بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Graduate Studies

Economic Efficiency and Return to Scale for Small Broiler Farms in Khartoum State, Sudan

الكفاءة الإقتصادية وعائدات الحجم لمزارع الدجاج اللاحم صغيرة الحجم

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(وَلَحْمِ طَيْرٍ مِمَّا يَشْتَهُونَ)

صدق الله العظيم

سورة الواقعة الآية(21)

Dedication

This work is dedicated to:

To the soul of my Father,

Mother, brothers and sisters,

With endless love

Acknowledgements

Firstly I would like to thank the God for enabling me to complete the research.

I would like to thank Professors. Abda Abdalla Emam for encouraging me and for giving a short time of supervision

Special thanks to my academic supervisor Dr. Elrashied Elimam Elkhidir Who spent three years monitoring my research with full support and his well guidance essentially in numerous econometric techniques. I am most grateful and much appreciated his kind help.

Many thanks to staff in the department of Agricultural Economics, College of Agricultural studies, Sudan University of Since and Technology also staff in the department of Agricultural Economics, College of Agricultural Science, Khartoum University.

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ABSTRACT

This study aimed at targeting the analysis of the current situation of broiler small scale farm producers' in Khartoum State, and measuring the economic efficiency and return to scale. Data obtain were analyzed using both descriptive and inferential statistics. The estimation of broiler farm efficiency was based on using Date Envelopment Analysis (DEA) and Stochastic Frontier Production function. The data for this study were collected using structured questionnaire administered on purposive sampling technique of 40 farms. The study depicted several results such as high Feed cost and day – old chicks cost were the main challenges for broiler small scale farm producers' since they represented 78%,55% respectively of the total challenges. On economic efficiency the result showed that the average of technical efficiency for these farms reached 83% that means these producing farms can increase their output by17%given the present state of technology and inputs levels. On average the allocative efficiency was 74%, that means producers' can reduce input price by 26% to obtain the full allocative efficiency. The level of economic efficiency range between high level 20% and low level 80% represented the total sample size. With average of %45 which means the producers' in research sample can reached the same level of production according to decreasing production cost or decrease the quantity of resources used at 55%. The study found some of the conclusion and recommendation, the most important of it obliges: the producer's level of education can be manipulated within the framework of an agricultural policy in order to improve the technical efficiency of broiler small scale producer. Actually, all policy measures that build the capacities of farmers will lead to a substantial reduction of technical inefficiency.

المستخلص

هدفت هذه الدراسة إلى دراسة الوضع الراهن وتحديد معوقات الإنتاج لمزارع الدجاج اللاحم صغيرة الحجم بولاية الخرطوم وقياس الكفاءة الإقتصادية وعائدات الحجم لهذه المزارع.

إعتمدت الدراسة في تحقيق أهدافها على التحليل الإقتصادي الوصفي وكذلك التحليل الإقتصادي الكمي وبصفة خاصة على نموذج تحليل مغلفات البيانات (DEA)، ودالة الإنتاج المجالية العشوائية. كما أعتمدت هذه الدراسة على البيانات الأولية التي تم الحصول عليها من خلال استمارة الإستبيان والتي تم توزيعها على عدد 40 مزرعة مستخدمة أسلوب المعاينة العمدية أو القصدية. أسفرت الدراسة فيما يتعلق بالوضع الراهن لإنتاج الدجاج اللاحم بولاية الخرطوم عن مجموعة من النتائج أهمها أن تكلفة التغذية وشراء الكتاكتيت من أهم التحديات التي تواجه صغار منتجي الدجاج اللاحم بالولاية حيث مثلت على التوالي 78%و55% من جملة التحديات. أما فيما يتعلق بالكفاءة الإقتصادية لمزارع الدجاج اللاحم فقد تبين من خلال المتوسط العام للكفاءة التقنية إن عينة البحث حققت بشكل عام كفاءة تقنية بلغت 83% حيث يمكن للمزارع زيادة إنتاجه بنسبة 17% مستخدما نفس الموارد والتقنية كذلك بلغ متوسط الكفاءة التوظيفية حوالي 74% أي أن هذه المزارع تحتاج إلى خفض أسعار مدخلاتها بنسبة26% حتى تصل للكفاءة التوظيفية الكاملة، أما مستويات الكفاءة الإقتصادية فتراوحت بين حد أعلى شكل 20% من حجم العينة وحد أدنى شكل 80% من حجم العينة، وبمتوسط قدره 45% الأمر وهذا يبين ان المنتجين في عينة البحث يستطيعون ان يحققوا نفس المستوي من الإنتاج في ظل تخفيض تكاليف الإنتاج أو تقليل كمية المواد المستخدمة بنسبة 55% . من أهم التوصيات: المستوى التعليمي يبين انه يمكن العمل علية ضمن إطار السياسات الزراعية لتحسين الكفاءة التقنية. حقيقة أن كل السياسات التي قدمت لبناء قدرات المزارعين قادت إلى تخفيض كبير في معيقات الكفاءة التقنية.

CHAPTER ONE

INTRODUCTION

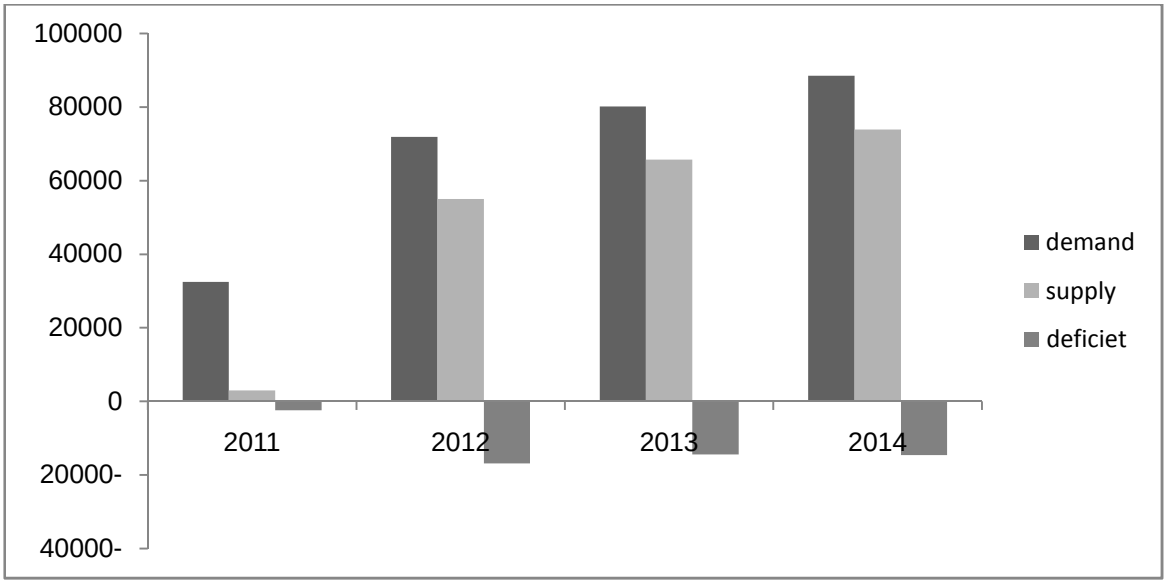
1.1Backgraound:

Chicken has become one of the most important meats consumed worldwide (Watt, 2012). Its importance in terms of consumption in Africa is becoming significant (Shane, 2006). Given a few information of broiler farms' importance in Khartoum as well as in Sudan, in the Sudan, Khartoum state produce70% of the broilers total production in the country. (Chamber of Poultry, 2012).In general producers, objective is to ensure efficient use of resource and to maximize resource and productivity (Onyebinama, 2002).The goal is to find ways of increasing output per unit of input and obtaining desirable inter-firm, intera-firm and inter-sector transfer of production resource in order to provide the means of raising our economic level (Awake, 2003). There are distinctly two types of efficiency; technical and allocative. Markovits, (2008) defined allocative efficiency as type of economic efficiency in which producers produce only that goods and services which are more desirable in the society and also in high demand. Sullivan and Sheffrin, (2003) defined technical efficiency as means in which natural resources are transformed into goods and services without waste, that producers are doing the best job possible of combining resources to make goods and services. Technical efficiency is just one component of overall economic efficiency. An economic system is said to be more efficient than another (in relative terms) if it can provide more goods and services for the society without using more resources (Barr, 2004).

1.2 Statement of Research Problem:

Khartoum State is considered the largest and most states of Sudan invest in the poultry industry in which invests more than 85% of poultry

production projects in Sudan. The reality of poultry production in the Khartoum state is based on breeding in the traditional open barns (International Center of Africa Studies, 2008).In spite of increasing investment in broiler industry, there are an obvious gap between the production of broiler and its demand, graphically show that:



Source: Ministry of agricultural in Khartoum state, 2014

Figure (1. 1): Demand, supply, deficient, in broiler production in Khartoum state (2011, 2012, 2013, 2014)

Although there is an increase in broiler production especially in small scale farm, but still the prices are increasing, and it is not well known whether this is due to increase in demand, high cost inputs or to fewer farms. Hence, this study focuses on small scale broiler farms. Its highlight on the factors that may affect productivity and the broiler farms production, Success of poultry industry depends on good management, good hygiene and economic sufficient feed. Poultry industry in Sudan is now facing great problems, mainly the feed, which represents about 75% or more of the total cost of production, due to the competition between human and animal, scarce in crop production and human population growth (Mukhtar *et al*., 2012).

However, in recent years there is an increase in the interest of commercial poultry production in the Sudan, and it divided into three farming system:

- Open System
- Semi Closed system
- Closed System

1.3 Objectives:

The main objective of this study is to examine the economic efficiency of production and return to scale among broiler farms in Khartoum state, which is responsible for almost 90% of Sudan's poultry production (Ministry of Agriculture, 2005).

Specifically, the study looks at the socio-economic characteristics and production factors that affect the economic efficiency of farmers.

The Specific Objective Include:

1. To describe the current situation of small scale broiler farms activities.
2. To estimate the economic efficiency of small scale broiler farms.
3. To identify constrains of economic efficiency.
4. To calculate small scale broiler farms return to scale.

1.4 Research Hypotheses:

1. The current situation of broiler small farms activities non economics.
2. Broiler small scale farms are efficient in resource allocation.
3. There are some inefficiently affect constrains the farm production.
4. Broiler small farms in Khartoum state have constant return to scale.

1.5 Significance of the Study:

This will be the first study looking at broiler small scale farms technical and allocative efficiency. It will therefore add to existing literature on technical and allocative efficiency as they relate to Sudan.

Farm and farmer characteristics observed among efficient farmers will be used to formulate policy recommendations that will help policy makers to develop strategies that will help inefficient farm. This will be also important in extension work as it highlights farmer characteristics more likely to enhance productivity among the farmer.

1.6 Research Methodology:

Efficiency in production is a way to ensure that products of firms are produced in the best and most profitable way. To prevent waste of recourses, efficiency is of great importance for every sector in the economy, but for the agricultural sector, the up-coming Mid Term Review will radically increase the already high need efficiency.

1.6.1Method of data collection:

The study were depended on both primary and secondary data. Primary and secondary data will be collected through questionnaire and relevant source, respectively. And also secondary data was collected from source related to topic of the study.

1.6.2 Statistical Method:

1. Sampling method:

   The primary data were gathered through a questionnaire distributed to 40 of broiler small scale producers from different localities in Khartoum State, by using purposive sampling technique.

2. Descriptive Statistical Analysis Method**:**

By using SPSS to describe the Socio-economic factors of the broiler small scale producer.

3. Stochastic Frontier Production Function(SFAM):

   The computer program, frontier, can be used to obtain Maximum likelihood estimates of a subset of the stochastic frontier production and cost function.

4. Data Envelopment Analysis(DEA):

   Data Envelopment Analysis is linear programming methodology to measure the economic efficiency (technical and allocative) of multiple decisions – making units (DUM) where the production process a structure of multiple inputs and output.

1.7 Limitations of the study:

The lack of official data on small scale broiler farms producers, places, bird stock and number of population size. No accurate records were available. Poultry producers showed poor response in answering most of the question, source of other income, income and revenue.

1.8 Research Orientation:

The research include five chapters, chapter one Introduction, chapter two includes Literature review and previous study, chapter three present Research methodology, chapter four Result and discussion, chapter five Summary, conclusion and recommendations.

CHAPTER TWO

LITERATURE REVIEW

This chapter contains a review of literature and includes the theoretical details of efficiency measurements, and related and previous studies.

