UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

PARTICIPATION IN CONTRACT FARMING AND ECONOMIC EFFICIENCY OF SOYBEAN PRODUCTION IN THE NORTHERN REGION OF GHANA

YAHAYA ABDULAI

2023

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BY

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(UDS/DEC/0004/2016)

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURE AND FOOD ECONOMICS, FACULTY OF AGRICULTURE, FOOD AND CONSUMER SCIENCES, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY DEGREE (PhD) IN AGRICULTURAL ECONOMICS

MARCH, 2023

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has previously been submitted for another degree at this University or elsewhere.

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We, hereby declare that the thesis preparation and presentation were supervised in accordance with the University for Development Studies' thesis supervision guidelines.

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ABSTRACT

Contract farming (CF) is emerging as a critical intervention to improve the livelihoods of Ghanaian small-scale soybean farmers. Farmers can achieve this if they become more efficient. Government and non-governmental organizations, including the Savanna Farmers Marketing Company (SFMC), the Northern Development Authority (NDA), and Adventist Development and Relief Agency (ADRA), have begun contracting farmers to cultivate soybeans in Ghana's northern region. Farmers are provided with inputs such as improved seeds, tractor services, credit facilities, and extension services as part of the terms of these contracts. Despite these provisions, there is serious concern about farmers' inability to produce efficiently. The primary goal of the study was to investigate the effects of CF on the economic Efficiency (EE) of soybean production in Ghana's Northern Region, as well as the factors that may be influencing famers' economic inefficiency. Using multi-stage sampling techniques, primary data were collected from 374 smallholder soybean farmers in three (3) districts of the Northern Region, composed of 200 contract farmers and 174 non-contract farmers. The stochastic frontier model was specified, along with technical, allocative, and EE models, and used to determine the effects of CF participation and soybean farmer efficiency. According to the findings, gender, education, off-farm business, FBO membership, farm size, access to agricultural extension service, and distance from farm to market centre all had a positive impact on CF participation. However, participation was negatively affected by experience in soybean production and production credit. The estimated average technical, allocative, and economic efficiencies scores among the contract farmers were 92%, 87%, and 94% respectively. For non-contract farmers, the estimated average technical, allocative, and economic efficiencies scores were 97%, 73% and 87% respectively. This implies that, for contract farmers 8% of production is lost due to technical inefficiency as compared to only 3% for their non-contract counterparts. the mean allocative efficiencies estimate mean that the average farmer's cost-saving potential in relation to the most efficient farmer stands at about 13.1% for contract farmers and 26.5% for non-contract farmers. Also the mean economic efficiencies of contract and non-contract farmers indicates that farmers on average were operating about 6% and 13% respectively below their optimum frontier output which maximizes profit from the best cost minimizing input combination. The findings also revealed that male farmers outperformed their female counterparts in terms of EE. Crop diversification, farm-to-home-market distance, and Farmers' Based Organization (FBO) membership all had a negative impact on economic inefficiency. Equipment and infrastructure for soybean production were found to be the most pressing problems, as most farmers found it difficult to access tractor services to plough their land during land preparation. In conclusion, CF can be a good intervention to address farmers' production and marketing needs especially for a cash crop like soybean. However, the results show that the sector is not regulated; currently there is no government institutional and legal framework stipulating general terms and conditions of CF. The absence of such a document to guide the operations of contracting institutions and farmers poses a threat to both contractors and potential beneficiaries. The study recommends among others that, soybean farmers should be taught more efficient farming methods to help increase their efficiency through a collaborative effort of the MoFA, and NGOs. Also, to reduce farmer inefficiency, MoFA, contracting firms, NGOs, and other agricultural stakeholders should build the capacity of soybean farmers through trainings and workshops. Furthermore, inputs, especially tractor services, should be delivered on timely basis by contracting firms to farmers to plough their lands. This will address the situation where there is a shortage of rain for the crop because of delay in cultivation.

ACKNOWLEDGEMENTS

I am very grateful to the Almighty Allah for guarding and guiding me throughout this PhD project. I wish to express my sincerest gratitude to my supervisors, Prof. Seidu Al-hassan and Prof. Samuel A. Donkoh whose invaluable comments, suggestions, encouragement, and constructive criticisms have resulted in the successful completion of this work.

Prof. Seidu Al-hassan, may Allah graciously bless you for your great advice and mentorship which gave me the hope of reaching this milestone of my academic career. I say a big thank you also to Prof. Samuel A. Donkoh for encouraging me to strive for the very best. I also thank Mr. Abraham Zakaria for his immense support and input in editing and analyzing the data for this work.

My appreciation will be incomplete without referring to the invaluable inputs from the faculty members. Your suggestions were very useful during the presentation of this thesis. I particularly appreciate Dr. Azumah S. Baanni. Your contributions for the achievement of this milestone are immeasurable.

Finally, I wish to thank my family, especially my mum, Nafisah Nasam, my brothers; Alhaji Alhassan Abdulai, Iddrisu Abdulai, Zakaria Abdulai and all others whose encouragements, prayers and support have brought me this far. I also extend my heartfelt appreciation to my wife, Adamu osman and children; Suhuyini Asrar Yahaya, Aayan Wun'pini Yahaya and Israh Wun'nam Yahaya I appreciate your enormous support in times of difficulties.

DEDICATION

I thank the almighty Allah for having brought me this far in life. This piece of work is dedicated to my dear mother Nafisah Nasam, my lovely wife Adamu Osman and our children Asrar Suhuyini Yahaya, Aayan Wun'pini Yahaya and Israh Wun'nam Yahaya.

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ADRA	Adventist Development and Relief Agency
AE	Allocative Efficiency
AGRA	Alliance for a Green Revolution in Africa
ATE	Average Treatment Effect
AVCMP	Agricultural Value Chain Mentorship Project
CARD	Center for Agricultural and Rural Development
CDC	Common Wealth Development Corporation
CF	Contract Farming
CRI	Crop Research Institute
CSIR	Council for Scientific and Industrial Research
DESA	Department of Economic and Social Affairs of the United Nations
EDIF	Export Development and Investment Fund
EE	Economic Efficiency
ERP	Economic Recovery Programme
ETERM	Endogenous Treatment Effect Regression Model
FAO	Food and Agriculture Organisation
FASDEP	Food and Agriculture Sector Development Policy
FELDA	Federal Land Development Agency
FBO	Farmer Based Organisation
FFF	The Flexible Functional Forms
FGD	Focus Group Discussion
GDP	Gross Domestic Product

GM	Genetically Modified
GoG	Government of Ghana
GSS	Ghana Statistical Service
Ha	Hectare
IFC	International Finance Corporation
IFDC	International Fertilizer Development Centre
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPM	Integrated Pest Management
ISFM	Integrated Soil Fertility Management
ISSER	Institute of Statistical, Social and Economic Research
METASIP	Medium Term Agricultural Sector Investment Plan
MoFA	Ministry of Food and Agriculture
MT	Metric Tonne
NCF	Non-Contract Farmers
NDA	Northern Development Authority
NGO	Non-Governmental Organisation
PPF	Production Possibility Frontier
PPPC	Programme for the Promotion of Perennial Crops
RSSP	Rice Sector Support Project
RTIMP	Root and Tuber Improvement and Marketing Programme
SAP	Structural Adjustment Programme

SARI	Savannah Agricultural Research Institute
SCF	Soybean Contract Farming
SFA	Stochastic Frontier Analysis
SFMC	Savanna Farmers Marketing Company
SPF	Stochastic Production Frontier
SRID	Statistics, Research and Information Directorate
SSA	Sub-Sahara Africa
TE	Technical Efficiency
TGR	Technology Gap Ratio
UN	United Nations
USAID	United States Agency for International Development
USDA	United States Development of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 Background

For many years, agriculture has been regarded as a vital industry for developing economies in their efforts to achieve the much-needed worldwide goal of poverty reduction in a more sustainable manner (MoFA, 2017). In developing countries, it employs 48% of the workforce and largely contributes to Gross Domestic Product (GDP) (Blein et al., 2013). It continues to have a substantial impact on the country's economic transformation, even though the sector's contribution to overall GDP has been diminishing over time as a result of the development of the country's oil and gas industries. Ghana's overall GDP increased by 18.9% in 2017, according to Institute of Statistical, Social and Economic Research (ISSER). Furthermore, the industry contributed to the economy's foreign exchange revenues by 29% (ISSER, 2017).

Low-income countries' agricultural sectors, particularly Ghana's, are characterized by low productivity and inefficiency. Contrary to other sectors of the economy, agriculture in underdeveloped countries is the least productive and inefficient (Mpeta et al., 2015). Low agricultural productivity is due to a variety of factors in less developed countries. Poor access to other productivity-improving farm inputs; and/or an unwillingness to invest in productivity-improving measures because of production risk, output price volatility, and unreliable market access, combined with poor farmers' (rational) risk aversion, are a few possible causes (Key and Runsten, 1999). The Ghanaian government and non-governmental organizations have implemented several initiatives aimed at increasing agricultural output and efficiency. Several of these interventions include the Programme for the Promotion of Perennial Crops (PPPC), which is responsible for implementing the agricultural strategies outlined in the Food and Agricultural Sector Development Policy (FASDEP), the Root and Tuber Improvement and Marketing Programme (RTIMP), the Rice Sector Support Project (RSSP), the Export Development and Agricultural Investment Fund (EDAIF), the USAID Feed the Future project, the ACDEP, and the Center for Agricultural and Rural Development (CARD) amongst others. The purpose of these interventions is to alleviate farmers' agricultural production constraints.

Contract farming (CF) is also believed to help developing economies increase agricultural productivity by increasing access to knowledge, improved technologies (e.g., highly productive varieties), productivity-enhancing inputs, and credit, as well as by providing more predictable and reliable output prices and guaranteed market access (Key and Runsten, 1999). CF is a newly developed modern agricultural approach that connects backward and forward markets in sub-Saharan Africa's agriculture produce (Mwambi et al., 2016). It is recognized as a viable method for agricultural transformation in poor countries because of its capacity to deal with the constraints of agricultural commercialization (Little and Watts, 1994). According to Mishra et al. (2018), CF not only aids in agricultural sector transformation, but also acts as an institutional innovation by lowering transaction costs and addressing market shortages through farmer-to-market connectivity. According to Masakure and Henson (2005), CF can help farmers overcome market inefficiencies by connecting them to a greater range of domestic and worldwide markets through the organization of high-value agricultural crop production.

The concept is defined as a system in which a central processing or exporting unit purchases the harvest of an individual farmer, with the terms of the purchase established in advance via contract (Bauman, 2001). Farmers benefit from CF agreements because they have access to a variety of services that they would not have had otherwise. Thus, CF is an agricultural and horticultural production and supply system based on pre-contractual agreements between producers/suppliers and customers (Haque, 2000). In CF, the grower contributes land, labor, and tools, whereas the enterprise firm/purchasing unit contributes inputs, credit, and technical assistance (Kirsten and Sartorious, 2002).

CF is also defined by Sharma (2016) as a production and marketing arrangement for agricultural outputs in which both enterprise firms (agro-inputs dealers/exporting enterprises) and farmers have legal procedures in place to buy farm outputs of predetermined quality and quantity at a predetermined price in a predetermined time based on specific farm inputs and technology. Farmers get market access, credit, new technology approaches, and risk management in agricultural production as a result of CF (Slangen et al., 2008).

There is growing concern that marginal farmers will struggle to compete in the market economy as trade liberalization, globalization, and agribusiness expand. As economies of scale become more critical for profitable agricultural production, such farmers face increasing marginalization. Breach of contract by farmers in diverting inputs and other resources provided to them and instances of contractors exploiting the farmers tend to be some limiting factors in contracting farmers (Abdulai et al., 2016). In Ghana, contracting firms are often more interested in cash/industrial/commercial crops. Among these crops include cocoa and oil palm, as well as non-traditional agricultural crops such as cashew, pineapple, mangoes, and soybeans. Except for soybeans, most of these crops are farmed in the southern part of the country. Soybean is rapidly eclipsing groundnuts as Ghana's primary cash crop, particularly in the Northern region, and is thus the subject of this research (Abdulai et al., 2016).

Soybean (Glycine max) is an arable crop that has been described as a low-cost source of protein with edible vegetable oil and an optimal amino acid profile. Soybean seeds contain roughly 20% and between 34% and 36% protein. These factors contribute to the economic value of soybean seed. It contains a high protein content to help impoverished farmer families improve their nutritional status, as despite advances in global agriculture, most people, particularly in Africa, remain critically malnourished (Ajao et al., 2012). As has been clearly shown, adequate food and nutrition are necessary components of economic development and progress. A nation that is malnourished is a nation that is underproductive.

Frequently, poverty and malnutrition afflict the same vulnerable people. Malnutrition rates are occasionally used as a proxy for poverty. According to Haddad and Alderman (2000), increased incomes result in improved nutrition over time. The most important nutritional problem currently affecting poor families in Ghana appears to be a deficiency of protein in the diet. This is owing to the high cost of the majority of animal protein sources, with few people able to consume an adequate amount. Sharp price increases in animal goods have also made the average Ghanaian aware that grain legumes may be a more affordable source of protein. Glycine max (soybean) is a significant grain legume grown around the world, particularly in Ghana.

Plahar (2006) contends that soybeans are a nutritional powerhouse, containing more protein, minerals, vitamins, and fatty acids than other foods. The crop has 40% protein, which is extremely high (Greenberg and Hartung, 1998). But only around 2% of this protein is eaten by humans, with the rest being processed soybean meal fed to pigs and poultry (Goldsmith, 2008).

Protein derived from soybeans has a higher protein content than protein derived from animals or other crop plants. When compared to soybean, these traditional protein sources are similarly less effective. Protein derived from 45 cups of cow milk, two kilos of beef, and five dozen eggs is equivalent to protein derived from one kilogram of soybean, according to Dashiell (1993). As a result, soybean benefits farmers by providing a source of income generation activity as well as nutritional balance in the human diet (Haddad et al., 2000).

When soybeans are supplemented with any cereal, such as rice, maize, wheat, or sorghum, a well-balanced and standard protein level is achieved, which is needed for human growth and development (FAO, 2005). It provides human nourishment, livestock feed, bioenergy, and industrial raw materials, among other things (Myaka et al., 2005). Soybean produces a high-quality vegetable oil for human consumption, as well as being used to improve soil fertility, reduce soil erosion, and control the parasitic weed Striga hermonthica species, according to Dugje et al. (2009). Both the cake and the by-products of the haulms make excellent poultry and animal fodder. According to Seidu (2008) and Dugje et al. (2009), soybean cultivation fulfills three key reasons for crop production; production of food, raw materials, and exports. The soybean crop's relevance to human survival and progress may also be seen in the fact that for the past two and a half decades, it has dominated global oilseed output (Smith and Huyser, 1987).

Global soybean production has increased gradually over the years and at a faster rate than that of other major grains or oilseeds (Goldsmith, 2008). Global soybean output was predicted to be 312.97 million metric tons in 2016, and 336.62 million metric tons in 2017. This indicates that global soybean production increased by 23.65 million metric tons (7.56 percent) (USDA, 2017). In 2018, the United States of America produced roughly 35 to 40% of the world's soybeans, totaling approximately 123.66 million metric tons USDA (2018). According to the FAO (2018), around 52% of the world's countries produce soybeans. Despite the legume's numerous benefits, these countries cultivate it on less than 6% of the world's arable land.

Between 1961 and 2009, soybean consumption was predicted to rise from 24.7 kg per person to 32.8 kg per person (FAO, 2009). According to the USDA (2018), soybean production has increased from 107 million MT in 1990 to 347.2 million MT in 2018. About 82% of the 347.2 million MT of soybean production comes from Argentina, Brazil, the United States, and China. Given the impact of COVID-19 and the Russia-Ukraine war on the food supply chain, including the production of soybean, world demand for soybeans dwarfs global output when these two factors are taken into account (FAO, 2022). Global stakeholders are concerned that the sharp increase in soybean demand for food, feed, oil, and fuel must be balanced, necessitating the development of pragmatic and efficient soybean production technologies.

CF may be a viable technique for increasing soybean supply to meet global demand because it alleviates some production difficulties (Abdulai et al., 2016). Soybean production in Ghana is one of the highest in sub-Saharan Africa. The production of the crop in Ghana was approximately 225,345MT in 2017 (SRID, MoFA, 2018). The Northern Region accounted for 131,151MT of this total. A total of 58.2% of the country's soybeans come from this region. Over 62,206 MT of cooking oil, seasoning, and animal feed cake is expected to be consumed domestically in the year ahead (MoFA, 2018).

Soybean production has been boosted in Ghana for both domestic and commercial purposes. National Committee on Soybean Production and usage was created in the 1980s and '90s by the Ministry of Agriculture, Ministry of Health, CSIR, Farmer based organizations and Industries (Plahar, 2006). Improved soybean varieties like “Jenguma”, “Quarshie”, Salintuya I and Salintuya II which have non-shattering characteristics were among several interventions developed and disseminated to farmers to enhance soybean productivity (CSIR, SARI, 2018).

Moreover, the Adventist Development and Relief Agency (ADRA) Ghana helps increase soybean yields in Ghana. ADRA provides farm inputs to smallholder soybean farmers to maximize soybean yield. For example, Bosbell Processing Company in Tamale helped roughly 4,500 soybean farmers with tractor services and linkages with industry participants (Daaku and Asante-Mensah, 2006). It is somewhat remarkable that, despite all the efforts made to encourage soybean production in Ghana, productivity remains poor, particularly in the Northern Region, where the crop is grown the most. MoFA (2018) reported that total production of soybean in Ghana in 2017 was about 225,345 MT. Out of this, the Northern, Upper West and Upper East Regions contributed 75.0%, 22.7% and 2.3%, respectively to national production. Although total production increased in the 2017 farming season in the Northern Region (131,151 MT) averaging 2.2 MTs per ha, this is still far below the potential output of soybean 3.0 MTs per ha (MoFA, 2017).

Despite some development partners' and non-governmental organizations' efforts to make soybean production a priority, there is still a market gap due to insufficient soybean output and/or storage (Mohammed et al., 2016), which may worsen if efforts are not made to make the soybean sector's growth more sustainable. For instance, the actual output of the crop was 1.65 metric tons per hectare (on farm) while the potential output is 3 metric tons per hectare in 2016 (MoFA, 2017).

More effort is needed to increase farmers’ knowledge capacity via training to close the output gap. The low soybean productivity could be attributed to poor adoption of good agronomic practices and low access to technical advice as well as poor access to market (Abdulai et al., 2016). Farmers have low plant population per hectare, according to Abdulai and Al-hassan (2016), because of a lack of knowledge about precise row spacing procedures to achieve the best plant population for the various soybean types used. Also, poor access to farm inputs either in contact or in subsidy have negative effect on soybean productivity (Abdulai et al., 2016).

From a production systems perspective, the variability in soybean outputs becomes worse if analyzed among farmers within the study area. This is so because of differences in soil conditions, the use of different seed varieties, differences in management practices and levels of agro-chemical application on farms, among others (Pingali and Heisey, 2014). To achieve a sustained reduction in differences in productivity among farmers and gain agricultural growth, there ought to be an improvement in road infrastructure, adoption of modern technologies, farmers' managerial skills, knowledge, and education, among others (Pingali and Heisey, 2014).

Increasing the efficiency of soybeans farmers through minimizing cost of production is a strategic way to increase soybean productivity (Mohammed et al., 2012). It is, therefore, imperative to note that soybean production presents lots of opportunities to any nation (like Ghana) engaged in its production. However, it takes much more efforts to harness these huge potentials, including the reality of soybean farmers especially in Northern Region being technically and allocatively efficient in the utilization of farm inputs. Many countries are into large scale (macro level) and small scale (micro level) soybean processing and Ghana as a nation is not an exception. Both the large- and small-scale processing contributes in transforming the agricultural industry (Mohammed et al., 2012). Soy processing is broken into oil extraction and animal feed on a big scale, with soy flour and high protein foods accounting for 55%, high protein foods accounting for 15%, soymilk and soy curd accounting for 5% (Plahar, 2006). At this level, soybean processing involves use of sophisticated machinery and technologies. This helps create more employment for the teeming youth as well as contribute to the GDP of the country.

Soybean processing on a small scale (household level) entails the use of simple and indigenous house level machines/tools. Soybean can be processed at home into a variety of products such as spice, soy dough, soy flour, soymilk, and soy meat

1.2 Problem Statement

It is impossible to underestimate the importance and relevance of soybean to Ghana's economy, and its potential for greater income and nutritional value is evident. As a result, certain stakeholders, including the CSIR and the Ministry of Foreign Affairs have joined forces to promote the crop's cultivation (Mbanya, 2011). Soybean production in Ghana has become both economically and nutritionally prudent, soybean also has therapeutic benefits, and it is very good for preventing and/or treating cardiovascular disease (Sanful and Darko 2010).

In 2012, the SRID of the Ministry of Food and Agriculture reported that the Northern Region accounted for the vast majority (77 percent) of Ghana's soybean production. The upshot is that most soybean-related interventions, such as the Agricultural Value

Chain Mentorship Project (AVCMP), which is funded by DANIDA through AGRA, are concentrated in the region.

Ghana's CSIR has been providing soybean technologies to farmers in Northern Ghana through the AVCMP and other development programs. The use of certified seed, dibbling, integrated soil fertility management (ISFM), integrated pest management (IPM), timely execution of agricultural activities, and soybean-rice rotation are just a few of the technologies that can help improve soil fertility. With these efforts, the average soybean yield of 1.97 Mt/Ha was significantly lower than the 3 Mt/Ha that could have been achieved, according to the MoFA (2021).

Closing the output gap allows for long-term production growth, which can be accomplished through improved technical and allocative efficiency. Farmers may produce more while using fewer resources and at a lower cost because of improvements in technical and allocative efficiencies in soybean production. Farmers' poverty can be alleviated by redistributing these limited resources to other productive areas of the economy.

According to studies, participation in CF increases farmers' production, efficiency, and income (Key and Runsten, 1999, and Warning and Key, 2002). Additionally, there has been evidence of farmers gaining minimally from contract farming (Key and Runsten, 1999 and Simmons et al., 2005). CF is being studied as a strategy for increasing the efficiency of production and marketing access for small farming firms.

Agricultural efficiency studies have been conducted in several developing countries (Squires and Tabor, 1991; Rios and Shively, 2005; Shafiq and Rehman, 2000; Fletschner and Zepeda, 2002). The impact of CF on smallholder welfare has been extensively examined in the literature (Miyata et al., 2009 and Prowse, 2012). However, to the best of the researcher's knowledge, little research has been conducted on the effects of CF on farmer efficiency. Additionally, a large portion of the existing study on soybean efficiency (Mohammed et al., 2016; Etwire et al., 2013; Sharma et al., 2016; and Ugbabe et al., 2017) has focused exclusively on TE. The allocation of farmers' resources in response to price incentives is a critical determinant of agricultural success. As a result, both TE and AE are crucial for maximizing current technology's productivity benefits.

The Low productivity of soybean in Ghana could also be attributed to constraints farmers face, including environmental factors, technological constraints and poor management practices. Environmental factors responsible for low yields in soybean productivity include the steady decline in rainfall which led to critical drought condition; and acidity and salinity leading to low productivity. Harvesting techniques of the crop, depletion of soil fertility, along with poor management of weeds, pest and diseases, is a major biophysical cause for the low per capita soybean production in the Ghana. Lack of infrastructure and appropriate equipment for cultivating the crop has also being identified as a major constraint (Sulayman et al., 2014). The identified constraints are likely to affect farmer's production levels and their overall efficiency in soybean cultivation.

Several studies in developing countries studied the productivity and efficiency of contract and non-contract farmers (Bravo-Ureta and Pinheiro, 1997; Begum et al., 2012). There have been few studies on CF in Ghana, one of which was undertaken by

Kudadjie-Freeman et al. (2008), who researched sorghum CF in North-East Ghana to determine how to make such arrangements lucrative for smallholder farmers. Their research discovered that contracting scheme flaws and challenges were technical in nature as well as institutional in nature. Another study by (Bidzakin et al., 2020) looked at CF and rice production efficiency in Ghana. The study discovered that, CF improves rice farmers' technical, allocative and economic efficiencies by 21, 23 and 26%, respectively. This study adopted the framework by Greene (2010) to consider sample selection in a stochastic frontier framework to compare the technical, allocative economic efficiencies of small-scale contract and non-contract soybean producers in the Northern Region of Ghana

The challenge of poor yields in the soybean sector is likely to persist if better understanding of the factors that account for farmers' level of (in)efficiency are not explored through empirical research. Consequently, this study has been undertaken to evaluate economic efficiency of contract and non-contract soybean producers and investigate the sources of (in)efficiency in soybean production as one way of determining factors responsible for low productivity in soybean production and provide appropriate policies to address these numerous constraints.

1.2 Research Questions

In this study, the following research questions will be addressed:

a. What factors influence farmers' participation in contract farming?

b. What are the levels of technical, allocative and economic efficiencies of contractual and non-contractual soybean producers and which category of farmers are more efficient?

c. What are the factors influencing the efficiency levels of soybean producers?

d. What challenges do soybean farmers face in the Northern Region?

1.3 Objectives of the study

The main objective of the study was to examine contract farming participation and economic efficiency of soybean farmers in the Northern Region of Ghana.

The study will focus on the following specific objectives:

a. Analyze the factors influencing farmers' participation in CF.

b. Analyze the technical, allocative, and economic efficiency levels as well as compare the efficiencies of contractual and non-contractual soybean producers in Ghana's Northern Region.

c. Examine the most important drivers of efficiency among soybean farmers in Ghana's Northern Region.

d. Assess the major challenges faced by soybean producers in the Northern Region of Ghana.

1.4 Hypotheses

The following hypotheses were tested:

a. **H_0:** Output of soybean is not influenced by; fertilizer, land size, labour, technical service and the kind of seeds used in sowing.

   H_1: Output of soybean is influenced by; fertilizer, land size, labour, technical service and the kind of seeds used in sowing.

b. **H_0:** Soybean farmers are technically and allocatively inefficient.

   H_1: Soybean farmers are technically and allocatively efficient.

c. **H_0:** Contractual soybean producers are less efficient than their non-contractual counterparts.

   H_1: Contractual soybean producers are more efficient than their non-contractual counterparts.

d. **H_0:** Farmers' socio-economic status has no influence on EE.

   H_1: Farmers' socio-economic status influences EE.

1.5 Justification and Contribution of the Study

Soybean has become a major cash crop of many Ghanaians, especially regions in the Northern part of Ghana thereby, attracting the attention of many actors in the agrifood sector (MoFA, 2018). The production of soybean is however challenged by many factors including ineffiencies within and outside the control of farmers.

It was the goal of this study to help find ways to boost soybean production's efficiency and overall output. Many researchers have done efficiency studies in agriculture including; (Mohammed et al., 2016; Etwire et al., 2013; Sharma et al., 2011; Ugbabe et al., 2017; Abdulai et al., 2017; Donkoh et al.,2011; Masuku et al., 2014; Osman et al., 2018; Degefa et al., 2017; Bidzakin et al., 2020 among others). However, many of these studies above did not address unobserved biases in estimating EE based on Greene’s (2010) framework or addressing sample selection in SFA.

The study also highlights and compares the efficiencies (TE, AE and EE) of contract and non-contract soybean farmers in the Northern Region of Ghana. Most efficiency studies have concentrated on TE. This study went further to consider AE and EE thereby providing more literature in the area.

The study will help researchers, soybean farmers, and government policymakers, while also adding to the body of production economics knowledge and offering policy recommendations for resolving the country's soybean production difficulties.

Soybean producers can make better use of their inputs by identifying inefficiencies in soybean production, which reduces the already limited resources of the country. To get the most from their crops, farmers must make the most efficient use of available resources. If resources are allocated and managed efficiently, soybean farmers may increase productivity while using the same input quantities, which will have a substantial impact on overall national development and food security. Additionally, we will be able to see if soybean farmers who are contracted are more efficient than their non-contract counterparts. Policymakers can use the study's findings to establish policies that focus on interventions based on the acknowledged needs and limits of soybean producers. Studies on production economics and, in particular, efficiency, will benefit from this research's conclusions.

1.6 Limitations of the study

Methodologically, the study has contributed to the academic discourse on efficiency and agricultural technology adoption in a number ways; For instance, Mohammed et al., 2016; Abdulai et al., 2017; Donkoh et al., 2011; Osman et al., 2018;; Bidzakin et al., 2020; Donkoh, Ayambila, and Abdulai (2013), Anang et al. (2016), and Abdulai, Zakaria and Donkoh (2018) have found some level of inefficiency among farmers in northern Ghana. The studies of the above-mentioned authors could not also address unobserved biases in estimating efficiency based on Greene's (2010) framework or addressing sample selection in SFA. This can view as an improvement over those previous studies. Nevertheless, there are a number of limitations associated with the study which need to be pointed out.

To begin with the study employed data from only three administrative areas of the Northern Region and hence the results may not generalize for the whole region. A comprehensive study covering the whole region would have been more appropriate and ideal. However, this could not be achieved due to limited resources.

Another limitation that needs to be acknowledged is the self-reported nature of data used for the analysis. It must be stressed that, much of the dataset employed for the analysis were based on self-reported information regarding farm size, yield and other farm level variables from farmers without ways to verify some of that information.

Much as information collected using this procedure remains an important source of data for empirical studies, there are calls for a change towards other methods such as the deployment of GPS for capturing some farm level variables and other means to verify information from farmers. Also, the study failed to estimate the levels of technical, allocative and economic efficiencies using the separate samples i.e the conventional and sample selection in order to be able to compare them.

Furthermore, the use of the two-stage modeling approach for parametric analyses of efficiency instead of the one-staged was a bit problematic. As a result of the limitations, the study recommends for further in the next section.

1.7 Future Research:

Contract Farming in the study area is a business model along the soybean value chain (production, processing, packaging and marketing). The study did not focus on the whole chain. This study was only focused on the farmer and not the contracting firms; A future research can take into account the other actors in the contract.

Additionally, a future study should estimate the technical, allocative and economic efficiencies using the separate samples i.e. the conventional and sample selection in order to be able to compare them. Also, a future study should use the one-staged approach to estimate the efficiencies.

Finally, the levels of efficiency indicated that, non-contract farmers were slightly technically efficient than contract farmers, however, further analysis using the endogenous treat effects model showed that the ATE values were in favour of contract farmers technically. This calls for further investigation in future.

1.8 The Study's Organization

The dissertation is divided into eight chapters. The first chapter contains a background statement, a problem statement, objectives, hypotheses, and justification. The second chapter conducts a review of the literature on soybean production and CF. Chapter three discusses the research methodologies and materials employed in the study. It discusses the study area's choice and location, the sampling strategy and analytical techniques, the theoretical framework and empirical model in detail. Chapter four presents and discusses the descriptive and empirical findings in detail. Chapter five discusses the socioeconomic characteristics of soybean producers and the factors that influence CF participation. Chapter six discusses the factors that influence technical, allocative and EE and compares the efficiency of contract and non-contract producers. Chapter seven discusses the challenges that soybean producers encounter in their operations. The eighth chapter summarizes the findings and makes policy recommendations

1.9 Research Scope

This study focused exclusively on soybean farmers in Ghana's northern region (both contract and non-contract). Contract farmers are those who work for the SFMC, NDA, or ADRA. The study relies on prior research on CF conducted in the Northern Region (Abdulai et al., 2016), which examined the impact of CF on soybean farmers' productivity and revenue but was unable to determine whether farmers used inputs to to their maximum.

CHAPTER TWO

SOYBEAN PRODUCTION IN GHANA: AN OVERVIEW

2.1 Introduction

The literature on soybean production is reviewed in this chapter. The significance of soybean production, and production patterns, as well as soybean marketing and processing in Ghana is discussed in this chapter.

2.2 Soybean Origin and Distribution

Soybean originated in Eastern Asia, notably China, Korea, and Japan (Ngeze, 1993). During the eighteenth century, the crop spread throughout Europe, America, and other parts of the world. According to Chinese history, the crop has been used as a food and medicine ingredient in China for over 5,000 years (Norman et al., 1995). It is mostly grown commercially in temperate and tropical regions like as China, Thailand, Indonesia, Brazil, the United States, and Japan, where it has developed into a significant agricultural crop and export commodity (Evans, 1996). In the early nineteenth century, South Africa was the first to introduce the crop to Africa (Ngeze, 1993).

The crop has now established a foothold throughout the continent. According to Shurtleff and Aoyagi (2007), the crop may have been introduced earlier in East Africa as a result of the region's long history of trading with China; these authors assert that Tanzania began soybean cultivation in 1907. In 1909, Portuguese missionaries brought the crop to Ghana. According to Mercer-Quarshie and Nsowah, 1975, the crop did not thrive in Ghana In the early 1970s, efforts were made to establish the crop's cultivation in Ghana; MoFA and IITA worked on this breeding project (Tweneboah, 2000).

2.3 Characteristics and Economic Importance of Soybean

Soybean (Glycine max (L.) Merrill) is a major global legume crop that grows in tropical, subtropical, and temperate zones. Hemp is a member of the Leguminosae family, subfamily Papilionideae, which contains peas and lentils. It has 40 chromosomes (2n = 2x = 40) and less than 1% outcrossing (IITA, 2009; Shurtleff and Aoyagi, 2007). Soybean is an annual herbaceous plant that grows 30–183 cm tall depending on the genotype (Ngeze, 1993). Some genotypes grow prostrately to 20cm, while others grow to 2m.

Soybeans come in two kinds: determinate and indeterminate, with six varieties allowed in Ghana (Ngeze, 1993; CSIR and MoFA, 2005). Indeterminate genotypes grow taller, generate more leaves, and produce more pods than determinate genotypes. The blooms are small, inconspicuous, self-fertile, and carried in the leaf axils (Ngeze, 1993). The stem, leaves, and pods are all covered in fine brown or gray hairs. Each trifoliate leaf has three to four leaflets. The fruit is a hairy pod with two to four seeds that forms in clusters of three to five. Each cluster is five to eight centimeters long and contains two to four seeds (Rienke and Joke, 2005). Soybean seeds are available in a variety of colors and sizes.

Gary and Dale (1997) claim that the vegetative and reproductive stages of soybean growth are separate. The vegetative stage begins to development. The vegetative stage includes seedling sprouting, unifoliate leaf unfolding, nodulation, and branching. The reproductive stage starts with flower buds and ends with full bloom flowering, pod creation, pod filling, and mature pods.

Soybean, like other legumes, fixes nitrogen into the soil to benefit other crops. As a result, less nitrogen fertilizer is needed to boost field crop yields. This is important in Africa, where fertile soils are few and fertilizers are prohibitively expensive (MoFA and CSIR, 2005; IITA, 2009). It also controls Striga hermonthica, an endemic parasitic weed of cereal crops in Ghana's savannah zone that reduces agricultural productivity by 70% to 100%. Soybean is not a Striga host plant, despite producing chemicals that help Striga seeds germinate.

Soybean plants require 60-75cm inter-row spacing and 5-10cm intra-row spacing, yielding an average of 19,750 plants per hectare (MoFA and CSIR, 2005). There are no exceptions to this rule. Choosing the best population density among early and mid-mature soybean cultivars might be difficult. However, Baligar and Jones (1997) discovered that plant density, pod density, seed density, and seed weight all affect legume seed output.

The soybean, according to Borget (1992), contributes to the feeding of both people and domesticated animals. Additionally, it offers agronomic properties such as soil conservation and nitrogen fixation, as well as industrial and commercial uses. Soybeans are high in carbs, oil, vitamins, and minerals (Rienke and Joke, 2005). A kilogram of soybeans also costs less than a kilogram of beef or eggs (Ngeze, 1993). As a result, it may be a viable meat replacement in underdeveloped countries where meat, fish, eggs, and milk are often unavailable or prohibitively expensive.

Aside from its nutritional value, soybean oil is odorless and colorless and does not readily agglomerate. It is vegetable cooking oil widely used in the food processing industry globally. It is also used in industry to make paint, soap, typewriter ink, plastics, glycerin, and enamels (Rienke and Joke, 2005; Ngeze, 1993). After oil extraction, the cake is a great protein source for chickens, pigs, and fish. Soybean production has increased in Ghana in recent years, leading to increased poultry, pig, and fish farming (Abbey et al, 2001; Ngeze, 1993; MoFA and CSIR, 2005). Harvested haulms are a fantastic source of protein for sheep and goats (Dugje et al., 2009). Soybeans also contain antinutritional compounds that are poisonous to humans and impair the nutritious content of the beans. This is not a problem because these chemicals may be easily removed by soaking and/or "wet" boiling the beans, resulting in a non-toxic product (Rienke and Joke, 2005; Ngeze, 1993).

Soybean also provides many health benefits. Consistent soy consumption may help prevent hormone-related malignancies like breast, prostate, and colon cancer (Rienke and Joke, 2005). It also relieves menopausal symptoms due to soy isoflavones' oestrogen-like action. Regular consumption of soy products lowers total cholesterol and lowers density lipoprotein cholesterol levels, reducing the risk of heart attack or stroke. It also has several uses for humans and livestock, as well as industrial and commercial usage (CSIR, 2005).

2.4 Global Soybean Production

Global soybean production is quickly expanding due to the crop's many health and nutritional benefits. According to the US Department of Agriculture (USDA, 2022), global soybean production in 2023 is anticipated to be approximately 391.17 million MT, with the United States, Brazil, and Argentina accounting for approximately 82 percent of global soybean production. Brazil produced 152 million MT, the United States produced around 118.27 million MT followed by Argentina (49.5 million MT) and China (18.4 milllion MT) Figure 2.1 illustrates the global soybean production data.

