inter-regional Productivity Differences. The differences are due basically to the classification into two groups and the period under which the study too place.

The mean technical efficiencies for regions were fairly stable over the years. For Southern African regions it was 0.967 and 0.918 (between 1991-2000 and 2001-2010) respectively while for MENA region, the result showed 0.836 and 0.775 for the same period of time respectively. The result of the technical efficiency for the whole of the two regions declines steadily from 0.870 (1991-2000) to 0.816 (2001-2010) though the overall regional technical efficiency was 0.870. The difference in the mean regional and metaproduction frontier model establishes some interesting results. Of note is the average technical efficiency for the MENA region relative to the meta-technology which is just 0.712, while its mean efficiency relative to the regional frontier of the MENA region was 0.836 having a difference of 0.124 which depicts the bias of the technical efficiencies obtained by using regional frontiers relative to the technology available for both regions. The constraints present in the regional frontier is a subset of that in the metafrontier linear programming problem which is responsible for the higher regional technical efficiency to that of metafrontier. The Souther African region's agricultural sector had the highest mean technical efficiencies relative to the regional and metafrontier production technology compared to those of the MENA regions. This suggests the need to acquire more technology in order to improve their productivity from the current level.

The Technological Gap Ratios (TGRs) of the pooled data ranges between 0.848 and 0.930. The productivity potential ratios for the Southern African Region and MENA REGION were 0.883 and 0.852 respectively for the reference period. These are interpreted as the technological gap faced by the two regions when compared with both regions. From table 3, it could be noted that the TGR for both the MENA and Southern African regions are higher than the whole of the two regions which was 0.848 which indicate that if the agricultural technology of the pooled data is improved, both regions would be better for it. The TGR were nonetheless decreasing across the periods under consideration which calls for concern.

The TGR values for MENA region revealed that they have high technological gap i.e. low productivity potential ratio which could imply that those imported could be obsolete, available to only very few who could afford it, lack of technical know-how or have reached their peak level of efficient usage. Therefore those in MEAN region must move to the best frontier if they are to improve on their productivity. Also, the TGR for Southern African region show that they have low technological gap i.e. high productivity potential ratio which means they need to seek for new technologies because they have almost exhausted the ones they have and the efficiency scores of the region also corroborate this fact because of its high values of almost 100 percent across the period. This is in line with the findings of Kappel and Pfeiffer (2013) where they reported that based on the performance of African countries,

Table III: Technical Efficiency and Technological Gap Ratio

Region	Year			MEAN
MENA Region	1991-2000	TE	DEA SA REG	0.836
			DEA SA MF	0.726
		TGR	DEA SA TGR	0.868
	2001-2010	TE	DEA SA REG	0.775
			DEA SA MF	0.741
		TGR	DEA SA TGR	0.956
	1991-2010	TE	DEA SA REG	0.836
			DEA SA MF	0.712
		TGR	DEA SA TGR	0.852
Southern African Region	1991-2000	TE	DEA GG REG	0.967
			DEA GG MF	0.899
		TGR	DEA GG TGR	0.930
	2001-2010	TE	DEA GG REG	0.918
			DEA GG MF	0.876
		TGR	DEA GG TGR	0.954
	1991-2010	TE	DEA GG REG	0.967
			DEA GG MF	0.854
		TGR	DEA GG TGR	0.883
Pooled Data	1991-2000	TE	DEA Pooled REG	0.870
			DEA Pooled MF	0.783
		TGR	DEA Pooled TGR	0.900
	2001-2010	TE	DEA Pooled REG	0.816
			DEA Pooled MF	0.759
		TGR	DEA Pooled TGR	0.930
	1991-2010	TE	DEA Pooled REG	0.870
			DEA Pooled MF	0.738
		TGR	DEA Pooled TGR	0.848

Source: Field survey, 2018

XII. Conclusion

The regional heterogeneity of African agriculture and the negative impact of weak technology on agricultural productivity coupled with instability, fragility and conflict carry huge costs. This thesis adopted the concept of metafrontier function for the sole aim of analyzing the technological gap of agricultural productivity among MENA and Southern African countries using panel data for the period of 20 years (1991-2010). The regional frontier revealed partially the state of the knowledge while metafrontier represents the overall state. The decomposition (ratio) of the metafrontier and the regional frontier avail us the opportunity to estimate the technological gap ratio (TGR). In the empirical aspect, we use Data Envelopment Analysis (DEA) to estimate the regional and metafrontier for the MENA, Southern African regions and the pooled data.

The study estimated the descriptive statistics of the regions. The mean technical efficiencies were stable over the years for the MENA and Southern African regions while that of the pooled data declined steadily through the period. The regional frontier were higher than the metafrontier because the regional constraints were subsets of that of the metafrontier. The mean efficiency, regional frontier and metafrontier of the Southern African region were higher than that of the corresponding MENA region. The value of the TGR for the Southern African countries were higher than that of the MENA countries. The TGR for the whole of the two regions declined steadily across the period. DEA assumes all noise to be inefficiency and may be prone to outliers but it can be used in studying multi-output and multi-input technologies. This area of multi-output can be delved into in future studies.

It can be recommended that MENA countries should maximize the opportunity they have by optimizing the use of the available technologies and availing genuine farmers the opportunity to these technologies so that their level of efficiency would be improved.

Transference of technology as well as diffusion of technical know-how should be encouraged between MENA and Southern African countries to boost agricultural productivity in every part of both regions and the world at large.

In addition, the government of MENA countries should start or continue to increase subsidy for agricultural technology to generate greater growth in agricultural productivity.

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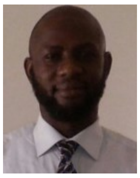

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