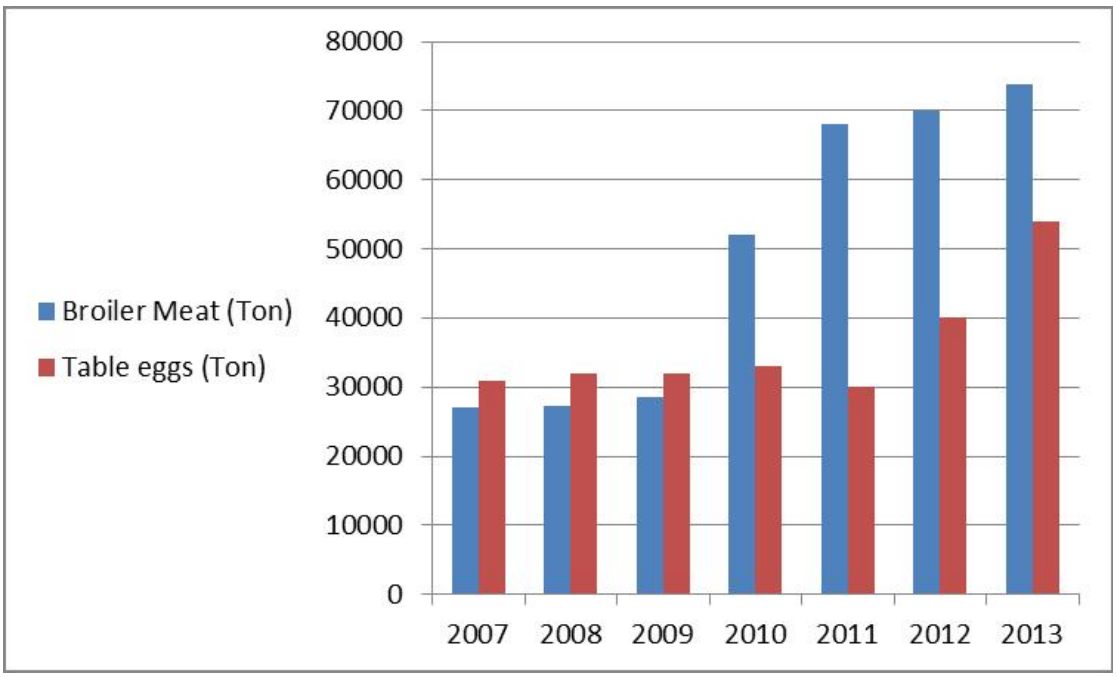
2.1 Introduction:

Broiler that side of poultry production is concerned with meat production, special breeds for those purposes which have ability to convert food to edible muscles i.e. rapid growth breeds (Asharabeen, 1996).

Meat Chicks topping the list of poultry meat consumed worldwide as they contribute more than 70% of the global poultry meat. Four continents, North America, South America, Asia and European union, produce 90% of chicks in the world (International Center of Africa Studies, 2008).

Poultry sector in Sudan is considered the most advanced and sophisticated, where the poultry industry has seen great development in Sudan to enter the national and exclusive investments in response to the growing demand for poultry products resulting from increased economic growth and improved living standards in addition to the expansion of the consumer food culture (Arab poultry production and processingCo.LTD, 2010).

Figure (2.1) showed that there were an increase in broiler production and egg production, this increase was approximately the same during the period (2007-2009) while broiler production increase was higher than egg production during period (2010-2012) which is due increase in broiler investment by small scale farms.



Source: Sirdar, 2014

Figure (2. 1): Sudan annual meat and eggs production (2007-2013)

Table (2.1) explains that Palestine, Libya, Saudi Arabia, Arab Emirates and Jordan have the most of poultry meat production on the individual level (kg per cap), in Arab world. Also showed that poultry meat production on the individual level (kg per cap) Sudan is the least country, in Arab world.

Table: (2.2) indicates that Saudi Arabia and Egypt are most importing country of poultry meat while Sudan was the least importing and consuming country but, consumption slightly increased due to the increase in the feed culture of people.

Table (2. 1): Per capita production of eggs and poultry meat in Arab World:

Country	Population Million	Egg production Number per cap.		Poultry meat production kg per cap	
	2005	2005	2015	2005	2015
Egypt	75.488	52	62	8.57	4.22
Sudan	38.560	24	29	0.75	1.00
Algeria	33.868	66	82	7.65	9.25
Morocco	31.224	133	146	10.03	5.68
Iraq	28.993	33	50	1.66	5.05
Saudi Arabia	24.735	96	115	22.01	23.18
Yemen	22.389	39	47	5.06	6.64
Syria	19.929	156	172	6.65	6.92
Tunisia	10.327	156	172	9.75	11.72
Somalia	8.699	-	-	-	-
Libya	6.160	195	215	18.35	23.82
Jordan	5.924	121	145	22.39	22.30
Arab Emirates	4.380	115	128	7.95	22.87
Lebanon	4.099	212	233	33.20	12.96
Palestine	4.017	170	200	21.09	25.30
Mauretania	3.124	34	37	1.95	2.30
Kuwait	2.851	165	182	16.32	4.89
Oman	2.595	61	73	2.31	10.50
Qatar	0.841	163	180	5.71	3.70
Djibouti	0.833	-	-	-	-
Bahrain	0.753	54	60	7.97	11.50
Comoros	0.682	17	22	0.67	3.18
Arab World	**334.776**	**71**	**83**	**8.62**	**8.28**
Total World	**6.650.000**	**146**	**157**	**11.15**	**12.00**

Source: Sirdar, 2014

Table (2. 2): Imports of poultry meat and per capita consumption in Arab countries:

Country	Import 1000 tonnes		Consumption kg/cap	
	2005	2015	2005	2015
Egypt	2.16	588.89	8.52	10.22
Sudan	0.04	0.05	0.77	1.00
Algeria	0.03	0.04	7.71	9.25
Morocco	0.24	234.18	9.73	11.68
Iraq	173.97	226.15	8.50	11.05
Saudi Arabia	474.62	617.27	38.53	42.38
Yemen	97.07	126.19	9.15	10.98
Syria	0.13	0.17	6.72	8.74
Tunisia	0.03	0.04	9.35	12.21
Libya	0.02	0.26	18.35	23.85
Jordan	19.74	29.31	22.11	26.53
Arab Emirates	118.26	133.63	42.13	46.34
Lebanon	0.38	79.94	23.37	28.04
Kuwait	170.22	204.26	57.10	60.00
Oman	20.76	26.99	15.42	18.50
Qatar	24.39	31.71	28.65	37.24
Bahrain	16.07	26.43	35.00	38.50
Comoros	5.20	6.76	8.31	10.60
Arab World	**1126.00**	**2333.00**	**12.28**	**14.89**

Source: Sirdar, 2014

2.2 Efficiency Measurements Concepts:

The primary purpose of this section is to outline a number of commonly used efficiency measures and to discuss how they may be calculated relative to an efficient technology, which is generally represented by some form of frontier function. Frontiers function have been estimated using many different methods over the past 40 years. The two principal methods are:

- Data envelopment analysis (DEA).
- Stochastic frontiers (SFAM).

The two principal methods involve are mathematical programming and econometric methods, respectively. The computer program FRONTIER can be used to estimate frontiers using stochastic frontier methods.

The discussion in this section provides a very brief introduction to modern efficiency measurement. Modern efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. He proposed that the efficiency of a firm consists of two components: **Technical efficiency**, which reflects the ability of a firm to obtain maximal output from a given set of inputs, **allocative efficiency,** which reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. These two measures are then combined to provide a measure of total **economic efficiency**.

The following discussion begins with Farrell's original ideas which were illustrated in input/output space and hence had an input reducing focus. These are usually termed input – orientated measures.

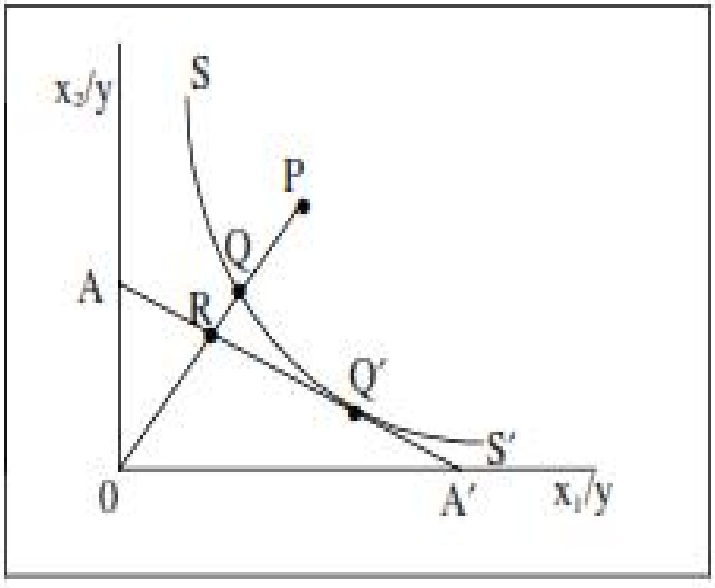
2.2.1Input orientated measures:

Farrell illustrated his idea using a simple example involving firms which use two inputs (x_1 and x_2) to produce a single output (y), under the

assumption of constant return to scale. Knowledge of the unit isoquant of the fully efficient firm represented by SS′ in figure (2.2) permits the measurements of technical efficieny. If a given firm uses quantities of inputs, defined by the point P to produce a unit of output, the technical inefficiency of that firm could be represented by the distance QP, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually expressed in percentage by which all inputs could be reduced. The technical efficiency (TE) of a firm is most commonly measured by the ratio:

$$\mathbf{TE_1 = 0Q/0P,} \qquad \mathbf{(1)}$$

Which is equal to one minus **QP/0P**? It will take a value between zero and one, and hence provides an indicator of the degree of technical efficiency of the firm. a value of one indicates the firm is fully technically efficient. For example, the point Q is technically efficient because it lies on the efficient isoquant.



Source: Farrell, 1957

Figure (2. 2): Technical, and allocative efficiencies

If the input price ratio, represented by the line **A A′** in figure (2.2), is also known, allocative efficiency may also be calculated. The allocative efficiency (AE) of the firm operating at P is defined to be ratio.

$$\mathbf{AE_1 = 0R / 0Q,} \qquad \mathbf{(2)}$$

Since the distance R**Q** represents the reduction in production costs that would occur if production were to occur at the allocativelly and technically efficient point **Q′,** instead of at the technically efficient, but a llocativelly inefficient, point **Q**.

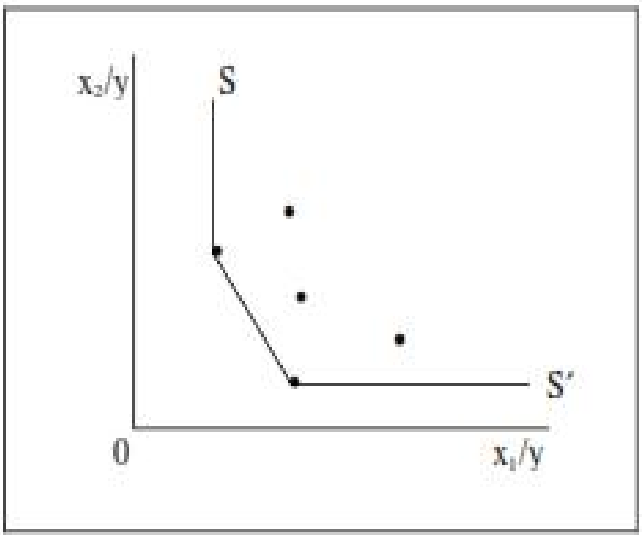
The total economic efficiency (EE) is defined to be the ratio

$$\mathbf{EE_1 = 0R / 0P,} \qquad \mathbf{(3)}$$

Whereas the distance RP can also be interpreted in terms of cost reduction. Note that the product of technical and allocative efficiency provides the overall economic efficiency.

$$\mathbf{TE1 * AE1 = (0Q/0P)*(0R / 0Q) = (0R / 0P) = EE_1} \qquad \mathbf{(4)}$$

Note that all three measures are bounded by zero and one.



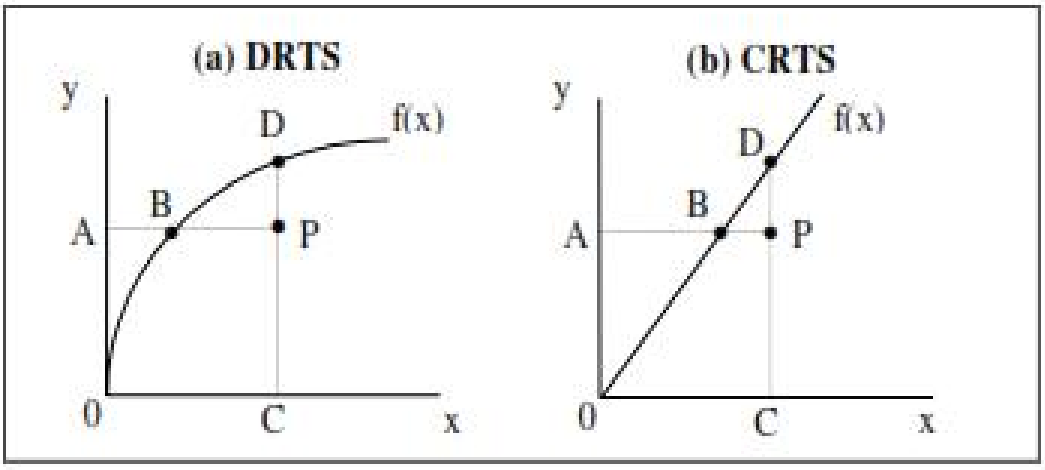
Source: Farrell, 1957

Figure (2. 3): Piecewise liner convex isoquant

These efficiency measures assume the production function of the fully efficient firm is known. In practice this is not the case, and the efficient isoquant must be estimated from the sample data. Farrell suggested the use of either (a) a non-parametric piecewise - liner convex isoquant constructed such that no observed point should lie to the left or below it (refer to figure 2.3), or(b) a parametric function, such as cobb – Douglas form, fitted to the data, again such that no observed point should lie to the left or below it. Farrell illustration of his method was by using agricultural data for the 48 continental States of US.