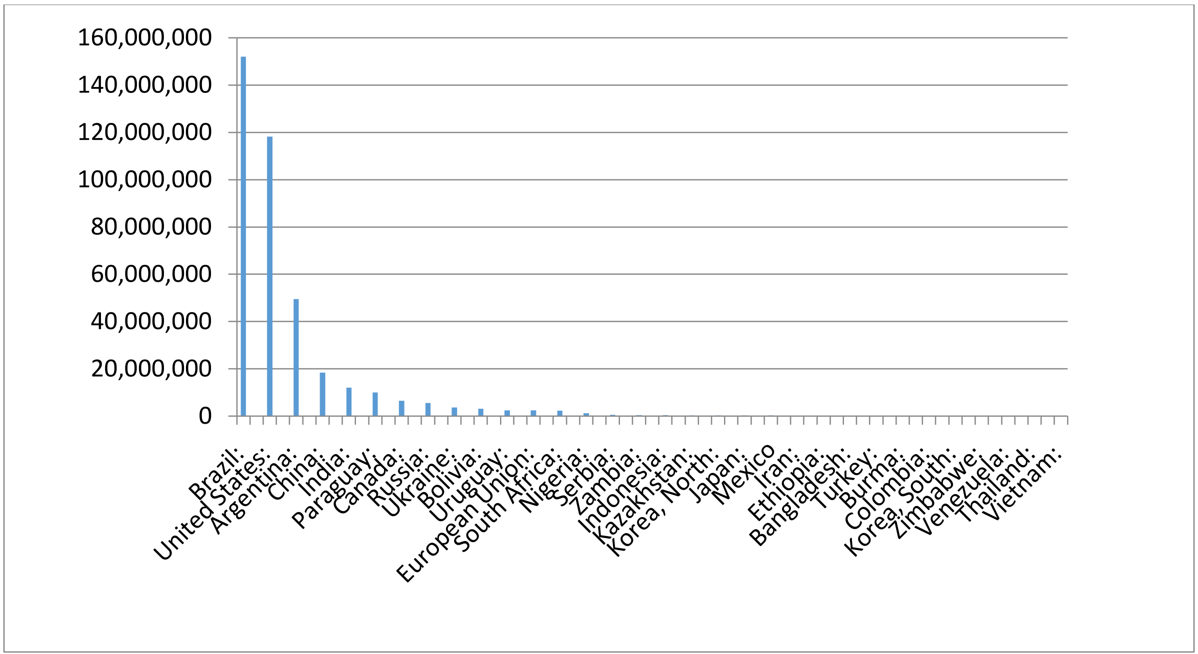


Figure 2.1: World Soybean Production 2022/2023
Source: USDA, 2022

The world soybean production has exponentially increased over the years. Figure 2.2 shows the growth of the sector with the corresponding usage of the crop. Since 1987, the sector's growth has been approximately 350%. This growth is closely tied to the commercial growth of livestock and poultry that use the crop more.

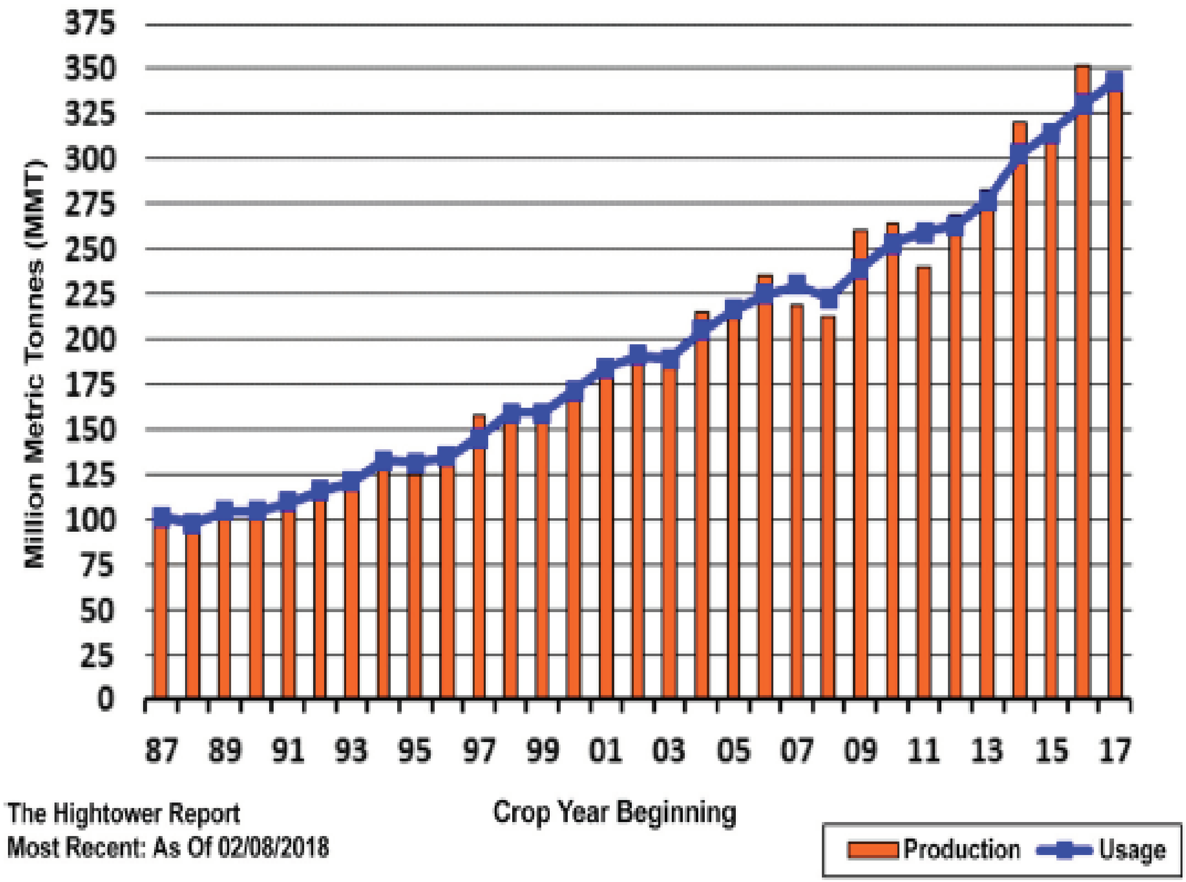


Figure 2.1: Soybean Production and Usage
Source: USDA, 2018

Global soybean cultivation land area is estimated to be 175.5 million hectares per year, with total production from this total land area allocated to soybean production being 346.02 million MT in 2017 (FAO, 2017). FAO (2017) also provided the following breakdown of global soybean production of 175.5 million hectares: Brazil had over 105.8 million hectares, the United States had nearly 100 million hectares, Argentina had 57 million hectares, China had 11.5 million, India had 11 million, Paraguay had

8.8 million, and Canada had 5.9 million hectares. With a grain production of 2.8 million tons, soybeans were grown on an average of 1.16 million hectares in sub-Saharan Africa in 2017. With a total surface area of 601 000 ha in Nigeria, the largest production areas in Africa were found in South Africa, Uganda (144 000 ha), Malawi (68 000 ha), and Zimbabwe (61 000 ha). Directly linked to the world production of soybeans is the usage. The top four producers of the crop (Figure 2.1) are the same countries that lead in the usage of the crop except for Argentina. China tops the chart at 73.87 million MT, United States uses 31.12 million MT, European Union (30.34 million MT) and Brazil (17.48 million MT). The soybean meal use by country is shown in Figure 2.3.

	Millions Metric Tons
China	73.87
United States	31.12
European Union	30.34
Brazil	17.48
Vietnam	6.11
Mexico	6.05
India	5.45
Indonesia	4.35
Thailand	4.30
Russia	3.60
Japan	3.52
Other	36.87
World Total	233.60

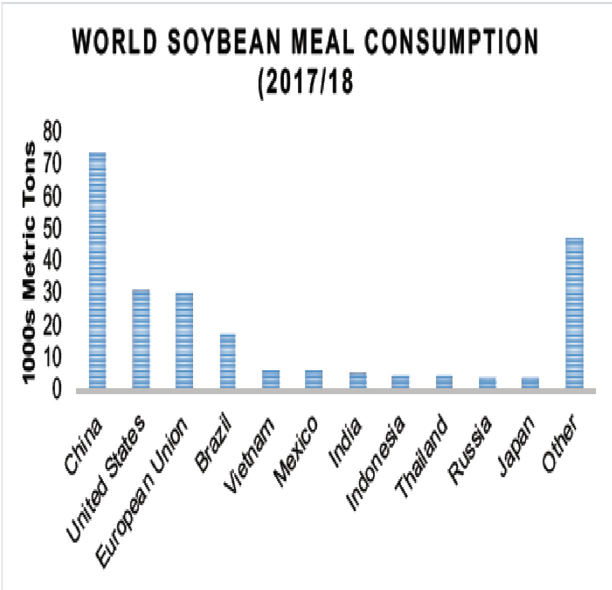


Figure 2.2: World soybean meal consumption
Source: USDA, 2018

2.5 Overview of Soybean Production in Ghana

Soybean is largely grown in Ghana's northern regions and in the transition zone between forest and savannah. The crop was originally introduced into Ghana in 1910 (approximately 110 years ago) (Plahar, 2006). Aoyagi and Shurtleff (2007) reported that the main reason for the production of soybeans in Ghana was for export to England as a cash crop while also supplementing farmers' food needs. Local farmers from Bimbila, Nakpanduri, Karaga, Tilli, and Bawku, all in the Northern part of Ghana were the first to cultivate the crop. Soybean production was an addition to the variety of traditional crops grown in Northern Ghana (Plahar, 2006). However, in the mid-twentieth century, there was an issue with the crop's cultivation. The seed has lost its viability while in storage.

The CSIR’s Crop Research Institute (CRI) and the University of Ghana Agricultural Research Station undertook soybean research in the late 1960s and early 1970s with the goal of enhancing human and animal health by boosting soybean planting. Attempts to establish a successful soybean sector, on the other hand, failed due to a lack of understanding of soy usage at home, a weak industrial basis for soybean processing, an unappealing production package for farmers, and a lack of a market for the commodity (Plahar, 2006).

To support Ghana's increasing chicken industry, a significant soybean-growing programme was initiated in 1975 and 1977 (Plahar, 2006). Farmers responded enthusiastically at first, and production climbed dramatically, but utilization was low, and processing knowledge was insufficient (Plahar, 2006). After a period of inaction, MoFA, as well as some NGOs such as the ADRA, re-engaged in effective and substantial efforts to promote soybean production, with a particular emphasis on small-scale farmers and commercial farming assistance.

Soybean is commonly recognized as the crop with the highest nutritional content, and it can be grown in all locations of Ghana that are suited for it (MoFA, 2006). The Ministry of Food and Agriculture's Women in Agricultural Development program, as well as some non-governmental organizations (NGOs), advocate for its use by promoting various home recipes, especially in rural areas, with the goal of incorporating soybean into the diet and reducing childhood malnutrition. Due to the recent global demand and supply of soybeans, its oil and its products especially for the poultry industry, there has been upsurge in the production of the crop vis-à-vis the area cultivated. As a result, attention has been given to the production of the crop by International organizations, government and NGOs. In Ghana, for example, cultivable land increased from 86,000 hectares in 2015 to 87,000 hectares in 2016, with about 83% of this land in the northern region (MoFA, 2016) (Table 2.1).

As we said before, the five regions of the North and some Northern parts of the Brong-Ahafo and Volta Regions are the country's top soybean producers, with most of the country's soybean production coming from these regions. As shown in Table 2.1 the Northern Region planted the greatest number of soybeans (49,950 hectares), followed by the Upper West Region (14,970 hectares) and the Upper East Region (6,940 hectares). There was an average of 4,360 hectares of agricultural land in the northern Volta Region (USAID, 2012).

Table 2.1: Soybean Production and Area Cultivated in Ghana

Region	Planted area (Ha)
Northern	49,950
Upper West	14,970
Upper East	6,940
Volta	4,360
Brong-Ahafo	1,220
Total	**77,440**
Ghana total	87,000
Average output	1.65Mt/ha
Potential output	3Mt/ha

Source: MoFA, 2016

2.6 Soybean Processing and Marketing in Ghana

Numerous agricultural businesses acquire and process soybean crops for use in human and animal feed (MoFA, 2009). There is a significant difference in Ghana between large-scale and small-scale soybean cultivation and processing (Mohammed et al., 2016). This distinction is made, among other things, on the basis of the equipment utilized, the processing processes used, and the technology used. Oil extraction and animal feed, soy flour and high protein foods, high protein foods solely, soymilk and soy flour, and soy curd are all examples of large-scale processing (Figure 2.4). In comparison to the more traditional and basic equipment and procedures used in small-scale (micro/household) soybean processing, large-scale soybean processing requires substantially more sophisticated technology and equipment.

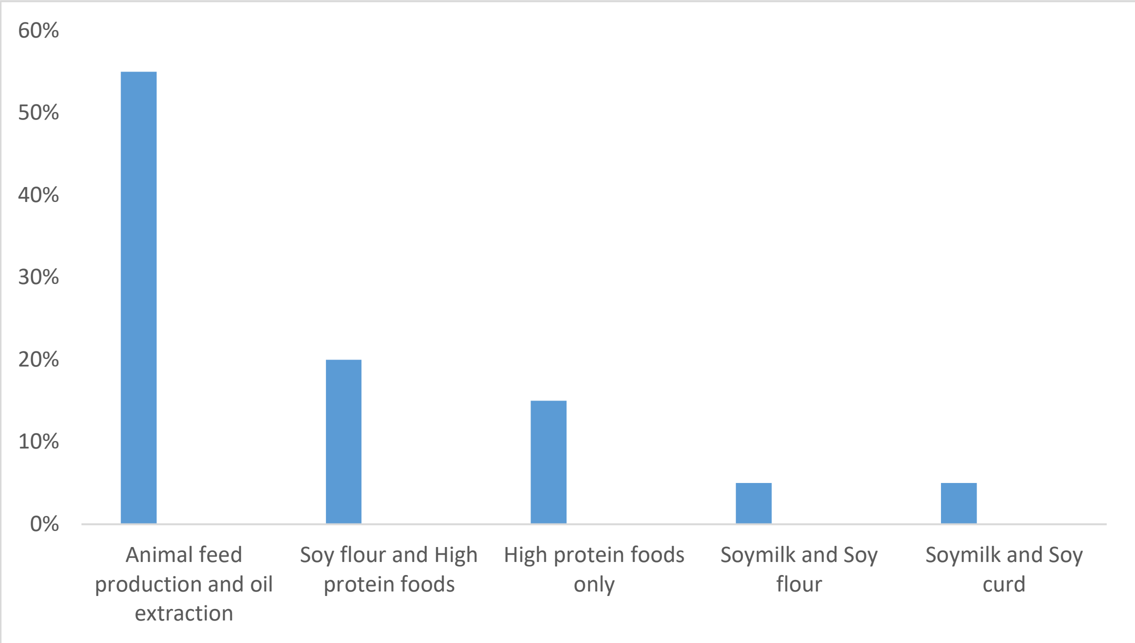


Figure 2.3: Categories of Large-Scale soybean Processing in Ghana
Source: Plahar, 2006

The local poultry sector, according to the USAID, is a prominent component in Ghana's soybean industry. Because of its high protein content, soybean cake is used in the poultry industry as feeds for layer and broiler chickens, guinea fowls, and turkeys. According to the USAID, the local egg business consumes roughly 75 percent of the 150,000 MT of soybeans required each year. The Ghanaian soybean market is summarized in Table 2.2. Soybean cake, which is used in layer feed rations, makes up a significant portion of Ghana's total soybean output and consumption. According to USAID (2012), the remaining produce is utilized to make soybean oil for industrial and human consumption.

Table 2.2: Soybean Products Marketing in Ghana

Product	**Total Market (Metric Tonnes)**	**Import Supply – (% of market share met by imports)**	**Wholesale and retail prices ($/MT)**
Soy cake	Between 75,000 and 100,000 MT	Between 48% and 61%	$1,060-$1,200/MT at 2011 peak
Soy oil	About 20,000 MT	70%	$1,733/MT
Food processing (Human)	<1,000 MT	0%	-
Producer Household retention	About 20,000 MT	N/A	N/A
Average (total)	150,000 MT	About 50%	-

Source: USAID, 2012.

2.7 Soybean Output and its Determinants

2.7.1 Soybean Productivity

Lower susceptibility to pests and diseases, higher storage quality, and larger leaf biomass, according to Ajoa et al., (2010), are some of the advantages of soybean over other grain legumes (such as groundnut and cowpea). Even though soybean is a relatively new crop in Ghana (Akramov & Malek, 2012), its growing relevance in the rural economy of farm households in northern Ghana, notably in the country's Northern Region's eastern corridor, cannot be understated.

Approximately 70% of national soybean acreage and 77 percent of national production are grown in the northern region alone (MoFA SRID, 2012). Several soybean demonstrations are set up in the region each year by both governmental and non-governmental organizations with the purpose of enhancing productivity and production. The crop is gaining popularity and acceptance among farmers in Ghana, notably those in the Northern Region (Etwire et al., 2013).

When it comes to typical soybean yields, the country's average ranges from just under 2 tonnes per hectare in 2011 to as much as 4 tonness in 1990, according to MoFA. Crop yield and quality can be affected by a variety of factors including the rate at which seeds are sown, planting method used, and sowing depth (Ajoa et al., 2012). New enhanced soybean varieties need to be tested for their potential and performance under a variety of agronomic techniques. This research is necessary. In soybeans, planting rates must be adequate to ensure a high crop stand at harvest time. Radiation interception and crop competition for resources can be limited by plant density and planting methods (Dapaah et al., 2005).

2.7.2 Determinants of Soybean Output

Smallholder farmers in Sub-Saharan Africa (SSA) typically achieve productivity levels that are significantly lower than what would be attainable under ideal conditions (Smaling, 2005). Even with low population densities, land is under strong strain due to limited soil fertility and generally bad weather. Soil fertility and the viability of African land usage have become a major concern since the early 1990s. Many studies have shown that soils are deteriorating over time. According to Sanchez et al. (1997), SSA's dropping per capita food production is primarily due to the degradation of soil

soil fertility on smallholder farms.

2.7.2.1 Land Size

Land is very crucial in farming. The farm's size is determined by the amount of land used by the household for soybean cultivation. The majority of farmers have insufficient land. According to Raghbendra et al. (2005), the number of plots has a negative relationship with efficiency. This suggests that land fragmentation (as measured by the number of plots per ha) has a detrimental influence on outputs. The most important variable explaining the difference in output is by far access to land. The size of a land holding is positively connected to its efficiency, according to Barnes (2008).

2.7.2.2 Soybean Seed

Seeds are the backbone of agricultural production. Despite its importance, African soybean farmers lack guaranteed access to sufficient, high-quality seed of desired varieties in time for sowing. In the 1970s and 1980s, public seed programmes in SSA generally encouraged the spread of better soybean cultivars. The seed sector was liberalized as part of the 1990s structural changes, though the private sector has only partially replaced the public sector in providing seed to farmers. With a rising recognition that promoting soybean production in Africa is critical for economic growth, food security, and social stability, 'seed' has ascended to the top of the priority list for many governments and technical and financial soybean development partners (Viatte et al., 2009). To effectively contribute to boosting productivity and sustainability of the African soybean seed system, the growth of the African soybean seed sector must address concerns of availability, accessibility, seed quality, varietal quality and purity, and resilience (Remington et al, 2002).

To improve soybean output in Sub-Saharan Africa, well-coordinated soybean breeding activities, functioning national varietal release procedures, and regional efforts to enable cross-border seed commerce are required (Kumashiro et al, 2013). Small-scale subsistence farmers do not acquire certified seeds; instead, they rely on recycled seeds collected after each harvest, while others purchase recycled seeds from their neighbors. This method has an annual impact on crop output, both in terms of quantity and quality (Douglas, 2008).

2.7.2.3 Age of Farmer

Depending on education and experience, the farmer's age is likely to have an impact on soybean production in any direction. Age contributes positively if farmers have a high level of education and experience in farming, and negatively if farmers have a low level of education and experience.

Soybean farmers range in age from 25 to 50 years old, according to Bellamare (2012). This study inferred that soybean farmers are young and, if lured, will continue to produce this crop for the next one, two, or three decades. Similar findings were observed by Dogbe et al. (2013), implying that soybean farming has a future if these relatively young farmers can be motivated to stay in the business. Ebong et al. (2011) also observed a link between age and increased TE in urban agricultural production. If proper extension services are offered, there is a substantial association between the ages of the producers and their capacity and willingness to enhance farming practices.

2.8 Empirical Studies on Constraints to Soybean Production

Farm level constraints take its bearing from certain key factors including those that relate to the demographic characteristics of farmers, farm specific features, farmer and farming environment, and socio-economic characteristics of farmers, among others. This opinion was shared by Ali and Byerlee (1991) when the authors documented that both exogenous and farm specific qualities could be sources of constraints. The researchers indicated that factors like environmentally related constraints like drought, bush fires, pests and diseases, input markets and lack of credit, poor road network could amount to the exogenous variables, while endogenous variables such as post-harvest losses, inadequate storage facilities, inefficiency among others constitute the endogenous constraints.

Insufficient farm credit, insufficient rainfall, and a lack of improved planting materials are the three most constraining challenges impeding soybean farming, according to Mohammed et al. (2011), while post-harvest losses, inadequate storage facilities, and a poor road network are the last three constraints.

Abdulai et al. (2013) also ranked the three topmost challenges facing contractual soybean farming as; tractor service, inadequate or no cash credit and scarcity of labour during harvesting periods. According to respondents from that study, tractor services was ranked highest because during land preparation, there is increased demand for tractors for ploughing but due to their inadequate numbers in the districts, procuring these services is difficult and results in delayed cultivation culminating in shortage of rain for their soybeans and bad outputs.

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This section discusses the theories, terminologies, and concepts of CF. It includes the models of CF, how contracts are arranged, types of CF, transaction costs and CF, reasons why farmers engage in CF, benefits of CF, challenges and theoretical/conceptual framework of the study, efficiency definitions and concept of efficiency.

3.2 Contract Farming (CF)

3.2.1 Concepts and Definitions of Contract Farming

Numerous concepts have been used to describe CF, including Core-Satellite Farming, Nucleus Estates, and Out-Grower Schemes. These terms are frequently used interchangeably. Nonetheless, several academics have attempted to distinguish between these notions. Glover (1984) asserts that there is a clear distinction between CF and out-grower strategies. According to him, CF schemes are those that are administered by private firms, both domestic and international, whereas out-grower schemes are those that are administered by parastatal agencies.

The phrase "Contract Farming" refers to vertical integration within agricultural commodity value chains, in which an organization that contracts farmers/clients obtains increased control over the production process, including quantity, quality, characteristics and timeliness. Historically, businesses have invested directly in production via enormous estates or plantations, a kind of vertical integration (particularly for traditional tropical goods like tea, bananas, and sugarcane). Other authors defined CF as:

"A contract between a business (contractor) and an independent producer (contractee) in the form of a 'forward agreement,' with well-defined obligations and remuneration for activities performed, and frequently with requirements on product attributes such as volume, quality, and delivery schedule" (Catelo and Costales, 2008).

"An intermediate mode of coordination in which transaction participants agree to particular terms of trade through some sort of legally enforceable, binding agreement." The specifications can be more or less precise, and they can include provisions for production technology, price discovery, risk sharing, and other product and transaction characteristics." (Da Silva, 2005).

"Agricultural production conducted in accordance with a prior agreement in which the farmer promises to produce a particular product in a particular manner and the buyer agrees to purchase it." (Minot, 2007).

"A contract between farmers and other enterprises that specifies one or more production and/or marketing standards for an agricultural commodity, whether oral or written." (Roy, 1963, quoted in Rehber, 2007);

"An oral or written contract between farmers and other enterprises that specifies one or more production and marketing requirements for a non-transferable agricultural item." (Rehber, 2007).

The definition of Prowse (2012) appears to encompass all the above definitions as follows:

"A non-transferable contract between a farmer and a firm for a fixed term, agreed verbally or in writing before production begins, that provides resources to the farmer and/or specifies one or more production conditions, in addition to one or more marketing conditions, for agricultural production on land owned or controlled by the farmer, that is non-transferable and gives the firm, not the farmer, exclusive rights and legal title to the crop."

The definition by Prowse (2012) is in tune with the kind of CF that is practice in the study area. Contract agreements are usually written or verbal, agreements are made before production, resources in a form of inputs are advanced to farmers, markets are provided by contractors and it is for a fixed term. Credit in a form of cash or kind is paid back after the produce are harvested and purchased by the contracting firm.

3.3 History and Extent of Contract Farming

For nearly a century, CF between farmers and businesses has been hailed as a game changer in terms of agricultural productivity. As an innovation in agricultural farming, sharecropping contracts between crop producers and landlords of agricultural land were well-modeled in antiquity in Greece and China (Eaton and Shepherd, 2001). It demonstrates how the Japanese operationalized CF in late-nineteenth-century Taiwan, in a manner comparable to how US corporations operationalized CF in Central America in the early twentieth century (Watts, 1994).

In the decades preceding World War II, CF was used for vegetable crop production in the United States and seed production in Europe (Rehber, 2007), as well as for pig production in the United States immediately afterwards (Hamilton, 2008). CF gained prominence following World War II and has evolved to be a sizable and growing agricultural organization (Prowse, 2012).

In developed countries, CF is estimated to account for 15% of agricultural productivity (Rehber, 2007). For example, contract agriculture accounted for 39% of the value of agricultural produce in the United States in 2001, up from 31% in 1997 (Young and Hobbs, 2002). Other developed countries have comparable, if not higher, forecasts for many sectors. For example, in Germany, CF accounts for 38% of milk, poultry, and sugar production (but only 6 percent for other commodities on average). Additionally, agreements in Japan and South Korea account for 75% and 23% of broiler production, respectively (Prowse, 2012).

Additionally, CF is critical in transitional economies. Swinnen and Maertens (2007) estimate that contracts are used by between 60% and 85% of corporate farms in the Czech Republic, Slovakia, and Hungary. Further east, from 25% in 1997 to 75% in 2003, the share of food firms contracting in Armenia, Georgia, Moldova, Ukraine, and Russia increased. However, pro-market and modern corporate reform models are intrinsically linked to the expansion of downsizing in transitional economies in the twenty-first century (Swinnen and Maertens, 2007).

Globally, CF has garnered increased attention due to its critical role in enhancing farmer access to farm inputs and productivity. Since the 1950s, CF has been on the rise in Latin America. The most frequently contracted food crops in Honduras were bananas, barley in Peru, and vegetables and grain in Mexico. According to Chiquita, Dole, Del Monte, and Fyffes, banana companies employ CF operations to boost per-acre productivity (UNCTAD, 2009).

Additionally, CF is claimed to have increased poultry production by 70% and soybean productivity by 30% in Brazil. According to Swinnen and Maertens (2007), CF has grown rapidly in recent decades throughout Southeast and South Asia. Since 1956, through the Federal Land Development Agency (FELDA), the Indonesian government has effectively promoted CF (Rehber, 2007). CF is particularly well-known in Malaysia, where it specializes in government-sponsored out-grower arrangements (Morrison et al., 2006).

CF produces over 90% of Vietnam's cotton and fresh milk, as well as more than 40% of rice and tea (UNCTAD, 2009). Since the 1960s, CF has been used to manufacture seeds in India, and it is now widely employed to manufacture chicken, dairy products, potatoes, rice, and spinach, among other things (Rehber, 2007). Nestlé, through a local partner, collects milk from nearly 140,000 farmers across an area of 100,000 square kilometers (UNCTAD, 2009).

East Asia also has a high prevalence of CF. Since 1990, China's government has supported CF, with remarkable results: by 2001, over 18 billion hectares had been planted under CF agreements (a 40% increase over the previous year) (Guo et al. 2005, quoted in Rehber, 2007). CF is also used by Japanese companies that produce rice, fruits, and vegetables for domestic industries.

CF is also on the rise in SSA. Many CF systems were fully or partially government-owned in the late 1980s (with the public sector holding some of the larger projects, according to Little and Watts (1994), but many are now privately owned. Swinnen and Maertens (2007) conducted an empirical investigation in Mozambique on cotton CF and discovered that approximately 12% of the rural population engaged in the practice. Over half of Kenya's tea and sugar harvests were produced by contract farmers, as were a considerable number of contract producers of horticulture products for export. Coffee (for example, Kawacom's Uganda operation) is another food product that has benefited from a successful CF approach (Bolwig et al., 2009).

In emerging nations, such as Ghana, the private sector has assumed responsibility for CF. In 2008, Nestle maintained partnerships with over 500,000 farmers in more than 80 developing and emerging economies (including Ghana). Olam Company Limited, headquartered in Singapore, is responsible for the delivery of 17 agricultural commodities and farm supplies to more than 200,000 farmers in more than 50 countries. Unilever believes that over 60% of its raw materials are sourced through CF from approximately 100,000 small and large farmers in developing nations. Additionally, Carrefour, a French retailer, has entered into CF agreements with farmers in around 18 developing countries (UNCTAD, 2009).

In poorer nations, more small-holder CF initiatives are being implemented. SAB Miller, for example, has contracts with over 16,000 small, medium, and large-scale farmers in India, South Africa, Uganda, Tanzania, and Zambia. In 2008, Kitoku Shinryo of Japan signed joint venture agreements with about 2,000 farmers in Vietnam, Cambodia, and Thailand, while Grupo Bimbo of Mexico signed agreements with over 3,000 Latin American farmers. According to these numbers, CF has become the norm in current farming systems. As CF gains global popularity, it's interesting considering the country with the most experience: the United States. In 1997, CF accounted for 31% of total agricultural production in the United States, an astounding figure of more over $50 billion (Young and Hobbs, 2002).

The circumstances surrounding the increasing use of CF in agricultural commodity value chains in emerging economies and underdeveloped countries have shifted dramatically since the 1970s. These variables can be divided into two categories: demand and supply (Prowse, 2012).

3.4 Drivers of Demand and Supply Factors of Contract Farming

3.4.1 Drivers of Demand for Contract Farming

Rapid population increase is accompanied by a strong demand for food and agricultural produce/products on an annual basis. According to the United Nations Population Division, the world's population will reach 9.2 billion by 2050. This represents a 56 million annual increase over the global population of 6.9 billion in 2010 (DESA-UNS, 2008). By 2050, the poorest regions, particularly SSA, will account for most of the population growth. One of the demand factors for CF is urbanization. There has been a substantial increase in urbanization throughout the decades, which has altered people's food preferences and diets. More than half of the world's population now lives in urban and peri-urban settings, according to DESA-UNS (2010). In urban and peri-urban areas, the population is expected to grow by 69 percent by 2050.

Food is another factor driving demand, as incomes in many developing countries rise. In the mid-2000s, the biggest 12-month income growth rates were calculated in Africa, Asia, and Latin America, at 4.2 percent, 3.5 percent, and 2.3 percent, respectively (Narrod et al., 2007, and Catelo and Costales, 2008). According to Addison et al. (2010), most developing countries' GDP per capita growth rates are expected to be much greater than advanced economies', because of the former's quicker and more robust recovery from the recent global recession. As a result of modern urbanization, food demand and tastes have shifted considerably, with increasing protein consumption and higher-quality produce being among the most notable examples. Overall, according to Da Silva (2005), demand for high-quality protein foods will rise from 2803 kcal/person/day in 1997/1999 to roughly 3000 kcal/person/day in 2015 and will surpass 3000 kcal/person/day by 2030.

Variables such as shifting global consumer baskets, increased female participation in the workforce, demand for pre-processed commodities, improved public awareness about healthy diets and food safety, and environmental and developmental credibility considerations are all factors on the demand side of CF (Catelo and Costales, 2008). Consumers have been more discerning in recent years, wanting higher quality and more distinctiveness from food items; they are concerned not only with nutritional and chemical information, but also with the entire supplier value chain process.

Changes in consumer preferences and diet have resulted in a significant reorganization of agricultural supply value chains. As a result, modern businesses demand higher quality guidelines and standards from their suppliers, and often include fully integrated production lines in their portfolios when possible (Reardon et al., 2009). Based on this, businesses (demand factor) hire producers (supply factor) to manufacture high-quality produce to meet the public's need.

3.4.2 Drivers of Supply of Contract Farming

Three decades ago, state-owned enterprises such as marketing boards and parastatal processing units oversaw most agricultural production systems in emerging and transition nations (Swinnen and Maertens, 2007). Following independence, these organizations were founded with the primary purpose of ensuring national ownership and control of agricultural supply value chains, which were usually enriched by private-sector mono/oligopolies in key crops (Lipton, 1977; Kydd and Christiansen, 1982).

Flexible capital policies, state-owned company privatization, and trade liberalization have all contributed to a rise in the value of international agricultural commerce, notably for slightly elevated and quasi products (horticulture and fisheries) (Swinnen and Maertens, 2007 and Da Silva, 2005). According to Wilkinson (2004), the value of processed food crops exported has increased significantly over time, particularly from

Argentina, Brazil, Malaysia, Thailand, and Taiwan.

Liberalization of trade, investment, and marketing regimes has produced a plethora of opportunities for companies that are the most efficient and capable of meeting public and private requirements, as well as people's desires for contemporary and cross-border supply-chain activities (Da Silva, 2005). As a result, there is more concentration in agricultural value chains in the production systems. Currently, supply networks have fewer, but larger, enterprises, with a high degree of vertical and horizontal interaction (Giovanucci et al., 2008).

This vertical and horizontal integrated coordination comprised marketing and processing systems with backward links to production and input supplies (Humphrey and Memedovic, 2006). Furthermore, the retail supply factor has experienced unprecedented concentration (Reardon et al., 2009).

In CF, advancements in transportation, logistics, and information and communication technologies have occurred in addition to economic liberalization (Prowse, 2012). Thanks to advancements in freight services and cooling technology, food has gone much further from production to consumption in recent years than it did in the early 1980s (Da Silva, 2005). Furthermore, ICT reduces the cost of supply chain contracting coordination. Improvements in supply chain solutions for retailers (such as networked sales, inventory, and ordering systems) also continue to improve purchasing efficiency (Prowse, 2012).

ICT advancement, which is critical and a supply factor for CF, has increased vertical integration because of the use of biotechnology (genetically modified (GM) crops). Agricultural producers in the United States have typically approved GM crops, thus technological advancement offers significant productivity gains. Nonetheless, GM crops are a hotly debated topic (Prowse, 2012). The implications raise a critical issue of standards, or "agreed criteria" or "external points of reference," by which a product or service's performance, technical and physical characteristics, and/or the process and conditions under which it was produced or delivered can be evaluated (Nadvi and Wältring, 2004; Humphrey and Memedovic, 2006). According to Giovanucci et al. (2008), vertical integration via CF is intended to ensure adherence to public or private standards, as well as traceability.

Agricultural output standards have altered dramatically in recent years, according to Humphrey and Memodovic (2006). Firms, organizations, governments, trade alliances, third parties, and non-governmental organizations (NGOs) can create internal and external standards for a certain value chain. Additionally, public standards are an appropriate place to start because they prioritize public health and safety, whereas private standards allow for greater product differentiation (making the former less relevant than the latter) (Reardon et al., 2009). Corporations have made these modifications in reaction to the heightened danger of civil or criminal prosecution (Giovanucci et al., 2008).

Furthermore, quality might be seen as a solution for the progressively discriminating consumer looking for exceptional value and one-of-a-kind items. It is undeniably costly and time demanding to comply with these laws (Prowse, 2012). This is especially true in developing nations, where smallholder farmers are the primary source. "Smallholders in the supply chain may be at a disadvantage unless they can make standard compliance cost-effective and ensure customer traceability. This problem has several solutions, including CF. By merging the drivers of demand and supply factors in agricultural production, CF can bridge the demand and supply gap in the production and consumption cycle. CF in the demand and supply factors presents more opportunities to firms and smallholder farmers across the developing world, especially Ghana (Prowse, 2012).

3.5 Prospects of Contract Farming to Farmers

For farmers, the most important prospect or benefit of a contractual agreement is that the contractor will acquire all agricultural produce cultivated within the contract's stipulated quality and quantity criteria. Farmers can also get management, technical, and extension services from CF that they would not have been able to get. Smallholder farmers can utilize the contract agreement as collateral to get commercial bank financing to purchase farm inputs via CF. For farmers, the following are the most important prospects/benefits of CF (Prowse, 2012).

3.5.1 Access to Production Services and Farm Inputs

Accessibility of farm inputs and production services is a constraint to farmers that affects them negatively to explore their production potentials. CF has provided golden opportunities to farmers by providing farm inputs and production services through contractual arrangements of firms. Mostly, contractors/sponsors provide production support such as seed and fertilizer to farmers to increase their production. In addition, contractors complement the provision of inputs by training farmers, help in land preparation, field cultivation, pre-harvesting and post-harvesting. These services provided to farmers, promote good agricultural practices in a sustainable manner in order to achieve a target output per hectare and standard qualities (Eaton and Shepherd, 2001). However, the disadvantage is that farmers may end up working for their paymasters instead of themselves (Eaton and Shepherd, 2001). These effects worsen the standard living of the resource poor farmers.

3.5.2 Credit access

Credit access has become a major challenge to farmers in agricultural production. Farmers find it difficult accessing credit from formal sources to purchase production inputs. Agricultural Development Banks and export crop marketing boards, which previously provided finance to farmers, have reduced their lending. CF, which is relatively a new model, has been substituted for banks and marketing boards by allowing farmers to access some credit to finance production. The majority of non-governmental organizations (NGOs) that provide CF to farmers rely on upfront financing from their management. Contract arrangements with commercial banks or government agencies, on the other hand, can be created through specific crops that they are interested in. The contractor guarantees such arrangements. This is mostly used as security for commercial bank loans (Eaton and Shepherd, 2001).

3.5.3 Access to Appropriate Technology

Improved agricultural technologies are key to enhancing productivity. Contractors target high returns and more output per hectare. For this reason, contractors disseminate improved technologies to farmers they are contracting with to achieve more output per hectare. Some contractors go to the extent of providing pre-harvest and post-harvest technologies to farmers they contract with to achieve standard and quality produce. Improvements in agricultural techniques are routinely utilized to increase the value of agricultural commodities in markets with high quality standards, according to Eaton and Shepherd (2001).

Frequently, it is necessary to improve production processes in order to increase output and ensure that the commodity satisfies consumer needs. Some small farmers are hesitant to adopt new technology because to the accompanying risks and costs, despite the fact that CF offers numerous benefits to them. Farmers that can rely on and/or receive assistance from external sources are more receptive to new technologies. Private agribusiness businesses distribute new technologies to farmers more frequently than government agricultural extension agencies, owing to their clear commercial interest in increasing farmer yields.

3.5.4 Guaranteed and fixed pricing arrangements

Without contract arrangements for farmers, high returns from the produce depend on market environment and bargaining power of farmers. Farmers' returns for their agricultural produce in an open market system are determined by market pricing and distance from market hubs. This creates price uncertainty in the production process, making farmers the disadvantage. CF is the surest way to overcome this price uncertainty affecting farmers. Mostly, contractors make quantity, quality and price arrangements to be paid after harvest (Eaton and Shepherd 2001).

Farmers are able to engage in more markets since there is a ready demand for their produce. Some contracts, on the other hand, are based on market values rather than predetermined rates at the time of delivery (Eaton and Shepherd 2001).

3.5.5 Access to Reliable Markets

Small-holder farmers are hampered by an unpredictable market for their products, forcing them to diversify their crops. Farmers find it difficult to expand their production area and/or cultivate new crops other than the national crops (maize, rice, and cassava, for example) unless they can be confident that their produce will be sold quickly and consistently. By creating a steady market for farmers and ensuring supply for purchasers, CF may be able to solve this problem (Eaton and Shepherd, 2001). Farmers' production efficiency is improved as a result of this.

3.5.6 Increased Farm Income

As farmers have access to appropriate technologies, more output per hectare is achieved leading to increased farmers' income, *ceteris paribus*. Therefore, CF provides an opportunity for higher incomes for farmers. Nevertheless, this is not always true as CF can make farmers worse off. Farmers anticipate to gain income stability through CF since the risks and uncertainties associated with the spot market are reduced (Ajoa et al., 2012).

Improved on-farm diversity, technical assistance and information sharing, better efficiency, commercialization of smallholder farming, and contracts serving as collateral for production finance are just a few of the advantages and opportunities that CF may provide. Input and transportation expenses are reduced as a result of internal economies of scale. Furthermore, businesses have a competitive advantage in marketing and technological expertise, as well as product traceability and quality. Contracting with smallholders can yield big results in terms of poverty alleviation (Hazell et al., 2006). The direct effect of these benefits to farmers is an increase in income.

3.6 Theoretical Models of Contract Farming

To boost production, various CF methods have been created and embraced by practitioners. The centralized model, nucleus estate model, multipartite model, informal model, and intermediary model are examples of CF models (Eaton and Shepherd, 2001; Da Silva, 2005; Bijman, 2008; and Mansur et al. (2009)). These models are briefly discussed in the following.

3.6.1 Centralized Contract Farming Model

Centralized CF is a vertical harmonization/arrangement in which the contractor buys the crop from the farmers, processes it, and sells it (Mansur et al., 2009). For quality and quantity, a corporation (typically a major processor) contracts a large number of farmers. This method provides farmers with quotas at the start of each growing season, and quality is rigorously controlled (Eaton and Shepherd, 2001). According to Eaton and Shepherd (2001), tobacco, cotton, sugar cane, and banana production are all tied to the centralized paradigm. Tree crops including coffee, tea, cocoa, and rubber, as well as chicken, hog, and dairy production, are all incorporated in this CF model.

3.6.2 The Nucleus-Estate Model of Contract Farming

The sponsors of this sort of CF also own or share a piece of the manufacturing facility. Mansur et al. (2009) assert that the project sponsor also owns and administers a portion of an estate plantation, which is frequently located near the processing factory. Additionally, this model depicts a scenario in which sponsors/firms enter the production node through an estate or plantation, but contract with independent seed providers to obtain bigger quantities of seed (Prowse, 2012). This strategy is often utilized for annual crops and is the ideal model for relocation or impermanence programs (such as Indonesia's palm oil production), according to Eaton and Shepherd (2001). In this CF configuration, out-growers from a central estate are utilized.

3.6.3 The Tripartite Model of Contract Farming

A joint venture establishes a contract with farmers (a public entity and a private enterprise). This strategy, according to Eaton and Shepherd (2001), can include both national and local government, and Bijman (2008) feels it is particularly popular in China. Contracting on the basis of this model may theoretically be politicized due to government intervention leading to inefficiency in production.

3.6.4 The informal Model of Contract Farming

This method is generally used for low-processing products, fruits, and vegetables, where entrepreneurs verbally contract with a small number of farmers on a yearly basis. Individuals or small businesses that enter into basic seasonal informal production contracts with farmers are ideal candidates for this strategy (Mansur et al., 2009). In many cases, technical assistance is limited to grading and quality control, while farm inputs are typically limited to seeds and basic fertilizers. Following the purchase of the produce, the sponsor simply grades and packages it for resale to the retail trade, which is a classic demonstration of the informal approach to agriculture.

Firms are often small, and the success of such projects is moderately dependent on the ability of other providers (the state and/or NGOs) to provide farmers with inputs, extension services, and loans (Eaton and Shepherd, 2001).

3.6.5 The Intermediary Model of Contract Farming

This is a strategy in which a corporation uses a middleman, such as a farmers' association or a trader, to manage ties with farmers (Prowse, 2012In this type of collaboration between the business and the farmer, middlemen (traders) are involved (Mansur et al) (2009). Typically, agricultural products are purchased by agribusiness firms from farmer committees that have their own contracts with farmers. Sponsors should exercise caution when dealing with intermediaries in this value chain model, as they may lose control over the output and pricing offered to farmers by middlemen. This style is extremely popular in Thailand and Indonesia. One of the primary causes of CF is the increasing distance between the enterprise and the farm, which erodes the enterprise's control over the process and output (Eaton and Shepherd, 2001).

3.7 Theoretical and Conceptual Approaches of Contract Farming

Theoretical and conceptual approaches to CF help us understand why CF occurs and how it has increased in current farming systems. The study's objectives are met by addressing seven hypotheses and conceptual approaches to CF before proceeding to a comparative review of instances. Each conceptual method or theory reveals the CF phenomena by abstracting from actual situations. Certain approaches are built on sound assumptions and can be used to test hypotheses and forecast the future, while others provide straightforward and insightful concepts.

Some CF concepts are predicated on assumptions, while others offer clarity and understanding. Life-Cycle Theory Approach, Transaction Cost Approach, Contract Enforcement Approach, Convention Theory Approach, Value Chain Governance Approach, Competency/Capability Theories Approach, Political Economy of Agrarian Change Approach, and Comparative Review of Theories are some of the conceptual theoretical approaches used by CF.

3.7.1 Life Cycle Theory

Stigler is known for his focus on vertical integration. Adam Smith's conclusion that "the division of labor is limited by the breadth of the market" formed the foundation of life-cycle theory (Stigler, 1951). In the early stages of an industry's growth, it is more vertically integrated. Specializing in an activity with increasing returns to scale is not profitable for a company while the industry is small. Existing and new companies in the industry may decide to specialize on one of the processes as the industry grows. When a company's business grows, it becomes more advantageous for it to specialize.

As a result, the second stage of disintegration occurs. As an industry nears its end-of-life cycle, vertical integration may be used as a protective strategy. This led to the hypothesis that vertical integration is more common in both new and old industries (Setboonsarng 2008).

Figure 3.1 shows the relevance of CF as a market transaction facilitator. Depending on the level of market development, this can differ. Stage 1 depicts a shift from subsistence to commercial agriculture because of market linkages. In order to ease the transition from subsistence farming to commercial farming, contract agriculture has been developed. Stage 2 emphasizes the significance of CF in the expansion of the agricultural business and in the diversification of crop types. Trades in the spot market have improved as manufacturing begins in stage 3. Right now, the market appears to be running normally, and CF is playing only a minimal role. Now that product differentiation and globalization have reached their final stages, CF has taken on the role of an institution to deal with market failures related to product quality in a globalized market.

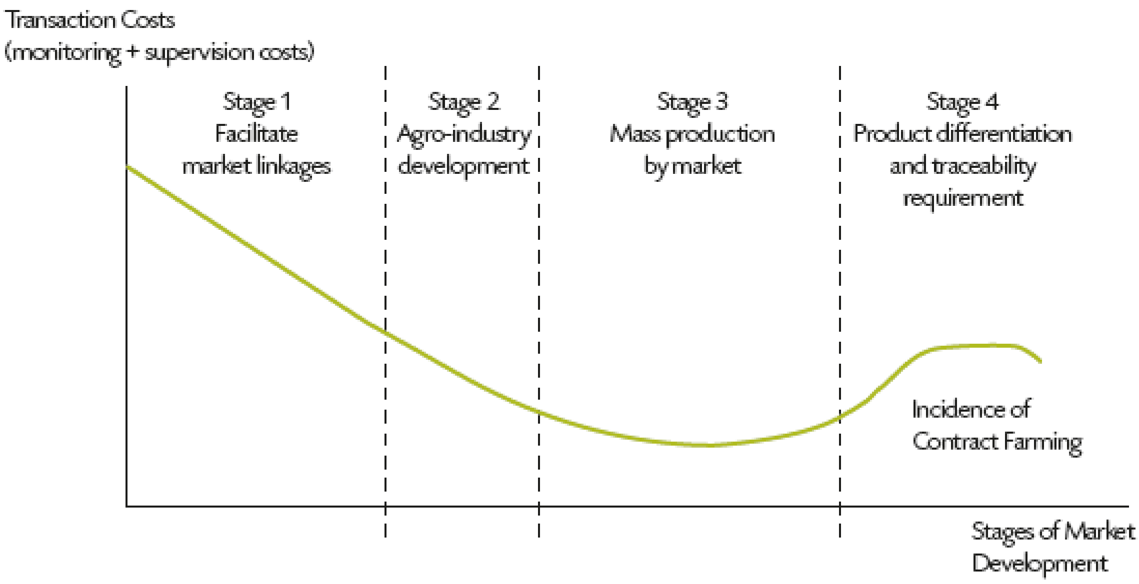


Figure 3.1: Life Cycle Theory: Stages of Market Development and Contract Farming
Source: Setboonsarng (2008) cited in Prowse (2012)

3.7.2 Transaction Cost Theory

A more prevalent meaning of CF is that it refers to transaction costs. This all begins with a straightforward question: why are businesses necessary? The approach is to keep currency transaction costs as low as feasible. As a result, if the cost of creating an input is cheaper than the cost of acquiring it in an inconsistent and unpredictable market, the business will integrate backwards. This approach to evaluating organizations and markets differs significantly from traditional neo-classical approaches, which ignore transaction costs in the mistaken belief that perfectly competitive spot markets provide all of the information necessary for economic actors to make decisions in the marketplace.

In accordance with transaction cost models, markets are formed of economically rational players who are opportunistic (they are subjected to substantial information asymmetries and are unable to comprehend all of the information available) (they can deceive, lie, cheat and steal). These characters are deceptive in their pursuit of self-interest. Market trades are intrinsically risky and can result in substantial losses. Transaction expenses are incurred as a result of a business's efforts to mitigate or eliminate these losses.

Transaction costs are divided into two types by Williamson (1979): ex ante and ex post. The costs of drafting, debating, and finalizing a contract are all ex-ante expenditures. The costs incurred by contracts that become a topic of contention are known as ex postal costs. Expenses of data collecting and storage, legal costs, organizational costs, and the cost of wasteful pricing and manufacturing behaviour. Small and fragmented marketplaces have the highest transaction costs (such as agricultural markets in many impoverished nations). In any case, they lead to market failures (where exchange shortages reduce production and innovation, and increase poverty).

Williamson (1979) asserts that three transaction characteristics determine a business's rate of transaction costs:

1) The transaction cost of uncertainty refers to the cost of insufficient information about a firm's existing and future conditions, as well as the chance that the other party will engage in opportunistic behavior.

2) Asset specificity refers to the cost of a business's assets that have a single or limited range of practical and commercially viable applications.

3) Frequency of exchange refers to the cost of a business's investments with a specific or limited set of practical and commercially feasible uses.

Consequently, economic structures and procedures have developed to help enterprises reduce volatility, specialize, invest, and improve the frequency of their transactions (Williamson, 1979). Legal systems, trade groups, grading and standardizing schemes, informal standards of conduct, and certification processes are just a few examples (Minot, 2007). These organizations will not eliminate stock market exchange risks, but they will help enterprises face fewer costs. Vertical integration via CF may provide a solution to these threats.

Three strategies for mitigating risks associated with CF are as follows:

(1) Providing a secure marketing channel for farmers and reducing the danger of fraud and deception.

(2) Enabling farmers to invest in specialized assets such as perennial shrubs or curing facilities as a result of a guaranteed selling route and, perhaps, financing; and

(3) Fostering recurring exchanges between farms and businesses (Young and Hobbs, 2002).

Another manner in which CF reduces uncertainty is through its unique characteristics or qualifications. Retailers must maintain the legitimacy of their products in this situation. This increases the cost of data distribution to appropriate distributors, as well as the control and compliance fees incurred by these and other upstream entities (Young and Hobbs, 2002). CF is one strategy for reducing these costs.

3.7.3 The Theory of Contract Enforcement

Contract enforcement theories concentrate on the incentives for contract adherence. Private incentives (the match between contract terms and market conditions at the time of sale), public incentives (such as legal remedies), or a combination of both (Klein, 1996). Both parties consider the risks and benefits of breaching their contract at any time during the contract (Gow et al., 2000). A "holdup" occurs when market dynamics shift quickly, making the incentives of extending or terminating the contract higher than one party's capital and prestige losses (i.e., settlement will be postponed, and the contract will not be honored). In contrast, the contract will be honored if the benefits projected by these unforeseen revisions do not outweigh the losses in resources and reputation. Gow et al. (2000) define the "self-enforcement range" as the range within which the contract will be performed, as shown in Figure 3.2. (PoA and PoB)

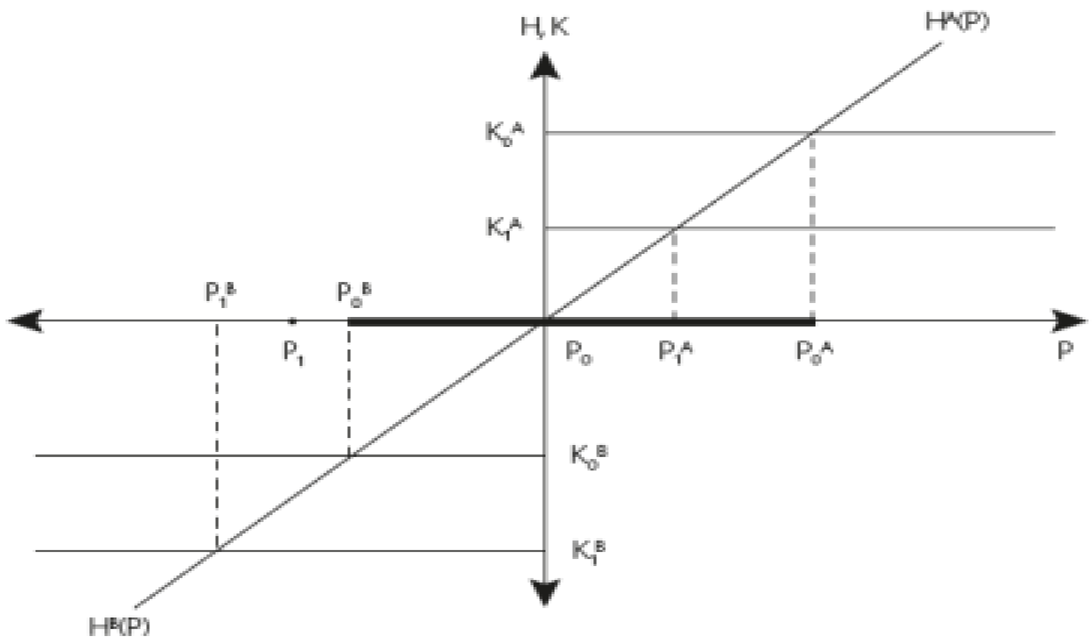


Figure 3.2: The Self-enforcing Range in Contracts
Source: Gow and Swinnen (2000) cited in Prowse (2012)

As shown in Figure 3.2, Farm A and Firm B stand to gain as a result of Farm A agreeing to supply Firm B with a certain product at a specific price P0, but they also stand to lose as a result of this agreement. Because of the contract's price specification, if the external market price rises over P0, Firm B will be able to charge rentals to its customers. Farm A, on the other hand, may be persuaded to terminate the contract if market prices considerably climb (as it can sell the produce for greater profit in spot markets). The increased revenues from Farm A's side-selling produce are insufficient to compensate for the reputational, capital, and discounted future-income losses sustained as a result of this contract breach (indicated as K1A), and the contract is honored as a result of this breach. The contract is terminated above P0B because the increased revenues from side-selling outweigh the losses in Farm A's reputation, capital, and discounted future income. Farm A's reputation, capital, and discounted future income losses are offset by the increased revenues from side-selling (indicated above K0A).

Alternatively, P0B marks the lower limit of the self-enforcement range, over which it becomes more profitable for Firm B to violate the contract and purchase the commodity on a spot basis from the open market (with K0B being the sum of reputation, capital and discounted future income losses if the contract was broken). Due to this, Firm B wishes to terminate the contract at Point 1B (with losses illustrated as K1B).

Keeping contracts is driven by more than simply short-term financial benefit; it also involves long-term prestige, integrity, and profit. From this, three inferences can be drawn: (1) the capacity to establish secure and mutually advantageous contract-farming arrangements is based on relatively stable market circumstances as much as the exact structure of the contract. (2) Small farmers in undeveloped countries are often less concerned with ethical losses than they are with urgent income access and (3) by raising the size of the contract, such arrangements can be devised to reduce the chance of default (through real resources or other means).

3.7.4 Convention Theory

The idea of convention method focuses heavily on the product's quality qualities. Product prices are intended to reflect all relevant qualitative qualities in well-established markets with perfect competition. Certain quality conventions can aid in the smooth operation of commerce when the quality criteria are stringent or the product quality is ambiguous (Young and Hobbs, 2002). A few instances of cooperation include market coordination, family coordination (based on long-standing connections and trust), industrial coordination (based on thresholds enforced by a third party), and civic coordination, among others (where there is a collective agreement among firms to avoid conflicts and set standards).

When implemented as a long-term strategic partnership, CF can function as a form of domestic coordination in which historical relationships and trust play a critical role in establishing the partnership's quality. Like the following conceptual realm, value-chain governance, convention theory makes it much easier to grasp how specific standards are developed.

3.7.5 Value-Chain Governance

In the realm of CF, value chain approaches are critical. The term "value chain" refers to the process of coordinating farm inputs, produce, farmers, and marketing organizations in order to give improved services. According to Humphrey and Memedovic (2006), value chain governance aims to solve two critical challenges in CF: demand for non-standard products and risk management.

Lead firms can also direct and/or persuade other firms to engage in specific dimensions if two criteria are met: economies of scale (which gives large firms greater influence over smaller enterprises) and the availability of sanctions (which allows leading companies to engage in specific dimensions) (such as creating, or increasing the height of, a barrier to entry). Therefore, according to Prowse (2012), value-chain governance is defined as a company's endeavor to impose control over its supply networks.

Markets, networks, and hierarchies are the three types of coordination that have been discussed in the literature. Take into account the complexity of the data to be conveyed, the ease with which it can be communicated, and the supplier's previous expertise before making a decision (Williamson 1979). As previously stated, standard products that do not involve the transfer of information are constantly exchanged on the open market in order to keep prices stable. Niche or exceptionally distinctive commodities, on the other hand, are traded through networks or hierarchies that rely on the knowledge of suppliers and the ease with which information about the product's quality and qualities may be transmitted to facilitate the exchange of commodities.

In network coordination, there are three distinct approaches: relationship linkages (also known as strategic partnerships with a degree of interdependence), captive linkages (in which small upstream suppliers are dependent on larger downstream buyers), and modular linkages (in which small upstream suppliers are reliant on larger downstream buyers) (where the customization of product occurs without substantial interactions or investment in specific assets, thus allowing flexibility in entering and exiting the value chain).

Farmers in CF function as a captive provider to the enterprise, which is a common instance of captive network coordination in the industry. There is a hierarchy formed when a single administrative body, often a firm, is responsible for and controls many supply chain nodes at the same time (in other words, vertical integration, with internal control coming from a centralized decision-making structure). As noted in the value-chain governance literature as well as convention theory, private sector enterprises, as well as state and non-state entities, are interested in regulating and managing commodity chains (often in concert). In addition to convention theory and, as previously said, value-chain governance is concerned with the increasing role of standards in the building of value chains.

3.7.6 Competency/Capability Theories

To emphasize on enterprise interactions, transaction-cost approaches and value-chain governance are used in CF, whereas other models and theories focus on enterprises' fundamental qualities and attributes. To put it another way, "from a competence perspective, individual or team competences, abilities, and implicit knowledge that are cultivated and maintained by that organization explain in some manner the existence, structure and limits of the firm" (Hodgson, 1998; Young and Hobbs, 2002).

It is apparent that the ability to set up and manage CF is strongly reliant on the expertise, experience, and willingness of the organization to optimize these factors. For example, if management can generate and efficiently use information, the tacit expertise of specific workers, which has been built up over decades, can only boost productivity and profitability.

Additionally, proponents of that approach argue that corporate expertise is intrinsically superior to market knowledge, arguing that practical knowledge in the form of competencies, which can be found only in a structured group of people, would not thrive in a world of contracting and re-contracting agents. This is a subject that is sometimes overlooked in CF literature: the operational expertise of individuals doing the operations is unquestionably critical to contract farmer activities being effective (Prowse, 2012).

3.7.7 Political Economy of Agrarian Change

During the 1970s and 1980s, the "political economy of agricultural reform" was a popular school of thought in agricultural policy. It was documented in the then Marxist and neo-Marxist corpus of study that agricultural civilizations were more deeply linked to capitalism than they were previously recognized, particularly in terms of class change but also in terms of gender and the reproduction of the kind and family, based on control over land, labor, and capital (Shanin, 1987; Hartmann and Boyce, 1983; Mackintosh, 1989; Murray, 1987).

CF was frequently viewed as a way for capital to profit from the peasantry's excess value. The following are the major characteristics of this school's understanding of CF: According to (Little and Watts, 1994; Glover, 1984, 1987, 1990): (1) Monopsonies are widely employed in contracting to promote efficiency; (2) They result in self-exploitation, as farmers choose to give control of their land and labor in exchange for payment proportional to the value added to the output; (3) Farmers opt to give up control of their land and labor in exchange for a remuneration that does not reflect the value they provide to the product, resulting in self-exploitation; (4) Despite their poor resistance and losses from big disasters, farmers normally carry all output risks; (5) Farmers are semi-proletarianized or pauperized peasants with limited authority over or ability to run their own farms for personal gain; (6) Farming contracts frequently shift the allocation of labor and income in the core household to women, and they frequently include child labor; (7) By acquiring land from the campesinos, CF establishes a class of farming capitalists, hastening the proletarianization of lesser farmers; and (8) Lower food output means higher local food costs - contract farmers' inputs could mean fewer spot markets and higher prices for non-participants.

Risk transfer to producers, intra-house difficulties, and spillover effects are all topics that are currently being discussed in current CF talks.

3.7.8 Comparative Review of Theories

As previously stated, this review does not seek to reconcile or rank the theories and concepts offered above. It just introduces them before considering attempts to combine the economic and managerial working bodies (in other words, all the strategies outlined above save value chain governance and the 'political economy of agricultural change'). Young and Hobbs (2002) conducted the synthesis, which is seen in Figure 3.3.

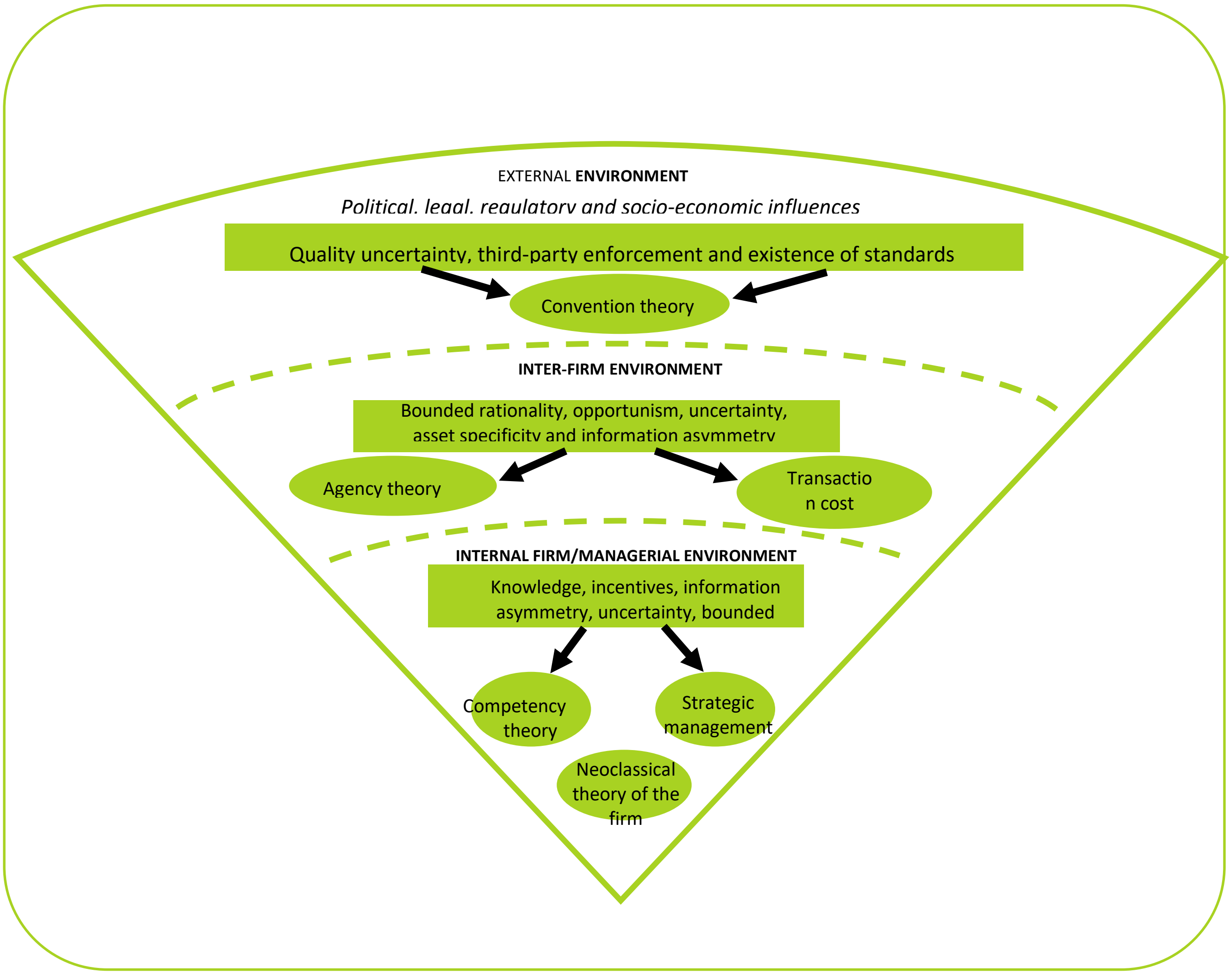


Figure 3.3: Synthesis of theoretical and conceptual approaches to contract farming
Source: Young and Hobbs (2002)

Some of the external context in which vertical integration and CF occur is shown in Figure 3.3, starting at the top. When it comes to providing public goods such as research and development, there is a significant lack of government involvement. Transaction costs, in conjunction with the principal-agent/agency model, play an important role in this section. Value chain insights can be used to both the top (based on standards) and middle segments of the value chain (on the governance and co-ordination of commodity chains). The bottom rung of the organizational hierarchy is occupied by the firm's management. The neo-classical firm theory, strategic management strategies, and competency/capability theories are all represented here.

The most developed body of work in this regard is transaction-cost economics. A good starting point here is the assertion by Minot (2007, p. 1) that:

"*In order to justify contracting, you must have at least one of the following: 1) the buyer is a large corporation (such as a processor, an exporter, or a supermarket chain); 2) significant quality variations exist; 3) the product has a high value-to-bulk ratio; and 3) the product has a high value-to-bulk ratio*".

These three conditions must all be present to justify contracting.

An abundance of contract-farming literature, much of it framed in terms of transaction-cost economics, supports the following claim: When it comes to products, non-perishable traditional crops are usually supplied on the spot market (since the transaction costs are low). Businesses in the agribusiness sector need improved control over plants that have a wide range of quality and die rapidly because they are difficult to grow.

Contracting will become more common for commodities with higher per-kilogram pricing as a result of increased costs (as all of these aspects increase transaction costs). Aside from these purposes, CF is used for "high-quality fruits and vegetables; organic products; spices; flowers; tobacco; seed crops; dairy products; and poultry". Large-scale plantation or estate production can be more cost-effective if the goods (such as bananas or sugarcane) benefit from huge economies of scale (although these often contract out-growers too). In addition, Minot (2007) provides a strong case for the use of huge firms in most CF arrangements. It is necessary to have a large staff of extension workers to interact with farmers, communicate with them, and keep an eye on their progress for such collaboration to be feasible. For large firms, it is far easier to tolerate fixed costs.

Since it has already been said, this is a delicate subject, with many detractors challenging the ability of smallholders to take part in CF in an increasingly globalized world. According to these assertions, the global food supply system is undergoing a significant transformation, with smallholder farmers being left behind as a result (Maxwell and Slater, 2003; Vorley and Fox, 2004). However, contrary to popular assumption, many small farmers have realized the benefits of such alliances and collaborations (particularly where the landholding structure is extremely even, such as in China).

3.8 Productivity and Efficiency

The proportion of output and its growth variables are used to determine productivity. It also displays how well input components are utilized in the production of output. According to Attar et al. (2012), productivity is defined as the ratio of output to resources. They also believe that depending on the raw materials, energy, capital, labour, and other resources used, production might be homogeneous or heterogeneous. They also mention that, production can be homogeneous or heterogeneous, and that the tools used in production include, among other things, raw materials, water, money, and labor. Therefore, productivity measures can be classified in two large categories, namely partial productivity measures relating to a specific output quantity to a single input unit as well as to total productivity measures related to a specific production quantity in the process.

Although mostly used interchangeably, the terms efficiency and productivity are not the same. They are however alike. Some authors, on the other hand, distinguish between the two concepts. Fried et al. (2008) define efficiency as a production unit's effectiveness in terms of the utilization of available resources for production, taking into consideration available technology and comparing it to a standard production frontier. According to Farrell (1957), a company's efficiency is defined as its ability to generate goods utilizing a specific input. Efficiency is called the degree to which inputs (time, energy, costs) are used to produce a certain output level. Efficiency is generally defined as the performance level. Performance estimates are more accurate than productivity predictions even though efficiency and productivity can be used interchangeably. They are stacked or weighed against the most effective frontier. As a result, the percentage of inputs to outputs can be used as a measure of efficiency. Efficient markets, efficient prices, and efficient farms are all examples of economic concepts that employ the term efficiency. An organization can, in general, do technical or advanced engineering tasks. An allocative efficiency assessment evaluates a company's capacity to select the most cost-effective input options at a given set of input costs (Daraio and Simar, 2007).

Kebede (2001) defines TE as the maximum level of yield for a given input and the widest range of technologies that can be employed by farmers. Further, he argued that TE does not always imply EE, characterizing EE as a hybrid of allocative and transitive expressions. Technical and allocative efficiencies do not always go hand in hand. The degree to which output can be improved to the most efficient scale is referred to as "scale efficiency." Size efficiency is maximized with a scale elasticity of one (Coelli et al., 2005).

In classical microeconomics, efficiency is defined as a company's or an entity's ability to create outcomes from a specific quantity of inputs at the lowest production costs. The concept of efficiency leads us to believe that a high degree of efficiency in production is the outcome of a mix of inputs resulting in higher output levels. However, there are several variables that could impede the achievement of these increased expectations. As a result, applied and theoretical economists alike are paying close attention to the concept of efficiency. Productivity analysis and production literature is dominated by empirical estimations of efficiency (Coelli et al., 2005).

Efficiency is mostly characterized within the classical microeconomic context as the ability of a business or an entity to produce results from a certain number of inputs with the lowest costs of production. It can be deduced from the definition of efficiency that an efficient production level is a combination of inputs that results in greater output levels.

3.8.1 The Concept of Efficiency

In 1957, Farrell created the concept of efficiency, which established a framework for measuring efficiency. According to Farrell (1957), TE (output) and AE are two components of efficiency in a production unit (price). The ability of a firm to obtain the highest number of units from the domain of available inputs, or to reduce the number of inputs utilized in the production of a certain output vector, is referred to as TE. To put it another way, a farmer is considered more technically efficient than his counterpart if he generates significantly more output from the same set of inputs.

Kalirajan and Shand (1999) proposed in their seminal article that a firm's performance is measured by the level of efficiency of both components, namely technical and AE, as proposed by Farrell (1957). To explain the disparities in frontier output "efficient levels" and the actual results observed, theoretical models based on the definition of production efficiency were developed. Individual companies' performance in relation to an estimated frontier is determined using regression and linear programming methods. In light of the minimal amount of input required to produce any output, the production frontier is linked to the greatest feasible output level.

To put it another way, it's the place or location where each input combination produces the highest possible result.

A production unit will only be deemed effective if it is located at a production line, as stated by Farrell (1957) and Debreu (1951) respectively. Nonetheless, due to the abundance of inputs available, the firm's failure to produce the frontier level of output is certified as technical inefficiency (Kumbhakar, 1994).

Figure 3.4 depicts the conceptualization of a multi-output multi-input production technology for a cross-sectional set of data. Assume a farmer generates two outputs (y_1 y_2) from a vector input set (x), and y* represent the production possibility frontier (PPF), as shown in Figure 3.4.

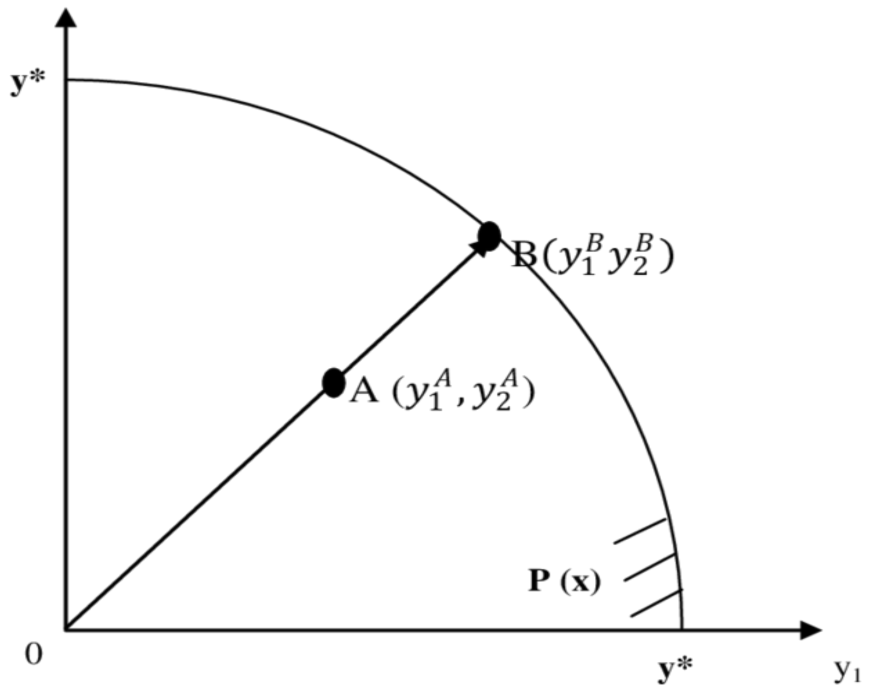


Figure 3.4: Output Distance Function with Two Outputs (y1, y2)

Source: Kumbhakar and Lovell 2000

The Production Possibility Frontier (PPF) curve displays all possible combinations of technically efficient output production points (y1, y2) that can be generated with the input vector (x) while keeping inside the viable production area P, according to production theory (x). Any place outside of this zone (region B) is a suboptimal point for production, according to stochastic frontier production theory concepts. In Figure 3.4, point A is judged inefficient, but point B is deemed efficient, with point A's inefficiency represented in its distance from point B (which lies at the frontier). According to Coelli et al. (2005), the proportionate growth of output A to point B, the efficient point of production, can be accomplished through upward scaling using a scalar (θ) that must be minimized.

$$D_o(x,y) = OA/OB \leq 1 \quad \text{thus} \quad D_o(x,y) \leq 1 \qquad (3.1)$$

$$D_o(x,y) = 1/TE_o \quad \text{thus} \quad TE_o \geq 1 \qquad (3.2)$$

The output distance $D_o(x,y)$ is the reciprocal of the output vector's maximum proportional extension (y), taking the input vector (x) into account, and fully characterizes the technology. According to Brümmer et al. (2002), the inverse of the distance function can be considered a performance measure that adheres to Debreu and Farrell's (1951) measure of output-oriented TE (TE_0). B indicates a position on the frontier curve where θ = 1 and indicates full technological efficiency. There is technical inefficiency at point A, θ < 1, as a result. Furthermore, any location above B is in an infeasible manufacturing zone. Depending on the production technology represented, several decompositions of productivity improvement can be derived. According to Brümmer et al. (2002), using the output distance function technique in a continuous time framework has additional components that account for the implications of shadow share fluctuations for outputs and inputs. In this study, the output approach function proposed by Brümmer et al. (2002) was used.

3.8.2 Further Definitions and Efficiency Types

Farell (1957) distinguishes between three types of efficiency: Allocative Efficiency, Technical Efficiency (TE) and Economic Efficiency (EE).

3.8.2.1 Technical Efficiency (TE)

TE, according to any technology, is a company's ability to create the required output while using the least amount of input (Fried et al., 2008; Shalma, 2014). A more technologically advanced business can produce larger volumes of production than other businesses using equal amounts of inputs from a combination of different input sets (Fried et al., 2008). TE is described as a company's ability to lower its input into the production system while the output is being produced when the output is predefined.

The actual output produced by a company is dependent on the maximum production limit when measuring a firm's TE (Pascoe and Mardle, 2003; Fried et al., 2008; Farrell, 1957). Actual and projected production can be compared to determine TE requirements (Greene, 2008). Some socio-economic factors can impact a production unit's efficiency significantly. Human and monetary capital, socioeconomic and demographic traits, and institutional factors affecting farmers are among these elements (Bhosale, 2012). Farmers' control factors can be endogenous or exogenous, allowing for a clear separation between them (Battese and Tveteras, 2006).

Technical efficiency studies are vital for agricultural productivity. Several Studies, including Onumah et al. (2010), Battese and Tveteras (2006), and Mohammed et al. (2016). have adapted technical efficiency studies across several agricultural sectors of fisheries and crop production. Agricultural efficiency studies use deterministic parametric estimation, non-parametric mathematical programming, and stochastic parametric estimation. Not all non-parametric measurements are equal. The first strategy is founded on neoclassical theories of consistency, regenerability, and extrapolation, as well as the constraint of the production form (Shalma, 2014).