2.2.2Output - Orientated Measures:

The above input –orientated technical efficiency measure addresses the question: By how much can input quantities be proportionally reduced without changing the output quantities produced? .One could alternatively ask the question: by how much can output quantities be proportionally expanded without altering the input quantities used? .This is an output- orientated measure as opposed to the input –orientated measure discussed above. The difference between output- and input – orientated measures can be illustrated using a simple example involving one input and one output. This is depicted in Figure (2.4) (a) where we have a decreasing return to scale technology represented by (x), and an inefficient firm operating at the point p. The Farrell input – orientated measures of TE would be equal to the ratio AB/AP while the output – orientated measures of TE would be CP/CD. The output-and input- oriented measures will only provide equivalent measures of technical efficiency when constant returns to scale exits, but will be unequal when increasing or decreasing returns to scale are present (Farrel and Lovell 1978). The constant return to scale case is depicted in Figure (2.4) (b) where we observe that AB/AP = CP/CD, for any inefficient point P we care to choose.



Source: Farrel and Lovell, 1978

Figure (2. 4): Input-and output-oriented technical efficiency measures and return to scale

2.3 Efficiency Measurements Theoretical Background:

2.3.1The stochastic frontier analysis (SFAM)

The computer program, FRONTIER program, can be used to obtain maximum likelihood estimates of a subset of the stochastic frontier production and cost functions. Since the stochastic production frontier model was first and nearly simultaneously published by Meeusen and Van den Broeck (1977) and Aignver, Lovell and Schmidt (1977), there has been considerable research to extend the model and explore exogenous influences on producer performance. Early empirical contributions investigating the role of exogenous variables in explaining inefficiency effect adopted a two –stage formulation which suffered from serious econometric problem.

In 1990, Kumbhakar *et al*., (1991), Reifschneider and Stevenson (1991) and Huang and Lui (1994) proposed stochastic models that simultaneously estimate the parameters of both the stochastic frontier and the inefficiency functions.

While the formulated models differ somewhat in the specification of the second error component, they all used cross-section data. Battese and coelli (1995) formulated a stochastic frontier production model similar to that of Huang and Liu and specified for panel data. In this study, we adopt the coelli but specified cross–section data context (Coelli, 1996).

The model of SFAM can be expressed by:

$$\mathbf{Q_i = \alpha + \sum \beta_i x_i + \sum \alpha_i Z_i + V_i - U_i}$$

Whereas:

Q_i: production Z_i: inefficiency parameter

α: intercept U_i: non-negative random variables

β_i: parameter V_i: random variables

2.3.2 The Data Envelopment analysis (DEA)

Data envelopment analysis is non-parametric mathematical programming approach to frontier estimation. The discussion of DEA models presented here is brief, with relatively little technical detail.

The piecewise –linear convex hull approach to frontier estimation, proposed by Farrell (1957), was considered by only a hand full of authors in the two decades following Farrell's paper. Authors such as Boles (1966) and Afriat (1972) suggested mathematical programming methods which could achieve the task, but the method did not receive wide attention until the paper by Charnes, Cooper and Rhodes (1978) which coined the term Data Envelopment Analysis (DEA). There have since been a large number of papers which have extended and applied the DEA methodology.

Charnes, Cooper and Rhodes (1978) proposed a model which had an input orientation and assumed constant return to scale (CRS) subsequent papers have considered alternative sets of assumptions, such as Banker,

Charnes and Cooper (1984) who proposed variable return to scale (VRS) model.

2.4Previous studies:

Technical, allocative, and economic input efficiency scores were estimated for an unbalanced panel of Swedish dairy farm, using data envelopment analysis (DEA) and the stochastic frontier approach (SFAM). By comparing the result it was concluded that when the entire dairy farm is studied the DEA is more appropriate to use since it does not require any particular parametric from to be chosen. (Johansson, 2005) in this study found that the average DEA technical and allocative and economic efficiency indices were eventually found to be 0.77, 0.57and 0.43 respectively, the influence of size on the efficiency scores was analyzed and significant evidence indicating appositive relationship between size and efficiency was found the study concluded that the main problem facing the Swedish dairy farms is to enhance their cost minimizing skills.

Almahdi, (2005) stated in her study of economic production of broiler, in Khartoum state, Sudan. For all values in the two system as comparison the result is completed also analyze budged for average cost in closed and Open system as through knowing the total cost and profit and profitability it become clear for comparing it become more higher in closed system than the open system. In the end of this study we gouged contented that the closed system is more efficiently according producing it is more cost on the contrary the open system is low in cost and productivity. Therefore the result we advise open farmers to take care for pushing wheel production forward.

In the study analysis the factor influencing the technical efficiency of Arabica coffee farmers in Cameron, to carry out this analysis, a trans log stochastic production frontier function, in which technical inefficiency effects are specified to be functions of socioeconomic variables, is estimated using

the maximum-likelihood method. the results obtained show the mean technical efficiency index is estimated at 0.896, and 32%of the farmers surveyed have technical efficiency indexes of less than 0.91The analysis also reveals that the educational level of the farmer, and access to credit are the major socio- economic variables influencing the farmers technical efficiency, that it means the education level has a negative and significant effect on the technical inefficiency. This result shows that farmers who have spent many years in formal education tend to be more efficient in coffee production (Nchare, 2007).

Hassan, (2007) revealed that in economics of poultry production in Khartoum State, with emphasis on open system production, socio – economics features 58% from commercial poultry produces their main job are poultry breeding and 60% of poultry producers have experience more than five years economic analysis of data show that feed costs is the main cost item in egg and meat farm in open system that it represent 89%, 89% and 92% in small, medium and large farm sizes of egg production.

Adepoju, (2008) specially looked at socio – economic characteristics which influence the technical efficiency of farmers of egg production in Osun State, Nigeria. The data collected were analyzed using descriptive statistics, budgetary analysis and stochastic frontier production function. The study revealed that Production of egg was profitable in the study area. Result also indicated that inputs were efficiently allocated and utilized and the farmers were operated in stage II of production function.

Islam *et al*., (2011) examined the technical, economic and allocative efficiency of agricultural microfinance borrowers and non – borrowers in rice farming in Bangladesh using Data Envelopment analysis (DEA). Inefficiency effects are modeled as a function of farm specified and institutional variables. The mean technical, allocative, and economic efficiencies are found to be

72%, 66% and 47% respectively, in the pooled sample under variable return to scale specification. This indicates the existence of substantial gains in output and/or decreases in cost in the study areas. Results reveal that after effectively correcting for sample selection bias, land, fragmentation, family size, household wealth, on farm-training and off-farm income share are the main determinants of inefficiency. Efficiency score between microfinance borrowers and non borrowers are significantly different which are also confirmed by the non-discretionary DEA model. This study also revealed that excess costs owing to inefficiencies was 53% and concludes that main challenge facing rice farmers in Bangladesh is to develop their cost minimizing skills.

In the study investigated the efficiency of resource use and return to scale among broiler farmers in Imo State, Nigeria .Data collected were analyzed using descriptive statistics, efficiency index, elasticity of production technique and the ordinary least square regression model. The result from this study showed that the farmers operated at increasing returns to scale with 1.1408 elasticity of production (EP). It was concluded that broiler enterprise among Fadama II farmers in Imo state is profitable but there is inefficiency in resource allocation. It was there for recommended that the farmer either keep labour constant and increase their farm size or keep the farm size constant and decrease their use of labour input for increased profitability of their enterprises (Maduike *et al.*,2013).

Elghouth *et al*, (2013) in study of some economic management and aspects beside the problems encountered in broiler production in Khartoum State, Sudan. Descriptive statistics namely percentage together with partial budgeting technique were used in the analysis. The study revealed that most broiler production in Khartoum metropolis was produced by the large companies and that of Khartoum North was produced by small and medium sized units. Most of broiler units (90%) operate under the open production

units. The remaining units were of closed system environment, these produce 95.4% of the total broiler production. Most of the open production units were rented (67%). About 85% of the open production units depend on purchased feed and one day old chicks and 47% of them have no technical supervision. This was opposite for the closed production units as they own the farms, produce one old chicks and adopt technical supervision. The major cost components are cost of feed, one day old chicks and depreciation on fixed items estimated at 56.7%, 28.3% and 9%, respectively. The main obstacle for effective production were the high cost of feed and chicks, instable electric current and electricity cost beside farm rent.

Aldai (2014) estimation of technical and profitable efficiency of broilers small producers in Khartoum State, showed that the production cost of one kilogram of broiler chickens was 15 SDG and its selling price was 18, with profit SDG 3 per kg. Also frontier production function showed that if production inputs are increased by a certain percentage of production, output increased by more than 1% the marginal size yield was 1.53, which means that the size yield for the production of broiler chickens increased – General average technical efficiency was 82%.

Mohammed, (2014) in the study of the economic of broiler production in Khartoum North locality, found that the majority of the respondents 86% were between the age 30 and 49 years, graduates and post graduates 83.32%, rented their farms 61.11% and all were self financed. The result indicated that the problem facing poultry producers was raising feed prices in addition to a number of other problems, e.g. financial administrative and marketing problems.

Alwali, (2015) stated that the efficient estimation was based on using Data Envelopment Analysis and stochastic frontier production function. The results showed that the average of technical efficiency for these farms reached 84% which show that the farmers should be able to produce the current level

of egg production using not more than 84%of its inputs, and its allocative efficiency at 65% meaning that the farmers should lower the production cost decreasing the prices of their inputs by 35%. The level of economic efficiency fluctuated between a low of 19% and maximum reached 100%. Generally economic efficiency was 55%, which indicates that to reach an efficiency level farmer allocates inputs to produces same level of production in order to be efficient. The research test the difference between the average of technical, allocative and economic efficiency based on changing return to scale showing the absence of significant between open, semi open and closed farms. This is consistent with the hypotheses that the averages of these efficiencies in the different pattern of production are equal. The study found some of the recommendations of the most important oblige that help agriculture project in Khartoum state to plant sorghum to reduce cost of feed and to encourage projects of small producer in terms of developing Sudanese agricultural statistics atlas.

The method used in measurement of technical efficiency that involving farmer's preference towards risk of rice farming in Malang, Indonesia, by (Shinta *et al*, 2016) are: a) expected utility of money to measure the farmer preferences towards the risk and b) stochastic frontier trans log production function with maximum likelihood estimation (MLE) approach to analyze the level of technical efficiency of farming. The results found that 77.7% of farmers have averter risk preferences, the level of technical efficiency obtained at 0.75 by pooling the data.

CHAPTER THREE

RESEARCH METHODOLOGY

The purpose of this chapter is to represent the general stochastic frontier production function, which used in estimation of technical, allocative and economic efficiency for small scale broiler producers' in Khartoum State .This binges with a brief discussion of the study area. The chapter then lays down the sample (collection, size, technique), describe source of data, data analysis and variables used in this study.

3.1 Study Area:

The study was conducted in Khartoum State because it has the largest poultry population in the country. Khartoum is the capital of Sudan, composed of seven localities and estimated population of approximately 7,125,102. It extended between latitudes 15.08° and 16.45° north and longitudes 31.36° and 34, 25°east. The State has an area of 22,122 km^2, and shares borders with River Nile from the North, White Nile from the South, Western Gazira State from the Western and North Kordofan State from the West, and Gedareaf and Kassala States from the East. The study area covered the following localities Khartoum, Khartoum Northern and Omdurman.

Locality of broiler small scale broiler producers'

The state geographically divided into blocks (or clusters), which are further subdivided into localities. There are a total of three blocks and seven localities.

First block:

- Jabalawliya locality.
- Al-Khartoum locality.

Second block:

- Al-Khartoum Bahri locality.
- Sharg an-Nile locality.

Third block:

- Omdurman locality.
- Ombadda locality.
- Karari locality. (http:// www.wekepedia.com) seen 2015.

Table (3.1): Scale of Poultry Farms in Khartoum state, 2012

Farms	Small farms(000)/year	Medium farms(000) /year	Large farms (000)/year
Egg layers	Less than 10	10 – less than 30	Equal and more than 30
Broiler	Less than 500	500- less than 1000	Equal and more than 1000

Source: chamber of poultry , 2012

- Broiler farms have six cycles per year (chamber of poultry).
- Mohammed, (2014) stated that 88.66% of producers' have starting stock not more than 9 thousand per cycle in the open and semi- closed system farms.

3.2 Data Collection:

In order to calculate economic efficiency the study depended mainly on primary data while secondary data was also collected.

The primary data was collected during May-August, (2015) in Khartoum State. The secondary data was collected from different sources related to the topic of the study.

Data were collected with use of a structured questionnaire, which was designed to collect information on broiler output, input, input amount and prices and prices of output, labour and feed costs, bird stock and some major socio economic characteristics of the respondent in study area such as age, experience, educational status and family size.

3.3 Sample size:

The primary data was gathered through a questionnaire given to 40 of broiler small scale producers' from different localities in Khartoum State. It took three months from May - August, on the average the questionnaire took 25 minutes for one respondent.

3.4 Sample size techniques:

The sampling method used for this research is multistage sampling technique. The first stage, involved a purposive based on population of the broiler small scale producers' availability size of the small scale. The second stage involved purposive sample of 40 broiler producers' in Khartoum state.

Purposive sampling is type of non -probability sampling technique. Non – probability sampling is focuses on sampling techniques where the units that are investigated are based on the judgment of the researcher.

The major benefits of purposive sampling is wide range of sampling techniques that can be used across such qualitative research designs; purposive sampling techniques that range from homogeneous sampling through to critical case sampling, expert sampling, and more. (http://wikipedia.com) seen 2015.The sample collection through purposive sampling was used to find out the sample size of broiler small scale producers' in Khartoum State.

The experts in this field such as veterinary pharmacies, small scale producers' themselves and the laboratories of forage plants helped in samples

collection through knowing production areas in the State and their markets such as veterinary pharmacies and sale points of production inputs.

3.5 Data Analysis:

3.5.1The descriptive statistics

SPSS (statistical package for social sciences)**,** was used to analyze the data gathered on the socio-economic characteristics of the broiler small scale producers' in the study area.

3.5.2 Method of Estimating the Economic Efficiency

The idea behind efficiency studies is to measure a firm's position relative to an efficient frontier, resulting in an efficiency score of the firm. The efficiency score is bounded between zero and one, where a score of one indicates full efficiency. A consequence of this and the fact that the economic efficiency is the product of the technical and allocative efficiencies is that the technical efficiency can never be smaller than the economic efficiency, since this would lead to allocative efficiency scores greater than one. Measurement of efficiency requires knowledge of the efficient production function, which thus has to be estimated from the sample data.

As was pointed out in the previous section DEA, and SFAM are two techniques of estimating a firm's relative position to the frontier. When using SFAM, estimation via the production, cost or profit function will be possible. The cost and profit functions are both dual to the production function, and thus they can be derived from the estimates. Cost and profit functions have the advantage of following multiple outputs, but if we want to limit the behavioral assumptions, as we do in this study, the production function is probably a better choice (Coelli, 1995). This study also believes that data on inputs have higher quality than price data, making the production function a more suitable choice.

3.5.2.1 The stochastic frontier analysis (SFAM)

The original specification involved a production function specified for cross-sectional data which had an error term of two components, one to account for random effects and another to account for technical inefficiency.

The model of SFAM calculated by:

$$\mathbf{Q_i = \alpha + \beta_m x_{mi}}$$

$$\mathbf{\ln Q_i = \ln\alpha_0 + \beta_1 \ln x_{1i} + \beta_2 \ln x_{2i} + \ldots + \beta_J \ln x_{Ji} + \ln\alpha_1 + \alpha \ln z_{1i} + \alpha_2 \ln z_{2i} + \ldots + \alpha_j \ln z_{ji} + U_i - V_i}$$

Whereas:

Q_i: the broiler production (or logarithm of the production).

α : intercept

β_m: parameters

x_m: independent variables

x_1: total costs /kg (SDG/kg)

x_2: bird stock /number

x_3: ration / ton

x_4: labour /number

z_m: inefficiency parameters:

z_1: Age / years

z_2: Education levels

z_3: Number of family member

z_4: Number of family member working in the farm

z_5: Experience /year

z_6: Information source

z_7: mortality rate / percentage

U_i: non-negative random variables

V_i: random variables

$Y_i = x_i\beta + (V_i - U_i)$,i=1,…,N,

Whereas:

Y_i: the broiler production (or logarithm of the production)of the i-th firm.

x_i: is input quantities of the i-th firm.

β: unknown parameters.

V_i: random variables which are assumed to be, $N(0,\sigma_V^2)$.

U_i: non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be, $|N(0,\sigma_U^2)|$.

3.5.2.2 Data envelopment analysis (DEA)

Data envelopment analysis is nonparametric method in operation an economic for the estimation of production functions. The frame work has been adapted from multi-output production and applied in many industries DEA develop function whose form is determined by the most efficient producers'.

This method differs from ordinary least squares (OLS) statistical technique that bases comparison relative to an average producer. Like stochastic frontier analysis (SFAM) DEA indentifies frontier on which the relative performance of all utilities in the sample can be compared.

Data envelopment analysis is a linear programming methodology to measure the efficiency of multiple decision-making units (DMU) where the

production process structures of multiple inputs and outputs. DEA has been used for both production and cost data.

DEA involves the use of linear programming methods to construct a non – parametric piecewise surface (or frontier) over the data, so as to be able to calculate efficiencies relative to this surface. The computer program can consider a variety of models. The three principle options are:

1. Standard CRS and VRS DEA models that involve the calculation of technical and scale efficiencies (where applicable). These methods are outlined in Farrell, Grosskopf and lovell (1994).
2. The extension of the above models to account for cost and allocative efficiencies. These methods are also outlined in (farrell et al., (1994).
3. The application of Malmquist DEA method to panel data to calculate indices of total factor productivity (TPF) change technological change; technological efficiency change and scale efficiency change. These methods are discussed in farrell, Grosskopf, Noris and Zhang (1994).

The constant return to scale model (CRS) can be calculated by:

$$\mathbf{min}_{e\,\theta,\lambda}\boldsymbol{\theta},$$

$$\text{st } -y_{i} + Y\lambda \geq 0,$$

$$\theta x_{i} - x\lambda \geq 0,$$

$$\lambda \geq 0,$$

Where θ is a scalar and λ is a N×1vector of constant. This envelopment form involves fewer constrains than the multiplier form (K+M < N+1), and hence is generally the preferred form to solve. The value of θ obtained is the efficiency score for the i-th DMU. It will satisfy θ≤1, with a value of 1indicating appoint on the frontier and hence a technically efficient DMU, according to the Farrell (1957) definition. Note that the linear programming

problem must be solved N times, once for each DMU in the sample. Avalue of θ is then obtained for each DMU.

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint: N 1‘λ =1(to provide CRS):

$\mathbf{min}_{e\ \theta,\lambda}\boldsymbol{\theta}$,

$$st\ -y_{i} + Y\lambda \geq 0,$$

$$\theta xi - x\lambda \geq 0,$$

$$N1'\lambda = 1$$

$$\lambda \geq 0,$$

Whereas N1 is an N×1 vector of ones. This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained using the CRS model. The VRS specification has been the most commonly used specification in 1990, but in this study we used both CRS and VRS.

3.5.2.2.1 Some of the advantage of DEA are:

1. No need to explicitly specify mathematical for the production function.
2. Proven to be useful in uncovering relationships that main for other methodologies.
3. Capable of handling multiple inputs and outputs.
4. Capable of being used any input-output measurement.
5. The source of inefficiency can be analyzed for every evaluated unit.

3.5.2.2.2 Some of the disadvantages of DEA are:

1. Result are sensitive to the selection of inputs output.

2. You cannot test the best specification.
3. The number of efficiency firm on the frontier tends to increase of input output variables. (http://www.Wikipedia. com) seen 2015.

3.6 Return to scale:

If:

$$\alpha + \beta = 1 \ constant\ return\ toscale$$

$$\alpha + \beta = >1 \ increasing\ return\ toscale$$

$$\alpha + \beta = <1 \ decreasing\ return\ toscale$$

3.7 Scale of Efficiency:

Many studies have decomposed the TE scores obtained from a CRS DEA into two components, one due to scale inefficiency and one due to pure technical inefficiency.

This may be done by conducting both a CRS and a VRS DEA upon the data. If there is a difference in the two score for particular DMU, then this indicates that DMU has scale inefficiency, and that the scale inefficiency can be calculated from the differences between the VRS TE score and the CRS TE score.

CHAPTER FOUR

RESULTS AND DISCUSSION

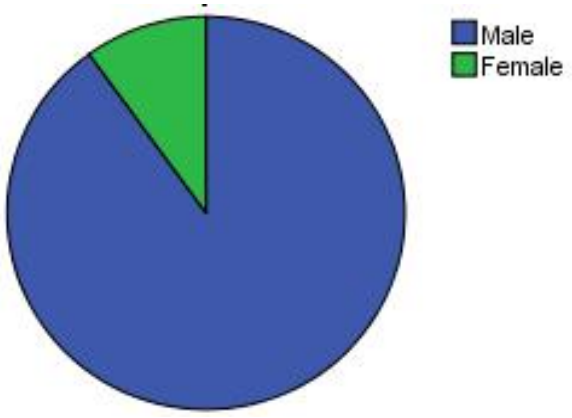
This chapter describes the socio – economic characteristics of the producers' the economic efficiency of farms return to scale and the challenges of small scale broiler farms in Khartoum State.

4.1 Social and economic characters:

There are several economic and a social factors which has an impact on the productivity of small scale broiler producers' farms, some raise the economic efficiency of the farms and increase their profitability, while others could lead to the loss.

4.1.1Gender

Figure (4.1) depicts that 90% of the surveyed producers' were males. This indicates that investment projects especially agricultural ones confined largely to males, but from the survey there were many broiler farms managed successfully by females (10%) whom were either veterinarians or agriculturists.

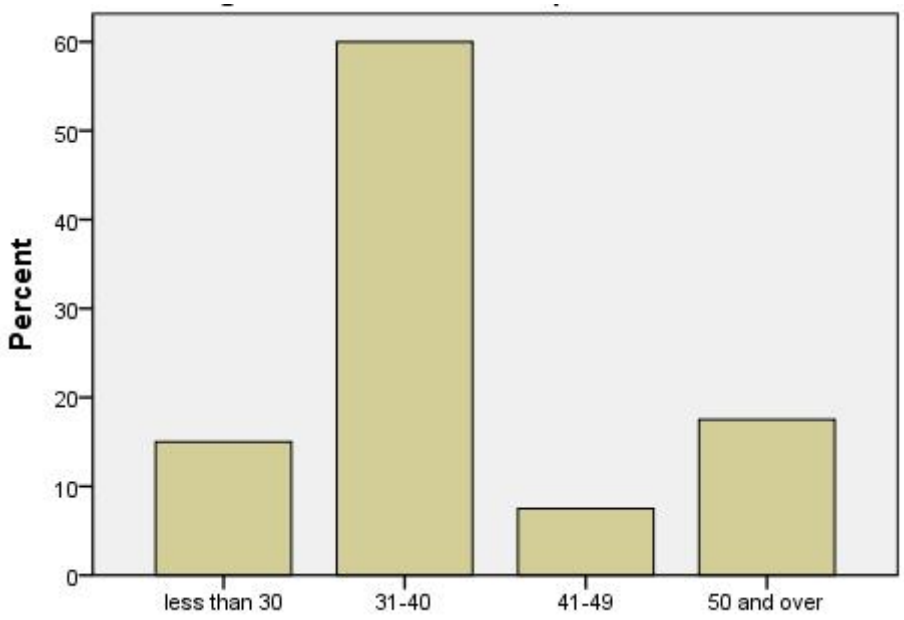


Source: Survey, 2015

Figure (4.1): Distribution of small scale broiler farms producers' according to gender in Khartoum State, 2015

4.1.2 Age

The percentage distribution of small scale broiler farms producers' according to age ranged among different classes of ages. This means broiler production is practiced by among different ages of small scale broiler producers' age class of 31-40 years was 60%of small scale broiler producers' indicates that young people are interesting in poultry industry (figure 4.2).

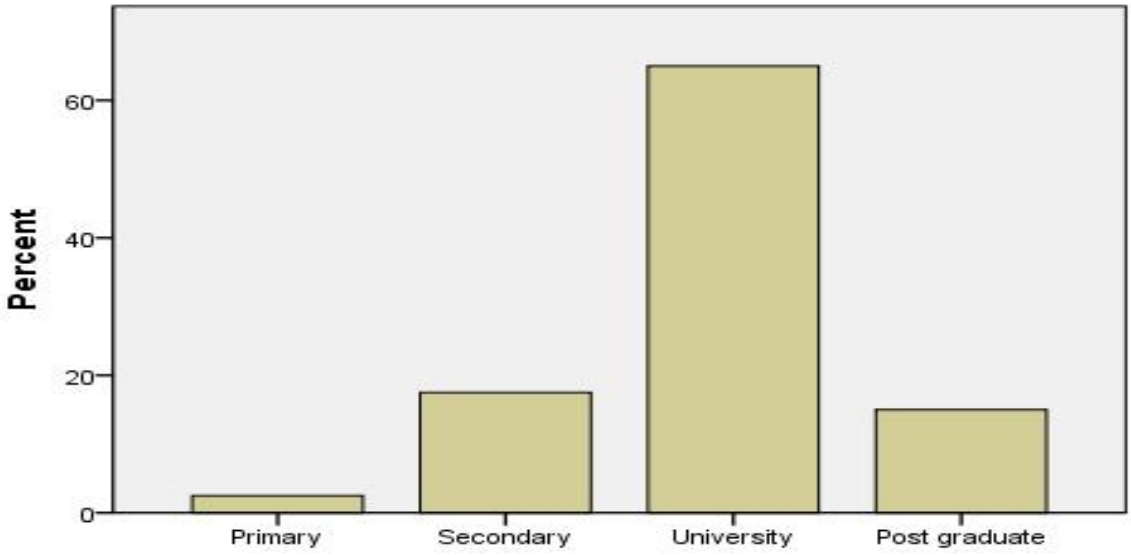


Source: Survey, 2015

Figure (4.2): Distribution of small scale broiler farms producers' according to age in Khartoum State, 2015

4.1.3 Education level

Figure (4.3) indicates that small scale broiler farms producers were highly educated 80%, only 3% and 17% of them were primary and secondary educated, in Khartoum State.