According to Farrell (1957), efficiency is separated into two parts: technical and AE. This was expanded by Fare et al. (1985) to include the limited assumption of constant returns to scale. The technical and allocative components have multiplicative relationships, according to Farrell (1957). Measuring TE is thus necessary but not sufficient for determining EE (Farrell, 1957).

Notably, measuring TE assumes that the production factors are homogeneous. There won't be much of a problem if all enterprises use the same inputs. The TE of a company will reflect both the quality of its inputs and the efficiency with which they are managed. As a result, if TE is defined in terms of a set of businesses and production factors, input quality varies between organizations (Farrell, 1957). As a result, firms' allocative and TE are estimated to define industries' EE.

3.8.2.2 Allocative Efficiency (AE)

While TE is concerned with getting the highest output from a given set of inputs, AE is concerned with a company's ability to make the best use of those inputs (Etwire et al., 2013). The ability of a firm to mix its production parts and allocate resources to input factors while accounting for current market prices is referred to as allocative or cost efficiency.

AE is reliant on market-determined input pricing and a consistent output. Thus, AE is defined as a producer's capacity to mix input elements optimally (which is constrained by the prices of production factors). As a result, AE evaluates how successfully a company selects the best inputs for production (Fried et al., 2008). It measures an organization's efficiency in using resources rather than its performance against the production frontier (Fried et al., 2008). According to Adinya and Ikpi (2008) and Badunenko et al. (2008), substantial AE studies are critical in Africa because most farmers are inefficient because of their incapacity to make the most of the resources at their disposal. However, due to the difficulties in acquiring input costs, which are critical for assessing AE, such studies are difficult to conduct. Aside from knowing the pricing of various inputs, it's also vital to be willing to believe that the company's principal goal is to minimize cost (Uri, 2001). Efficiency studies are inadequate without AE, particularly in developing nations with limited resources. (Kuosmanen and Post, 2001).

Recent studies including (Sulayman, 2014; Inkoom, 2016; Masuku et al., 2014) have at attempted to estimate AE by determining and applying upper and lower bounds on

EE, which is especially useful when input pricing data is incomplete or missing. Therefore, it is an important AE statistic, particularly in countries where input price data is not readily available or accurate (Kuosmanen and Post, 2001).

3.8.2.3 Economic Efficiency (EE)

According to Farrell (1957), EE is a firm's ability to generate a specified output at a lower cost. It's worth noting, though, that estimating a production system's optimal output in a real-world context can be difficult (Kumbhakar and Lovell, 2003). The idea of scarce resources, which states that no economy can constantly operate at maximum capacity underpins and connects the concepts of EE. Due to a scarcity of resources, this is not possible.

The comprehensive assessment of production facilities taking the factors of input and output into consideration is an important advantage of EE studies (Coelli, 1995). Technical, allocative, and EE are the three components of efficiency (Farrell, 1957). According to the author, technical and AE lead to economic production efficiency. Also, according to Farrell (1957), a firm must be technically and allocatively efficient to be deemed economically efficient.

The concept of frontier production was thus founded on Farrell's (1957) efficiency concept. Because the production function defines an appropriate input mix for any given output that minimizes the cost of making that much of output, technical and AE can be determined as components of EE from it. As a starting point, Figure 3.5 depicts Farrell's efficiency measurement technique. Under conditions of constant returns to scale, it is assumed that a soybean farmer uses only two inputs (X and Y) to create a single output (P).

Due to these assumptions, the production function may be represented graphically using a simple isoquant diagram, designated in Figure 3.5 by SS'. Additionally, this author assumed that the efficient production function was already known; otherwise, it would have to be discovered by one of several sample data-based procedures.

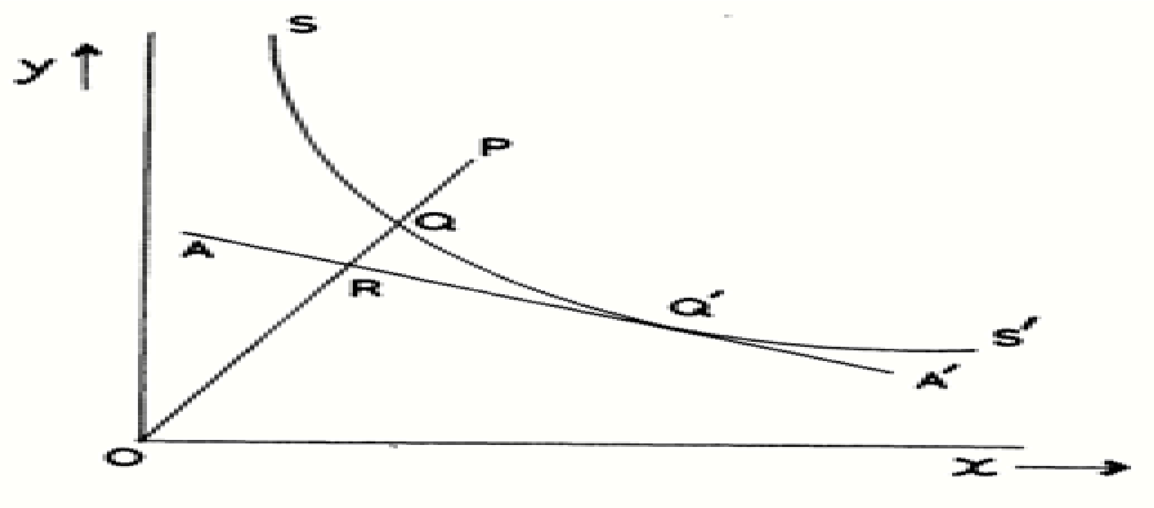


Figure 3.5: Measure of Technical and Allocative Efficiencies of Production
Source: Ajibefun (2008)

The point P denotes the quantity of two components per unit of output that the business is known to employ. The isoquant SS' denotes various combinations of the two components that a completely efficient firm might use to generate a unit output. Additionally, because SS' is the lower bound of a scatter with the same output level, Q and P are isoquants. The point Q denotes a productive firm that utilizes the two components in the same proportion as P. It may be proved that it accomplishes the same result as P while utilizing only a fraction of the OQ/OP of each factor. It creates OP/OQ times the amount of output from the same inputs. As a result, Firm P's TE is OQ/OP. The distance QP, which is the proportional reduction in all inputs without reducing outputs, demonstrates the firm's technological inefficiency. If the ratio equals one, the business is technically efficient. If the ratio falls below one, the business is inefficient.

Using the same schematic as before, the firm's price, or AE, may be computed. This metric assesses how well a company uses the key production elements in the most cost-effective proportions. The budget line's slope, denoted by AA', is equal to the price ratio of the two production items. As a result, the optimal placement becomes point Q', where the isoquant curve is tangential to the budget line. The corporation is currently both technically and allocatively efficient. The AE is denoted by the OR/OQ fraction.

Again, because it is on both SS' and AA' , the producer utilizes his resources technically and allocatively efficiently at point Q'. As a result, the soybean farmer on Point Q' is considered economically efficient. The formula (OQ/OP)*(OR/OQ) is used to calculate EE. As a result, EE is a product of both technical and AE considerations.

While EE requires technical and AE capabilities, Aung (2012) claimed that agricultural enterprises could demonstrate technical and AE capabilities without exhibiting EE. For EE measurement, input and/or output quantity data, as well as input and/or output pricing data and producer behavioral assumptions, are necessary.

Producers' behavioral assumptions may include cost minimization, profit maximization, and revenue maximization. The frontier of each behavioral assumption is used to determine efficiency (Kiatpathomchai, 2008). According to Chukwuji, Inoni, Ogisi, and Oyaide (2006), EE is accomplished by integrating resources to obtain the smallest possible (technical) maximum production while also ensuring the lowest possible cost (allocative).

As a result, a cost-effective production set requires more than TE. The input combination should be carefully chosen based on its price. As a result, the junction point of the isoquant and isocost curves, at which technically viable production units are produced at the lowest possible cost, is the optimal combination of pricing inputs (Erkoc, 2012).

Two distinct ways for calculating a firm's EE have been developed under the auspices of mathematical programming and econometric methodologies (Erkoc, 2012). Charnes, Cooper, and Rhodes (1978) proposed the Data Envelopment Analysis (DEA) approach of mathematical programming. The DEA advises that efficiency be determined using linear programming in a single output-input form with multiple outputs and inputs. However, due to the non-stochastic nature of DEA, researchers are frequently unable to obtain comprehensive and long-lasting results. As a result, an econometric technique or stochastic frontier analysis (SFA) became preferable due to their ability to disentangle the TE influence of changes from external stochastic errors on the firm's output. This study used a stochastic frontier approach to estimate the EE of contractual soybean farmers and this was establish whether participating in an intervention such as CF will lead to an increase in efficiency on the part of the treated group (contract farmers/participants) more than the control group (non-contract farmers/non-participants).

Farmers' direct EE improvement gains, according to Kiatpathomchai (2008), are tied to cost savings or enhanced gross margins. Farmers might, for example, cut total variable expenses from EUR 236.56 per hectare to EUR 212.89 per hectare (a reduction of EUR 23.65 per hectare) while still producing 3,411 kg of paddy with a 10% increase in EE. In other terms, a 10% increase in EE raised the gross margin per acre by EUR 23.65.

3.9 Other Concepts of Efficiency

3.9.1 Scale Efficiency

When a firm's scope and scale are perfect, changing a production unit's size makes it less efficient, it displays a firm's size and capacity. This efficiency has evolved in three ways (Fried et al., 2008). It required high input disposability and a constant return to scale, as used by Farrell (1957).

According to Banker et al. (1984), measuring efficiency by constant returns to scale is the product of a scale efficiency measure and a model of TE. The third scale model involves a non-linear production function (translog or Cobb-Douglas) from which a scale measure can be determined quickly (Sengupta, 1994).

3.9.2 Structural Efficiency

Farrell (1957) developed this method to assess the industry's ability to keep up with the output of its own best-practice firms (Fried et al., 2008). As a result, it establishes the maximum possible farm size for the sector and the degree to which the industry's short-term production level is successfully allocated. When the distribution of the best enterprises in an industry is more concentrated than the sector's overall efficiency boundary, the industry is structurally reasonably efficient. Bjurek et al. (1990) suggested a method for determining structural efficiency measures that entailed generating an average unit for the entire enterprise agglomeration and then computing individual efficiency measures for this unit (Fried et al., 2008).

Along with the major efficiencies, some authors have examined secondary efficiencies (Gonzalez-Vega, 1998; León, 2001; Alpzar, 2007). Gonzalez-Vega (1998), for example, investigates five additional categories and classifies them according to the actions that production units should do to attain maximum efficiency:

i) Technological efficiency: the ability to select the most appropriate technology (production function) for each output;

ii) Dynamic efficiency: the capacity to rapidly absorb new products and processes;

iii) Approach efficiency: the ability to select relevant technologies based on the type and severity of each market challenge;

iv) Pure TE: utilizing no more inputs than are necessary to generate a particular quantity of output, given existing technology.

v) Joint-production efficiency: determining the most economically viable combination of output given the opportunity to produce scope economies.

3.10 Approaches to Measurement of Productive Efficiency

In any study area the original promoter of an idea is often probable, but hard to track. In economics, the case is no different. The managers of corporations, associations and public agencies find that certain efficient units in an enterprise or company had higher productivity outputs than others. The production efficiency has become important. Competition between companies or public agencies in the same sector has increased and increased efficiency is needed. To assess client performance, correct methods must be employed.

Organizations conduct performance measurement and analysis in three distinct methods. These approaches are classified as parametric (deterministic and stochastic), non-parametric (data envelopment analysis, DEA), and semi-parametric (Coelli et al., 2005). Efficiency metrics are used to motivate firms to plan and set goals for future productivity growth. Firm management is capable of identifying best practices with higher estimated efficiencies and reorganizing inputs and other resources in order to maximize their efficiency, i.e., their distribution and allocation.

3.10.1 The Parametric Approach (Stochastic Frontier)

Suffice it to say that Koopmans' 1951 paper was the starting point for stochastic frontier analysis. According to Koopmans (1951), for a corporation to be called technically efficient, it must be able to generate more output with less input. According to Debreu (1951), the frontier function is a measure of the TE between the frontier function and the observed output function. These discoveries led to a significant shift or paradigm shift in frontier analysis approaches. Following

Koopmans (1951), Debreu (1951) and Farrel (1957) used stochastic frontier (parametric method) to estimate an empirically efficient output. The parametric programming methodology investigates the deterministic and stochastic frontier approaches that use cross-sectional or panel data (Aigner & Chu, 1968; Ali & Chaudhry, 1990).

3.10.2 Deterministic Frontier Approach

The deterministic frontier is determined using either mathematical programming or econometric methods, whereas the stochastic frontier is computed primarily using econometric methods. In cross section, the deterministic frontier model according to (Aigner & Chu, 1968, Ali & Chaudhry, 1990) is defined as:

$$Y_i = f(X, \beta)\exp(u_i) \quad \text{.........} 3.3$$

Where:

i = 1, 2, 3…N

Yi = denotes the possible production level for the *i-th* sample farm bounded by a deterministic component *f (X; β)* shown above.

β = refers to the unknown parameters to be estimated

μ_i = the inefficiency component in the production process and it is a non-negative random variable

Xi = inputs for the *i-th* farm

N = Sample size

The TE of individual farm Yi to the corresponding potential frontier output Yi* is given as:

$$TE = \frac{Y_i}{Y_i^*} = \frac{f(x_i;\beta).\exp(-u_i)}{f(x_i;\beta)} = \exp(u_i) \quad \text{...3.4}$$

All discrepancies in production are assigned to technical inefficiency effects by the deterministic frontier technique, regardless of whether the deviations are caused by random errors such as weather effects and measurement errors that are beyond the producer's control.

3.10.3 Stochastic Production Frontiers

Stochastic Frontier was created using a model developed by economists such as Meeusen and Van den Broeck (1977) and Aigner et al. (1977). Two error terms are included in the model. Unobserved inputs contribute to the technical inefficiency error, which accounts for the error term's unilateral component. The two-sided error occurs because of circumstances that contribute to increased data noise. Noise can be caused by random and exogenous shocks that are beyond the control of the production unit, as well as measurement and statistical noise issues (Aigner et al., 1977; Meeusen & Van den Broeck, 1977).

Additionally, the model can be used to test hypotheses and create confidence ranges (Wadud & White, 2000). The disadvantage of this method is that it requires knowledge of both the underlying functional structure of the production frontier and the distribution of an error term, which results in technical inefficiency. When several inputs and a single output are required, the stochastic production frontier is utilized; however, it is confined when multi-input and multi-output modeling is necessary. In this paradigm, random noise and inefficiency are the two types of errors. This kind of TE analysis is used to demonstrate that deviations from the production frontier are not always under the control of the production unit.

Environmental shocks, which are not under the manufacturer's control, may play a role in causing unpredictability (Kebede, 2001). The effects of both the environment and disease on the plant's output value are examples of natural or extra shocks. These impacts can be differentiated from variations in the TE of the model's application. The stochastic frontier function is given by;

$$Y_i = f(X;\beta)\exp(v-u) \qquad 3.5$$

Where:

Yi = denotes the output

X = input variables

β = is a vector of technology parameters.

To approximate the distance function of the production unit, the stochastic frontier function uses a one-step stochastic performance distance approach. The multi-output method's functional performance degree is then calculated by inverting the distance function (Brümmer et al., 2002).

3.10.4 The Stochastic Frontier Model

Both Aigner et al. (1977) and Meeusen & Van den Broeck (1998) proposed the stochastic frontier model (1977). They state unequivocally that external noise impairs productivity by introducing errors, and that it is vital to distinguish the influence of exogenous error events from technical inefficiency caused by faults. As previously stated, they displayed an error term caused by external noise and inefficiency.

The frontier technique is used to create a connection between inputs and outputs in the study of TE. It makes use of a number of functional strategies. Cobb-Douglas and translog output functions are the most frequently utilized. The hypothesis test will establish the functional form that is most appropriate for this study.

For the SPF model, the Cobb-Douglas specification is:

$ln\ Y_i = \beta_o + \sum_{i=1}^{n} \beta_i\ ln\ Xi + \varepsilon_i$..3.6

$\varepsilon_i = v_i - u_i$...3.6.1

$ln\ Y_i = \beta_o + \sum_{i=1}^{n} \beta_I\ ln\ Xi + v_i - u_i$..3.7

where:

v_i = the noise component; it is bidirectional and has a normal distribution.

u_i = the non-negative technical inefficiency term.

The translog stochastic frontier output function specification was used in various efficiency studies. The specification is mostly utilized in production analysis. This definition makes no assumptions regarding the homogeneity or separability of its constituents. The model has the advantage of not limiting the function's variable substitution flexibility. Another advantage is that it enables the function to consider many input variables (Berndt & Christensen, 1973). This computational model is robust, with no severe constraints on the system's parameters and inputs. However, the functional form has a few disadvantages including the presence of multicollinearity among the data variables (Abdulai and Huffman, 2000).

Also, it demands a larger sample size. For each measurement, inefficiency is calculated further to produce a technical inefficiency benefit. A half-normal, gamma, or truncated normal distribution will be denoted by the term inefficiency, u_i. Typically, maximum likelihood is used to compute the stochastic frontier, although Kumbhakar and Lovell (2000) advocate using the moments approach.

When output reaches one, the stochastic frontier method has been accused for failing to anticipate performance. The difficulty of calculating multi-outputs can be solved using the distance function method. The inclusion of many functions, on the other hand, enhances the potential of endogeneity (dependent variables on both sides of an equation) and exogeneity (dependent variables on both sides of an equation). The problem of endogeneity, according to Kumbhakar and Lovell (2000), has no effect on the model and can thus be neglected.

Coelli & Perelman (2000) agreed with this viewpoint and reached similar conclusions. Because the Cobb-Douglas has some definitional restrictions, the implementation of the principle of translog specification includes the unitary elasticity of substitution between the inputs and total returns to match at all input and output stages. The Flexible Functional Forms (FFF), which is commonly used to define the production frontier, includes the translog.

Generally, the FFF can be expressed as:

$$f(y) = \beta_o + \sum_{i=1}^{n} \beta_i g_i(x_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{i=1}^{m} \beta_{ij} g_i(x_i) g_j(x_i) \qquad 3.8$$

Where:

each g_i is a known twice-continuously differentiable function of x_i, and $b_{ij} = b_{ji}$.

The quadratic, translog, normalized quadratic, and generalized Leontief specifications are some of the most often used FFF specifications. The model described above examines a technology situation with a single output and several inputs.

3.11 Non-Parametric Frontier Approach

In 1957, Farrell developed Data Envelopment Analysis (DEA), a non-parametric efficiency analysis technique. The DEA approach is distinct from regression-based approaches. The DEA is a programming method that utilizes multiple inputs and outputs. DEA is a non-parametric technique for determining the efficiency of decision-making units (DMUs) that makes use of mathematical or operations research programming tools. Charnes et al. (1978), followed by Banker et al. (1980), familiarized and humanized the DEA. This technique has achieved significant adoption and is currently used to evaluate a business's technological efficiency.

The Charnes, Cooper, and Rhodes (CCR) DEA model, which compares inefficient operations to best practice firms within a group, was established on the basis of Farrell's work by Charnes et al. (1978). The concept of continuous scale returns serves as the foundation for this system. A new constraint was added to the CCR model in order to allow for different returns to scale, and the Banker, Charnes, and Cooper (BCC) DEA model was established to account for this. DEA has been frequently employed in studies of the efficiency of both the public and private sectors. DEA has been used in agricultural economics in a number of researches, including those by Wang et al. (2014) and González-Flores et al. (2014).

The purpose of this study was to determine the impact of CF on the EE of soybean farmers who were either contractual or non-contractual. There has been a great deal of research into efficiency, utilizing either a parametric technique such as stochastic (production, cost, or profit) frontier analysis (González-Flores et al., 2014) or a non-parametric technique such as Data Envelope Analysis (DEA) to analyze efficiency (Wang et al., 2014). However, there are some disadvantages to employing the DEA technique, including attributing nonconformities at the production frontier to inefficiency, assuming no stochastic errors and therefore being sensitive to outliers, and assuming no stochastic errors and hence being susceptible to outliers (Wang et al., 2014). According to Kebede (2001), this limitation limits the applicability of the method to agricultural studies, where production is frequently influenced by uncontrollable factors such as weather, natural catastrophes, droughts, and unobservable characteristics of farmers.

According to González-Flores et al. (2014) and Abdulai and Abdulai (2017), the stochastic production approach (SPA) model is appropriate for measuring agricultural innovation (CF) on technical and/or EE grounds because to the DEA model's constraints. As a result, the effect of CF on EE was studied in this study utilizing the SFA model. To simplify matters, let us assume that all CF in our sample is either contract or non-contract. The SFA model can be illustrated as follows:

$$Y_i = f\left(X_i, M_i\right) + e_{1i}, with\, e_{1i} = v_{1i} - u_{1i} \quad \text{.........} 3.9$$

where Y_i is the soybean output in kg of the *i*th producer; X_i is a vector of variables representing factor inputs (such as seed, labour, farm size etc.); M_i is a dummy variable that captures the CF status of soybean producers (1 = contract farmer; 0 = otherwise); e_i is the error term, which is composed of $v_i \approx N(0, \sigma_v^2)$ is a symmetric stochastic term apprehending statistical noise, and $u_i \approx N^+(0, \sigma_u^2)$ is a half-normal stochastic term that accounts for inefficiency in soybean production.

As this study focuses on effect of CF on EE, we modified the equation (3.9) into cost function as follows:

$$C_i = f\left(X_i, M_i\right) + e_{2i}, with\, e_{2i} = v_{2i} + u_{2i} \quad \ldots\ldots 3.10$$

Where C_i is total cost of soybean production, X_i represents the factor inputs prices, other parameters are already defined.

For estimation effect of CF on EE we assume that all soybean producers have access to information and technology which will increase their efficiency. This assumption is false since soybean growers choose whether or not to participate in CF based on both observable and unobservable criteria (Mojo et al., 2017; Wossen et al., 2017).

This is the problem of selectivity bias. Contract and non-contract farmers may experience constraints as a result of self-selection, resulting in divergent production frontiers. Hence, the variable of CF (M_i) in equation (3.10) is not exogenously determined rather endogenous determined. To overcome this flaw in the analysis, the selectivity bias problem connected with farmer self-selection must be addressed. This would ensure, analyzing the unbiased and consistent effect of CF on EE of soybean producers.

The DEA offers two main advantages which give it an edge on techniques of regression. The definition of the production function is irrelevant in the DEA because it is a nonparametric method. The frontier is estimated using the minimum principle of extrapolation based on the production possibility set's retained monotonicity and convexity (Banker et al. 1984).

Chang and Guh (1991) assert that the DEA is not non-parametric because it quantifies efficiency through the usage of frontiers (linear production functions). Second, the primary advantage of DEA is its capacity to manage a large number of outputs and inputs efficiently, as well as to perform absolute comparisons of production options without requiring additional input pricing data. Numerous studies on the efficiency of regression-based approaches and DEA have been undertaken. Along with the simulation analysis, a data generating technique is used, which involves incorporating a single output into a production function.

Gong and Sickles (1992) compared the stochastic frontier technique to the DEA for a range of products using only input prices. Banker et al. (1993) used cross-sectional data to compare DEA and COLS results. The data indicated that while the DEA significantly altered the computation inaccuracy, the COLS did not. The two models, on the other hand, performed poorly as measurement error increased. Ruggiero (1999) demonstrated that the deterministic COLS model effectively controlled measurement errors in the absence of the stochastic frontier model.

Managing directors of enterprises and government agencies aim to maximize efficiency within the restrictions of existing resources and technological capabilities. This is often performed by comparing the relative efficiency of businesses operating within a given sector or industrial segment. Because of this, it is not possible to evaluate absolute efficiency with DEA; rather, it can only be used to evaluate relative efficiency.

DEA, as a linear programming tool, determines efficiency through an optimization process, which is carried out on a computer. The optimization approaches that should be used are dictated by the direction of the goal function. Using an input-oriented model, businesses can lower the number of inputs required to achieve a specific level of output. This is known as a cost-cutting technique. For output-oriented models, output maximization is used, which entails increasing output given a set of inputs. According to Cook et al. (2014), the output maximization version of DEA is represented by equation 3.11 as shown below;

$$Max \frac{\sum_{j=1}^{j=n} v_j y_j}{\sum_{i=1}^{i=m} u_i x_i} \quad \text{..} 3.11$$

Where the weight allocated to output j is denoted by v_j, and the weight applied to input i is denoted by u_i. In terms of production space, the businesses with efficiency of one form the frontier that encompasses all DMU in terms of efficiency. Aspects of the DEA model that include returns to scale are also included. There are two sorts of returns to scale efficiency measurement: constant returns and variable returns.

To get at these two categories, the researcher had to make some assumptions regarding the level of proportionality that would be observed between changes in output and changes in input level. The DEA has a lot of advantages as well as drawbacks. When applied to huge numbers of inputs and outputs, it can be used to calculate the efficiency of a system in a variety of measurement units. Producing production borders and evaluating the efficacy of a production system regarding those borders are both accomplished through the use of DEA.

The following is how Charnes et al. (1978) describe efficiency: efficiency is defined as the weighted sum of outputs divided by the weighted sum of inputs. Whenever the inputs return to scale in a steady manner, the model was appropriate for the circumstances. A fundamental flaw in the DEA model developed by this group was that it did not account for the effects of drug addiction. Therefore, Banker et at; (1984) designed a model with shifting returns on scale to get around the restriction. Nonparametric techniques such as differential equation modeling (DEA) are used to examine whether changes in an enterprise's productivity performance are due to inefficiency on their part. In the end, this model had to be discarded because it was unable to identify those components of firm administration that were out of the control of the company, such as measurement errors, missing variables, and weather-related shocks. To the extent that it is not a statistical technique but rather a mathematical programming tool, DEA can be used with any form of data, be it qualitative or quantitative

3.12 Inefficiency Determinants

In incorporating exogenous variables in measuring differences in technical inefficiency, Kumbhakhar and Lovell (2000) offer three important techniques. The three approaches are the initial, two-stage, and single-phase.

3.12.1 The Initial Approach

This method of detecting inefficiency is based on the concept that exogenous factors have an impact on production. The initial approach's stochastic frontier model is as follows:

$$\ln Y_i = \ln(x_i, z_i; \beta) + v_i - u_i \qquad 3.12$$

The output, input variables, exogenous variables, and production parameters are represented by Y_i, x_i, z_i, and β respectively. The exogenous variables (z_i) vector is thought to alter the shape of the production function by influencing output directly. Variations in efficiency are not effectively described by this model due to the assumption that external variables are uncorrelated with the error terms (v_i and u_i).

Exogenous factors have an indirect effect on the output variable via their efficiency effect, according to the two-stage approach. In contrast to the first method, exogenous influences have no effect on the structure of production technology. Exogenous variables are thought to influence the efficiency of manufacturing. Because the dependent variable is constrained to values between one and zero, the method of estimating ordinary least squares is inapplicable. When the effects of technological inefficiency are regressed on some unique farm characteristics, the two-stage technique is constrained by violations of the same u_i distribution.

3.12.3 The Single Stage Approach

This method expresses the effects of inefficiency as an explicit function of a collection of well-known production parameters (Kumbhakar and Lovell, 2000). By estimating all productivity and inefficiency model parameters, the maximum likelihood estimation approach calculates and explains variation in efficiency. This solution prevents the issues that come with the same distribution. Battese and Coelli (1995) describe inefficiency using the single stage technique as follows:

$$\mu_i = \delta_o + \delta_i Z_i \qquad 3.14$$

The δs are parameters to be calculated, while Z_i reflects some socioeconomic aspects that influence technological inefficiency.

3.13 Functional Forms for Production Frontier Estimations

Depending on the research goal, mathematical models used for estimation purposes through empirical studies can be defined variously. As a result, the parameters of an economic model are determined by the analyses' goals and objectives, as well as the research's conditions. Cobb-Douglas, translog, Leontief, logarithmic, and Spillman production functions are some of the most popular functional types used in production frontier analysis (Griffin et al., 1987). In this study, we looked at two of the most common functional types.

3.13.1 The Cobb-Douglas Production Function and its Limitations

The Cobb-Douglas (C-D) production function is a logarithmic model containing logarithms for both input and output variables. A synopsis of the Cobb-Douglas model is as follows:

$$Y = aX^{b} \quad \text{..} 3.15$$

Y is the output, *X* is the input, and the unknown parameters *a* and *b* must be calculated. The Cobb-Douglas function, in its most basic form, is a non-linear multiplicative function that can be linearized by taking the model variables' logarithms. The generalized Cobb-Douglas function in equation 3.15 becomes equation 3.16 after performing logarithmic modifications to linearize it:

$$\ln Q = \beta 0 + \Sigma_{i=1}^{n} \beta_i X \quad \text{..} 3.16$$

Constant returns to scale and a substitution elasticity of one characterize the Cobb-Douglas production function. The C-D production function formulation and its practical application are based on three basic assumptions: first, that no output can be produced without the use of labor or capital; second, that labor's marginal productivity is directly proportional to the quantity of output per unit of labor use; and third, that capital's marginal productivity is also directly proportional to the quantity of output per unit of capital use.

In every production method including the C-D production function, there is some level of constraints. C-D production function is estimated based on marginal productivity theory of value. Nevertheless, as econometrics keeps on advancing, the theoretical method of measuring factor input substitutability becomes necessary. Some of the limitations include (1) the C-D function contains only two factor inputs while it neglects other factor inputs; (2) C-D function assumes constant returns to scale which is unrealistic; (3) There are huge bottlenecks of capital measurement as the capital takes only the quantity of capital available for production; (4) The C-D function is restricted to only nonlinear functions.

However, in some efficiency studies, the Cobb-Douglas production function has proven to be effective. Hassani (2012) used the Cobb-Douglas function to estimate productivity differentials in Ghanaian aquaculture between family and hired labor, and Onumah and Acquah (2010) used it to estimate productivity differentials in the construction sector.

3.13.2 The Transcendental Logarithmic (Translog) Production Function and Limitations

The Translog (Transcendental Logarithm) production function is an extension of the C-D production function. Translog production functions were designed to address the constraints of the C-D production function (Christensen et al., 1972). Translog has received widespread use in modern economics due to its numerous conceivable meanings and mathematical usefulness. In multiplicative form, the model of translog functional form is as follows:

$$Y = f(X_1, X_2 \dots\dots X_n) = \alpha_0 \prod_{i=1}^{n} X_i^{\alpha_i} \prod_{i=1}^{n} X_i^{1/2\left[\sum_{j=i}^{n} \beta_{ij}\, InX_j\right]} \quad \dots\dots\dots\dots\dots\dots\dots\dots 3.17$$

where Y is output, α_0 is an efficient parameter, X_i is a set of factor inputs and α_i and β_{ij} are unknown parameters to be estimated. To interpret the coefficients as elasticity we take the natural logarithm of both sides. Therefore, the equation 3.17 can be transformed as:

$$\ln Y = \ln\alpha_0 + \Sigma_{i=1}^{n}\alpha_i \ln X_i + \frac{1}{2}\Sigma_{i=1}^{n}\Sigma_{j=1}^{n}\beta_{ij} \ln X_i \ln X_j \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.18$$

The second order partial derivatives of the function with respect to i are equal to the differential j according to Young's theorem of integral functions in β_{ij} (Berndt and Christensen, 1973). The equation 3.18 can transform back to the C-D production function if and only if $\beta_{ij} = 0$. This makes it easy to test the hypotheses of the appropriateness of the C-D production function. According to Maddala (1977), this test can be achieved by using F-test statistical tool and by restricting the quadratic terms.

Additionally, the translog production function has significant difficulties in econometric analysis. To begin, as the number of production inputs grows, a problem of multicollinearity occurs. The squared and cross products needed to estimate a translog production function increase the number of parameters that must be calculated.

Vinod (1972) recommended eliminating all squared terms to reduce multicollinearity while preserving functional features. Despite the translog production function's flexibility assumption, it may not be economically feasible to estimate the translog function if estimates of substitution elasticities are less essential than estimates of scale elasticities. Because the translog production function is theoretically difficult to alter, it suffers from a degrees of freedom constraint.

3.14 Functional Forms Choice Criteria

The functional form employed in the analysis is determined by the analysis's purpose; nevertheless, defining the true functional form for each relationship can be challenging (Griffin et al., 1987). As a result, when selecting a functional form, we must ensure that it is the best fit for the task at hand. Aligning a production technique with desired theoretical characteristics is a critical criterion for selecting a functional form. Some of the analysis's hypotheses are tested, while others are assumed to be true and so remain testable when selecting a functional form. As a result, if the governing assumptions are acceptable and advantageous, the model is judged effective for deciding on a functional form. When there is insufficient empirical or theoretical support for a theory, however, an unrestrictive functional form can be adopted.

Another factor to consider when choosing a functional form is the availability of data and resources for making estimates. A lack of sufficient data for analysis could be a challenge for functional forms that do not make estimations using linear least square techniques. Consider difficulties of data conformity (fit) while selecting a functional form, when a model is chosen based on data-specific criteria (Griffin et al., 1987). Comparing nested and non-nested models is one method of determining which model best fits the data (Judge et al., 1985). When selecting an appropriate model, application-specific functional form considerations may be considered. When selecting a functional form for optimization and simulation, researchers may look for specific desirable qualities. Consider properties such as linearity, robustness, parsimony, and regularity while choosing a functional form.

3.15 Measurement of Efficiency

Farrell's seminal paper (1957) resulted in the emergence of numerous methods for measuring production efficiency. Farrell presented significant efficiency measurement results several years ago, and his findings have since been used to estimate efficiency. Economists such as Aigner and Chu (1968) and Meeusen and Van den Broeck (1977) have worked on and provided information on these topics over the years. Farrell's work was expanded by Aigner and Chu (1968), who assessed production using programming models for deterministic models in which all anomalies or deviations from the anticipated frontier are unilateral and inefficient.

To estimate the inefficiency of the frontier with one-sided variations, Winsten (1957) suggested, and Greene (1980) showed the Ordinary Least Square (OLS). Because the parameters of the production function are constantly being estimated, the individual must correct the intercept term by adding the greatest residual to the intercept in the production setting; this method is known as Corrected Ordinary Least Squares (COLS). However, due to the nature of the regression analysis, the Corrected Ordinary Least Squares (COLS) is limited because the production function can only have one output. When seen through the perspective of econometrics, attributing all deviations to inefficiency in production is erroneous, as deviations from the frontier can be caused by measurement error, statistical noise, and inefficient behavior.

Lovell et al. (1994) proposed a solution by defining a distance function for a situation with multiple output events, leveraging the homogeneity property, and reshaping the terms in the production process with a single output considered a dependent variable and the remaining outputs considered explanatory. Grosskopf et al. (1997) and Coelli

& Perelman (1999 and 2000) explained this method, known as the Stochastic Distance Function (SDF), to the public.

According to Atkinson and Primont (2002), unbalanced handling of a single product produces an endogenous problem. To separate errors caused by production inefficiencies from errors induced by model misspecification, Aigner et al. (1977) and Meeusen & Van den Broeck (1977) constructed a stochastic production function. The deviation from the frontier, according to these articles, was caused by an error term that contained both inefficiency and statistical noise.

3.16 Theory of Impact Evaluation and Efficiency Estimation

The magnitude of an impact can be measured in a variety of ways. As part of an impact assessment, new technologies and practices are scrutinized for their effect on welfare (income and expenditure), productivity, and efficiency as well as other factors. Project involvement can also be measured in terms of how it affects participants' well-being. Agriculture technology can have a significant impact on outcomes such as productivity, efficiency, and family well-being. Participant (contract farmers, for example) and non-participant (non-contract farmers) disparities in outcomes cannot be fully explained by technical adoption.

To solve the problem of causal inference, experimental data collected by randomization should include information about the counterfactual condition. As a result, attempts to correlate outcomes to specific agricultural technology programs encounter data problems. It is because of this that many researchers are forced to draw conclusions based on the variations in results between farm households. As a result, the randomization requirement is not met because producers make their own adoption decisions. In this instance, estimate methods that ignore self-selection may produce biased findings.

The Heckman two-stage treatment effect model, the IV, randomized designs, the double difference estimator, propensity score matching, regression discontinuity, and pipeline techniques are the most often used strategies for addressing the self-selection problem (Abadie, 2003; Cameron & Trivedi, 2005; Heckman & Vytlacil, 2007; Imbens & Angrist, 1994; Imbens & Wooldridge, 2009). CF's impact on the EE of soybean farmers in the research area was estimated using the endogenous treatment effect model. Section 3.23 explains this model in detail. Following that, we will talk about sample selectivity bias and the Heckman estimation process.

3.17 Selectivity Bias in Non-experimental Studies

This section presents concepts and meaning of sample selectivity bias and theoretical framework of the sample selection bias related to this study. The section begins with concepts and meaning of selectivity bias and end with theoretical model for sample selection.

3.18 The Meaning of Selectivity Bias

Sample selection bias occurs when a dependent variable selection technique alters data availability. The estimator is biased and inconsistent due to the sample selection error term and one or more regressors. Individuals' control (or treatment) status relates to unobservable or unmeasured variables important to the program outcome under assessment, according to Barnow, Cain, and Goldberger (1980). Experts say "bias" refers to the tendency to underestimate the impact of a therapy or program on a specific outcome. Sample selection bias occurs when unmeasurable or unobservable characteristics such as farmer competence, administrative talents, and entrepreneurial skills have an effect on contract soybean production but are correlated with soybean revenue and household consumption spending.

Estimating the effects of CF on soybean producers' efficiency is one of the objectives of this research. The dependent variable (participation in CF) is binary and endogenously determined. Estimating the effects of CF on farmers' efficiency by adding the CF variable to an OLS regression will either underestimate or overestimate the effects of CF on farmers' efficiency. Finding a positive effect of CF on efficiency means farmers who participate in CF are better off their counterparts but this could be an overestimation. It could be that contract farmers have inherent characteristics that give them upper hand over their non-participant counterparts. This problem is simply referred to as selectivity bias or sample selection bias.

In estimating the EE of contractual and non-contractual soybean production in this study, it is important to include all the variables that affect participation as well as inefficiency in both the participation and inefficiency effect models, otherwise by implication the two error terms of the two models are said to be correlated (Madalla, 1983) cited by (Donkoh, 2011).