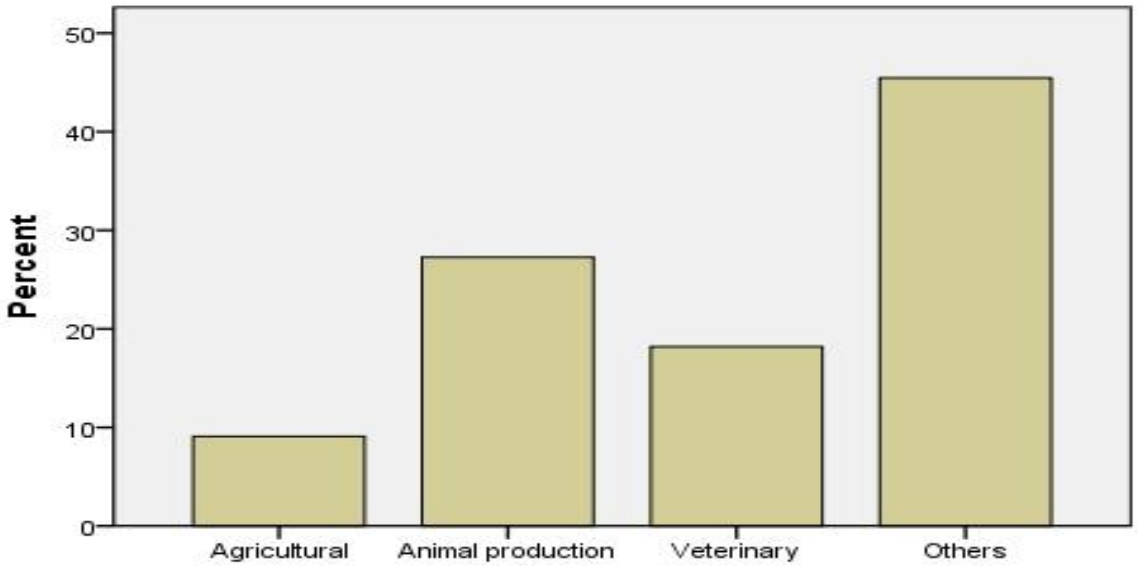


Source: Survey, 2015

Figure (4.3): Distribution of small scale broiler farms producers' according to education level in Khartoum State, 2015

4.1.4 Academic specialization

According to Figure (4.4) 46% of small scale broiler farms producers in Khartoum State have an academic and specialization in other field than animal production. Highly education level without specialization of animal production might be expected to have less production and income levels.



Source: Survey, 2015

Figure (4. 4): Distribution of small scale broiler farms producers' according to Academic specialization in Khartoum state, 2015

4.1.5 Family size

Table (4.1) shows the producers' family size, which was on average of five members. In general, the larger the family size the burden will be on the head of the household. Thus, those who have the smallest family size are relatively better by assuming that all members are dependent and do not contribute to family labour in this industry.

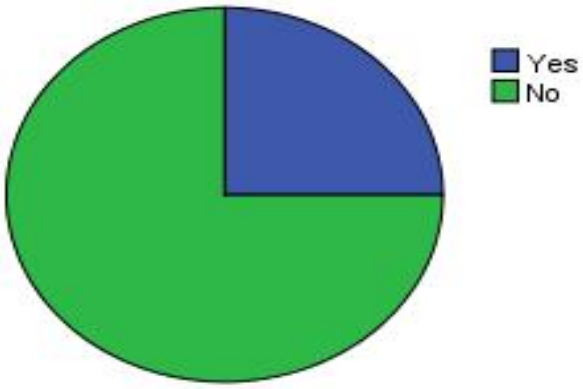
Table (4. 1): Family size of small scale broiler farms producers' in Khartoum State, 2015

Descriptive Statistics	Family size
Minimum	1
Maximum	14
Mean	5.03
Std. Deviation	2.55

Source: Survey, 2015

4.1.6 Family labour

The survey results revealed that only 25% of the small scale producer family members were working with him in the farm Figure (4.5).



Source: Survey, 2015

Figure (4. 5): Producer family member's working in small scale broiler farms production in Khartoum State, 2015

4.1.7 Average number of family members working in farm

Table (4.2) represents on average there was one person family members worked with small scale broiler farms producers such like management and supervision activities.

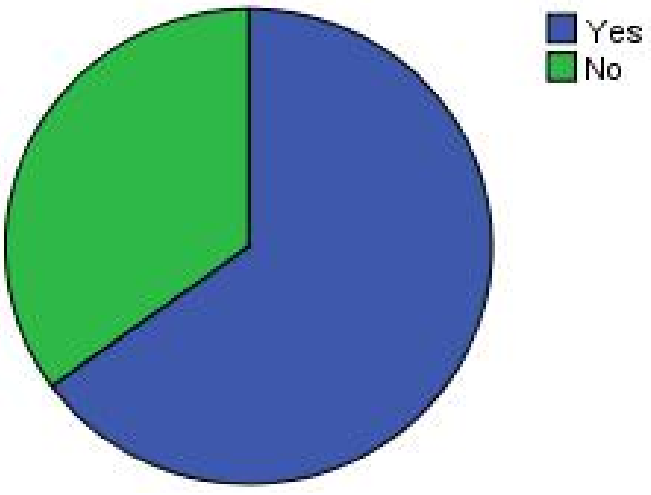
Table (4. 2): Number of family member working in farm of small scale broiler farms producers' in Khartoum state, 2015

Descriptive Statistics	Family member worked in farm
Minimum	0
Maximum	3
Mean	0.40
Std. Deviation	0.810

Source: Survey, 2015

4.1.8 Source of income

Figure (4.6) shows that 65% of small scale broiler farms producers' were gained their income from working in broiler farms as main source. The other used 35% considered broiler farms as a secondary source to improve their living welfare.

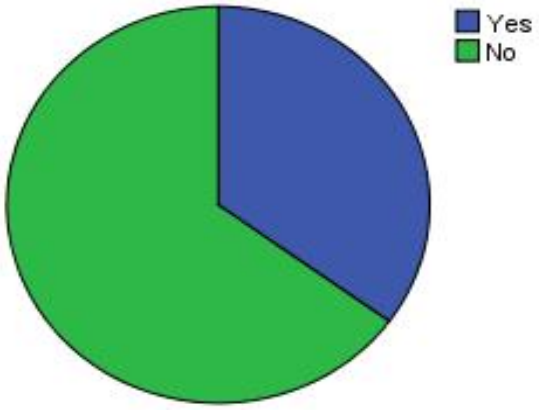


Source: Survey, 2015

Figure (4. 6): Working in farm is the main source of income of small scale broiler farms producers' in Khartoum State, 2015

4.1.9 Job

Figure (4.7) portrays that 35% of small scale broiler producers' had other sources. This means the broiler production in Khartoum State is practiced together with other activities. Production will be improved more with more specialization in particular when broiler production is separately practiced.



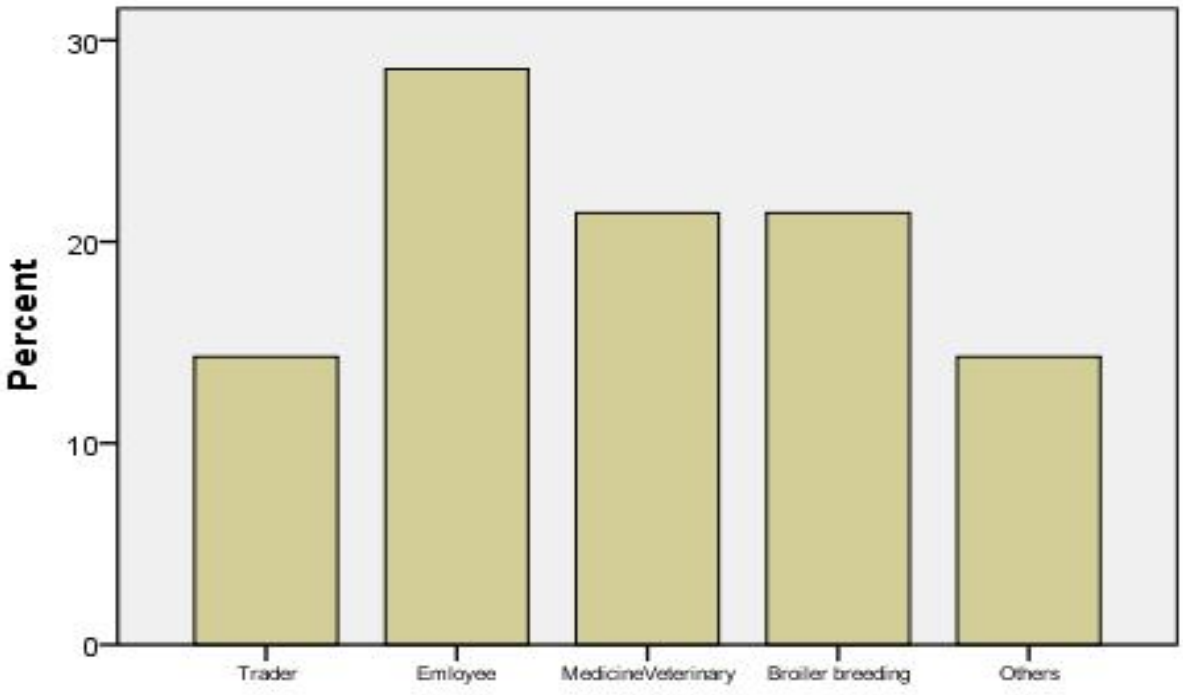
Source: Survey, 2015

Figure (4. 7): Job of small scale broiler farms producers' in Khartoum State, 2015

4.1.10 Main Job

According to Figure (4.8) broiler production in Khartoum State was practiced as a secondary occupation by some governmental officials, accounting for 28% of the total producers of poultry industry. Traders, on the other hand, constituted 14% of the producers.

Similarly, broiler breeding and veterinarians were prevailed small scale broiler farms production 22% each. The presence of such type of producers could have positive effects on the production process. One effect could be through the expected high level of management. Second is the benefit by the other producers represented by improved management practices as a free extension service. Others estimated to be 14% of the total producers such as engineering.



Source: Survey, 2015

Figure (4. 8): Distribution of small scale broiler farms producers' according to main job in Khartoum State, 2015

4.1.11 Level of income from other sources

The average of other sources of income for small scale farms producers was 856 SDG/ month which indicated that the producers have other income sources those who had employed in governmental offices (Table 4.3).

Table (4. 3): Level of income from other sources of small scale broiler farms producers' in Khartoum State, 2015

Descriptive Statistics	Revenue of other income sources of small broiler producer SDG/month
Minimum	0
Maximum	15000
Mean	856.67
Std. Deviation	2851.942

Source: Survey, 2015

4.1.12 Experience

Table (4.4) indicates that the average of the experience of small scale broiler farms producer was 8 years, which means broiler production is practice by well experienced producers. This level of experience also might indicate that these broiler producers had reach maturity in broiler production.

Table (4. 4): Experience years of small scale broiler farms producers' in Khartoum State, 2015

Descriptive Statistics	Experience of small broiler producers'
Minimum	1
Maximum	35
Mean	8.95
Std. Deviation	6.251

Source: Survey, 2015

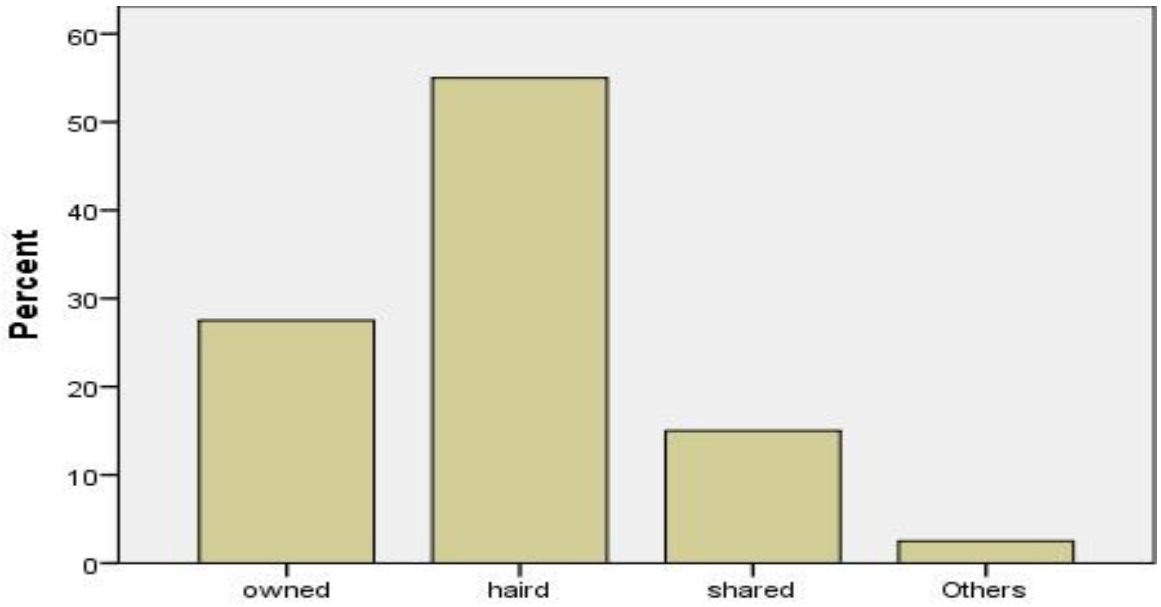
4.2 Production unit:

4.2.1 Type of farm system

The study found that small scale broiler farms producers were open and semi- closed systems for having broiler production.