The selection problem is divided into two versions, according to Smits (2003). In the standard case, part of the respondents' information on the dependent variable is missing, and thus the results will be skewed if this is not considered in the model formulation. The often-cited example (Heckman, 1979; Smits, 2003) of selectivity bias is measuring the effects of female education on income. However, in their study, because some women have little or no education, estimates of the impact of education on income was biased. In the other version, all respondents have access to data on the dependent variable, but respondents are randomly assigned to different categories of the independent variable they are interested in. For example, a study of the effects of CF on EE using a sample of the population found that farmers, whether they participated in the CF program, allocate their farm resources to minimize costs.

If you just run a regression with output as the dependent variable and a dummy variable indicating whether the respondent participated in the CF program as one of the explanatory variables in the inefficiency model, the results would be skewed. This is because responses were not randomly distributed among the groups of participants and non-participants, but rather selectively. Farmers who choose to participate in CF may differ from farmers who do not participate in the program in a variety of ways (both measured and unmeasured). If the unmeasured characteristics are related to EE, the CF variable's coefficient may be able to account for these effects. As a result, the results would be biased, and the estimates would be inadequate.

Numerous studies (Breen, 1996; Heckman, 1979; Winship & Mare, 1992) explained sample selection bias. According to them, the issue of selection bias has essentially two versions. The first is when information is missing for part of the respondents on the dependent variable and the other is when information is available for all respondents on the dependent variable. However, a common sample selection method used in this study is one in which all respondents have access to information on the dependent variable, but respondents are randomly assigned to different categories of the independent variable of interest. The following is based on using an Ordinary Least Squares (OLS) model to evaluate the effect of CF participation on soybean yield and efficiency:

$$Y_i = \gamma X_i + \delta D_i + \varepsilon_2 \ldots\ldots 3.19$$

$$W_i = \gamma X_i + \delta D_i + \varepsilon_3 \ldots\ldots 3.20$$

where Y_i and W_i are yearly soybean output and welfare, respectively, D_i is a dummy (1 = contract soybean farming; 0 = non-contract soybean farming), X_i is a vector of farmer and farm attributes, γ and δ are vectors of parameters to be estimated, ε_2 and ε_3 are the error terms with $N(0, \sigma^2 v)$.

The effect of participation on the outcome variables (soybean output and wellbeing) is quantified using parameter δ estimations. However, if δ the effect of CF participation on soybean production and welfare is to be correctly measured, farmers should be randomly assigned to CF (participation) or non-contract (non-participation) (Faltermeier & Abdulai, 2009; Kassie, Shiferaw, & Muricho, 2011; Stefanides & Tauer, 1999).

Because farmers choose whether or not to participate in CF (self-selection), unobservable characteristics associated with the desired outcome (soybean output and welfare) are likely to influence the participation decision. Contract farmers' soybean productivity and welfare would be higher regardless of whether they practiced CF if they are more diligent and enterprising than non-contract farmers. In this situation, the participation dummy variable's coefficient would include both unobservable traits and CF, therefore overestimating the effect of CF participation. The estimation of eqns. (3.19) and (3.20) does not account for self-selection when unobservable features such as farmers' managerial skills and diligence are related with dependent variables or error terms. This selection bias can be explained by the joint normal error distribution:

$$\frac{\varepsilon_{1i}}{\varepsilon_{2i}} \sim N\left(\begin{bmatrix}0\\0\end{bmatrix},\begin{bmatrix}1 & \rho\\ \rho & \sigma^2\end{bmatrix}\right)$$

$$\frac{\varepsilon_{1i}}{\varepsilon_{3i}} \sim N\left(\begin{bmatrix}0\\0\end{bmatrix},\begin{bmatrix}1 & \rho\\ \rho & \sigma^2\end{bmatrix}\right) \ldots\ldots\ldots\ldots\ldots 3.21$$

And by recognizing that the expected output and efficiency of choosing soybean contract production, given as:

$$E[Y_i / Q_i = 1] = Z\beta + \delta + E[\varepsilon_{2i} / Q_i = 1] = Z_i\beta + \delta + \rho\sigma\lambda_i$$

$$E[W_i / Q_i = 1] = Z\beta + \delta + E[\varepsilon_{3i} / Q_i = 1] = Z_i\beta + \delta + \rho\sigma\lambda_i \ldots\ldots\ldots 3.22$$

Where

And φ and ϕ are the density functions of a typical normal distribution and its cumulative distribution function, respectively. The Inverse Mills Ratio (IMR) is a symbol λi that represents the proportion of a standard normal ordinate to the distribution's tail area (Greene, 2003). Sample selection bias is not a concern if it not statistically significant (Heckman, 1979, 1980). Furthermore, if the finding of λ_i is statistically significant in the soybean output and efficiency equations, it suggests that there is a substantial difference between the farmers who used CF and those who did not. When calculating the equations, this discrepancy must be considered. In addition, equation (3.23) suggests that the coefficients β and δ will be biased when estimating equations (3.19) and (3.20) without the Inverse Mills Ratio (IMR). With self-selection, the treatment effects model (also known as the Heckman selection–correction model) is the typical approach. This is covered in the following section.

3.19 Treatment Effects Model

When participation in an intervention is not distributed randomly, Heckman's sample selection technique is employed to control self-selection into participation (Awotide et al., 2016; Heckman, 1976; 1979; Siziba, Kefasi, Diagne, Fatunbi, & Adekunle, 2011).

Heckman Treatment effect model is two system equations designed to estimate effect/impact of a programme. Therefore, the Heckman Treatment effect model has two equations known as selection equation and substantive equation. A non-zero correlation exists between the equations' error terms. Thus, we cannot estimate the substantive equation without first solving the selection equation.

Therefore, the residuals are used to estimate the selection (usually a probit model) equation, which is equivalent to the Inverse Mills Ratio (IMR), to construct a selection bias control factor known as hazard lambda (λ). The value of the λ is computed for each respondent. As an additional regressor, λ is included in the substantive equation. It should be noted that in the selection equation the coefficient, λ, reflects the effects of all unmeasured characteristics related to the treatment (CF). As a result, the coefficient of λ captures the portion of the effect of these qualities that is related to the study's outcome in the substantive equation. After correcting for selectivity bias λ in the analysis, the pure effect of CF on EE, as well as other independent variables in the substantive equation, can be estimated, as the coefficients are now freed (Smits, 2003), as cited by Donkoh (2011).

The adoption variable is included as a covariate in the treatment effect model. Furthermore, the treatment model enables the researcher to estimate the adoption and output or welfare equations concurrently. This computation takes into consideration any selection bias and generates unbiased and consistent assessments of output or utility models. As a result, Maddala (1983) states that equations (3.19) and (3.20) assume the following form:

$$\ln W_i = \beta'(\phi_i \ln Z_i) + \delta(\phi_i Q_i) + \sigma\varphi_i + \varepsilon_{3i} \ldots\ldots\ldots 3.24$$

$$\ln Y_i = \beta'(\phi \ln Z_i) + \delta(\phi_i Q_i) + \sigma\varphi_i + \varepsilon_{2i} \ldots\ldots\ldots 3.25$$

Where $\phi_{\mathrm{I}} = \phi(w_i, \gamma)$, δ measures the effect of CF on the natural logarithm of gross income from soybean Y_i, natural logarithm of per capita consumption expenditure W_i

respectively; ε_{2i} and ε_{3i} are also two-sided error terms. X_i is a vector of independent variables affecting farm income, Q_i is a binary variable representing adoption of CF, δ, γ and β are parameters to be estimated. Section 3.20 throws more light on sample selection in a SFA model.

Because participation in soybean CF is voluntary and participants are not assigned at random, self-selection bias may occur, resulting in a skewed sample using nonprobability sampling. As a result, omitting to account for CF participation will lead to possible bias resulting in inaccurate treatment model estimates and an overestimation of the influence of contract farming on farmers' technical, allocative, and economic efficiency. As a result, we employed the endogenous treatment effect model (ETRM) to examine the impacts of CF on technical, allocative, and economic efficiency. This model is delved more into in the methodology delves deeper into this concept.

3.20 Self-Selection of Soybean Contract Farming

Many researchers have looked at the effects of agricultural innovations on TE (Azumah 2019; Mojo et al., 2017). Recent studies by Osman et al. (2018); Masuku et al. (2014) and Bidzakin et al. (2020) have also looked at agricultural innovations on EE. This study tried to investigate the effect of participation in CF on efficiency. The effect of CF on EE was modeled using SFA with selection in this study. We assume that a farmer weighs the expected benefit versus the risk of participating in soybean CF when deciding whether to participate. According to the utility maximization hypothesis, a farmer will choose to participate in soybean CF if and only if the projected profit from contract farming outweighs the cost of not participating.

While disparities in satisfaction levels cannot be detected directly, demographic and socioeconomic factors can best explain farmers' decision to participate in CF (Ma et al., 2018). The following is a mathematical expression of the sample selection model for CF: $M_i^* = \alpha Z_i + e_i,\ M_i = \begin{cases} 1 \text{ if } U_i^m - U_i^{nm} > 0 \\ 0 \text{ if } U_i^m - U_i^{nm} \leq 0 \end{cases}$ …. …………………………….3.26

where U_i^m is the ith farmer's expected satisfaction gain from engaging in CF, and U_i^{nm} is the expected utility gain from not participating in CF. M_i^* is a latent variable that represents a farmer's propensity to participate in CF; the observed dependent variable; Z_i is a vector of exogenous variables that influence a soybean producer's decision to participate in CF; α ' are unknown parameters to be estimated and; e_i is the error term that is assumed to be normally distributed with a zero mean.

3.21 Review of empirical studies on Economic Efficiency and factors influencing efficiency and productivity using SFA

The EE of maize production in Northern Ghana was assessed by Abdulai, Nkegbe, and Donkoh (2017). Using cross-sectional data, the study used the stochastic frontier model to analyze the technical, allocative, and EE of maize production in northern Ghana. According to the Cobb-Douglas functional form, traditional inputs such as farm size, seed, fertilizer, labor, and weedicides were statistically significant and had a favorable effect on maize output in northern Ghana. On average, technical, allocative, and economic efficiencies were 85.1 percent, 87.8%, and 74.7 percent, respectively. Experience, agricultural extension service, and gender all played a role in determining technical inefficiency.

Sharma, Leung, and Zaleski (1999) investigated the technical and environmental aspects of swine production in the United States using SFA and input-oriented DEA approaches. Cross-sectional data were used for 53 pig farms. Cobb-Douglas stochastic production function and dual cost function were assumed for the technical and economic analysis of SFA.

Using the SFA technique, Abdulai and Huffman (2000) evaluated the EE of rice fields in northern Ghana. For the investigation, cross-sectional data from 256 rice farms were employed, and translog stochastic profits were assumed. According to the findings, the average efficiency (benefit) was 0.73. Education, access to loans, and level of rice specialization were significant negative factors of profit inefficiency (negative impact on profitability), whereas non-farm working hours, age, and distance from the market were significant positive factors of profit inefficiency (negative impact on profitability) (positive impact on profit efficiency).

Kiatpathomchai (2008) evaluated the economic and environmental efficiency of rice production systems in southern Thailand using the DEA method. The results show that for farm households in irrigated and rainfed areas, the average economic efficiencies were 0.681 and 0.671 respectively while that for the entire sample was 0.676. This suggests that the sample farms' overall rice expenses might be reduced by around 32% while maintaining current output levels.

Kareem, Dipeolu, Aromolaran, and Williams (2008) conducted a stochastic frontier production analysis to assess the technical, allocative, and EE of fish producers employing concrete and earthen pond systems in Ondo, Nigeria. The average EE of the concrete pond system was 76 percent, whereas the earthen pond system had an EE of 84 percent, according to the findings. The size of the pond, the amount of lime used, and the number of workers employed were all significant factors in the TE of the concrete pond system, whereas the size of the pond, the amount of feed used, and the number of workers employed were all significant factors in the TE of the earthen pond system, according to more research.

Farmer efficiency is influenced by a wide range of factors, according to the research. Conventional and non-traditional non-conventional variables are the two types of variables. Macroeconomic variables such as public investment and agro-ecological variables are captured by non-conventional components. In farmers' production decision-making processes, conventional parameters have long been considered the most important elements.

Traditional inputs include labor intensity, fertilizer use, tractor use intensity, and animal stock, according to Frisvold and Ingram (1994). Examples of non-traditional inputs inputs include land quality, irrigation, agricultural research, calorie availability

agricultural export, and instability.

Pender et al. (2004) and Deininger and Olinto (2000) found efficiency to be explained by fertilizer, cattle ownership, access to funding, extension supply, and human capital (education, age, and gender of household head). Productivity is affected by plot-level features such as farm size, tenure, and distance between the field and the residence (Xu et al., 1998). Ownership of livestock, particularly oxen, is likely to help framers get their fields ready sooner and expand their planted area. Farmers can more easily access funding and fertilizer markets because livestock acts as a buffer. For the purpose of increasing agricultural productivity and preventing land degradation, econometric analysis was used by Pander et al., (2004) to evaluate cross-sectional data from Uganda.

Animal ownership (especially oxen), agro-climatic zones, significant sources of income, household head age, land ownership, and engagement in agricultural extension activities all had a positive impact on production, according to the research. According to this research, irrigation facilities, for example, have a higher likelihood of increasing productivity. Studies show that farmers in urban settings are more likely to use intensive agricultural production strategies, which are more common in rural areas. Labor-intensive land management practices were adopted by households in densely populated areas, such as Frisvold et al. (1994) and Pender et al. (2014), to increase agricultural yield per hectare.

Productivity is affected by the size of the farm. In Uganda, Pender et al. (2004) found that the size of a farm was adversely correlated with productivity. Cotton marketing reforms in Zambia were studied using post-harvest survey data by Brambilla et al. (2009). Small farms are more efficient, according to this research. Despite their small size, Frisvold and Ingram (1994) agree that small plots are more productive than bigger ones in terms of production per hectare.

Frisvold and Ingram (1994) used cross-sectional time series data from 28 countries in sub-Saharan Africa to compute an aggregate agricultural output function to investigate explanations for gains and stagnation in agricultural productivity. The agricultural export coefficient was found to be positive and statistically significant, according to the data. In contrast, little evidence was found by Pender et al. (2004) that market access affected agricultural intensification and crop productivity.

Pander et al., (2004) used cross-sectional data but Frisvold and Ingram (2004) used panel data. Even though education is a valuable source of human capital, it has not proven to be viable solution to Uganda’s poor productivity problem (Pender et al., 2004). Similar findings were found by Deininger and Olinto (2000) using post-harvest survey panel data. According to research on the poor performance of the country's agricultural industry following deregulation, more educated farm owners seek out more fertilizer and credit per acre than those who are less well-educated.

Agriculture productivity and efficiency studies have been undertaken on a wide range of plants and animals to estimate their production efficiency. Technology development in emerging and underdeveloped countries is aided by stochastic frontier studies, which focus on the development of more efficient technologies (Shalma, 2014).

The stochastic frontier function tells us that every production process has technical productive inefficiencies, which in turn tell us about output efficiency. To boost output, these efficiency improvements are critical. Using farm-level data, Battese and Corra (1977) first used the stochastic frontier model to estimate Cobb-Douglas production frontiers (deterministic and stochastic). There was a significant amount of variation in the logarithm of sheep production value that was attributed to farm impacts (Shalma, 2014).

As a result of this research, the stochastic production frontier model is now being used in additional agricultural settings. Onumah et al. (2010) used cross-sectional data to examine the TE and subsequent drivers of Ghanaian fish farms using the stochastic frontier function. To quantify the efficiency of Ghana's fish farming business, they were able to establish output elasticities for certain inputs. Battese and Coelli (1995) used panel data from Indian paddy rice farms to use the stochastic frontier approach to assess EE levels, particularly for older versus younger farmers.

In a research on rice farmers' efficiency in Ghana's northern area, Abdulai and Huffman (2000) employed a normalized stochastic profit function frontier to examine rice sector inefficiency and how it impacts profit. Both technical and AE issues were found to contribute to the discrepancy between the frontier profit and the observed profit.

The stochastic frontier production function was used by Etwire et al. (2013) and Mohammed et al. (2013) to estimate and assess soybean efficiency (2016). Stochastic frontier analysis was used by Battese and Tveteras (2006) to examine the impact of agglomeration externalities on the production frontier and efficiency of Norwegian salmon farming, which was one of the most pioneering studies to quantify technical and productive efficiency. Their study confirmed the importance of agglomeration externalities for the productivity and technical inefficiency of salmon farms. Overall productivity increased with increasing regional industry size. There was a negative relationship between overall productivity and regional farm density, suggesting the presence of negative biological congestion externalities.

When Liu and Zhuang (2000) conducted an EE analysis on post-collective Chinese agriculture, they discovered that economic inefficiency could be explained by interactions within the efficiency models (Shalma, 2014).

Similarly, Battese and Coelli (1992) demonstrated the value of the frontier production function in predicting the technical inefficiency of individual businesses in an industry. After looking at panel data from 38 Indian farms with time-varying firm effects, they found that technical inefficiencies among farmers did not persist even after removing the year of observation from consideration. This was reversed when the stochastic frontier took into consideration the year of observation.

The classic (average) Cobb-Douglas function and the generalized frontier model were also compared, and the results show that generalized frontier models are better models for the investigation of technical inefficiencies. Firm-level technological efficiency could not be predicted using the typical Cobb-Douglas production function, as demonstrated, for example, by Battese and Coelli (1988). The dairy industry in New South Wales and Victoria was studied using a stochastic frontier production function. Researchers found that a more extensive model for capturing firm impacts in frontier production functions may be able to account for cases where businesses are unlikely to be near full TE.

Peasant farming in the Dominican Republic was studied by Bravo-Ureta and Pinheiro (1997) in terms of its technical, economic, and AE aspects. To estimate a Cobb-Douglas production frontier, they used maximum likelihood approaches, which were then used to construct an equivalent dual cost frontier. Two frontiers were used to calculate farm-level efficiency metrics. They found that the average levels of technical, allocative, and EE were 70%, 44%, and 31%, respectively, in their investigation. With today's technology, it is possible to increase output and/or reduce costs significantly.

The findings show that TE, AE, and EE must all be considered when assessing productivity. Tobit regression results showed that younger, more educated farmers had greater levels of TE, AE, and EE than their older counterparts. CF, medium-sized farms, and being a beneficiary of agricultural reform, all showed a statistically beneficial connection with EE and AE, according to the study. AE was shown to be negatively associated with the number of people living in the household, according to the findings of the study.

Finally, the researchers discovered that AE appeared to be more relevant than the TE as an EE source for Dominican peasant farmers, with the variables considered most promising for policy action being contract production, farm size, and agrarian reform status (Kabwe, 2012). For small and medium-sized tobacco farmers in Uganda, Obwona (2000) assessed the TE difference between the farmers who adopted new technologies and those that did not. In the study, the researchers found that the availability of credit, access to agricultural extension services, and farm assets all contributed to TE's success. Only socioeconomic and demographic factors may explain for the disparities in efficiency between farmer groups.

Smallholder farmers in Ethiopia were studied by Arega (2003) using stochastic efficiency decomposition technique to determine the impact that new maize production equipment had on their efficiency. Both old and enhanced production methods showed inefficiencies, even though the study discovered good results for increased production technology and efficiency. Therefore, inefficient conventional maize production was found to be the outcome of technical inefficiency, whereas efficient upgraded systems were found to have both technical and allocative inefficiency. Both technical and allocative efficiencies must be improved as technology progressed further.

According to Tchale (2009), a nationally representative sample survey of rural households was conducted in Malawi in 2004/2005 by the National Statistical Office. They conducted this research to provide agricultural officials with a better understanding of how inefficient smallholder farming systems are and what must be done to improve production. It was decided that a parametric frontier approach would be employed to account for the numerous variables that influence smallholder output in developing countries. Statistical noise and measurement errors, as well as farm-specific inefficiency, were also blamed in part by the stochastic frontier for some of the fluctuation (Coelli et al., 1998).

The data revealed that allocative or cost inefficiency is higher than technical inefficiency, and that the low level of EE can be attributed in large part to the low level of AE against TE. The lack of agricultural market expansion is most likely to blame for the high levels of cost inefficiency.

3.22 Review of Empirical Studies on Factors influencing participation in Contract Farming

Viewed through the economic lens, maximizing profit is the main reason which motivates contracting parties to sign the agreement. For Eaton and Shepherd (2001), well-managed CF is an appropriate way to promote and coordinate agricultural production and marketing. Motivation for CF can be seen at both the farmers' level and at the processor's level. Bogetoft and Olesen (2002) studied ten rules of thumb in contract design and came to a conclusion that the two parties' preferences for a particular contract attribute motivate them to engage in contract agreement. For these authors, each of the contract parties tries to maximize his profit but it is difficult to redistribute the total benefit without negatively affecting any of the contracting parties (Bogetoft & Olesen, 2002). It is not easy for a contract to become 'Pareto efficient' because no one can become better off without someone else becoming worse off.

In their studies on why smallholders grow under contract, Masakure and Henson (2005) identified eleven factors that motivate small-scale producers to contract with agro-system companies in Zimbabwe. The factors are listed as follow: get satisfaction from growing export crops, lack of alternative sources of income, benefits to other farmers, stepping stone to other projects, guaranteed minimum prices, acquired knowledge for use on traditional crops, acquire knowledge for growing new crops, reliable supply of inputs, guaranteed market for crops, no need to transport crops to market and to earn extra income.

In their analysis, Masakure and Henson (2005) found that these eleven factors explain four broader latent motivation factors: i) market uncertainty, ii) indirect benefit, iii) direct income benefit, and iv) intangible and/or latent benefit. The issues broaden on accessing transport, gaining a reliable supply of inputs, the prevailing nature of the local markets, and uncertainty associated with market demand and prices. Though these authors' study focused on non-traditional crop (vegetables that are produced for export), it had a big lesson for staple food produced under contract.

Schipmann and Qaim (2011) identified four contract attributes that are important to farmers' motivation for contract farming. These are i) relation to the trader, 2) input provision, iii) payment mode and iv) price. Puspitawati (2013) conducted an in-depth study on potato farmers' motivation to contract with an agro-food company in Indochina. He came out with sixteen motivation factors that motivated famers to engage in contact farming arrangement. Here too, the issue of gaining reliable input (potato seed) and guarantee market emerged as the main concern of potato producers.

Other issues identified were uncertainty with the market and prices. Various strategies to motivate farmers to participate in contract arrangement and invest in quality improvement could be considered.

Abougamos, White, and Sadler (2012) in their study identify three strategies that could be considered: The first one is to provide farmers with an incentive to deliver quality paddy, the second is to provide farmers with assets (plastics or tarpaulin) for threshing and drying on , the third is to develop extension services to train farmers on quality paddy production. The combination of these strategies makes a contract more attractive for farmers to engage in. It is clear that market uncertainty, indirect benefits, direct income benefits and intangible and/or latent benefits constitute the main motivation factors for engaging in a contract scheme.

Market Uncertainty: Puspitawati (2013), like Masakure and Henson (2005), found that market uncertainty is the first broad latent factor to motivate small farmers to contract with a processor. A guaranteed market for crops, guaranteed minimum prices, provision of reliable input supply, and someone to buy the harvest crop at home (no need to transport crops to market) were the principal motivation for contract farming. Many authors also view CF as a means to link producers with agricultural markets, especially in developing countries (Kirsten & Sartorius, 2002; Torero, 2011; Will, 2013). In developing countries, farms are small and they mostly produce for their own consumption or sell at low price in local markets. CF offers them a unique opportunity to produce higher quality varieties and sell them at a high price to a processor (Miyata et al., 2009; Wang, & Delgado, 2014). By organizing farmers into a farmer base organization, providing them with quality input (seed rice, facilitate their access to fertilizer) and giving them advices on rice production, CF offered contract farmers the opportunity to produce quality rice.

CF is a fine means that helps smallholder farmers to reach new lucrative markets that are unavailable otherwise (Eaton & Shepherd, 2001). The access to such a market motivates farmers to engage in CF (Will, 2013). The most obvious economic incentive for participating in a particular contract arrangement is the output price (Saenger et al., 2013 Schipmann & Qaim, 2011). The main drivers of farmers' motivation for contracting are: the best price for the higher grade, the specification of price in advance, and input supply (Eaton & Shepherd, 2001; Saenger et al., 2013). The best price for the higher grade is the best motivation.

The difference in the price obtained by contract farmers and noncontract farmers may not be the main motivation factor of farmers' contract choice. Price risk reduction (by specification of prices in advance) may be the main motivation (Saenger et al., 2013; Schipmann & Qaim, 2011). Guaranteed minimum prices for the output, motivate farmer to engage in a contract arrangement.

There were some cases where the State provided financial incentives to farmers. With that support, farmers adapted their production to reach market requirements. The incentive programme focused on a quality evaluation and a certification system and its administration came from a trusted company. Prowse (2012) shows that incentive to engage and honour contracts must include longer-term reputation and credibility rather than short-term financial interest.

Due to uncertainty in input markets, input supply can be the main motivation for farmers to participate in the contract schemes (Eaton & Shepherd, 2001). Poor seed and fertilizer markets severely constrain staple crop production in rural area. Providing a reliable input system is therefore a motivating factor for CF (da Silva& Rankin, 2013; Masakure & Henson, 2005). Certain famers' tendency to divert input supplied has caused processors to limit input supplied to seed and essential agrochemicals (da Silva & Rankin, 2013; Eaton & Shepherd, 2001).

Due to the state of road and transportation cost, farmers find it profitable to sell their product at home rather than taking it to the market place where there is no guarantee they can sell all. In Zimbabwe, for example, farmers felt that they were excluded from more lucrative urban markets in Harare, due to distance and transport costs (Masakure & Henson, 2005). When processor proposed to collect the product at home farmers were more motivated to engage in such contract arrangement.

Indirect Benefits: Some indirect benefits the farmer can draw from CF motivate their decision to engage in CF arrangement with a processor (Silva & Rankin, 2013,Salenger et al., 2013). Masakure and Henson (2005) identify two main indirect benefits farmers acquire when they engage in contract farming. These are: i) acquire knowledge on how to grow the contract crop and ii) 'steppingstone' other projects. Evidence showed that government agents were less effective in providing extension service. When well designed, a CF scheme provides extension services and training to farmers. Therefore, the processor, by offering alternative extension services to farmers, helps them to acquire new knowledge. Reliable and up-to-date sources of agronomic advice that the processor provides, therefore motivates farmers to engage in contract farming. Farmers gain experience and become more efficient in farming activities such as ridging, fertilizing, transplanting, pest controls, harvest and postharvest activities such as threshing, winnowing, and drying (Eaton & Shepherd, 2001). The high yield that occur due to good agricultural practice in CF generate high profit, this motivates farmer participation in contract (Schipmann & Qaim (2011).

Farmers in developing countries are experiencing difficulties in accessing credit from formal financial institutions. By offering credit directly to farmers, the processor motivates them to participate in CF scheme (da Silva & Rankin, 2013; Eaton & Shepherd, 2001). Sometimes, processors can make arrangements with commercial banks or with government as guarantee to provide credits to farmers; this motivates farmers to participate in CF (da Silva & Rankin, 2013; Eaton & Shepherd, 2001). An arrangement is made by other parties to access credit for fertilizer purchase; this also motivated farmers for CF.

Direct Economic Benefit: According to Masakure and Henson (2005), CF is seen as extremely valuable by farmers because of the direct benefit they draw from it. Therefore economic incentive can be motivation factors for farmers' participation in a contract scheme (da Silva & Rankin, 2013; Saenger et al., 2013; Will, 2013). When there is lack of alternative sources of income, of earning extra income from the contract crop, these motivate farmers to engage in a CF scheme (Masakure & Henson, 2005).

Other authors look at financial incentives as the only means to motivate farmers to engage in CF and invest in quality performance (Baumann, 2000; Saenger et al., 2013) although financial incentive has its limits. Gneezy, Meier, and Rey-biel (2011) studied when and why incentives work or do not work to modify behaviour. Though their study focused on students' behaviour in response of their fathers' financial incentive to read, the study has important lessons for the agricultural sector. Based on the principal agent theory, incentives might have the desired effects in the short term, but weaken intrinsic motivation (Gneezy et al., 2011).

For these authors monetary incentives from the principal may change how tasks are perceived by agents, with negative effects on behaviour in some cases (Gneezy et al., 2011). Given the cost constraint faced by firms in the rice market (price taker) and the tremendous concurrence of imported rice, firms could find it difficult to increase the certain price level incentive for quality rice production. Yovo (2010) investigated price incentive, profitability and competitiveness in rice production in the south of Togo and found that a price incentive increased rice profitability but not necessarily the competitiveness of local rice, which mostly depends on quality improvement. He concluded that there is a need to improve local rice quality/rice relationship. This conclusion is also supported by Tabone, Koffi-Tessio, and Diagne (2010). In such circumstances, other forms of incentives are better alternative to be used.

Gneezy et al. (2011) identified two kinds of effect of monetary incentive: the standard direct price effect, and an indirect psychological effect. The standard direct price effect makes the incentivized behaviour more attractive, while the psychological effect can sometimes work in the opposite direction to the price effect and can crowd out the incentivized behaviour. This means that an incentive can reduce motivation or effort to undertake a task during a short run when such incentives are in place (Gneezy et al., 2011). The authors also recognize that incentives could foster good habits for a long time. They conclude that when individuals experience the positive aspect of the incentive, their motivation to continue their improved habits will increase enough even without the extrinsic motivation.

What is clear is that CF have to create enough value in the chain for possible interlink among actors. The problem is that stable crops such as rice are characterized by limited quality upgrading potential and low value (Colen et al., 2013). Most of price set ups in staple crop contracts are based on the market price. For Wang et al. (2014) there is no expected price advantages in CF in circumstances where the contract price is set up based on market price. It is not easy to base quality upgrading only on price incentive; other incentive means are needed. CF can develop a broad variety of incentive instruments such as input supply, field visits and advice, quality assessment, guaranteed market and incentive to cash and carry, with the aim to produce high-quality output (Bellemare, 2012).

Intangible Benefits: Intangible benefits, such as getting satisfaction in growing a quality product under contract, or see benefits to others, may motivate farmers to engage in a CF scheme. Deng and Hendrikse (2013) studied the interaction between social capital, quality premiums and pooling and their influence on cooperative member's decisions regarding their product quality. They found that the social motivation in cooperatives can guarantee high quality product when the level of social capital is high, even while economic incentive are weak. But when the level of social capital declines, their findings showed that, to maintain the product quality, an income rights structure with stronger quality incentives must be adopted by the cooperative.

Processor Motivation for Contract Farming: Farmers are not the only ones who have motivation for contract farming; processors, firms or buyers also have. Most of the time processors have their own quality standards that are not easy to meet when buying raw material in spot markets. Singh, (2002) recognized that the availability of quality raw material constitutes a huge problem for agribusiness or processor firms, and CF has emerged as prerequisites for them whether operating in the domestic or the international market. Small farmers and their families are more likely to produce high-quality when well trained (Singh, 2002). Increase in product quality is one of the most important reasons for them to contract (Eaton & Shepherd, 2001). Desired quality and supply of continuous quantities are often not available on the open market.

3.23 Exogenous Factors

Exogenous conditions have an impact on farm productivity and efficiency. Agricultural variables, farmer-specific factors, and institutional factors are the most common exogenous elements found in farm research. Farmers' productivity can be influenced positively or negatively by a variety of socioeconomic and external factors.

According to the results of the study, these factors may or may not be statistically significant. Size, seed, fertilizer, and labor all have a role in determining a farmer's success or failure. Onumah et al. (2013) found that access to credit, household size, contact with extension agents, and the distance between the farm and the farmer's residence are all farm-specific characteristics.

The a priori expectation of the link between certain farm factors and output is virtually always consistent thanks to many efficiency studies in agriculture. Efficiency and production can be boosted by factors such as education, financial resources, and membership of an FBO.

In agriculture, institutional factors have a role as well. These factors influence the size, type, and productivity of farms, and they include social institutions, tenancy issues, and property ownership.

3.24 Econometric Packages for Efficiency Analysis

To estimate various types of efficiency, researchers have employed a variety of econometric tools, including Ox-SFAMB (as used by Onumah et al. (2010)), STATA, LIMDEP, GAUSS, and SAS. The econometric software FRONTIER 4.1 (Coelli, 1996) and FRONTIER 4.1 (Greene, 1995) are widely used for efficiency analysis. For efficiency estimations, the Ox-SFAMB software (Brümmer, 2003) required under FRONTIER 4.1 is also commonly used. The LIMDEP has been used in EE analysis in this and other empirical investigations. The FRONTIER 4.1 package was created with stochastic frontier estimations in mind. The LIMDEP, on the other hand, is more versatile in terms of non-standard econometric computations (Sena, 1999). The efficiency estimates are generated as a direct output from the package for the FRONTIER 4.1 econometric tool, which is useful because the distribution assumptions for the inefficiency term estimations may be defined in a program control file (Coelli, 1996).

3.25 Conclusion

This section of the study analyzed literature on concepts and definitions of CF, as well as the history and scope of CF, the drivers of demand and supply for CF, and the prospects and models for CF, among other areas.

The theoretical and conceptual approaches to CF were also discussed in the chapter. For the purposes of this study, seven different CF theories and conceptual approaches were addressed in detail. The seven theoretical and conceptual approaches are as follows: the Life-Cycle Theory Approach, the Transaction Cost Approach, the Contract Enforcement Approach, the Convention Theory Approach, the Value Chain Governance Approach, the Competency/Capability Theories Approach, the Political Economy of Agrarian Change, and a comparative review of theories.

The chapter reviewed the productivity and efficiency literature, as well as various measurement approaches, and concluded that efficiency and productivity are linked when the way inputs are used in a production system leads to the production of optimal output levels. The research reviewed has demonstrated the importance of doing efficiency analyses when attempting to determine farm-level productivity. The papers under consideration were written between 1957 and 2020. Several studies have demonstrated that identifying the causes and primary predictors of inefficiencies among a group of farmers is critical to developing the most effective policy to address such issues. These studies have demonstrated that identifying the causes and primary predictors of inefficiencies among a group of farmers is critical to developing the most effective policy to address such issues.

A major advantage of the parametric method is that it allows for the expression of frontier technologies in a straightforward mathematical form while also supporting non-constant returns to scale. It also divides the error term into two categories: statistical noise (which is outside of the control of the production agent) and inefficiency (a one-sided error term). Unobserved heterogeneity among firms can be controlled using stochastic frontier models, which has a number of advantages. A function efficiency study was performed on the selected functional form, and judgements on the sample were created based on the results of the analysis.

Also, the chapter pointed out that the Greene (2010) approach is the most appropriate model for accounting for selectivity bias arising from observable and unobservable variables. This was adopted for this study. The impact assessment models which are used to solve selection bias problem emanating from observational cross-sectional data are Heckman treatment model, PSM, instrumental variables (endogenous treatment effects model). Out of these, the endogenous treatment effects model are superior since they have the ability to account for both observable and unobservable heterogeneity. Estimators from endogenous treatment effect models are consistent because the models have the ability to deal with any hidden biases, However, whether or not a researcher uses endogenous treatment effect model or any other model depends on the appropriateness of the data collected.

CHAPTER FOUR

METHODOLOGY OF THE STUDY

4.1 Introduction

This chapter discusses the study methodology, the study area, conceptual framework, theoretical framework, study area, data types and sources, sampling mechanism and sample size. It also covers research design, data analysis methods and empirical models. It concludes with the definition of possible variables used in the models, as well as their measurement and *a priori* expectations.

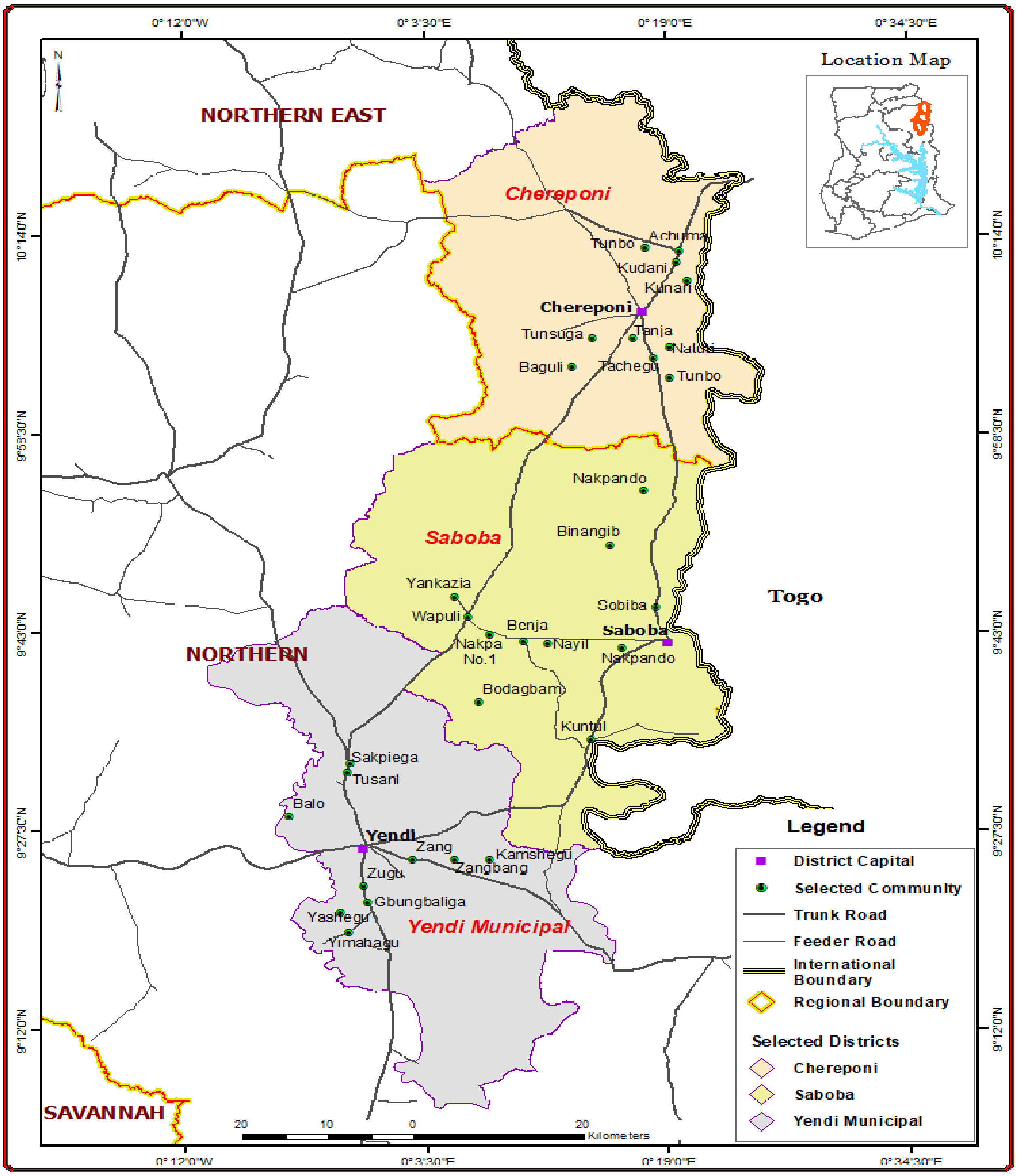
4.2 The Study Area

The study took place in Ghana's Northern Region. In the 2021 Population and Housing Census, the Northern Region had a total population of 2,310,943 (a little more than 2 million people), making it Ghana's sixth most populous region (GSS, 2021). The Northern Region was divided into two additional regions, the North East and Savanna. Tamale serves as the regional capital. The region is divided into fourteen administrative and political districts. It is bounded on the north by the North East Region, on the south by the Oti Region, on the west by the Savanna Region, and on the east by the Republic of Togo. The White and Black Volta combine to form the Region's largest lakes. The land is relatively flat and low lying (MoFA, 2011), which makes agricultural production feasible. It is estimated that about 68.5% labour force are directly into agriculture in the Northern Region. Administrative, professional and service sector workers (including transport and sales) share employment by 4.4%, 7.8% and 19.3% respectively (MoFA, 2015). The area is predominantly populated by Dagombas, with other tribes such as Gonjas, Kokombas, Chekosis and Mamprusis. The Northern Region is covered by the guinea savanna agro-ecological zone and has a seasonal rainfall spanning from March or April through to October after reaching a peak in September. It is characterized by a rainfall variability of 15-20% (MoFA, 2006). The region is one of the homes to most of the foodstuffs produced in Ghana especially cereals, tubers, and legumes.

Soybean is a leguminous crop mainly produced in the five regions of northern Ghana (MoFA, 2011). Within these regions, the Northern Region, is the leading producer of soybean in Ghana. The climatic and agricultural land conditions in the region are suitable for soybean production. This presents an opportunity to explore factors hindering the productivity of soybean producers in the Region. One way to increase soybean productivity could be CF and there are many organizations like ADRA, SFMC, SADA and Masara N'Arziki into CF with smallholder farmers to increase the crop's productivity. This necessitates the choice of this study in the Northern Region.

The study targeted the districts and communities where these organizations contract farmers to produce soybeans to meet the demand in the market. Figure 4.2 is a map showing the major soybean production areas as well as where contractual soybean production takes place in the region. The study's focus was on these areas.

Map of Selected Districts and Communities in the two Northern Regions of Ghana



Source: Survey Department, Accra, Ghana Date: 2015

Figure 4.2: Map of the study area

4.3 Research Design

Research design is very important in the body of research work. It gives a clear picture of what research methods to employ for a research work. It highlights the problem, the location, duration of the study and how to address the issues. It is an overall framework for the researcher to answer the research problem, test research hypotheses and/or monitor variance (Kothari, 2004). A research design, according to Kothari (2004), is essentially an arrangement of data collection and analyzing circumstances that correspond to research questions or hypotheses. Descriptive, correlational, quasi-experimental, and experimental research designs are the four categories of research designs (Dulock, 1993). Research design does not have a universal or standard training system, however, but depends on the overall goal of the investigator (Dulock, 1993; Teddlie and Tashakkori, 2003). To achieve its objectives, the study used a combination of research design types.

The target population of this study were small-holder soybean farmers under CF and non-contract farmers in the selected districts. The mixed research method, consisting of quantitative and qualitative research designs were adopted during this study. The Research Quantity Design (RQD) consists of experimental and non-experimental designs (including surveys) (Creswell, 2003; Rond and Thiétart, 2007). The quality research design was used to generate an in-depth discussion of why some farmers did not participate in soybean CF.

4.4 Sources, Type and Method of Data Collection

Small-scale soybean farmers who operated under contract or on their own provided most of the data for the study. Data were acquired primarily through surveys, focus group discussions, and key informant interviews for the 2017/2018 cropping season. In October 2017, the survey instruments were pretested in two communities in the study area, Zagbang and Wapuli, to ensure that they were clear, consistent, and appropriate for the survey. The instruments were revised after a thorough examination of the pre-test sample. To assist in the collection of data for the research, five enumerators were trained in data collection methodologies. The main survey was done in January 2018 and lasted for five months. The study combined both quantitative and qualitative methods popularly known as research mixed design. Quantitative data which measure values or counts and mostly numeric included cost of inputs, revenues from productions, age, number of acres cultivated among others.

A qualitative study, according to Taylor and Bogdan (1984), is one in which descriptive data are generated through summarizing people's own written or spoken words, as well as behaviour. Some qualitative data that were collected include constraints in soybean production, benefits from CF, satisfaction from soybean production, among others. The research design for this study was non-experimental.

A semi-structured questionnaire was distributed to respondents from the study population. It contained both closed- and open-ended items (See Appendix 2). The questionnaire elicited information regarding farmers' demographic and administrative characteristics, husbandry techniques, and understanding of CF, among other things.

Additionally, the questionnaire requested detailed information about credit availability, seeds, land ownership, assets, expenditure, extension contacts, and involvement in farmer-based groups. Further, the questionnaire gathered data on the quantity and types of labour, as well as the pricing of inputs and outputs.

Through focus group discussions, farmers offered more primary data. Focus group discussions were utilized to gather information and, if there was a general agreement, to validate the findings of the individual interviews conducted earlier. Respondents were divided into groups of 20-25, and a checklist of questions was used to guide the discussion and take notes. A total of 13 focus group discussions were conducted.

4.5 Sampling Procedure and Sample Size

This section explains the procedure used in sampling respondents and the number of respondents. According to MoFA-SRID (2015) six (6) Districts, namely, Yendi, Soboba, Tamale, Chereponi, Tolon, and Savelugu are large producers of soybean in the Northern Region. The research concentrated in these Districts because of that. However, contractual soybean production largely takes place in three of these districts; Yendi, Soboba and Chereponi (SFMC, 2017).

The study chose soybean growers using a multi-stage sampling method. Northern Region was purposively chosen for the study in the first stage because it is the country's leading soybean producer (MoFA SRID, 2015). The three (3) districts were chosen on purpose since they are the largest soybean growers in the Northern Region and also because they have contractual soybean production.

This was followed by a sampling method known as Probability Proportion by Size (PPS). A random sampling method was used to select ten (10) communities from each district based on the number of soybean farmers and the existence of contract farmers in the community. In total, thirty (30) communities were chosen at random for the study.

The soybean farmers in each selected district were separated into two groups in the second stage: contract soybean farmers (participants) and non-contract soybean farmers (non-participants). Prior to the start of the survey, SFMC and NDA, two of the companies that contract these farmers to cultivate soybeans, provided a list of contract soybean farmers.

The list revealed 655 farmers from the 3 districts where these CF takes place. In determining the sample size for the study, Slovin's formula used by Visco (2006) and Rivera (2007) was adopted. It is expressed as:

$$n = \frac{N}{1 + Ne^2} \quad \ldots\ldots 4.1$$

Where *n* is the sample size, *e* is the margin of error (which is 0.06 with confidence level of 94%). N is the population of contract soybean farmers, which is 655 for this study. By substitution, the sample size *(n)* is computed as 195. The sample size was however adjusted to 210 to cater for some design effect that might have arisen. These 210 contract farmers were randomly selected, representing 32% of the total farmers in soybean CF.

The non-participants (non-contract soybean farmers) were also distributed throughout the selected communities of the contract farmers. Non-contract farmers make an excellent comparison group since they originate in similar areas to contract farmers, have comparable infrastructure, face comparable prices, and own comparable assets. Additionally, 210 non-contract farmers with comparable characteristics were chosen at random to match the contract farmers in the study. Thus, the study comprised an equal number of contract and non-contract soybean producers from each stratum. The interview drew a total of 420 respondents. However, following data collection and cleaning, the number of respondents reduced to 374 (200 contract farmers and 174 non-contract farmers).

4.6 Methods of Data Analysis

The data were analysed and the research objectives were met using qualitative and econometric techniques. The data was processed and analysed by using MS excel, LIMDEP 11 and STATA 14 econometric software. Descriptive statistics was done using SPSS to examine the socioeconomic characteristics of farmers. To investigate the challenges that farmers encounter in soybean cultivation, the Kendall's coefficient of concordance was utilized. The constraint with the lowest mean was deemed the most urgent, while the constraint with the highest mean was deemed the least urgent.

4.6.1 Focus Group Discussion

A focus group is a group of people who have been gathered to talk about a specific topic, issue, or concern. The meeting is guided and structured by a moderator (chair), who incorporates open-ended questions to encourage discussion. The method is based on group synergy, which is defined as the interaction between individuals during a discussion (Kitzinger, 1994). Qualitative data are gathered by focus groups. Rather than statistically validated facts, they offer detailed insights into people's beliefs and experiences. As a result, the information gathered through focus groups differs greatly from that gathered through quantitative methods. Focus groups, as opposed to surveys, allow for greater flexibility in the way questions are asked. Because the discussion's content may take unexpected turns or open new topics, the method is more open-ended.

In a short period of time, focus groups produce enormous amounts of highly concentrated, well-targeted, and pre-filtered data. While focus groups are more efficient than observational analysis, they sacrifice the realistic context provided by nonverbal communication on a conscious and subconscious level, as well as the fine precision required for naturalistic functioning. By incorporating the various data collection methods required for the analysis, this flaw was overcome. Because each participant has less time to contribute and draw out thoughts, the depth of the data is limited when compared to interviews. Focus groups collect many forms of data because of interactions with people and the social group context, which results in reactions such as encouragement and stimulation. Because they eliminate repetition and overlap, focus groups are more effective than interviews (Morgan, 2002).

This was used to seek information on the nature of contractual arrangement in the districts, to identify challenges in contractual and non-contractual soybean cultivation and to suggest ways of improving contracting guidelines that is best suitable for farmers in a win-win strategic manner. Meetings for contract and non-contract farmers were held separately. Male respondents were also separated from female respondents; this was to give the females the freedom to freely express themselves during the discussions. Culturally, in the study areas where the research was carried, women are unable to express themselves when mixed with their male counterparts especially their husbands. Checklist questions and flip chart was used during discussion. Discussions were held in each village with farmer groups.

4.7 Analytical Framework and Empirical Models

This section outlines the various analytical approaches used in attaining each specified objective. It also outlines how the variables were measured in the study.

4.7.1 Estimating Factors Influencing Participating in Contract Farming

Farmers'decision on whether to participate in an innovation/intervention or not has been studied in a wide range of literature (Afolami, Obayelu, & Ignatius, 2015; Kontogeorgos, Sergaki, Migdakos,& Semos, 2008; Manda, Alene, Gardebroek, Kassie, & Tembo, 2015; Sodjinou et al., 2015). In practice, the probit or logit models are used to determine the probability that smallholder farmers will participate in a technology or not. In this study, as the participating in CF is a dichotomous or binary dependent variable with the option of either participation' or non-participation', the probit model was considered to be the most appropriate analytical tool because it allows for the estimation of marginal effects and its fitness to the data. Therefore, as specified in the theoretical model in equation 4.45 the farmers' CF participation decision was specified as follows:

$$P_r(j) = P_r(Q_i = 1/X) = F(Z_i) = F(\beta' X) \qquad 4.2$$

A vector of explanatory variables is represented by X, where F($\bullet$) represents the cumulative normal P_r distribution probability, and β is the vector of parameters to be estimated, and $\beta' X$ is the index function that permits the estimation of the probability of participation. The parameters in the above equation (4.2) are estimated by maximum likelihood methods. According to Greene (2008) and Maddala (1983), in the case of the normal distribution function, the model to estimate the probability of observing a farmer participating in CF can be stated as;

$$P_r(Q_i = 1/X) = F(Z_i) = \int_{-\infty}^{x'\beta} \Phi(t)dt = F(\beta' X) \qquad 4.3$$

Where $\Phi(\cdot)$ is a the normal density function and its derivative is given as:

$$\Phi(t) = \frac{1}{\sqrt{2\pi}} \exp^{-0.5t^2} \qquad 4.4$$

Since the estimated coefficients (*β's*) do not have simple interpretation, except that they tell how the explanatory variables are related to the dependent variable (Greene, 2003; Hill *et al.*, 2008; Stock & Watson, 2007), the model is best interpreted by computing the marginal effects as follows:

$$\frac{\partial E(Q/x_i)}{\partial x_i} = F(Z_i)\beta_j \qquad 4.5$$

Where;

$$Z_i = \beta_o + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots \beta_k x_{ik} + \varepsilon_i \qquad 4.6$$

The marginal effect shows the effect of an increase in x_i on p_r and this effect depends on the slope of the probit function which is given by $F(Z_i)$ and the magnitude of the parameter. In order to estimate the probabilities of farmers making a decision to participate or not to participate in CF as a function observed characteristics (X_i) and unobserved characteristics (ε_i) that is:

$$Q_i^* = X_i^{'}\beta + \varepsilon_i \qquad 4.7$$

Where Q_i^* is a latent variable which is unobservable, and what is observed is the CF production decision that can be related to the observable binary variable Q through the expression

$$\begin{matrix} 1 \; if \; Q_i^* > 0 \\ 0 \; if \; Q_i^* \leq 0 \end{matrix} \qquad 4.8$$

Equation 4.7 can be expanded as;

$$Q_i = \beta_0 + \beta_1 SEX + \beta_2 AGE + \beta_3 EDUC + \beta_4 EXP + \beta_5 CD + \beta_6 OFFBUS + \beta_7 FSIZE \\ + \beta_8 PCRE + \beta_9 EXT + \beta_{10} FMDIS + \varepsilon_1 \qquad 4.9$$

Where: Q_i is the 0-1 outcome with 1 corresponding to farmers who produced soybean under CF and 0 relating to farmers who produced soybean independently $\beta_1 - \beta_{10}$ are the parameters to be estimated, and is the ε_1 error term which is assumed to follow a

standard normal distribution with mean zero and variance 1. Table 4.3 presents a summary of the explanatory variables in the equation (4.9).

4.7.2 Economic Efficiency Differences Between Contract and Non-Contract farmers: A Comparative Analysis

This section describes the approach that was used to assess efficiency levels for contract and non-contract producers in Ghana's Northern Region. A total of 374 farmers from three Northern Region districts contributed data for the study.

4.7.2.1 Stochastic Frontier and Efficiency Analysis

The most frequently used method for calculating efficiency is using a stochastic frontier production function (Rahman, 2003; Coelli et al, 2005). As a result, the stochastic frontier production function is utilized to evaluate both the yield and efficiency of soybean varieties and farmers. Numerous functional forms are utilized to model production functions. Cobb-Douglas (linear logs of outputs and inputs), quadratic (in inputs), normalized quadratic, and transcendental logarithmic are some of the most prominent functional forms. When dealing with production function estimations, it is vital for a researcher to pick and employ the suitable functional form. While Ahmad and Bravo-Ureta (1996) and Kopp and Smith (1980) revealed that the functional forms used have little effect on efficiency, it is critical to choose the one that produces the best estimates.

The functional form used must be adaptable, simple to calculate parameters, and satisfy the homogeneity constraint. Additionally, the suitability of a given functional form can be determined. As shown in Table 6.2, this study's hypothesis test determined that the translog functional form was more appropriate for the analysis.

Sharma, Leung, and Zaleski (1999) proposed the following single-output stochastic frontier for the Cobb-Douglas example expressed as:

$$Y_j = g(X_{ij};\beta) \quad \text{..........4.10}$$

Where, Y is the output of the *Jth* farm X_{ij} is the input used by farmer j and β is a vector of unknown parameter. From equation 4.10, it is possible to drive the *technically efficient input quantities* X_{it} for any given level of output Y, by solving simultaneously the following equation:

$$Y = g(X_i;\beta) \quad \text{..........4.11}$$

And the observed input ratio $X_1/X_i = k_i$ where K is the ratio of the observed level of input $k_i X_i (i \rhd 1)$ at output Y. Let's assume that the production frontier in equation 4.10 is self-dual (e.g. Cobb-Douglas), therefore, the dual cost frontier can be derived and written in general form as:

$$C = h(P,Y;\alpha) \quad \text{..........4.12}$$

Where C is the cheapest way to create output *Y*, *P* is the *jth* farmer's input price vector, and α is a set of parameters to be estimated. It is possible to calculate the farmer's economically efficient (X_{ie}) input vector. We find the following partial derivatives with respect to input prices for the system connected to cost-minimizing input demand functions:

$$\partial C/\partial P_i = X_{di} = f(P,Y;\Phi) \quad \text{..........4.13}$$

Where θ is a parameter vector. The observed technically efficient input vector (Xit), and economically efficient input vector (*X*ie), cost of production of the *jth* farm are used to compute allocative efficient input vector (*X*ia), the actual cost of operating input. The basis of calculating *TE* and *EE* are as follows

$TE = (X_t.)(X_a.P)$ ……………………………………………………….…4.14

$EE = (X_e.)(X_a.P)$ ………………………………………………………..4.15

Finally, in Farrell (1957) methodology, EE can be explained as a product of TE and AE. Therefore, we can calculate AE from equations (4.14) and (4.15) as:

$$AE = \frac{(X_t)}{(X_e.P)} = \frac{EE}{TE}$$ ……………………………………………4.16

However, according to Schmidt and Lovell (1979), the deterministic frontier approach of Farrell (1957) is extremely sensitive to outliers because the parameters are not estimated statistically, but rather computed using mathematical programming techniques. Furthermore, as Schmidt points out, statistical noise affects efficiency measures derived from deterministic models (1986). Thus, the Stochastic Frontier Production Function is employed in this study, and it is specified using the following equation (4.10)

$$\ln(Y_1^*) = \beta_0 + \sum_i \beta_i \ln X_{ij} + \varepsilon_{ij}$$ ……………………………………4.17

Where;

$$\varepsilon = V - U$$ ……………………………………………………4.18

Where V is a two-sided (-∞ < V < ∞) normally distributed random error $N(0, \sigma_v^2)$ that captures stochastic effects beyond the farmer's control (e.g. weather, natural disasters, etc.), as well as the effect of measurement error in the output variable, omitted explanatory variables from the model, and other stochastic noise. The term U refers to a one-sided non-negative random variable (u>0) connected with the efficiency component, which represents the farmer's technical inefficiency. In other words, U is the difference between the highest value of output Y and the value given by the stochastic frontier function $f(Xi;\beta) + V$. This one-sided error term can follow half-normal, exponential, or gamma distributions (Aigner et al., 1977; Green, 1980; Meeusen and Van den Broeck, 1977). *U* will be assumed to have a half-normal distribution $N(0,\sigma^2_u)$ in this analysis, as is customary in the applied stochastic frontier literature. $cov(v,u)=0$ is derived from the assumption that the two components V and U are independent of one another.

Equation (4.15) produces consistent estimators of β, λ and σ^2 where β is a vector of unknown parameters, $\lambda = \sigma_u/\sigma_v$ and $\sigma^2 = \sigma^2_u + \sigma^2_v$. According to Jondrow et al (1982), conclusions regarding individual farmers' technical inefficiency can be drawn by evaluating the conditional distribution provided for V and U, and assuming that these two components are independent of each other, the conditional mean of U given Ɛ is defined as:

$$E = (\mu/\varepsilon) = \sigma^* \frac{f^*(Ɛ_j\lambda/\sigma - Ɛ_j\lambda}{1-F^*(Ɛ_j\lambda/\sigma)\sigma} \text{..4.19}$$

Where $\sigma^2_* = \sigma^2_u \sigma^2_v / \sigma^2$,f^* are the standard normal density function and F* is the distribution function, both of which are evaluated at $\varepsilon_j\lambda/\sigma$. As a result, we may deduce the estimates of V and U by substituting their estimates for ε, σ_* and λ and in equations (4.15) and (4.17). The stochastic frontier function is obtained by removing V from both sides of equation (4.15):

$$ln(Y_1^*) = \beta 0 + ilnXij - Ui = ln(Y_1^*) - Vi \text{.................................4.20}$$

where *ln (Yi*)* is the farm's observed output after accounting for the statistical noise in *Vi*. We can compute the TE input vector, X_{it}, and deduce the cost frontier, which is the basis for deriving minimum cost factor demand equations, both of which are then utilized to estimate EE, $X_{ie}.P^{-1}$ using equation 4.18.

The economically efficient input vector, X_{ie}, is determined using Shepherd's Lemma by putting the firm's input prices and adjusted output quantities into a system of compensated demand equations stated as:

$$\frac{\partial C_j}{\partial P_j} = X_j = \beta_i P_i^{-1} Y^* \quad \ldots 4.21$$

As a result, TE, EE, and the actual cost of production are equal to $P_j X_j^T$ and $P_i X_j$ at a given level of output. The *jth* firm's TE and EE are calculated using these three cost indicators. As a result, TE and EE can be calculated as follows:

$$TE_j = \frac{\text{PjXjT}}{\text{PjXj}} \quad \ldots 4.22$$

$$EE_j = \frac{\text{PjXJc}}{\text{PjXj}} \quad \ldots 4.23$$

EE is the multiplication of TE and AE (TE*AE), hence equation 4.20 and 4.21 can be transformed to compute the AE as follows.

$$AE = \frac{\text{PjXJc}}{\text{PjXjT}} \quad \ldots 4.24$$

With this information, the researcher can compare the TE, EE and AE levels and determinants of inefficiencies of contract and non-CF of soybean producers in the study area.

4.7.2.2. Sample Selection in a Stochastic Frontier Model

Stochastic Production Frontier (SPF) models have been used widely in many areas, including agriculture, to model input–output relationships and to measure the EE of farmers (Bravo-Ureta et al., 2007). Additionally, comparable methodologies have been used to evaluate farmer performance in response to a range of technological interventions. For instance, the approach was employed to investigate the effect of technology adoption on rice farm output and TE (Villano et al., 2015).

Most studies that used stochastic production frontiers (SPFs) to compare the EE of participants versus non-participants versus non-adopters failed to account for selectivity bias caused by both observable and unobservable variables in a manner consistent with the nonlinear nature of the SFM.

For example, various attempts have been made to account for selection bias using Heckman's (1979) methods in a stochastic frontier framework. Sipilainen and Oude Lansink (2005) examined sample selection bias in a comparison of organic and conventional farms by inserting an inverse Mill's ratio (IMR) into the deterministic section of the frontier function. Solis et al. (2007) used a similar approach in examining Central American farmers who adopted varying degrees of soil conservation. This method, however, has been shown to be ineffective for nonlinear models such as the SPF (Greene, 2010).

Recent years have seen the development of alternative strategies for addressing this issue, including one by Kumbhakar et al. (2009), who developed a model in which the selection mechanism is assumed to operate via one-sided error in the frontier and then used their model to compare the performance of organic and conventional dairy farming in Finland. Lai et al. (2009) investigated wage determination using a copula function, assuming that selection is connected to the frontier's constructed error. Both models necessitate the employment of computationally intensive log likelihood functions.

Greene (2010) extended Heckman's technique to include sample selection within a stochastic frontier framework by assuming that the selection equation's unobserved attributes are related to the stochastic frontier's noise. The following blocks of equations summarize Greene's (2010) model, which was used in this study.

$d_i^* = 1[\alpha' z_i + w_i](d_i^* > 0), w_i \sim N(0,1)$ (Selection equation) ……………………..…4.25

$y_i = \beta' x_i + \varepsilon_i$ ………………………………………………………………………4.26

(y_i, x_i) were observed only when $d_i = 1$. The error structure was specified as:

$\varepsilon_i = v_i - u_i$ ………………………………………………………………………4.27

Where $u_i = |\sigma_u U_i| = \sigma_u |U_i|$ *where* $U_i \sim (0,1)$ ……………………………………4.28

$v_i = \sigma_v V_i$ *where* $V_i \sim (0,1)$………………………………………………………...4.29

$(w_i v_i) \sim N_2[(0,0),(1, \rho\sigma_v, \sigma_v^2)]$

Bivariate standard normal $[(0, \quad 0),(1, \quad \rho, \quad 1)]$, (y_i, x_i) only observed when $d_i = 1$.

- *d* is a binary variable, specified as 1 for contract farmers, and 0 for non-contract counterparts
- The (binary) sample selection model includes a vector of explanatory factors called *z*.

- *wi* is the unobservable error term;
- y is the output for soybean farmers;
- x is an input vector on the production frontier; and
- *ε* is the composite error term.

The coefficients α and β were estimated, whereas the factors in the error structure correspond to those often included in stochastic frontier formulations. Sample selection occurred in this case because the noise in the stochastic frontier v_i-u_i was related to unobserved attributes in the sample selection equation. If the selectivity variable ρ is statistically significant, then sample selection bias exists. Is this study, the ρ was significant for the stochastic production function after the analysis was done as seen in Table 6.3 in the discussion, justifying the use of this approach.

4.7.2.3 The Technical Efficiency Model

The results of testing on Table 6.2 for functional form showed that, translog functional form was best fit for the analysis. The stochastic production frontier model's empirical translog specification is as follows:

$$LnY_i = \beta_0 + \beta_1 \ln farmsize + \beta_2 \ln seed + \beta_3 \ln agrochemicals + \beta_4 \ln labour + \frac{1}{2}\beta_5(\ln farmsize)^2 + \frac{1}{2}\beta_6(\ln seed)^2 + \frac{1}{2}\beta_7(\ln agrochemicals)^2 + \frac{1}{2}\beta_8(\ln labour)^2 + \beta_9 \ln farmsize * seed + \beta_{10} \ln farmsize * agrochemicals + \beta_{11} \ln farmsize * labour + \beta_{12} \ln seed * agrochemicals + \beta_{13} \ln seed * labour + \beta_{14} \ln agrochemicals * labour + v_i + u_i \quad \ldots\ldots 4.30$$

Where Y_i is an *ith* farmer's total soybean output in kg/ha, and $\beta_1, \beta_2 \ldots\ldots \beta_{14}$ are the slope coefficients. The term $(v_i - u_i)$ is the composed error term, where v_i represents randomness and reflects stochastic effects beyond the control of the farmer (e.g., measurement mistakes, weather, natural disasters, luck, and other statistical noise) and u_i indicates farmer technical inefficiency. The approach employed was a one-step maximum likelihood estimation procedure.

Following Greene (2010), the study estimated a series of SPF models, including (1) a conventional pooled sample model with CF participation dummy as an independent variable, (2) two SPF models, one for participants and one for non-participants using the Greene's (2010) sample selection model, which corrects for selection bias from both observable and unobservable variables. Preliminary comparisons led to the rejection of the Cobb-Douglas in favour of the translog (TL) functional form. The TL specification correcting for sample selection bias used in the analyses is given as follows:

$$\ln(Y_i) = \beta_0 + \Sigma_{j=1}^{4}\beta_j \ln X_{ji} + \frac{1}{2}\Sigma_{j=1}^{4}\Sigma_{k=1}^{4}\beta_{jk} \ln X_{jki} + v_i - u_i \text{.............................4.31}$$

Where *Yi* represents output, *X* are inputs, *β* are the unknown parameters, and *v* and *u* are the elements of the composed error term, *ε*. The explanatory variables include: farm size, seed quantities, agrochemicals quantities, labour.

4.7.2.4 Allocative Efficiency Model

In the empirical specification of the cost function, the translog stochastic cost frontier function is also assumed to be adequate for analyzing the economic efficiency of soybean production. As with the production frontier, a one-step maximum likelihood estimation procedure was used. As illustrated below, this was accomplished by integrating the cost inefficiency model in the translog cost function.

$$\ln C_i = \beta_o + \sum_{n=1}^{N} \beta_n \ln P_{ni} + \frac{1}{2}\sum_{n=1}^{N}\sum_{n=1}^{N} \beta_{ij} \ln P_{ni} \ln P_{nj} + \beta_y \ln Y_i + \frac{1}{2}\beta_{yy}(\ln Y_i)^2$$
$$+ \sum_{n=1}^{N} \beta_{iy} \ln Y_i \ln P_i + v_i + u_i \text{..}4.32$$

Where lnC_i signifies the natural logarithm of an *ith* farmer's total cost of soybean production in (GH¢). The average exchange rate in Dollars ($) in 2019 as at the time the data was collected was $1 to GH¢5.240 (Bank of Ghana, 2019). $P_{1i}, P_{2i}..........P_{4i}$ represent traditional input prices in GH¢. (P_1 denotes farm size cost, P_2 labor cost, p_3 seed cost, P_4 herbicide cost) y_i is the amount of soybeans produced in kilos. In addition, u_i is farm-specific and socioeconomic factors are linked to production efficiency, and v_i is a random variable linked to production disruptions.

4.7.2.5 Efficiency Indices Model

A range of farmer, farm, and institutional factors influence farmers' technical and allocative efficiency. According to Battese and Coelli (1995), the efficiency effects models (for technical and EE) are as follows:

$$U_i = \delta_o + \delta_1 \ln Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 + \delta_5 \ln Z_5 + \delta_6 \ln Z_6 +$$
$$\delta_7 \ln Z_7 + \varpi_i \text{..}33$$

Where $Z_1, Z_2 .... Z_7$ are sex (female =0, male = 1), crop diversification, number of years in education, farm-market distance in kilometres, farm size in hectares, farmer-based organization (FBO) membership (1 if a member, 0 otherwise), and soybean CF (1=yes,0=no)

4.7.3 The Effect of Contract Farming on TE, AE, and EE: Endogenous Treatment Effect Regression Model (ETERM)

The endogenous treatment effect regression model is a linear model that allows for correlation between unobservable variables affecting the treatment equation and variables affecting outcome measurements. The objective of this exercise is to model the effect of endogenous treatment on the outcome metric. In this model, the treatment and outcome equation errors are assumed to have a mixed normal distribution (Greene, 2002).

4.7.3.1 The Endogenous Treatment Effect Regression Model (ETERM) Specification

In economics empirical research, it is customary to assess the endogenous treatment impact. When a treatment can be characterized by a binary indicator function, the effect of the treatment is often evaluated using instrumental variables or the control function technique (Heckman, 1979). The endogenous treatment effects model (ETEM) is a linear model in which unobservable factors affecting household decision-making (CF) are linked to measures of household efficiency (HEM) (technical, allocative, and economic efficiencies). The technical, allocative, and economic efficiencies of a household are expressed as a percentage, with 0 representing total inefficiency and 1 representing maximum efficiency. The goal of this study is to duplicate the effect of household CF on small-scale soybean producer efficiency measures. Greene (2002) used the same endogenous treatment regression assumption to assess the effects of CF on technical, allocative, and EE. The errors in the selection equation (contract/non-contract farmers) and treatment equation (contract/non-contract farmers) are assumed to have a mixed normal distribution in this model (the measure of technical, allocative, and economic efficiencies). The following is the outcome model:

$$Eff_i = X_i\beta + \delta CF_i + \varepsilon_i \qquad 4.34$$

The influence of CF on technical, allocative, and economic efficiencies (Eff_i) is quantified here. The influence of CF on technical, allocative, and economic efficiency is not captured by the δ because participation in the CF program was a personal choice of the participants (case of self-selection). Therefore, failing to account for CF's potential endogeneity will lead to inaccurate treatment model estimates and an overestimation of the impact of contract participation on farmers' technical, allocative, and economic efficiency. Participation or non-participation in farmer contracts is based on household, individual, and farm characteristics $G_{i,}$ and is modeled as follows:

$$CF_i^{'} = G_i\alpha + \mu_i \qquad 4.35$$

$$CF_i = \begin{Bmatrix} 1 & if\ CF_i^* > 0 \\ 0 & Otherwise \end{Bmatrix} \qquad 4.36$$

Where CF_i^* indicates CF, X_i and G_i are unrelated variables. β and α are parameters to be estimated. The assumption is that ε_i and μ_i are jointly normally distributed, with a mean vector of 0 and a variance covariance matrix Σ given as:

$$\Sigma = \begin{pmatrix} \sigma_1^2 & \rho\sigma_1 \\ \rho\sigma_1 & 1 \end{pmatrix} \qquad 4.37$$

To estimate the model, you can use either the maximum likelihood or two-step approaches. As a result, a CF decision model (equation 3.35) as well as an outcome model are used to model this (equation 3.36). When endogenous involvement is considered, estimates of the impacts of households' decisions to participate in CF on their technical, allocative, and economic efficiencies become more consistent. The factors that influence the CF decision and the efficiency are calculated in tandem. Maximum likelihood analysis was used to assess the model.

4.7.4 Analysis of Major Constraints Faced by Soybean Producers

The relative prevalence of abiotic, biotic, and socio-economic constraints was assessed in the study area. Data was collected from respondents, for each constraint, information on awareness and its occurrence was elicited from each sampled farmer per ecology. Producers of soybeans were asked to rank the constraints. Kendall's Coefficient of Concordance was used to test the rankers' agreement and the relevance of the ranked constraints. The rankings' total sum and mean were determined.

The Kendall's coefficient of concordance (W) model was used to identify and rank the obstacles that contract and non-contract soybean farmers face (objective four). The Kendall's W model is a non-parametric measure for determining the level of agreement among different raters or judges (variables, characters, etc.) studying a set of objects (N) (Dodge, 2003; Legendre, 2005; and Corder and Foreman, 2009). The constraints experienced by soybean farmers should be assigned a range of weights, scores, values, or ranks by each rater, with each number signifying different degrees or magnitudes of the obstacles. The Kendall's W is modeled to produce a coefficient that ranges from 0-1, with 0 indicating no absolute agreement and 1 indicating absolute agreement (unanimity) among raters, and intermediates (0 and 1) indicating the degree of greater or lesser agreement (unanimity) among the responses. Kendall's statistic can be calculated as follows:

$$S = \sum_{i=1}^{n} \left(R_i - R\right)^2 \qquad \text{.......} 4.38$$

S is the sum of squares statistic applied to the row sums of rankings. Kendall's W statistic (Kendal and Babington Smith, 1939) can then be calculated as follows:

$$W = \frac{12S}{P^2\left(n^3 - n\right) - pT} \qquad \text{.......} 4.39$$

where n is the number of items or challenges to rank, and p is the number of persons who responded (raters). The letter T is used to break ties. Kendall's W statistic is an estimate of the variance of the row sums of ranks R_i divided by the greatest possible value for the variance when all respondents are in total agreement, hence $0 \leq W \leq 1$.

Legendre (2005) conducted a simulation study to compare the Friedman test and its permutation variation. Legendre (2005) explored a variant of the W statistic that allows for ties in ranks, as well as ways for doing W-based significance tests. Legendre's simulation work was hampered by the fact that neither the copula nor the F test was included. Kendall's W is a rank-based correlation measure, meaning the marginal distributions of the underlying variables have no bearing on it; only the multivariate copula does. The Kendall concordance statistic (W), which is analogous to the Spearman rank (nonparametric correlation between two variables), expresses the relationship between several cases, which is why it was chosen in this study.

4.8 Conceptual Framework

Figure 4.2 depicts the study's conceptual framework. The conceptual framework is a profound thought of processes or connections or systems to facilitate understanding of a particular study (Smyth, 2004). It sets out the relationship or interplay between the main variables. The framework demonstrates how environmental factors, farmer-specific attributes, institutional and regulatory considerations influence a farmer's decision to participate in soybean CF, as well as the impact of that participation on efficiency and, subsequently, output. The output levels of the production system are defined by farm EE and productivity (Lovell, 1993).

As previously said, farmer characteristics such as age, gender, management abilities, family size, and education may have an impact on their ability to participate in soybean contracts in the Northern region of Ghana. Apart from the farmers' decision-making criteria, a multitude of external factors influence whether to engage in a soybean CF. The primary external factors influencing a farmer's decision to participate in CF are farm-specific variables (farm size, seed, fertilizer, soil type, and agrochemicals among others); institutional and country-policy variables (input subsidies, extension services, and market access, among others); and environmental variables (rainfall, pest and disease, temperature, and so on). These factors are sufficient to enable the farmer to decide. Farmers are rational and information-conscious economic agents, aiming to maximize utility or profit from the adoption of agricultural technologies, which are critical to the changing agricultural product prices (Kijima et al., 2011). The farmer's ability to choose the best option is critical to utility maximization.

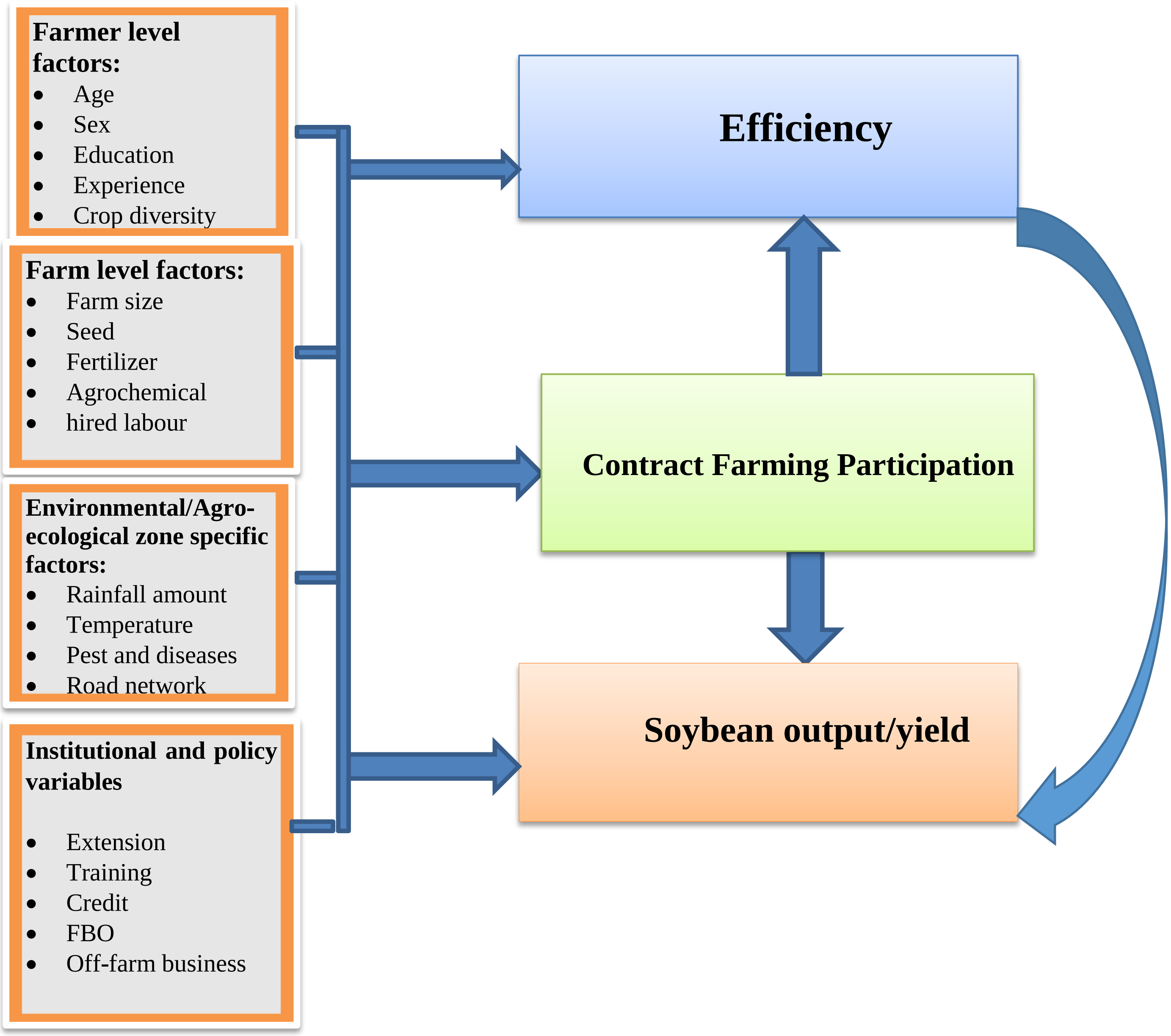


Figure 4.2 Conceptual Framework of the Study
Source: Modified from Kiatpathomchai (2008) and Alemaw (2014).