4.2.2 Type of Farm ownership

Figure (4.9) revealed that 55% of the producers hired farm, 27% owned farms, 15% shared farms and 3% are those who have other ways of forms of property such as donations that most of the production in small scale broiler farms is considered as a secondary income.

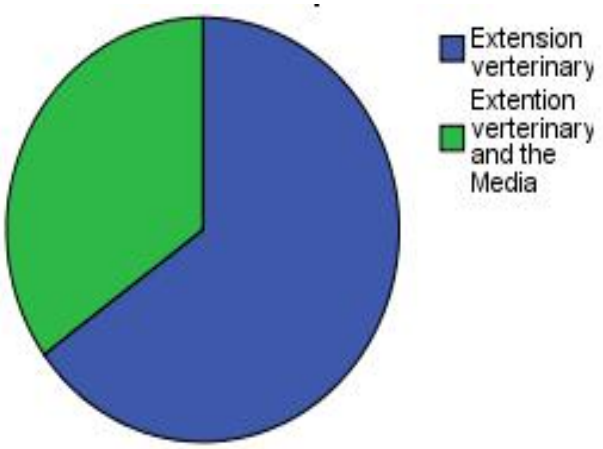


Source: Survey, 2015

Figure (4. 9): Distribution of small scale broiler farms producers' according to type of farms ownership in Khartoum state, 2015

4.2.3 Source of information

Figure (4.10) shows 65% of small producers receive information and knowledge through the guidance of Veterinary, and 35% from media and veterinary.

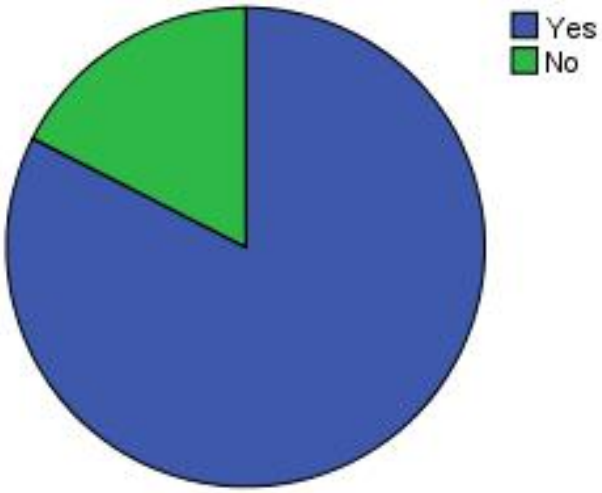


Source: Survey, 2015

Figure (4.10): Distribution of small scale broiler farms producers' according to source of information in Khartoum state, 2015

4.2.4 Technician labour

The technician tasks in broiler farm include feeding, watering, cleaning, in addition to the application of drugs and vitamins. Figure (4.11) shows that 83% of farms had farm technician while the other 18% don't have farm technician. That means broiler producers in Khartoum State are quite aware of the role of the farm technician. Concerning diseases and nutrition, broiler requires great attention, thus farm technician is very important.

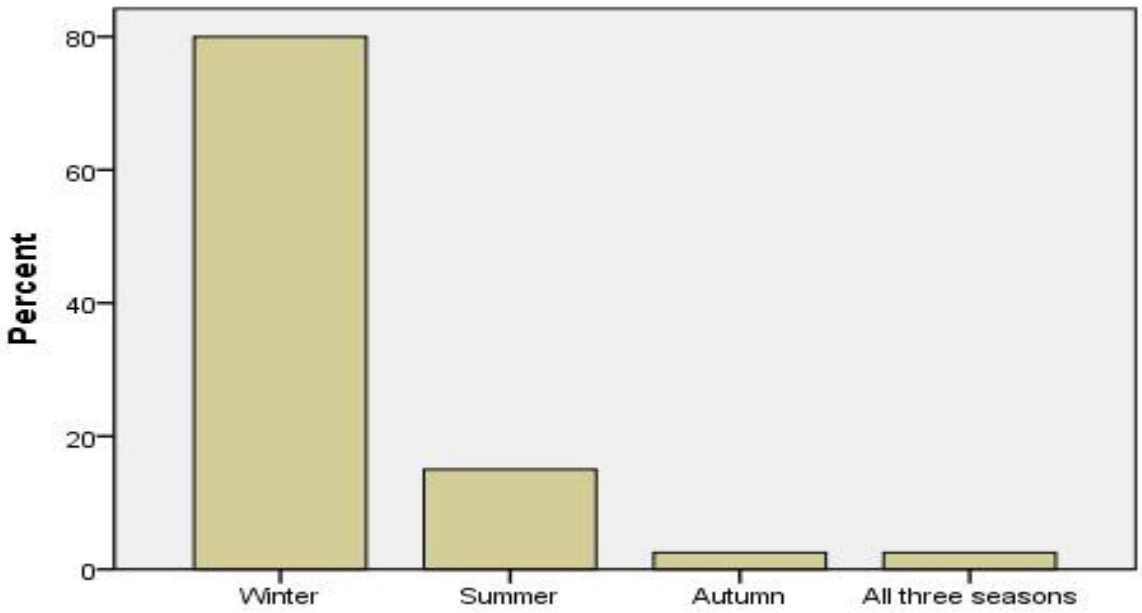


Source: Survey, 2015

Figure (4. 11): Distribution of small scale broiler farms producers' according to presence of farm technician in Khartoum State, 2015

4.2.5 Production in different seasons

Figure(4.12) present 80% of production was in the winter season which matching with nature of the production system in the open and semi-closed,15% in the summer,3% in autumn and 2% in all seasons of the year.



Source: Survey, 2015

Figure (4.12): Distribution of small scale broiler farms producers' according to seasons of production in khartoum State, 2015

4.2.6 Mortality

Due to the survey result, morality rate had shown important in study. It may reach in average 8% of the total production. It is very important problem that facing poultry production as a whole and broiler production at specific .The reason behind this variation is that chicks in the open system are exposed to hard environment conditions, under good management practices mortality rate will range between 5% to 10% / year. Table (4. 5).

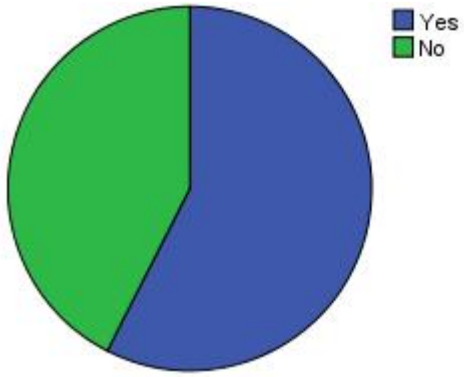
Table (4. 5): Mortality rate of small scale broiler farms in Khartoum State, 2015

Descriptive Statistics	Mortality rate (%)
Minimum	2
Maximum	50
Mean	8.35
Std. Deviation	7.9

Source: Survey, 2015

4.2.7 Temporary labor inputs

Figure (4.13) Represent 57% of broiler farms used wage labor inputs, while 43% doesn't use it .That means highly skilled labor is required in broiler production and the major role is to operate the different processes, which are mechanically done.



Source: Survey, 2015

Figure (4. 13): Temporary labor inputs of small scale broiler farms producers' in Khartoum State, 2015

4.2.8 Type of finance of small broiler producer

Table (4.6) illustrated that 85% of the sample of broiler producer are self – finance, 10% are acquired loans from banks(Murabaha), and 5% of the total broiler producers farm financing others such like Gard Hassan.

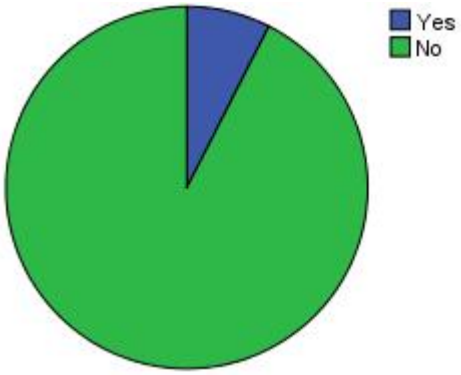
Table (4. 6): Distribution of small scale broiler farms producers' according to type of finance in Khartoum State, 2015

Financing type	Percent%
Self – finance	85
Bank	10
Others	5

Source: Survey, 2015

4.2.9 Insurance

According to figure (4.14) 93% of small scale broiler producers farms have no agricultural insurance which means that insurance companies do not expect that the small scale farmers can face the potential risks. And only 7% have insurance.



Source: Survey, 2015

Figure (4. 14): Agricultural insurance of small scale broiler farms producers' in Khartoum state, 2015

4.3 Estimate the technical efficiency:

Technical, allocative, and economic input efficiency score were estimated for one product cycle of broiler small scale producers in Khartoum state, using data Envelopment analysis (DEA) and the stochastic frontier approach (SFAM).

The maximum likelihood (ML) estimates of the stochastic frontier translog production parameters for the broiler small scale farms producers presented in Table (4.7) The Sigma – squared (σ^2 = .41) and the gamma(γ = .90) are quite high and highly statistically significant at 1% level . The high and significant value of sigma - square (σ^2) indicates the goodness of fit correctness of the specified assumption of the composite error terms distribution. The gamma (γ = .90) shows that 90% of the total variation in broiler output is due to the technical inefficiency.

The coefficient of the total costs is negatively correlated with the production and highly significant at 1% level of significance. This indicates that the negative relationship between total costs and production, this implies that one percent increase in total costs of broiler, make production decreases by 0.17%.

The coefficient of the stock bird is positive and it significance at 1% level of significance. 1% increase in day old chicks brings about 0.18% increases in broiler production. This means that farms can still increase their broiler production substantially by increasing their stock of birds.

Ration coefficient was positive and highly significant at 1% level of significance. this implies that ration are important in broiler production, also indicates if this variable increase output would increase, because feed had highest cost challenge faced broiler producers' reach 78% of total costs challenges.

The estimated coefficient of labor was -0.11 and insignificant, this means that labor had no significant effect on broiler production. This is due to the availability of labour in broiler production in particular, while in agricultural sector in general in Sudan.

Table (4. 7): Maximum likelihood Estimates (MLE) of the Stochastic Production Frontier Function of small scale broiler farms in Khartoum state, 2015

Production Factors	Parameter	Coefficient	Standard-Error	t-ratio
Intercept	β_0	5.7	0.62	9.1***
Total cost	β1	-0.17	0.52	-3.4***
Bird stock	β_2	0.18	0.59	1.9*
Ration	β_3	0.17	0.98	7.2***
Labour	β_4	-0.11	0.83	-1.4
Technical inefficiency:				
Intercept	α_0	1.7	4.7	2.5***
Age	α_1	-0.14	0.62	-0.24
Education level	α_2	-7.8	1.6	4.6***

Member of family	α_3	-0.94	0.57	-1.6
Member of family working in the farm	α_4	0.50	0.82	0.61
Experience	α_5	0.51	0.35	1.4
Information source	α_6	-0.66	0.83	-0.79
Mortality rate	α_7	-0.42	0.54	-0.76
Variance parameters:				
Sigma – squared	σ^2	0.41		5.8^{***}
Gamma	γ	0.90		20.6^{***}
ML		-4.37		
LR		32.42		

*** = significant at level 1% ** = significant at level 5% * = significant at level 10%

Source: Survey, 2015

4.3.1Determinations of technical efficiency

Stochastic frontier and the inefficiency model are presented in table (4.7) a negative inefficiency coefficient signifies a positive relationship with technical efficiency and vice versa.

Age has negative effect but insignificant on the technical inefficiency of broiler farmer, that means in general economy increase in age decreases the inefficiency that the older ones are more efficient than the younger ones. A attributed this trends to the fact that older people are more experience in broiler production while as younger willing to adopt new ideas of doing things.

Education level of farmers has a negative sign and it was highly significant at 1% level of significance. The impact of technical inefficiency indicates that the higher the education level of farmers will reduce the level of technical inefficiency reached by farmers. This is because education helps in the adoption and use of improved technological innovations. This result also shows that farmers spent many years in education to be more efficient in broiler production. Similar results were obtained by (Nachare, 2007).

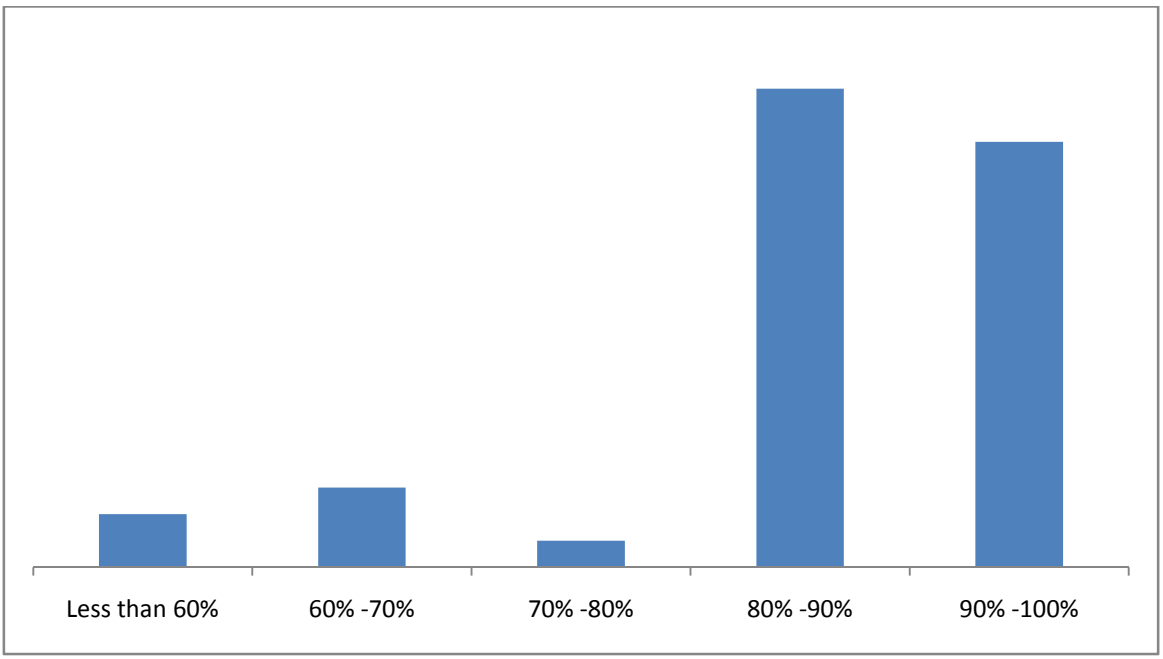
The coefficient of number of family member had anegative sign and insignificant effects on the technical inefficiency, family labour is a good way of providing labour for the farm activities.