A farmer who cultivates soybeans has two options: either to participate in CF or not to participate in CF at all. The choice of a farmer is based on the assumption that he/she is a rational economic agent, and that his goal is to maximize utility or profit depending on the available inputs. The production function of a farmer is the technical link that connects the technology used and the output that is produced. Contract versus non-contract soybean farmers will have different soybean output and efficiency because of variances in production technology, characteristics specific to the individual farmer, environmental conditions, institutional and policy considerations, among other things.

How efficient a farmer is will determine how much output he or she can produce within the boundaries of the maximum yield frontier. Three facets of efficiencies have already been discussed, this include; the efficient allocation of resources (AE), the adoption of technology to provide the highest possible output (TE), and the product of these two components (EE). Since farmers' unique and agricultural qualities in different places are not the same, it is expected that their obtained efficiency would be varied, unless otherwise stated.

In addition to the characteristics listed above, farmers differ in a variety of characteristics, including socio-demographic and economic characteristics (such as age, gender, educational attainment, and income); farm-specific characteristics (such as seeds, labor, and farm size); institutional factors (such as access to credit and markets; extension service; and other factors); and environmental characteristics (rainfall amount, temperature, pests and diseases road network etc). In addition to contract participation, membership in soybean CF may have positive effects on efficiency and output in addition to contract participation. Farmers must improve on their individual characteristics (such as managerial talents) and/or farm-specific characteristics to increase production levels and catch up with those on the upper frontier (farm size, soil conditions, for example). Further discussion of the theoretical relationship between participation in CF technology and its impact on efficiency and production will be provided in the subsequent sections.

4.9 Theoretical framework

Three major theoretical principles underpin this work. To begin, we will examine the theory of utility maximization and, specifically, the factors influencing farmers' participation in contract agriculture, as well as the random utility theory. There are a variety of reasons why a farmer might be interested in CF, all of which have the potential to impact output and efficiency. However, it is difficult to explain observed differences in participant and non-participant outcomes only due to CF participation. This puts a sample selection bias into the procedure. The conventional method to self-selection problems is the Heckman selection–correction strategy (Heckman, 1979). Additionally, the study makes use of stochastic frontier theory to examine the EE of various farming systems (contract and non-contract soybean production). The sections below detail the various theories.

4.9.1 Theory of Producer Decision

It is necessary to employ choice modeling to accurately represent a farmer's decision to participate in CF or not to participate in the program. A common approach is to study the concept of choice in the context of a framework centered on utility maximization. It is presumed that the soybean farmer is a logical creature with a clearly defined economic goal while the decision-making process for soybean production is being carried out. When a rational producer is faced with a choice between two different activities, such as contract or non-contract soybean production, the rational producer seeks the option that provides the greatest amount of benefit, referred to as utility. Utility maximization, which will be discussed in greater detail below, will be necessary to acquire a better understanding of the factors affecting farmers' CF participation.

4.9.1.1 Decision to Participate in Contract Farming

The research was driven by producers' theory of behavior and decision-making. Farmers are typically presented with choices between several alternatives in decision making on agricultural production. The preference of one option over the other is often based on the utility of this specific product by the decision-maker. People's satisfaction with new ideas, technology, and interventions can be explained by the concept of utility. According to the idea of utility, a rational person makes production decisions for CF participation, market access, and extension services by selecting the option that will provide her with the most expected advantage (Fernandez-Cornejo et al., 1994; Loureiro and Umberger, 2007). This is stated as follows:

$$Max\, U_{ij} = f\left(X_{ij}\right) \qquad \text{.......................................,...........................4.40}$$

where U is the utility defined by a combination of individual, farm, and institutional factors (X); j can be any linkage (relationship) that farmer i chooses to participate in. The decision variable is unknown to the researcher, and hence, it is treated as a random variable (McFadden, 1974). However, the net (overall) decision to participate j, is stimulated if the expected utility $E(U_{i,j})$ is greater than the expected utility $E(U_{i,k})$, derived from participating in k alternative (open market) as shown below;

$U_i^* = E(U_{i,j}) \geq E(U_{i,k})$……………………………………………………………4.41

Where Ui^* represents the farmer's unobserved satisfactions or benefits from participating in CF as opposed to not participating. Instead, we can observe the farmer's participation in the linkage as her revealed preference, which can be modeled as a linear relationship of deterministic and unobserved components (also known as the random component) as follows:

$U_{ij} = X_{i,j}\beta + \mathcal{E}_{i,j}$……………………………………………………………………4.42

The deterministic component ($X_{i,j}\ \beta$) is made up of the observable characteristics (individual, household, farm-specific and institutional variables) associated with the decision maker while the random/stochastic component ($\mathcal{E}_{i,j}$) is the part of the unexplained utility function with a list of parameters to be estimated. We model the random decisions ($U_{i,j}$) as the probability of participating in linkage Pr (j=1). According to Verbeek (2004), the probability of choosing alternative j (that is if the farmer decides to contract) is given by:

$$\left.\begin{aligned} P_r(j/C) &= P_r\{(V_{ij}+\varepsilon_{ij}) \geq (V_{ik}+\varepsilon_{ik})\} \\ &= P_r\{(V_{ij}-V_{ik}) \geq (\varepsilon_{ik}-\varepsilon_{ij})\} \\ &= \forall_j \neq K \in C \end{aligned}\right\} \text{……………………………………4.43}$$

There are two types of producers in this study: those producing under contract, and non-contract producers. It is assumed that those producing under contract would optimize their expected utility. The non-contract farmers, on the other hand, have inherent reasons behind their choice. What are the reasons or factors for that?

From equation (4.4), the probability of choosing alternative *k* (non-CF) can be derived by;

$$P_r(k) = 1 - P_r(j) \qquad 4.44$$

Utility models are created by defining the probability distributions of the two disturbances $\varepsilon_i = (\varepsilon_{ik} - \varepsilon_{ij})$. Normal distribution and logistic distribution are the two most prevalent types. If the disturbance (ε_i) is distributed identically and independently as a Weibull distribution, this follows the logistic distribution, yielding the logit model (Maddala, 1983).

If the disturbances (ε_i) are believed to be normally distributed independently and identically, then their difference $(\varepsilon_{ik} - \varepsilon_{ij} = \varepsilon_i = u)$ will likewise be normally distributed, and the probit model can used to describe farmers' decisions to produce under contract using transformation.

The logistic density has larger tails than the typical normal density, although both models produce densities that are symmetric and bell-shaped. As previously stated, the logit and probit models are both used to evaluate dichotomous choice models (Greene, 2008). However, because the distributions of the two models are comparable, it is impossible to distinguish between the two models solely based on theoretical considerations (see Greene, 2003; Hill, Griffiths, & Lim, 2008; Maddala, 1992; Stock & Watson, 2007). The probit model is as stated below in equation 4.45

$$P_r(j) = P_r(Q_i = 1) = F(\beta_j^{'} X_j) \qquad 4.45$$

A vector of explanatory variables is represented by X, where F ($\bullet$) represents the cumulative normal P_r distribution probability, and β is an estimate of the coefficient of correlation.

The parameters in the above equation (4.45) are estimated by maximum likelihood methods. This is because the dichotomous dependent variable in the probit regression (4.45) cannot predict a numerical value and violates the assumptions of homoscedasticity, linearity, and normality. As a result, the use of ordinary least squares (OLS) estimates for the best fit approach of minimizing the sum of squared distances is inefficient (Maddala, 1983).

Maximum likelihood estimation, which maximizes the log-likelihood, is used to estimate the regression coefficients in the probit model to overcome inefficient parameter estimates. The probability function of the model is as follows:

$$L = \prod_{Qi=1} P_r \prod_{Qi=0} (1 - P_r) \qquad 4.46$$

The objective of this study was to investigate the association between CF participation and EE among soybean producers. The Impact Assessment Theory was used to determine this.

4.10 Definition, Measurement, and *A priori* Expectation of Variables

Tables 4.1, 4.2, and 4.3 show the definition, measurement, and a priori expectation of variables employed in this EE study.

Table 4.1 Variables Expected to Influence Soybean Production Output in the Study Area

Variable	Description	Measurement	A-Priori Expectation
Y	Soybeans output	Kg/ha	+
X_1	Size of farm	ha	+
X_2	Family labour	Man Day	+
X_3	Amount of Fertilizer	Kg/ha	+
X_4	Seed Volume	Kg/ha	+/-
X_5	Extension service	No visits	+/-
X_6	Education	No of years in sch	+/-

Table 4.2: Variables that are expected to influence the cost of Soybean Production

Variable	Description	Measurement	A-Priori Expectation
C	Total cost of soybean production per farm	GH¢	+
P_1	Unit cost of rent per hectare of land	GH¢	+
P_2	Labour unit cost	GH¢	+
P_3	Fertilizer unit cost	GH¢	+
P_4	Unit cost of seed	GH¢	+
Y	Farm output adjusted for any statistical noise	Kg/ha	+

Table 4.3: Expected Socio-Economic Variables Influencing Soybean Farmers Efficiency

Variable	Description	Measurement	A-Priori Expectation
EI	Efficiency indices	TE, AE, EE	+/-
Z_1	Age of farmer	Number of years	+/-
Z_2	Gender of farmer	1=female 0=male	+
Z_3	Education	Number of years in sch.	+/-
Z_4	Household size	Number of people in the soybean farmers house	+/-
Z_5	Credit	1=receive credit 0=otherwise	+
Z_6	Training	1=yes 0=no	+
Z_7	Variety of seed	1= improved 0= traditional	+/-

4.10.1 Description and Measurement of Variables

Contract participation, fertilizer, seed, labour, and farm size were all incorporated in the model as inputs for soybean production in the research area. Production/output refers to the quantity of soybeans produced by each farmer, expressed in kilos. Fertilizer is defined as the quantity of inorganic fertilizer purchased and applied by soybean producers per hectare of land during the study period, expressed in kilograms. The term "seed" refers to the kilograms of soybean seed planted per hectare of land by each soybean farmer throughout the season. The number of man-days spent by farmers in the sample growing soybeans is counted. Farm size refers to the area cultivated for soybean production by sample farmers during the study period, measured in hectares.

4.10.2 A-Priori Expectations and Description of Predictor Variables

The quantity of soybeans produced in kilograms per hectare during the season under consideration is referred to as soybean output. The output was used as the dependent variable, and it was influenced by several independent variables known as inputs.

The size of a farm is measured in hectares of soybean cultivation. The effect on output was investigated using the variable. The number of man-days spent on the farm from land preparation to harvesting is measured on a hectare of land. The quantity of chemical fertilizer applied to a soybean plot is measured in kilograms per hectare (kg/ha). Fertilizer is supposed to boost output, but overdosing can result in low yield or crop failure.

Seed is measured in quantities of soybeans seeds in kilograms (kg) used. Seeds are the backbone of agricultural production.

The efficiency indices are the dependent variables; they assess the efficiency of a particular farm/farmer in the study area. It has been demonstrated that it is influenced by several socioeconomic independent variables; a positive sign indicates that the associated variable has a favorable effect on efficiency but a negative effect on inefficiency, and vice versa.

A farmer's efficiency in producing a crop is proportional to his or her age; more experienced farmers tend to minimize losses and have superior management skills in their production process. Farmers' age is projected to have a favorable impact on efficiency because agricultural experience grows with the number of years spent farming. Even if older farmers are more conventional and conservative, and hence less willing to adopt new approaches, this remains true (Coelli, 1996).

Sex is a variable that indicates how sex of the respondent affects efficiency scores. This variable was a dummy variable with a value of 1 representing a male farmer and 0 representing a female farmer. On the other hand, the expected direction of the gender coefficient is uncertain due to the notion that both men and women farmers are resource efficient (Adesina and Djato, 1996).

The number of years a farmer spent in school, excluding any repeated years, was used to determine his education. Education, a measure of human capital, influences technological adoption. Farmers with a higher education level are more inclined to adopt new agricultural technology, which results in higher efficiency ratings. Farmers with a lower education level are less likely to adopt new agricultural technology, resulting in poorer efficiency scores (Seyoum et al., 1998). It is anticipated that this will have a good effect on efficiency indices.

The number of individuals (adults, women, and children) who live with the farmer is determined by the size of the household. The indicators are mixed in terms of household size. A positive indicator suggests that efficiency increases according to household size. A favorable indicator is the provision of financial resources to family members for education and health care (Coelli et al, 2002). Alternatively, a bigger family size requires less hired labour, resulting in a lower overall cost of production, and vice versa.

The binary variable Access to Credit measures the effect of credit on a farmer's efficiency. This variable is measured as a dummy, with 1 indicating that the farmer had access to finance during the period examined and 0 indicating that the farmer did not. Access to financing improves efficiency by removing liquidity constraints that impair the ability to utilise agricultural inputs and implement farm management decisions on time. Due to a lack of credit, the farmer will become inefficient. The outcome is expected to be positive.

Variety was defined as the type of soybean variety used, where 1= Improved varieties 0=Traditional or Conventional. The expected impact on efficiency indices is indeterminate. The effect of CF participation on farmer efficiency is measured using a binary variable called contract participation. This variable is measured as a dummy, with 1 indicating farmer participation and 0 indicating non-participation. The expected outcome is positive.

CHAPTER FIVE

SOCIOECONOMIC CHARACTERISTICS OF SOYBEAN PRODUCERS AND DETERMINANTS OF CONTRACT FARMING

5.1 Introduction

This chapter presents and discusses the results of the study. Section 5.2 discusses the socioeconomic and demographic characteristics of respondents, summary statistics of the variables that are contained in the probit model is discussed in section 5.3. Section 5.4 discusses the determinants of CF participation.

5.2 Respondents' Socioeconomic and Demographic Characteristics

The demographic characteristics of respondents (contract and non-contract soybean farmers) in the sampled communities are listed in Table 5.3. This section will aid readers in comprehending the nature of the respondents that were sampled for the study.

5.2.1 Sex Distribution of Respondents

Figure 5.1 depicts the sex distribution of respondents in the two types of farmers in the study districts. Male dominated the respondents, accounting for almost 65% and 55% for contract and non-contract farmers respectively. Since farming, particularly cash crop farming, is a male-dominated occupation in Ghana's Northern Regions, male respondents dominated for both groups of farmers. This is because most families rely on their male breadwinners.

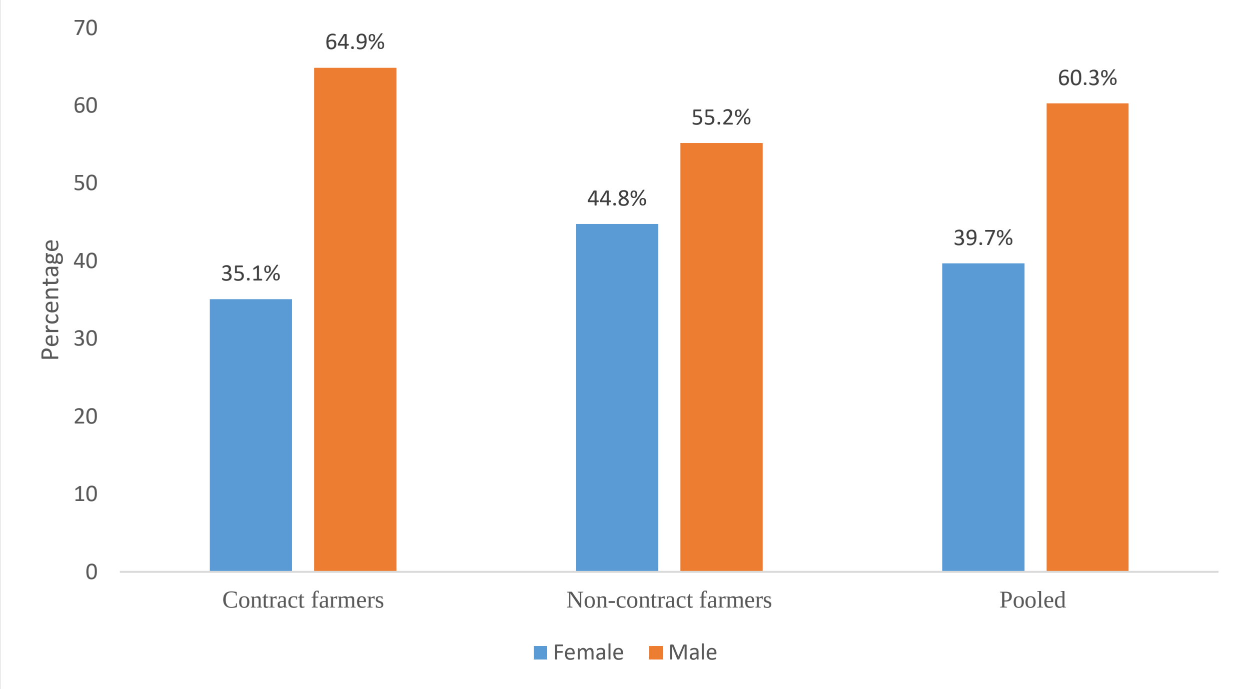


Figure 5.1: Sex Distribution of Respondents
Source: Field survey, 2019

5.2.2 Age Distribution of Respondents

The dominant age group for both categories of farmers in the study area was between 36-45 years. This was approximately 42% for contract farmers and 30% for non-contract farmers. This demonstrates that economically active people are actively involved in soybean production. The field experience showed that, majority of these age groups are married with children hence the need to engage in a cash crop farming like soybeans to fend for their families.

The average age of soybean farmers was found to be nearly 40 years in the pooled sample. However, the mean age among contract farmers was 40 years while that of non-contract farmers was almost 39 years as shown in Table 5.1. These mean ages amongst soybean producers in the Northern region suggest that most individuals engaged in soybean production in the country are still active. This can be of great benefit in the soybean sector as farmers in this age group readily accept and try new technologies.

Table 5.1: Age Distribution of Soybean Producers

	CF		Non-CF		Pooled	
Age category	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
16-25	17	8.42	27	15.70	44	11.80
26-35	46	22.77	50	27.91	94	25.10
36-45	82	41.58	51	29.65	135	36.10
46-55	36	17.82	27	15.70	63	16.80
56-65	18	8.91	17	9.88	35	9.40
66-75	1	0.50	0	0.00	1	0.30
76-85	0	0.00	2	1.16	2	0.50
Total	200	100.00	174	100.00	374	100.00
Mean	40.446		38.762		39.671	

Source: Field data analysis, 2019

5.2.3 Educational Status of Respondents

The educational background of respondents reveals that majority of the contract farmers (54.4%) had primary education whilst the modal category of non-contract farmers (45.4%) had no formal education at all (Figure 5.2). This result reveals that, even though, education was not a criterion for soybean CF participation, some amount of education was important to understand some basic concepts in the contractual arrangements.

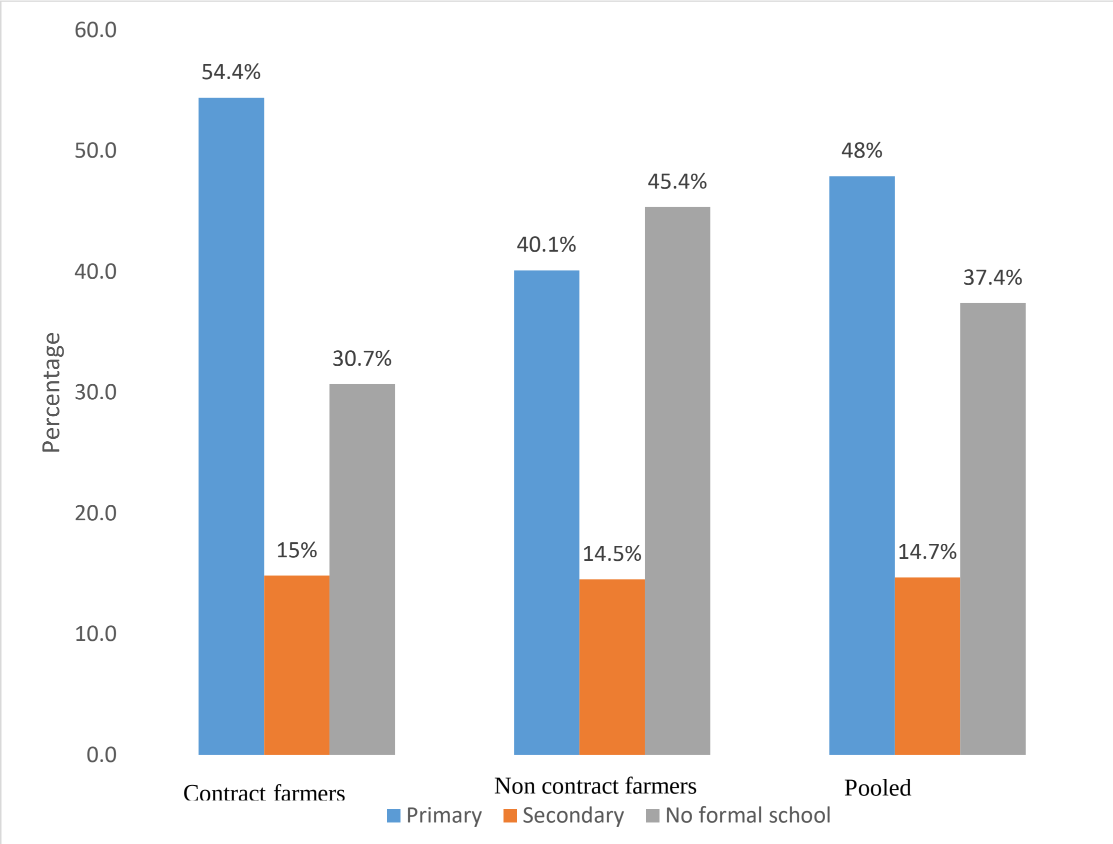


Figure 5.2: Educational Status of Respondents

Source: Field data analysis, 2019

5.2.4. Distribution of Farmers by Farm Size

Majority of soybean producers interviewed were small scale producers cultivating on less than 2 ha of land. The average farm sizes as shown in Table 5.2 were found to be 2.23 ha in contract and 1.86 ha in non-contract soybean production indicating that soybean fields are generally bigger under the contractual soybean production. For the pooled data the average land size is 2.057 ha.

Table 5.2: Farm Size of Respondents

Farm size distribution (Ha)	CF		Non-CF		Pooled	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
0-1	148	73.20	134	77.90	282	75.40
2-3	45	23.30	40	22.10	85	22.73
4-5	2	1.00	0	0.00	2	1.07
5-6	5	2.50	0	0.00	5	0.80
Total	200	100.00	174	100.00	374	100.00
Mean	2.230		1.855		2.057	

Source: Field survey, 2019

5.3 Variables Used in the Probit Model for Analysis

Several farm, household and socioeconomic characteristics contribute to influence farmers' decisions to engage in CF (Eaton & Shepherd, 2001; Bogetoft & Olesen, 2002; Masakure & Henson, 2005; Saenger et al., 2013 Schipmann & Qaim, 2011; Prowse 2012). In this study, farm size (hectares), sex, crop diversification, education, farm-market-distance, FBO membership, experience, extension, off-farm business, age, and credit were used to achieve objective one; that is, the factors that influence soybean farmers' decision to join CF. With a sample distribution of farmers divided into contract and non-contract, descriptive statistics were used. A t-test was performed to compare the mean values of the variables for contract and non-contract farmers.

Table 5.3 shows the summary statistics for the important variables used in the probit model study. These variables are listed to indicate the distribution of contract and non-contract soybean farmers. Contract and non-contract farmers differ significantly in farm size, education of respondents, distance from farm to nearest market, FBO membership, soybean production experience, and extension services.

Table 5.3: Summary of Variables Used for the Analysis

Variable	Non-contract farmers		Contract farmers		Pooled		t-test value
	Mean	SD	Mean	SD	Mean	SD	
Farm size (hectares)	1.855	3.620	2.230	1.054	2.057	1.021	-2.661***
Crop diversification	2.919	8.541	3.060	4.257	2.995	1.254	-1.277
Education	3.450	5.142	4.034	5.051	4.103	2.581	-2.839***
Farm– market-distance	10.174	8.164	12.445	8.212	11.401	6.001	-3.343***
FBO membership	0.029	0.547	0.886	0.142	0.492	0.142	-31.716***
Experience	5.953	2.651	5.639	3.895	5.783	2.870	1.147
Extension	0.052	0.501	0.528	0.023	0.147	0.014	-4.912***
Off-farm business	0.081	0.147	0.218	0.042	0.155	0.042	-3.689***
Age	38.762	11.920	40.446	42.124	39.671	35.147	-1.405
Credit	0.308	0.415	0.361	0.654	0.337	0.114	-1.085

Source: Field survey, 2019

It is clear from Table 5.3 that contract farmers had larger average farm size (2.2 ha) as compared to their non-contract counterparts of farmers (1.8 ha). The educational attainment of contract and non-contract farmers differs significantly. From the Table 5.3, a contracted soybean farmer had up to 4 years of formal education. This was slightly lower for the non-contract counterparts (3 years). A soybean farmer's formal education, on the other hand, can take as little as four years (Arabic Education included). This finding shows that Ghanaian farmers, particularly those in the

Northern Region, have a low degree of formal education. According to GSS (2014), the national average for 15-year-olds who have ever attended school in Ghana is 85.3 percent, but the Northern Region's average is 55.7 percent, making it one of Ghana's worst performing regions in terms of formal education.

The average distance from farm to market for contract farmers is 12 kilometers, whereas it is 10 kilometers for non-contract farmers. Almost all contract soybean producers (89%) are members of a Farmer Based Organization (FBO). However, a significantly lower percentage (< 1%) of non-contract farmers belong to any FBO. The field survey revealed that one of the criteria for participating in any soybean CF is to belong to a farmers' group or organization. However non-contract farmers are not under any obligation to join FBO's.

Non-contract farmers have almost up to 6 years of experience in soybean production like their contract counterparts. Even though this variable is not significant, focus group discussions in the study area revealed that non-contract farmers do not enter CF because they believe they are familiar with soybean cultivation and will not require any training or extension service to produce soybean efficiently and effectively.

Farmers who were not on a contract had a lower rate of access to agricultural extension services (5%) than those who were on a contract (52%). The government's recent low investment in the agriculture sector may be to blame for Ghana's poor agricultural extension system.

According to GSS (2014), Ghana has a 1:3000 extension agent to farmer ratio. This disparity can be attributed to non-automatic postings of extension workers from the agriculture training colleges by MoFA to work in the various farming communities across the country.

A soybean farmer's average farm size in the Northern Region is 2 ha. Contract soybean farmers however have slightly bigger farms (2.2 ha) as compared to their non-contract counterparts. The results are expected because, support in the form of credit and input provision from contracting firms give contract farmers the opportunity to cultivate relatively larger areas.

5.4 Determinants of Contract Farming among Soybean Producers

The probit model was estimated to study socioeconomic factors impacting farmers' participation in soybean CF in the Northern Region. Table 5.4 summarizes the findings. The LR chi-square of 382.15 is statistically significant at 1% and shows that the selected explanatory variables in the

model contribute to explaining the variation in the probability of participation in CF. In other words, the explanatory variables in the probit model together explain the probability of CF participation.

The variables *credit access, extension service* and *FBO* membership were considered potentially endogenous because they are part of the terms of the contract with the firms. The FBO variable was however dropped during the regression analysis because it behaved abnormal. The Wooldridge's (2015) control function approach was used to address the potential endogeneity of access to credit and extension service in this context. In the control function approach, the credit and extension variables are expressed as function of the rest of the variables together with an instrument. The generalized residual in the auxiliary probit regression is retrieved. The *credit* and *extension* variables and their residuals are then included as explanatory variables in the probit model. The variable *Land tenure* was used as an instrument in the first-stage regression. The validity of the instrument was tested using a simple falsification test by Di Falco (2014). The results of the endogeneity test are shown in the appendix. Marginal effects were also estimated after the regression of the probit model. The marginal effects help to explain the coefficients of the explanatory variables as probability value.

The insignificance of the estimates of the residuals credit-residual and extension residual indicates an absence of simultaneity bias, and consistent estimation of the credit access and extension variables (Wooldridge 2015).

Table 5.4: Probit Estimates of the Determinants of Soybeans Contract Farming

Variable	Coefficient	Std. Err.	Z	Marginal effects	Std. Err.
Sex	0.131**	0.348	0.38	0.013**	0.102
Age	-0.006	0.014	-0.44	-0.001	0.001
Education	0.023**	0.090	0.24	0.316**	0.100
Experience	-0.048***	0.677	-0.71	-0.005***	0.012
Crop diversification	-0.065	0.214	-0.30	-0.006	0.032
Off-farm business	0.125	0.656	0.22	0.012	0.012
Farm size	0.137*	0.186	0.74.	0.013*	0.023
Production credit	-0.603*	1.804	-0.33	-0.059*	0.011
Extension	0.366***	0.584	063	0.036***	0.053
Distance; farm to market	0.054**	0.020	2.67	0.005**	0.003
Credit_residual	-0.747	1.232	-0.61	-0.075	
Extension_residual	-0.072	0116	-0.63	-0.036	
Constant	-2.005***	1.235.	-1.62		
Number of obs.	374				
LR chi2(11)	382.15***				
Prob > chi2	0.0000				
Log likelihood	-66.09				
Pseudo R2	0.7405				

Note: ***, **, and * denote a 1%, 5%, and 10% level of significance, respectively.

Source: Field data analysis, 2019

Sex, education, farm size, access to agricultural extension service, and distance from farm to market center were found to have a positive and significant effect on soybean CF participation in the study. Similarly, the study discovered that soybean production experience and credit access had a negative and significant effect.

To begin with, sex of respondents has a positive link to participation in soybean CF and it is significant at 5% level. It implies that males were more likely than females to engage in CF. In the research area, men had access to resources and control. Men also have more access to information in the study area than women, which allows them to look for ways to boost productivity. This is consistent with the findings of Zoundji et al. (2015) which concluded that, soybean cultivation is dominated by males. Saïdou et al. (2007) argued that males are normally landowners; they also inherit land from their parents much more than their female counterparts. The small number of females involved in soybean cultivation accessed land from their husbands, relatives, borrowed or lease.

The likelihood of farmers participating in soybean CF was shown to be positively correlated with their educational attainment. It was also strongly and statistically significant at the 1% level. The implication is that adding one year to a farmer's education enhances his or her chances of participating in soybean CF by 31.6%. This is not a mirage since educational attainment enhances farmers' ability to seek more information on agricultural production techniques as well as exploring other marketing channels to increase profit margin. Also, farmers who attend school are also equipped with planning and record keeping skills as well as adopting storage techniques to reduce post-harvest losses.

Furthermore, soybean farming experience was found to have a negative impact on soybean CF participation, which was significant at the 1% level. This means that as a farmer's years of soybean cultivation increase by one year, the likelihood of him or her participating in CF decreases by 5.4 percent.

At the 10% level, the marginal effect of respondents' farm size was also positive and marginally significant. This means that whenever a farmer's average farm size increases by 1ha his or her likelihood of participating in soybean CF improves by 1.3%. This is in conformity with our a *priori* expectation. Farmers with huge farm sizes are anticipated to join in the soybean CF to get the help they need for their farming businesses.

It was discovered that the availability of production credit has a negative and significant impact on soybean CF. Farmers with access to production credit were less likely to participate into CF, as evidenced by the negative marginal effect of production credit access. This suggests that farmers with access to production credit are 6% less likely to enter into CF. The implication is that, with an access to production credit (cash or kind) from other sources, a farmer will not be motivated to join CF again since joining the scheme will only increase his/her indebtedness. This finding is consistent with Saigenji (2010), who found an inverse relationship between credit access and CF participation amongst tea farmers in Vietnam.

Access to agricultural extension services was determined to have a positive marginal effect (0.036), which is highly significant at the 1% level. This means that people who have access to extension services have almost 4% higher chance of going into CF than those who do not. The positive significance of extension services in determining farmer's years of soybean cultivation increase by one year, farmer decisions to participate in programmes have been well discussed in literature (Doss and Morris, 2001; Ransom et al., 2003).

Having access to extension services enhances a farmer's chances of engaging in soybean CF by roughly 4%, according to this study. Farmers who had access to agricultural extension officers had a higher likelihood of participating in CF than those who did not. The distance from the farm to the market shows a positive marginal effect (0.005) and is statistically significant at the 5% level. The result is that if a farmer's walking distance from farm to market center increases by 1km his or her chances of contracting increases by 0.5%. Distance farmers cover to market centers play a greater role in participating in CF. If a farmer's distance from farm to market center is longer, it increases his/her transportation cost, thereby increasing his production costs hence the need to contract to cushion him/her.

CHAPTER SIX

EFFICIENCY OF CONTRACTUAL AND NON-CONTRACTUAL SOYBEAN PRODUCERS

6.1 Introduction

This chapter presents the findings and discussions of the factors that determine soybean output, as well as the level of Technical, Allocative, and EE for both contractual and non-contractual soybean producers. This chapter also includes the results of the efficiency scores for contractual and non-contractual soybean producers, as well as the main determinants of efficiency among soybean producers in the research area. This chapter begins with a summary of the variables utilized in the SFA model.

6.2 Variables Used in the SFA Analysis

The literature focused heavily on farm-level efficiency. A variety of farm, household and socioeconomic factors influenced efficiency. This study looked at age, gender, education level, household size, credit access, cooperative participation, soybean farming training, and cropped varieties. The study looked at the data of 374 soybean growers in the area.

Table 6.1 shows summary statistics for the important variables in the model. These variables are listed to indicate the distribution of contract and non-contract soybean farmers. Contract and non-contract farmers differ significantly in terms of average total cost of production, farm size, cost, quantity, and quality of seeds used, cost of herbicides, cost of labor, sex, crop diversification, respondents' education, distance from farm to nearest market, and FBO membership. At the 1% level, there is a significant mean difference in total cost of production between contract and non-contract soybean farmers. Contract farmers, as expected, spend more

on soybean cultivation than their non-contract counterparts. Contract farmers' land is on average 2.2 ha, while non-contract farmers' land is on average 1.8 ha. In comparison to their non-contract counterparts, contract farmers spend more on seed purchases for sowing.

At the 5% level, the difference in output between contract and non-contract farmers is significant, as expected. The high investment made by contract farmers can be attributed to this. Contract farmers have greater labour and herbicide costs than non-contract farmers.

The sex of the respondents is significant and positive, implying that many male farmers participate in CF. There is a significant difference in educational achievement between contract and non-contract farmers. According to the findings, 69% of contract soybean farmers have at least a primary education, compared to only 55% of non-contract farmers. On the average, contract farmers travel 12 kilometers to the market, while non-contract farmers travel 10 kilometers. Almost all contract soybean producers (89%) are members of an FBO whilst less than 1% of non-contract farmers belong to any FBO. As indicated, one of the criteria for participating in any contract obligation is to belong to a farmers' group or organization.

Table 6.1: Summary of the SFA variables:

Variable	Non-contract farmers		Contract farmers		Pooled		t-test value
	Mean	SD	Mean	SD	Mean	SD	
Total cost (GHC)	220.944	195.214	289.781	301.121	255.728	354.120	3.897***
Output (output/ha)	2949.634	3215.214	3247.791	3142.21	3086.754	3214.045	1.480**
Farm size (ha)	1.855	2.784	2.230	4.251	2.057	5.901	-2.661***
Seed (GHC/ha)	20.559	22.561	27.874	31.245	24.510	30.147	-6.318***
Seed (Kg/ha)	9.945	10.321	14.646	18.124	12.485	20.702	-6.179***
Herbicides (GHc/ha)	17.55	18.1245	24.460	30.021	21.283	25.540	-2.360***
Labour (GHc/ha)	35.884	42.024	43.212	54.124	40.000	51.001	-1.735**
Sex	0.552	0.654	0.649	0.124	0.604	0.802	-1.900**
Crop diversification	2.919	4.215	3.060	6.014	2.995	5.031	-1.277
Education	0.547	0.600	0.688	0.201	0.623	1.045	-2.839***
Farm– market-distance	10.174	18.651	12.445	15.245	11.401	13.010	-3.343***
FBO membership	0.029	0.046	0.886	1.285	0.492	0.605	-31.716**

Source: Field data analysis, 2019

6.3 Results of Hypothesis Tests

The generalized likelihood ratio test was used to examine the relevance of agricultural input usage, costs and socioeconomic factors in explaining the stochastic production and cost frontiers as well as the technical and cost (in)efficiencies as shown in Table 6.2. To assess which model was most suited for the investigation, the generalised likelihood ratio (LR) test was also used. The LR Chi^2 was 93.97 (Prob>chi^2 = 0.0000) and statistically significant at 1% level. This suggests that the Translog frontier cost function performed better in the analysis than Cobb-Douglas. As a result, the null hypothesis that Cobb-Douglas model is the most appropriate for the analysis was rejected. Similarly, when testing for cost inefficiency, the model with inefficiency effect recorded a lower AIC value than the deterministic translog model, indicating that cost inefficiency had a non-trivial effect on soybean production in the sample. This informed the rejection of the null hypothesis that there was no cost inefficiency.