Source of information and mortality rate has a negative signs but is insignificance, this implies that source of information and mortality rate are not major determinants of technical efficiency among the broiler producer small scale farm.

No significant relationship was found between technical efficiency and number of family member working in farm and experience.

4.3.2 Technical efficiency

Percentage distribution results of technical efficiency are represented in Figure (4.20). Estimated efficiency measures reveal the existence of substantial technical inefficiencies of broiler farms. The computed average technical efficiency was 83% similar result were obtained by (Aldai, 2014) and (Alsaraf Alwali, 2015). Given the present state of technology and input level. This suggests that farms in the sample are producing on average at 83%of their potential. These results make inquiries about heterogeneity and the possibility that these producing farms can increase their output by17% given the present state of technology and input levels.



Source: Survey, 2015

Figure (4. 15): Percentage distribution of technical efficiency of the stochastic production frontier function of small scale broiler farms producers' in Khartoum State, 2015

4.3.3 Return to scale of farms

Table (4. 8) contain the return to scale of the farmers. This was derived through the summation of elasticity of production of various resources used .The coefficients of the stochastic frontier production function were the direct elasticity of production.

In Table (4.8) it can be observed that bird stock is an important factor in broiler production, followed by ration, other total costs, and labour.

Summation of the partial elasticity of production with respect to every input for a homogeneous function (all resources varied in the same proportion).This represents the return to scale coefficient, also called the function coefficient or total output elasticity. If all factors are varied by the same proportion, the function coefficient indicates the percentage by which output will be increased. In this case, the production function can be used to estimate the magnitude of return to scale. A constant return to scale only

holds if the sum of all partial elasticities is equal to one. If this sum is more than one, the function has increasing return to scale, if less than one, as in this case, the function has decreasing return to scale. Less than one and positive (0.63), indicating that broiler production is in stage 2 (rational zone) of the production function and that inputs allocation and utilization are efficient. Similar results were obtained by (Adepoju, 2008).

Decreasing positive return to scale, where resource and production were believed to be efficient. Hence, it is advisable that the production units should maintain the level of input utilization at this stage, as this stage, will ensure maximum output from given level of input ceteris paripus.

Table (4. 8): Elasticity and return to scale of the parameters of SFP function of small scale broiler farms producers' in Khartoum State, 2015

Variable	Elasticity
Ration	0.17
Bird stock	o.18
Labour	-0.11
Total costs	-0.17
EP	**0.63**

Source: Survey, 2015

4.5 Estimates of economic efficiency:

The idea behind the data envelopment analysis (DEA) is to use linear programming method to construct a surface, or frontier around the data. Efficiency is measured relative to this frontier, where all deviations from the frontier are assumed to be inefficiency.

Table (4.9) indicates in the data sample mean of TE, AE, and EE are 10%, 83% and 83% for VRS DEA model and those are 58%, 74% and 45%for CRS DEA model. The Result of both models, especially with VRS assumption, shows that there are substantial inefficiencies in the broiler

production activities in sample area during the survey. This indicates that there is substantial scope to reduce production costs and hence obtain output gain through improving efficiency. The low TE indicates that, if the farmer operates at the optimal efficiency level, they can reduce, on average the production cost by 90%. This findings shows that the main problem of both VRS,CRS are their inability to use their input in a technical efficient way rather than to allocate inputs in the most cost minimizing way.

Table(4.9) shows the interval >0.20 is the most frequent interval of technical efficiency, indicating that the main problem of the broiler small scale producers farms under variable return to scale is the ability to use the resources in technically most efficient way.Whereas the most frequent interval of a llocative efficiency is 0.70-0.80, indicating that the main problem of broiler small scale producers farms is inability to allocate the inputs in the cost minimizing way, rather than inabilities in using the resource in the technically most efficient way under constant return to scale.

Generally the average DEA technical, allocative and economic efficiency, were eventually found 0.58, 0.74and 0.54 respectively. This result also was concluded that the main challenge that facings the broiler farms is to enhance their resource in most efficient way skills. Similar result by (Johansson, 2005).

Number of farms whose economic efficiency reached the highest level 0.90-.100 were 17 farms and represented 42% of the total farms at VRS.

Also, at the lowest level 3farms represented 7.5%. On average 83% which means the producers' can reduce their input costs or quantity by 17% on average to reach economic efficiency at the same level of inputs.

But on CRS a number of farm reached technical efficiency >0.50 21farms represented 52.5% of the sample size and those reached technical efficiency <0.70 10 farms represented 25% on average 58%, that means the

farmers can increase their output by 42% given the state of technology and input levels.

A number of farm reached allocative efficiency >0.70 13farms represented 32.5% and those reached <0.70 represented 67.5%, on average 74% of the total sample size that means farms can reduce production costs by 26% at the same level of production to reach highest level of allocative efficiency.

At constant return to scale also there are 8 farms their economic efficiency reached the highest level 0.70 - 1.00 they represent 20% of the sample size. Farmers reached the lowest economic efficiency>0.20 about 11 farms which represented 27% of the total farms.

The level of economic efficiency range between high level 20% and low level 80% represented the total sample size. with average of %45 which means the producers in research sample can reached the same level of production according to decreasing production cost or decrease the quantity of resources used at 55%.

In general the percentage of loss in resources production costs according to these farms, reached more than half of used resourced production which is due to high cost of production.

Table (4. 9): Technical, allocative, and economic efficiency indices for the DEA under variable and constant return to scale of small scale broiler farms producers' in Khartoum State, 2015

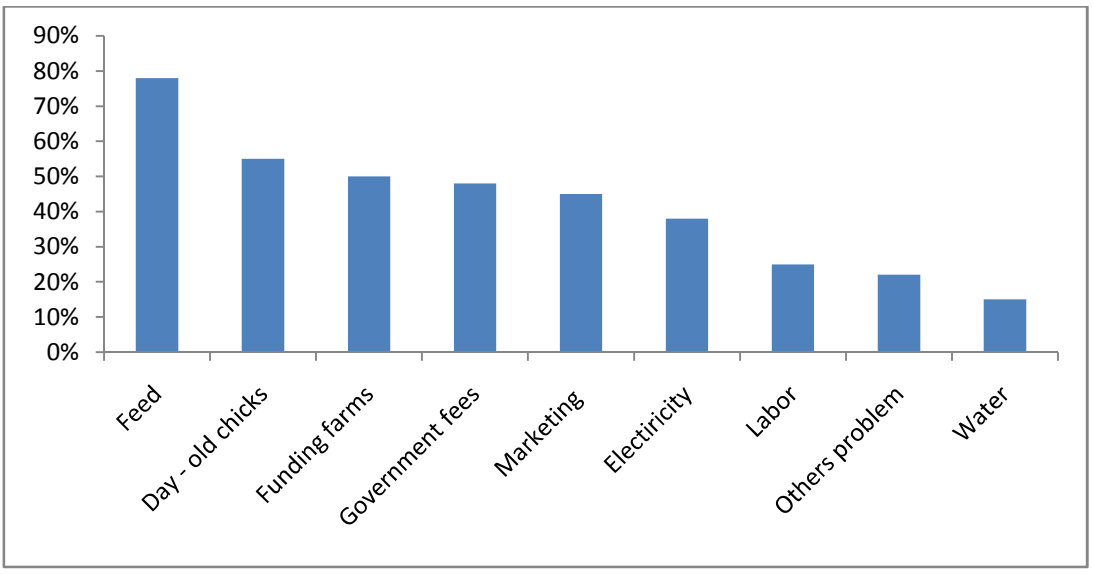
Interval	VRS			CRS		
	TE	AE	EE	TE	AE	EE
>0.20	40	3	3	9	1	11
0.20- 0.30	-	-	-	4	3	3
0.30-0.40	-	-	-	5	-	6
0.40-0.50	-	-	-	3	-	3

0.50-0.60	-	-	-	2	1	4
0.60-0.70	-	-	-	7	8	5
0.70-0.80	-	14	14	3	10	5
0.80-0.90	-	16	16	2	9	2
0.90-1.00	-	17	17	5	8	1
Total	40	40	40	40	40	40
Mean	0.10	0.83	0.83	0.58	0.74	0.45

Source: Survey, 2015

4.6 Challenges:

Figure (4.17) shows that the feed represent the highest percentage (78%) this due to modified feed ingredient costs, while Day – old chicks showed a percentage of (55%) similar results were obtained by (Elghouth *et al*., 2013). This result may be due to insufficient supply of day old chicks at the time of this study some poultry farms produce their own -day -old chicks, while others imported them from abroad, mainly from the Netherland. Also government fees percentage of (48%) that means government does not support poultry industry. Of farm fund showed percentage of (45%), which means the availability of credit source not an easy terms of repayments. Marketing had a percentage of (42%) this due to economies of scale, electricity showed about (38%) this due to the production area, and labor had a percentage of (22%) as stated by many producers labour represent small problem to them because some workers dishonest or they do not perform their tasks perfectly with high price and water is lowest challenge percentage (15%) this may be due to the stability of water in small scale farms. Other challenges showed (22%) such as land use for broiler projects, Biosecurity measures and Diseases.



Source: Survey, 2015

Figure (4. 16): Challenges facing small scale broiler farms producers' in Khartoum state, 2015

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

Finally, this chapter represents the conclusion of the major findings and recommendation, and suggestion for further research.

5.1Conclusions:

In the Sudan, poultry industry plays a major role in contributing towards addressing key national development goals and improving the standard of living of people through poverty alleviation and creating employment opportunities. For all these reasons, the study focus on the broiler small scale farms producers' Specifically, the study look at the socio-economic characteristics and production factors that affect the economic efficiency of farmers. To fulfill:

1. To describe the current situation of small scale broiler farms activities.
2. To estimate the economic efficiency of small scale broiler farms.
3. To identify the constrains of economic efficiency.
4. To calculate small scale broiler farms return to scale.

   The study depended mainly on primary and secondary data to achieve their objectives, SPSS was used (statistical package for social sciences)**,** to analyze the data gathered on the socio-economic characteristics of the broiler small scale producers in the study area, used Data Envelopment Analysis to estimate economic efficiency(DEA).

The sampling method used for this research is multistage sampling technique. The first stage, involved a purposive based on population of the broiler small scale producers, availability size of the small scale. The second stage involved purposive sample of 40 broiler producers in Khartoum state.

The research included five chapters, chapter one Introduction, chapter two Literature review and previous study, chapter three Research methodology, chapter four Result and discussion, chapter five Summary, conclusion and recommendations.

This study revealed the following conclusions:

- Feed cost and day – old chicks the main challenges for broiler small scale farm producers' due to high costs represented 78%,55% respectively of the total challenges.
- 90% of the producers' were males.
- On the average family size of the broiler small scale farms producers in Khartoum State five members.
- Younger people are interesting in poultry industry.
- 46% 0f the broiler small scale farms producers in Khartoum State have an academic and specialization in other field than animal production.
- Broiler production in Khartoum State was practiced as secondary occupation by some governmental officials and a trader that means the broiler production in Khartoum State practiced together with other activities.
- 83% of the farms had farm technician.
- From the sample 85% was self finance, and 93% of the broiler small scale farms producers' have no agricultural insurance.
- In the survey the mean of the mortality rate8%.
- The maximum likelihood(ML) estimates of the stochastic frontier trans log production parameters for the broiler small scale farms producers, The Sigma – squared (σ^2 = .41) and the gamma(γ = .90) are quite high and highly statistically significant at 1% level . The high and significant value of sigma - square (σ^2) indicates the goodness of fit correctness of the specified assumption of the composite error terms distribution. The

gamma (γ= .90) shows that 90% of the total variation in broiler output is due to the technical inefficiency.

- The coefficient of the total costs is negative correlated with highly significant at the production the 1% level of significance. This indicates that the negative relationship between total costs and production, this implies that one percent increase in total costs broiler production decreases by 0.17%.
- Education level of farmers has a negative sign and it was highly significant at 1% level of significance. The impact of technical inefficiency, indicating that the higher the education level of farmers will reduce the level of technical inefficiency reached by farmers. This is because education helps in the adoption and use of improved technological innovations. This result also shows that farmers spent many years in education to be more efficient in broiler production.
- On CRS a number of farms reached technical efficiency >0.50, 21farms represented 52.5% of the sample size and those reached technical efficiency <0.70, 10 farms represented 25% on average 58%, that means the farmers can increase their output by 42% given the state of technology and input levels.
- A number of farms reached allocative efficiency >0.70 13farms represented 32.5% and those reached <0.70 represented 67.5%, on average 74% of the total sample size that means producing farms can reduce production costs by 26% at the same level of production to reach highest level of allocative efficiency.
- At constant return to scale also there are 8 farms those economic efficiency reached the highest level 0.70 - 0.10 they represent 20% of the sample size. Farmers those reached the lowest economic efficiency>0.20 about 11 farms were represented 27% of the total farms.

- The level of economic efficiency range between high level 20% and low level 80% represented the total sample size. with average of %45 which means the producers in research sample can reached the same level of production according to decreasing production cost or decrease the quantity of resources used at 55%.
- Broiler production is in stage two of the production function and inputs allocation and utilization are efficient.

5.2 Recommendations:

1) Some productivity gains can be linked to improvements in technical efficiency which can still be realized in broiler small scale producer. Moreover, producers can still take advantage of scale economics can be linked to increasing return to increase output.
2) the producer's level of education can be manipulated within the framework of an agricultural policy in order to improve the technical efficiency of broiler small scale producer. Actually, all policy measures that build the capacities of farmers will lead to a substantial reduction of technical inefficiency.
3) Prerequisites for establishing a Broiler project before setting up a project, one should have; land, water, skills and experience in poultry management is essential for running the project and capital is a source of potential funding for acquiring inputs and equipment needed to run the project. Requirement and policies of financial institutions ought to be known prior to loan acquisition.
4) In management practices Broiler production is the raising or keeping of chickens (broilers) primarily for meat production. The key to success broiler production depends on a systematic and efficient management program that farmers have adopted. In addition, it is advisable to do proper planning and preparation well on time for the arrival of chicks on site.

5) As in the case of most empirical studies, the result obtained in this study should be considered as relative and not absolute in terms of magnitude. Moreover, the model used is limited in the sense that it does not consider other factors such as risks and market imperfections that can also influence the economic efficiency of farmers. Nevertheless, these limitations do not subtract from the validity of the study, since it has permitted us to not only estimates the economic efficiency indexes of broiler small scale producers in Khartoum state, in the first time, but also to identify the factors that affect their economical performance.

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APPENDICES

Appendix No1:

بسم الله الرحمن الرحيم

جامعة السودان للعلوم والتكنولوجيا

كلية الدراسات العليا

إستبانة عن قياس الكفاءة الإقتصادية وعائدات الحجم لمزارع الدجاج اللاحم الصغيرة الحجم بولاية الخرطوم

المحلية: **الخرطوم** ☐ جبل اولياء ☐ بحري ☐ شرق النيل ☐

ام درمان ☐ **أمبدة** ☐ **كرري** ☐

الاسم..... **التلفون**.....

أ- الخصائص الإجتماعية والإقتصادية :

1. **النوع:** ذكر ☐ **انثى** ☐
2. **العمر:أقل من** 30سنة ☐ 31-40سنة ☐ 41- 49سنة ☐ 50 سنة **فأكثر** ☐
3. المستوى التعليمى :**أمى** ☐ **خلوة** ☐ **أساس** ☐ **ثانوى** ☐

جامعى ☐ **فوق الجامعى** ☐

4. التخصص الأكاديمى : **زراعى** ☐ انتاج حيوانى ☐ بيطرى ☐ آخرى ☐
5. **كم عدد افراد الأسرة؟**.....
6. هل هنالك عدد من افراد الاسرة يعمل بالمزرعة؟.....
7. اذا كان هنالك افراد من الاسرة يعملون بالمزرعه كم عددهم؟.....
8. **نوع العمل: خاص** ☐ **حكومي** ☐
9. هل العمل بالمزرعة هو مصدر الدخل الرئيسى لك(الوظيفة الرئيسية لك)؟

.....

10. هل لديك مصادر دخل أخرى :

نعم	**لا**	العائد بالجنية

11. **اذا** لم يكن كذلك ما هو **مصدر** الدخل الرئيسي؟.....
12. **كم عددسنوات الخبرة؟**.....

ب- **وحدة الإنتاج:**

1. **نوع المزرعة** : مفتوح ☐ شبه مغلق ☐
2. نوع ملكية المزرعة: ملك ☐ ايجار ☐ شراكة ☐ **آخرى** ☐
3. **مصدر المعلومات:** الأرشاد البيطرى ☐ وسائل الإعلام ☐ آخرى ☐
4. هل يوجد بالمزرعة فنى متخصص: **نعم** ☐ **لا** ☐
5. عدد العنابر المنتجه (**الحظائر**):

....

6. كم تبلغ مساحة العنبر الواحد :

.....

7. عدد الكتاكيت المرباة (حجم المزرعة):

.....

8. ما هى الطاقة التصميمية للمزرعة(الدورة)؟

.....

9. كم تبلغ طاقتها الفعلية؟.....

10. أعلى فترة للإنتاج: شتاء ☐ صيف ☐ خريف ☐

جـ- تكلفة الإنتاج والتسويق:

1. تكاليف الإنتاج (دورة الإنتاج):

البند	العدد/ الكمية المستخدمة	التكلفة (جنية سودانى)
الصوص		
العليقة		
العمالة		
الأدوية والفاكسينات		
المضافات الى العليقة		
الكهرباء		
المياه		
الفرشة		
الترحيل		
الإيجار		
الذبيح		
رسوم المحلية		
النفايات		
الأكالات		
الشرابات		
الثلاجات		
الحظائر		
تكلفة التمويل		
تكلفة الرعاية البيطرية		
الظافة		
تكلفة مكافحة الآفات		
آخرى		

2. هل يتم استخدام العمالة المؤقتة؟.....
3. اذا كانت تستخدم لأي الأغراض؟.....
4. فترة الإنتاج (عدد الدورات).....

5. **حجم الإنتاج** (كيلو أو طن).....
6. وزن الذبيح : **أقل من1 كجم** ☐ 1- 1.25**كجم** ☐ 1.5-2 **كجم** ☐ **أكثر من 2كجم** ☐
7. سعر بيع الكيلوجرام المذبوح (**عند باب المزرعة**).....
8. آلية البيع: جملة ☐ تجزئة ☐ للمستهلك مباشرة ☐ آخرى ☐
9. **كم تبلغ نسبة الفوق؟**.....
10. هل تقوم بعملية التسويق:

نعم	**لا**	**التكلفة بالجنيه**

11. وسائل التسويق : ذاتية ☐ إيجار ☐ مشاركة ☐ **أخرى** ☐
12. نوع التمويل: **ذاتي** ☐ **بنكي** ☐ **أخرى** ☐
13. هل المزرعة مؤمنة تأمين **زراعي؟**.....
14. معوقات إنتاج مزارع الدجاج اللاحم التقليدية:

البند	**نعم**	**لا**
الصوص		
ارتفاع تكلفة العليقة		
الكهرباء		
المياه		
الرسوم الحكومية		
التمويل		
ارتفاع سعر العمالة		
التسويق		
آخرى		

Appendix No 2:

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal

data file = d:f5.txt

Tech. Eff. Effects Frontier (see B&C 1993)

The model is a production function

The dependent variable is logged

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.57453106E+01	0.62466223E+00	0.91974676E+01
beta 1	-0.17790603E+00	0.52131511E-01	-0.34126391E+01
beta 2	0.18366209E+00	0.95027833E-01	0.19327190E+01
beta 3	0.71254064E+00	0.98406236E-01	0.72408078E+01
beta 4	-0.11919048E+00	0.83329087E-01	-0.14303587E+01
delta 0	0.10731361E+02	0.41768365E+01	0.25692557E+01
delta 1	-0.14962479E-01	0.62259933E+00	-0.24032277E-01
delta 2	-0.78052020E+01	0.16902852E+01	-0.46176835E+01
delta 3	-0.94858097E+00	0.57653672E+00	-0.16453088E+01
delta 4	0.50389473E+00	0.82499323E+00	0.61078650E+00
delta 5	0.51600501E+00	0.35803546E+00	0.14412120E+01
delta 6	-0.66439144E+00	0.83780200E+00	-0.79301726E+00
delta 7	-0.42052856E-01	0.54843209E+00	-0.76678328E-01
sigma-squared	0.41606471E+00	0.70666209E-01	0.58877462E+01
gamma	0.90202685E+00	0.43620246E-01	0.20679087E+02

log likelihood function = -0.43738854E+01

LR test of the one-sided error = 0.32424741E+02

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.91207022E+00
2	1	0.88352597E+00
3	1	0.86739170E+00
4	1	0.85848972E+00
5	1	0.91142841E+00
6	1	0.76062874E+00
7	1	0.82315330E+00
8	1	0.82175089E+00
9	1	0.91912563E+00
10	1	0.93747352E+00
11	1	0.87672420E+00
12	1	0.82958255E+00
13	1	0.88397787E+00
14	1	0.94174800E+00
15	1	0.92979034E+00
16	1	0.91938270E+00
17	1	0.90434411E+00
18	1	0.33352663E+00
19	1	0.92613676E+00
20	1	0.86556080E+00
21	1	0.86328891E+00
22	1	0.93961559E+00
23	1	0.62111314E+00
24	1	0.91645335E+00

25 1 0.84762278E+00

26 1 0.86050248E+00

27 1 0.88557004E+00

28 1 0.83027611E+00

29 1 0.90134927E+00

30 1 0.95326777E+00

31 1 0.88376083E+00

32 1 0.80613598E+00

33 1 0.93281206E+00

34 1 0.93790863E+00

35 1 0.86412193E+00

36 1 0.87663887E+00

37 1 0.68303779E-01

38 1 0.90818668E+00

39 1 0.64059644E+00

40 1 0.79200821E+00

mean efficiency = 0.83588362E+00

Appendix No 3:

Results from DEAP Version 2.1

Instruction file = D:Z1-ins.txt

Data file = d:sabah2.txt

Cost efficiency DEA

Scale assumption: VRS

EFFICIENCY SUMMARY:

firm te ae ce

1 1.000 0.711 0.711

2 1.000 0.806 0.806

3	1.000	0.784	0.784
4	1.000	0.786	0.786
5	1.000	0.704	0.704
6	1.000	0.724	0.724
7	1.000	0.860	0.860
8	1.000	0.789	0.789
9	1.000	0.864	0.864
10	1.000	0.777	0.777
11	1.000	0.729	0.729
12	1.000	0.948	0.948
13	1.000	0.902	0.902
14	1.000	0.754	0.754
15	1.000	0.791	0.791
16	1.000	0.837	0.837
17	1.000	0.754	0.754
18	1.000	0.829	0.829
19	1.000	0.803	0.803
20	1.000	0.800	0.800
21	1.000	0.798	0.798
22	1.000	0.931	0.931
23	1.000	1.000	1.000
24	1.000	0.788	0.788
25	1.000	0.878	0.878
26	1.000	0.896	0.896
27	1.000	0.925	0.925
28	1.000	0.914	0.914
29	1.000	0.833	0.833

30 1.000 0.950 0.950

31 1.000 0.780 0.780

32 1.000 0.856 0.856

33 1.000 0.807 0.807

34 1.000 0.815 0.815

35 1.000 0.871 0.871

36 1.000 0.831 0.831

37 1.000 0.904 0.904

38 1.000 0.828 0.828

39 1.000 1.000 1.000

40 1.000 1.000 1.000

mean 1.000 0.839 0.839

Note: te = technical efficiency

ae = allocative efficiency = ce/te

ce = cost efficiency

Appendix No 4

Results from DEAP Version 2.1

Instruction file = D:Z1-ins.txt

Data file = d:sabah2.txt

Cost efficiency DEA

Scale assumption: CRS

EFFICIENCY SUMMARY:

firm te ae ce

1 0.032 0.566 0.018

2 0.057 0.724 0.041

3 0.086 0.720 0.062

4 0.129 0.623 0.081

5 0.357 0.253 0.090

6 0.429 0.260 0.111

7 0.200 0.771 0.154

8 0.261 0.619 0.162

9 0.257 0.776 0.199

10 0.286 0.697 0.199

11 0.302 0.697 0.210

12 0.373 0.784 0.292

13 0.325 0.926 0.301

14 1.000 0.271 0.271

15 0.375 0.812 0.304

16 0.400 0.858 0.343

17 0.425 0.774 0.329

18 0.514 0.744 0.382

19 0.632 0.619 0.391

20 0.660 0.622 0.410

21 0.689 0.624 0.430

22 0.567 0.927 0.526

23 0.605 0.977 0.590

24 0.600 0.828 0.497

25 0.625 0.901 0.563

26 0.661 0.903 0.597

27 0.767 0.836 0.641

28 0.719 0.914 0.657

29 0.725 0.854 0.619

30 0.877 0.834 0.731

31 1.000 0.620 0.620

32 0.914 0.768 0.702

33 0.943 0.735 0.693

34 0.850 0.836 0.710

35 1.000 0.782 0.782

36 0.957 0.801 0.767

37 0.953 0.901 0.858

38 0.986 0.818 0.807

39 1.000 1.000 1.000

40 1.000 0.952 0.952

mean 0.588 0.748 0.452

Note: te = technical efficiency

ae = allocative efficiency = ce/te

ce = cost efficiency