Table 6.2: Generalised likelihood-ratio test of hypothesis

Model	(model)	DF
Cobb-Douglas function	388.322	8
Translog function	341.335	23
LR Chi^2= 93.97*** Prob>chi^2 = 0.0000		
Decision: Reject Ho: Estimated Cobb-Douglas Frontier not different from translog frontier		
Deterministic Translog function	341.335	23
Translog function with inefficiency variables	329.715	30
LR Chi^2 = 23.25*** Prob> Chi^2= 0.0015		
Decision: Reject Ho: there is no inefficiency among soybeans farmers.		

Note: *** represents 1% level of significance.

Source: Field survey, 2019

6.4 Factors Influencing Contract and Non-contract Farmers Soybean Output

The results of maximum likelihood estimations of the stochastic production frontier model with selection are shown in Table 6.3. A translog functional specification was used to estimate both conventional SPF and sample selection SPF. All variables in the translog models were normalised by their corresponding geometric means so that the first-order coefficients can be interpreted as partial elasticities of output with respect to inputs at geometric mean values (Villano et al., 2015; Coelli et al., 2003).

Table 6.3: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Model

Model	Conventional SPF			Sample selection SFP		
Column	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Pooled	CF	NCF	Pooled	CF	NCF
	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
Farm size	(0.767)***	0.721***	0.765***	(0.724)***	0.901***	0.817***
	(.087)	(0.052)	(0.062)	(0.035)	(0.081)	(0.124)
Seed	-0.021	0.021	0.011	-0.018	0.097	-0.035
	(.063)	(0.032)	(0.042)	(0.038)	(0.06)	(0.126)
Agrochemicals	-0.260)	0.038	0.058	-0.047	0.015	-0.534
	(0.245)	(0.321)	(0.202)	(0.141)	(0.228)	(0.525)
Labour	0.3811***	0.312***	0.214***	0.147***	0.370***	-0.146*
	(0.105)	(0.065)	(0.077)	(0.049)	(0.123)	(0.081)
Farm size squared	-0.439***	-0.343**	-0.240**	-0.176***	-0.302**	-1.123***
	(0.120)	(0.075)	(0.099)	(0.061)	(0.122)	(0.138)
Seed squared	-0.174***	-0.056	-0.041	-0.061*	0.011	-0.281***
	(0.049)	(0.043)	(0.031)	(0.035)	(0.054)	(0.040)
Agrochemicals squared	0.296	0.123	0.162	0.373***	.00049	-0.188
	(0.253)	(0.332)	(0.221)	(0.103)	(0.203)	(.795)
Labour squared	-0.095	-0.234*	-0.128*	-0.197***	-0.086	-0.412***
	(0.081)	(0.073)	(0.066)	(0.030)	(0.132)	(0.054)
Farm size*seed	0.320***	0.054	0.033	0.035	-0.143**	0.327***
	(0.063)	(0.056)	(0.046)	(0.026)	(0.058)	(0.031)
Farm size*agrochemicals	0.131	-0.076	-0.064	-0.283***	0.242	-0.945**
	(0.209)	(0.167)	(0.193)	(0.090)	(0.196)	(0.476)
Farm size*labour	0.374***	0.675***	0.542***	0.467***	0.244	-0.027
	(0.138)	(0.201)	(0.103)	(0.058)	(0.173)	(0.088)
Seed*agrochemicals	-0.213**	-0.023	-0.015	-0.050	-0.082	1.087**
	(0.102)	(0.092)	(0.056)	(0.092)	(0.152)	(0.483)
Seed*labour	0.040	-0.021	-0.036	0.007	-0.047	0.197***
	(0.55)	(0.026)	(0.038)	(0.023)	(0.078)	(0.037)
agrochemicals*labour	-0.195*	-0.145***	-0.327***	-0.368***	-0.149)	-0.939***
	(0.111)	(0.054)	(0.079)	(0.045)	(0.129)	(0.263)
Constant	0.454	0.988***	0.988***	1.021***	0.873***	1.572***
	(23.370)	(0.214)	(0.104)	(0.072)	(0.126)	(0.183)
Lambda	0.25D-04	7.287***	7.287***			
	(39.705)	(1.056)	(1.066)			
Sigma	0.738***	1.191***	(1.191)***			
Sigma (u)				1.339***	1.151***	1.084***
				(0.027)	(0.068)	(0.019)
Sigma (v)				0.156***	0.270***	0.105***
				(0.0155)	(0.029)	(0.017)
Rho(w,v)				-1.000***	-0.999***	-0.990***
				(0.002)	(0.003)	(0.083)
Returns to scale				0.806	1.983	0.102

Note: *, **, * ==> Significance at 1%, 5%, 10% level.**

Source: Field survey, 2019

Examining the productivity differences between contract and non-contract soybean producers is not straightforward because of sample selection problem. Therefore, two sets of hypothesis tests were conducted by using conventional SPF and sample selection SPF. The diagnostics of the model are shown in the Table 6.3. Both sigma (u) and sigma (v) are highly statistically significant at the 1% level, according to the estimations. Similarly, at the 1% level, the estimated coefficient of the selectivity variable rho (w,v) is highly statistically significant. This corroborates the findings of a selection bias problem, justifying the employment of a selectivity correcting approach. The coefficients and efficiency scores have been found and adjusted using the sample selection approach, thus they are bias-free.

Furthermore, because the rho is significant, there are variations in soybean productivity between contract and non-contract farmers; thus, estimation of separate frontiers for each group is reasonable and legitimate. This finding is consistent with Rahman et al. (2009) and Rahman (2003), who discovered a strong selection bias in Thailand's Jasmine rice and Bangladesh's contemporary rice production systems. Since there is evidence of selectivity bias problem which has been corrected, the results of sample selection SPF are chosen for discussion. All the variables used for the estimation in the first order term exert direct relationship to the output of soybean. When the direct relationship effect of input variables on the output satisfies the a priori expectations, the functional form behaves normally. This demonstrates that the correct amounts of conventional inputs will increase soybean output. Increases in all production inputs will lead to a higher-than-proportional increase in soybean output. All of the input factors were mean-corrected except for the socioeconomic variables, therefore the coefficients of the input variables are described as output elasticities. From the Table 6.3 (column 5), four variable inputs were found to exert significant effects on soybean output by contract farmers. These variables include farm size and labour (two conventional factors), one for the squared terms (farm size) and one for the interactions terms (farm size and seed). Also, column 6 on Table 6.3 illustrates the drivers of output of soybean producers who are not participating in CF (non-contract farmers). The first order conventional variables found to significantly affect soybean output of non-contract farmers are farm size and labour.

The farm size for the pooled data according to the findings has a positive coefficient of 0.724 and is statistically significant at the 1% level. This suggests that if the size of the farm is extended by 100%, soybean output will increase by 72.4 percent, provided all other things remain constant. The farm size coefficient had the highest coefficient value, indicating that farm size plays a larger role in increasing productivity. Significant relationship in farm size and maize productivity in southern Malawi, rice productivity in Nigeria's Cross River State, and soybean productivity in Northern Ghana were reported by Chirwa (2007), Idiong (2007), and Etwire et al (2013). Furthermore, Al-hassan (2008) conducted an empirical evaluation of rice farmers' TE in Northern Ghana, concluding that farm size and rice yield are positively related. This study, however, contradicts Kebede and Adenew (2011) findings in Ethiopia, which indicated a negative link between farm size and commercial wheat production.

The coefficient of labour in the pooled results has the second highest coefficient (0.147) and is statistically significant at the 1% level. In other words, increasing the number of man-days on a soybean farm by 100% would result in a 14.7 percent increase in soybean yield in the research area. The greater value of the coefficient of labour emphasizes the importance of labor in the production process. According to Hasan & Rahman (2008), labour had a considerable positive impact on increasing pulse productivity in Bangladesh.

The squared terms of the input variables explain the continuous effect on soybeans production. For the squared terms, farm size squared, agrochemical squared, and labour squared were found to have significant effects on soybean output in a long term. The negative coefficient (-0.176) for farm size squared is statistically significant at the 1% level. This means that continuing to farm soybeans on the same amount of land will result in a 17.6 percent reduction in soybean output.

Similarly, the coefficient of -0.197 for labour squared measured in man-days is significant at the 1% level for the pooled data. Also, the coefficient for the same variable (labour squared) for NCF is -0.412. This suggests that if same amount of labour is continuously employed in the production of soybean, with time soybean output will decrease by 19.7% for the pooled and 41% for NCF. These findings confirm that production function is a quadratic function and conform to production theory. These results are in harmony with Osman et al. (2018). Unit cost of agrochemicals, on the other hand, had a positive coefficient (0.374) and was statistically significant at the 1% level. This means that continuous application of the proper amount of pesticide herbicides in the study area enhances soybean output by 37.4 percent.

The significant interactive terms show whether conventional inputs in soybean production are substitutes or complements. The interaction of farm size and agrochemicals had an inverse relationship with soybean output. It was statistically significant at the 1% level and had a negative coefficient (-0.283). This means that having a larger farm and using agrochemicals on a regular basis does not always imply higher outputs. It also implies that farm size and agrochemicals are interchangeable, implying that you can expand your farm without using agrochemicals while still recording some outputs. This is in direct opposition to the study's presumption.

The interaction between farm size and labour had positive coefficient (0.467) and highly significant at 1%. The elasticity from Table 6.3 implies that as farmers increased their farm size and labour by a unit each, the output will increase by 47%. Donkoh, Ayambila, and Abdulai (2013) reached the same conclusion. This finding also corroborates those of Rahman and Barmon (2015), and Rahman et al. (2009). This finding indicates that farm size and labour are complements in soybean production. Labour in production process plays a critical role. Without labour, every activity in the production process will come to a halt. Labour helps in translating farm inputs to output (i.e. production goal). Hence, it is not surprising to have the interaction of farm size and labour having a positive coefficient. This also conforms to production theory.

The final interaction variable is agrochemicals and labour, which has a negative coefficient (-0.368), which is significant at the 1% level. This explains that the pairs of these input variables are substitutes in soybeans production. From the results, the return to scale value for the pooled is 0.806 showing decreasing returns to scale. It is 1.983 for CF and 0.103 for NCF. This shows increasing and decreasing returns to scale respectively for CF and NCF. The total of all the output elasticities in the first order term is the return to scale value. This means that increasing the usage of traditional variable inputs in the production process, such as farm size, seed, agrochemicals, and labor, will result in a less than proportionate rise in soybean output for the pooled and NCF. However, for CF increasing the usage of traditional variable inputs in the production process will lead to a more than proportionate increase in soybean output. This also means that if all other parameters remain constant, a 100 percent increase in all factors of production will result in an 81 percent increase in soybean yield for both CF and NCF. This result agrees with Mukhtar et al., (2018) who reported decreasing returns to scale, but differs from the findings of Abdulai et al. (2017), Waluse (2012), and Osman et al. (2018).

6.5 Drivers of Production Cost of Soybeans

This section is divided into three subsections: determinants of soybean production cost, determinants of soybean production cost for contract farmers, and determinants of soybean production cost for non-contract farmers. Each subcategory is discussed in detail.

Table 6.4 shows the findings of the translog stochastic cost frontier model for the three categories. Except for labour cost, the analysis included four input and one output factors, all of which had a positive effect on soybean production costs and were statistically significant. All the estimated coefficients for input prices were significant and had both positive and negative signs, indicating that the cost function behaved well.

Decision to participate in CF is a self-choice; hence there could be selectivity bias problem. Therefore, LIMDEP statistical software was used to perform the estimates to check whether there is evidence of selectivity bias in participating in CF in the study area. After the study, the rho value (see Table 6.4) was not significant, indicating that the data had no evidence of selectivity bias. As a result, the discussions are based on conventional SPF results. The variables' first, second and third orders are discussed in the following order.

Because all the input variable prices were mean-corrected, the estimates of the translog cost function show a relative change in soybean production costs resulting from a change in the explanatory variables (i.e., input prices). The discussion of the parameter estimates is based on the cost elasticities with respect to each individual input price evaluated at their mean values (Onumah et al., 2010). Column 1 (pooled results) represent the determinants of cost of soybean production.

Table 6.4: Maximum Likelihood Estimates for the Parameters of the Stochastic Cost Frontier Model

Column	(1)	(2)	(3)	(4)	(5)	6)
Model	Conventional SPF			Sample selection SFA		
Variable	Pooled	CF	Non-CF	Pooled	CF	Non-CF
	Coeff. (Std. Err.)	Coeff. (Std.Err.)	Coeff. (Std. Err.)	Coeff. (Std. Err)	Coeff. (Std. Err.)	Coeff. (Std. Err.)
Constant	0.072	0.076	0.077	0.750***	0.873***	0.640
	(20.364)	(37.972)	(0.144)	(0.083)	(0.138)	(0.524)
Farm size	0.16166*	0.342***	-0.224*	0.337***	0.513***	-0.144
	(0.086)	(0.124)	(0.135)	(0.090)	(0.140)	(0.290)
Labour	-0.081	-0.103	-0.117	0.025	0.238**	0.086
	(0.076)	(0.1087)	(0.132)	(0.066)	(0.107)	(0.39)
Seed	0.565***	1.531***	1.020***	0.482***	0.096	0.966**
	(0.099)	(0.202)	(0.150)	(0.129)	(0.144)	(0.471)
Herbicides	0.863***	0.845***	2.761***	0.820***	0.681**	2.714
	(0.164)	(0.210)	(0.640)	(0.160)	(0.313)	(2.909)
Output	0.156***	0.012	0.256***	0.055	0.042	0.288
	(0.053)	(0.082)	(0.090)	(0.057)	(0.088)	(0.380)
Farm size sq.	0.192*	0.064	0.265	0.141	-0.034	0.155
	(0.104)	(0.139)	(0.290)	(0.106)	(0.152)	(0.412)
Labour sq.	-0.109**	-0.070	-0.109	-0.028	-0.004	-0.092
	(0.049)	(0.075)	(0.072)	(0.047)	(0.097)	(0.183)
Seed sq.	0.936***	0.337	2.280***	0.744***	0.378	2.074***
	(0.235)	(0.400)	(0.361)	(0.239)	(0.489)	(0.501)
Herbicides sq.	-0.609***	-0.619***	-3.073***	-0.597***	-0.441	-3.009
	(0.132)	(0.154)	(0.654)	(0.178)	(0.373)	(3.307)
Output sq.	-0.102***	-0.055	-0.181***	-0.070**	-0.057	-.158**
	(0.026)	(0.036)	(0.039)	(0.029)	(0.038)	(0.074)
Farm size*labour	-0.035	-0.066	-0.174	-0.185	-0.127	-0.181
	(0.147)	(0.189)	(0.340)	(0.129)	(0.218)	(0.741)
Farm size*Seed	-0.702***	-0.008	-2.020***	-0.714***	0.086	-1.878***
	(0.228)	(0.338)	(0.350)	(0.244)	(0.441)	(0.574)
Farm size*herbicides	0.837***	0.703***	1.678***	0.839***	0.857	(1.628)
	(0.223)	(0.256)	(0.644)	(0.220)	(0.602)	(1.463)
Farm size*Output	-0.084	0.009	-.240***	-0.027	0.096	-0.220
	(0.056)	(0.086)	(0.089)	(0.061)	(0.107)	(0.136)
Labour *Seed	-0.010	-0.175	0.619**	0.058	0.237	0.557*
	(0.164)	(0.264)	(0.256)	(0.154)	(0.320)	(0.301)
Labour*Herbicides	0.186	0.355**	-0.453	0.143	0.112	-0.452
	(0.140)	(0.171)	(0.492)	(0.171)	(0.378)	(2.767)
Labour*Output	0.252***	0.254**	0.240***	0.312***	0.289**	0.261**
	(0.063)	(0.101)	(0.082)	(0.078)	(0.119)	(0.105)
Seed*Herbicides	-0.548***	-0.299	-0.705*	-0.515**	-0.438	-0.668
	(0.185)	(0.257)	(0.398)	(0.219)	(0.407)	(2.952)
Seed*Output	-0.120	-0.213	-0.300	-0.099	-0.032	-0.245
	(0.111)	(0.174)	(0.184)	(0.158)	(0.171)	(0.314)
Herbicide*Output	0.124	0.090	0.073	0.020	-0.026	0.118
	(0.094)	(0.109)	(0.443)	(0.120)	(0.373)	(2.648)
Lambda	0.651	0.346	0.715***			
	(42.345)	(74.441)	(0.189)			
Sigma	0.603***	0.639***	0.534***			
	(0.0014)	(0.003)	(0.003)			
Sigma(u)				0.903***	0.965***	0.388*
				(0.047)	(0.051)	(0.233)
Sigma(v)				0.264***	0.172***	0.416***
				(0.035)	(0.041)	(0.070)
Rho(w,v)				0.305	0.355	-0.044
				(0.635)	(1.657)	(0.828)

Note: ***, ** and * represent 1%, 5% and 10% level of significance, respectively

Source: Field survey, 2019

The coefficient of unit cost of land was 0.162, which is marginally significant at the 10% level. The positive coefficient suggests that, in the research area, as the value of land increases by 100%, cost of soybean production will increase by 16.2 percent for all soybean farmers, holding other factors constant. This conclusion is supported by Jiang and Sharp (2014) and Abdulai et al. (2017). .

The coefficient of the unit cost of seed was found to have positive coefficient (0.565) associated with cost of soybean production and it is significant at 1% level. As seed cost increases by 100%, cost of soybean production will increase by 56.5% for all soybean farmers, holding other factors constant. Seeds are one of the major farm inputs in production process. This finding is in line with the findings of Abdulai et al. (2017), who found that the cost of seeds can lead to an increase in total cost of production in Ghana. Masuku et al. (2014) in Swaziland came to similar conclusions. Farmers have been encouraged to adopt improved/certified seeds in production to reap benefits such as drought and pest tolerance. However, these seeds are mostly costly compared to the conventional seeds used for production. Adoption of improved seeds results in a higher cost of production.

A positive relationship (0.863) was found between the cost of agrochemicals and the cost of producing soybeans, which is statistically significant at the 1% level. When all other factors remain constant, a 100 percent increase in the cost of agrochemicals will result in an 86.3 percent increase in the cost of soybean production. In Ghana, Abdulai et al. (2017) found something similar.

As expected, the output of soybean in kilogram had positive association with cost of production. The output coefficient is 0.156, and it is statistically significant at 1%. In other words, if soybean output is increased by 100%, the total cost of soybean production will increase by 15.6 percent. This finding corroborates the findings of two Ghanaian studies, Abdulai et al. (2017) and Osman et al. (2018). In the production process, if the output (productivity) is higher, it increases cost of production.

Sixty percent (60%) of the squared and interaction terms had statistically significant effects on total production cost, indicating that the translog cost functional form is appropriate. The total cost of production increased or decreased for all second order terms; the coefficients of the squared terms for farm size, labour cost, seed cost, agrochemicals cost, and output. The squared terms explain the long-term effects of input prices on total cost of production. For instance, in future, 100% increase in labour cost and output would increase and decrease total cost of production by 5.9% and 10.8% respectively, *ceteris paribus*.

The interaction terms show whether the variables are complements or substitutes in cost of production. If the two interaction variables have positive coefficient, it means that the variables are complements while negative means the variables are substitutes. Variables that have negative coefficients and statistically significant effects on total cost of production include farm size and seed cost and seed and agrochemicals. On the other hand, the interaction terms for farm size and agrochemicals as well as and labour cost and output cost were found to have positive coefficients.

Columns 2 and 3 of Table 6.4 present the determinants of costs of production by contract and non-contract soybean farmers. The first order variables used for the analysis all had positive coefficients but only farm size, soybean seed and agrochemical significantly exerted some effects on cost of soybean production.

The study found that farm size allocated for soybean production under CF has a positive coefficient of 0.342, which is highly significant at the 1% level. This means that, if all other factors remain constant, increasing farm size for soybean production by 100% in the case of contract farmers will result in a 34.2 percent increase in total production costs. The positive coefficient of farm size could also mean that contract farmers are more efficient in soybean production. Ideally, farmers who are into CF have access to farm inputs and this makes them to expand their farm sizes to enjoy economies of scale.

On the part of non-contract farmers, farm size was found to have inverse relationship to total cost of production of soybean. It had a -0.224 coefficient and was marginally significant at the 10% level. This means that if farm size is increased by 100%, the total cost of soybean production will be reduced by approximately 22.4 percent. This finding does not meet our *a priori* expectation, it is inconsistent with the findings of Saigenji (2010) who found a direct relationship between farm size and total cost of tea production in Vietnam.

In the study area, the price of soybean seed had a positive and statistically significant effect (coefficient=1.531) on total cost of production for contract farmers. This means that if the unit price of soybean seed for planting increases by 100%, the total cost of soybean production will rise by 153.1 percent, assuming all other variables remain constant. Access to soybean seeds, particularly improved/certified seeds is a key factor to participation in CF and productivity. As farmers have access to certified seeds, productivity is assured to increase thereby improving the welfare of smallholder farmers in the rural areas.

For non-contract farmers, both soybean seeds and agrochemical usage were found to have positive coefficients of 1.020 and 2.761 respectively and both are highly significant at 1% levels. The indication is that increasing the use of seeds and agrochemicals by 100% will result in a 102 percent and 276 percent increase in the total cost of soybean production, respectively. However, at the 1% level, output was found to have a positive coefficient of 0.256 and a statistically significant effect on total cost of production of non-contract farmers. This means that if non-contract farmers increase their output of soybeans by 100%, the total cost of production will increase by almost about 26%. This finding is consistent with the findings of Osman et al., (2018).

Only herbicide squared variable was found to have a significant impact on total cost of soybean production in the second order of variables for the pooled, CF and NCF. The herbicide squared has a coefficient of -0.609 for pooled, -0.619 for CF and -3.073 for NCF. The explanation to this effect is that the continuous use of herbicides on the same land will reduce total cost of production of the crop by about 61% for the pooled, 62% for CF and 307% for NCF.

Reducing the use of herbicide lowers the total cost of production. The health of consumers is also not threatened by these inorganic chemicals. Similarly, agrochemical usage and output square terms both have a negative relationship with the total cost of non-CF soybean production in the study area. Also, the output for contract farmers had a coefficient of -0.181, which is significant at the 1% level on the total cost of soybean production for non-contract farmers.

The interaction terms of the variables (third order term) found to have a positive effect on the total cost of production for contract farmers were farm size and agrochemicals; labour and agrochemicals; and labor and soybean output. These interaction term variables are all statistically significant and have positive coefficients, meaning that they are complements in usage to reduce total cost of soybean production.

Similarly for non-contract farmers the interaction terms of farm size and agrochemicals; labour and seed; and labour and output all have positive coefficients and statistically significant effects on non-contract farmers total cost of soybean production in the area. This means that the variables are complements in soybean production to reduce total cost of production by non-contract farmers. Additionally, farm size and seed; farm size and output; and seed and agrochemicals were found to exert negative coefficients effects on total cost of soybean production. They were all significant.

6.6 Determinants of Technical Efficiency, Allocative Efficiency and Economic Efficiency in Soybean Production

Examining the determinants of TE, AE, and EE in soybean production was one of the study's objectives. The traditional two-staged approach involves regressing efficiency estimate on proposed socioeconomic and environmental factors (Liu et al., 2016). The applications started with the standard linear models like ordinary, generalized and truncated least-squared models. These were followed by the Tobit, ordered logit and probit models, and then fractional response models (FRMs) (Gelan & Muriithi, 2012).

The Tobit regression was widely used and accepted until Simar and Wilson (2007) argued that censoring efficiency estimates between zero and one is questionable, especially given that efficiency estimates are not generated through a censoring process which could lead to inconsistent estimates. To address the problem of inconsistent estimates associated with OLS and Tobit approaches, Ramalho, Ramalho, and Henriques (2010) proposed FRMs in the second-stage analyses of the determinants of efficiency scores. Contrary to the OLS and Tobit models, the FRM deals with dependent variables defined on the unit interval, irrespective of whether or not the boundary value (0,1) is observed (Papke and Wooldridge, 1996; Ramalho, Ramalho, andHenriques, 2010).

The application of fractional regression got grounded with the work of Ramalho et al. (2010a). They criticized the work of Hoff (2007) and McDonald (2009) as inadequate because they used only logit specification to the neglect of alternative specifications such loglog and cloglog. The technical and allocative efficiencies were estimated using the stochastic frontier two-step estimation method. The two-stage technique is limited by the violations of the identical distribution of the u_i when the technical inefficiency effects are regressed on some unique farm features. The EE was computed using fractional regression. Table 6.5 displays the estimated EE, TE, and AE efficiency for the sampled farms. In connection to EE, if a variable's coefficient is positive, it shows that the variable has a positive association with efficiency and vice versa. Similarly, positive coefficients for variables under the TE and AE indicate that the variable has a positive effect on efficiency and vice versa.

Table 6.5: Maximum likelihood Estimates for Parameters of the Fractional Regression Model

Variable	**TE**		**AE**		**EE**	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Gender	-0.048	0.092	-0.086	0.075	-0.014	0.033
Education	0.168**	0.091	0.158**	0.078	0.036	0.032
Farm size	-0.046	0.034	-0.001	0.011	-0.025	0.001
Age	-0.000	0.003	-0.001	0.002	0.008	0.009
Experience	0.003**	0.017	0.004	0.015	0.001*	0.007
Crop diversity	0.010	0.046	-0.013	0.038	-0.047***	0.015
Off farm activity	-0.522***	0.112	-0.478***	0.098	-0.102***	0.039
Extension	0.229**	0.132	0.206**	0.113	0.039**	0.044
Credit	0.253	0.083	-0.055	0.069	0.035	0.026
Training	0.918**	0.111	0.229	0.087	0.229**	0.113
Credit_resid	-0.138	0.114	-0.107	0.097	0.052	0.050
CF	0.039**	0.085	.049 **	0.070	0.041 **	0.029
_cons	0.269*	0.222	0.004***	0.189	0.069**	0.147
Number of obs.	374		374		374	
Wald chi2(10)	52.23		56.36		27.25	
Prob > chi2	0.0000		0.0000		0.0071	
Pseudo R2	0.0334		0.0254		0.0025	
Log pseudo likelihood	-242.714		-252.615		-164.825	

Note: ***, ** and * represent 1%, 5% and 10% level of significance, respectively

Source: Field survey, 2019;

The variable, credit was suspected to be endogenous since cash credit might be invested in soybean production which could make the farmer more efficient (income effect). In the same vein, a farmer may be efficient because of his/her access to credit. The potential endogeneity of the variable (credit) was addressed utilizing the control function approach proposed by Wooldridge (2015).

The approach requires the specification of the prospective endogenous variable (i.e., credit) as a function of explanatory variables impacting access to credit, combined with a set of instruments in a first-stage probit regression. Instead of using the predicted values of credit variable as in two stage-least-squares, the observed values of credit variable and the generalized residual (Credit_res) from a first-stage regression are used as covariates in the SPF model. Including the residual serves as a control function, enabling the consistent estimation of the credit variable. The residual term, credit_resid is not significant in the determination of efficiency of soybean farmers indicating the exogeneity of this variable (Wooldridge, 2015). The results of the endogeneity test is shown in the appendix.

To begin, education had no significant effect on EE, but it did have significant positive effects on both TE and AE at the 5% level in the study. This means that as a farmer's formal education years increase, so does his or her allocative and TE. Amaza and Olayemi (2000) found a positive relationship between education and TE and AE, and this finding is consistent with their findings. A farmer's knowledge, skill, and attitude improve as his or her years of schooling increase, and he or she is more likely to adopt new technologies and best practices, according to Ogundari and Ojo (2006). Similarly, educated farmers can obtain relevant information from a variety of sources and make better informed decisions than their less educated colleagues to improve farm management and, as a result, increase soybean production efficiency (Mengistu, 2014). This finding is compatible with Mukhtar et al., (2018) research in Pakistan's Peshawar District, although it contradicts Chirwa's findings (2007).

In the efficiency model, farmers who have been producing soybeans for a long time have been found to be more technically and economically efficient, as indicated by the positive sign of experience and statistical significance at 5 percent and 10%, respectively. In addition, farmers with several years of experience may be more technically and economically efficient than farmers with only a few years of experience. This finding is consistent with the findings of Donkoh et al. (2013), who reported that experience was essential in determining the efficiency of tomato farmers in the Tono irrigation schemes in the Upper East region of Ghana. Okike et al. (2004) went on to say that, in this situation, soybean farming experience is a crucial element contributing to TE because of the expected acquisition of dexterity with time. Lapple (2010) also argued that an increase in agricultural experience offers greater awareness of the production context in which choices are made. On the other hand, Oyewo et al., (2009) found maize farmers with several years of experience to be less technically efficient in Nigeria's Ogbomoso South local government area.

Crop diversification had negative effect on EE and significant at 1%. This means that cultivation of many food crops decreases farmers' EE. This also means that, as more farmers cultivate many crops, their AE also decreases. Cultivation of several crops by farmers makes them incur more cost and make them have difficulty in allocating farm inputs and other resource to maximize output.

Off-farm activity had negative and significant effect at 1% for AE, EE and AE. This means that farmers who earned income in other ways than farming were inefficient economically, technically, and allocatively. The reason for this may be that time and other resources invested into farming activities by these farmers are less compared to investment in the other things they do.

Access to extension services was found to have a favorable and significant impact on technical, allocative and cost efficiencies. The goal of Extension is to improve farmers' knowledge of agronomic methods like pest and disease control, adoption of improved seed varieties, soil and water conservation technologies, and how to properly allocate resources to minimize waste. This puts the framer in a better position to make the most of his or her limited resources in order to accomplish better results and so improve efficiency.

The coefficient of the training variable was positive and statistically significant at 5% for both TE and EE but not AE. This was in line with *a priori* expectations. This means that farmers who had access to training on soybean production were more economically, technically and allocatively efficient than those who had no training. This finding is expected because access to training exposes farmers to new technologies, better agronomic practices and information sharing and dissemination, all these can help a farmer in better managing his/her farm to be efficient.

Soybean CF had a positive coefficient and was statistically significant at 5% across EE, TE, and AE. This indicates that farmers who were into soybean CF were not only economically efficient but also technically and allocatively efficient in soybean production, which is in line with the study's *a priori* expectation. The reasons for this finding are not far-fetched; 1) Soybean contract farmers had access to regular trainings from contracting firms who teach them how to better manage their farms, 2) they were also provided with inputs such as herbicides, weedicides, tractor services and cash credit at lower costs making them allocatively efficient 3) contract farmers were also taught how to effectively allocate their inputs and resources to avoid waste thereby reducing cost. This makes them economically efficient.

6.7 Comparison of Efficiency Distribution Technical Efficiency, Allocative Efficiency, and Economic Efficiency for Contract Farmers

Table 6.6 contains information on technical, allocative, economic, and scale efficiency. The efficiency range revealed a significant disparity between the lowest and highest efficiency indices. Contract farmers had an average TE score of 0.92, with minimum and maximum values of 0.179 and 1.00 respectively, implying that 8% [100-92] of the production is lost due to technical inefficiency alone. This implies that the average farmer producing under contract could increase their production of soybean by improving their technical efficiency.

Similarly, the mean allocative efficiency level among contract soybean farmers in northern region of Ghana is estimated to be 86.9%, with minimum and maximum values of 0.612 and 1.00 respectively. The mean allocative efficiency level is higher compared to that of Ajao, Ogunniyi, & Adepoju (2012); Akhilomen, Bivan, Rahman, & Sanni (2015); Magreta, Edriss, Mepemba, & Zingore (2013); Degefa (2014). The allocative efficiency estimates suggest that an average soybean farmer would enjoy a cost saving of 13.1% derived from [1 – (0.869/1.00) x 100] if he/she were to attain the level of the most efficient farmer. The most allocatively inefficient farmer would have an efficiency gain of 38.8% derived from [1-(0.612/1.00) x 100] to attain the level of the most efficient farmer. This indicates that there is a great opportunity to increase the efficiency of soybean producers by the reallocation of resources in cost minimizing way.

The economic efficiency of an average soybean farm was estimated as 0.943 for CF meaning that an average soybean farmer producing under contract in the study area experiences economic efficiency that is 6% below the frontier. A good number of them almost 75% is operating at an EE above 90%. The result of the average economic efficiency is high compared to Magreta, Edriss, Mepemba, & Zingore (2013), Degefa (2014) and Shalma (2014) who had 53.32%, 54% and 64.7% respectively. Again, Akhilomen, Bivan, Rahman, & Sanni (2015) who analyzed economic efficiency of pineaple production had a mean economic efficieincy of 64.3%.

Furthermore, the results show that a farmer with an average level of EE would save roughly 93.39 percent (i.e., 1- (0.943/0.999) x100) in order to reach the most efficient level. Similarly, to reach the level of the most efficient farm, the most economically inefficient farm would need to gain 33.83 percent from (1- (0.348/0.999) x100).

Table 6.6: Efficiency Scores Distribution TE, AE and EE for Contract Farmers

	Contract farmers						Non-contract farmers					
	TE		AE		EE		TE		AE		EE	
Efficiency range	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
0.00-0.29	6	2.97	0	0	0	0.00	2	1.16	7	4.07	1	0.58
0.30-0.39	3	1.49	0	0	1	0.50	1	0.58	7	4.07	0	0.00
0.40-0.49	0	0.00	0	0	0	0.00	0	0	17	9.88	0	0.00
0.50-0.59	5	2.48	0	0	0	0.00	2	1.16	32	18.60	0	0.00
0.60-0.69	8	3.96	2	0.99	6	2.97	3	1.74	29	15.70	3	1.74
0.70-0.79	5	3.47	45	24.26	12	5.94	0	0.00	5	2.91	5	2.91
0.80-0.89	4	1.98	78	38.61	30	15.84	1	0.58	0	0.00	16	8.14
0.90-1.00	169	83.66	73	36.14	151	74.75	165	94.77	77	44.77	149	86.63
Total	200	100.00	200	100.00	200	100.00	174	100.00	174	100.00	174	100.00
Mean	0.920		0.869		0.943		0.973		0.734		0.866	
Min.	0.179		0.612		0.348		0.170		0.079		0.031	
Max.	1.00		1.00		0.999		1.00		0.999		0.999	

Source: Field survey, 2019

6.8 Efficiency Distribution TE, AE and EE for Non-Contract Farmers

Table 6.6 also shows the efficiency scores for non-contract farmers in the study. The results show that the minimum and maximum TE values are 0.173 and 1.00, with a mean of 0.973. This implies only 2.7% [100-97.3] of the production by NCF is lost due to technical inefficiency. The production losses incurred by NCF due to TE are better than their CF counterparts. NCF may be managing their resources better to avoid waste due to the fact they do not have access to the benefits that comes with contracting hence cannot afford to waste their meager resources hence the reason they are better off technically.

Furthermore, the mean allocative efficiency level among non-contract soybean farmers in northern region of Ghana is estimated to be 73.4%, with minimum and maximum values of 0.079 and 0.999 respectively. The mean allocative efficiency level is higher compared to that of Ajao, Ogunniyi, & Adepoju (2012); Akhilomen, Bivan, Rahman, & Sanni (2015); Magreta, Edriss, Mepemba, & Zingore (2013); Degefa (2014). The allocative efficiency estimates suggest that an average non-contract soybean farmer would enjoy a cost saving of 26.5% derived from [1 – (0.734/0.999) x 100] if he/she were to attain the level of the most efficient farmer.

In terms of EE distribution, about 86.63% of the non-contract farmers' EE is between the range of 0.90-1.00 and 8.14% is between 0.80-0.89. With EE distribution being skewed to the efficiency range above 0.80. The mean EE of 0.866 of non-contract farmers means that, in the study area NCF experiences EE that is 13.4% below the frontier. The result of the average EE is higher compared to Magreta, Edriss, Mepemba, & Zingore (2013), Degefa (2014) and Shalma (2014) who had 53.32%, 54% and 64.7% respectively. Again, Akhilomen, Bivan, Rahman, & Sanni (2015) who analyzed economic efficiency of pineaple production had a mean economic efficieincy of 64.3%.

Furthermore, the result also indicates that a NCF farmer with average level of economic efficiency would enjoy a cost saving of about 13.31% (i.e., 1- (0.866/0.999) x100) to attain the level of the most efficient household. Also, the most economically inefficient household would have an efficiency gain of 96.9% derived from (1- (0.031/0.999) x100) to attain the level of the most efficient household. This implies that smallholder non contract soybean farmers' productivity could increase if key factors that currently constrain overall efficiency are addressed adequately.

6.9 Effects of Contract Farming on Technical Efficiency, Allocative Efficiency and Economic Efficiency

The study also wanted to know how CF affected technical, allocative, and EE. The analysis was conducted using the endogenous treatment effect model. The methodology chapter went through this in detail. This analysis is carried out using maximum likelihood estimation, which estimates all parameters simultaneously rather than in two steps. Using the fractional regression model, the determinants of TE, AE, and EE were thoroughly examined in section 6.10. As a result, the focus of this section is on the effects of CF on TE, AE, and EE. The empirical findings are reported in the following section.

6.9.1 Effect of Contract Farming on Technical, Allocative and Economic Efficiencies

Table 6.7 shows the results of the endogenous treatment effect model on the effects of CF on TE, AE, and EE. The influence of CF on soybean growers' efficiency was estimated using the maximum likelihood estimation method. As a result, the selection equation's outcomes are shown in Table 6.7, columns 8 and 9. The 2nd, 3rd, 4th, 5th, 6th, and 7th columns in Table 6.7 exhibit the results of the outcome equation, which shows the impact of contract participation on soybean farmers' technical, allocative, and EE.

According to the findings, the Wald test is very significant for all efficiency categories, showing that our endogenous treatment effect model is the best fit. This suggests that endogeneity issues existed, necessitating the use of the endogenous treatment effect model. The likelihood ratio test of independence of the selection and outcome equations for TE can be used to reject the null hypothesis of no correlation between CF and TE. This implies that CF is associated to TE in a positive way.

Table 6.7: Maximum Likelihood Estimates for Parameters of the Endogenous Treatment Effect Model.

Variable	TE		AE		EE		CF	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Gender	-0.032	0.035	-0.021	0.030	0.004	0.008	-0.098	0.329
Age	0.000	0.001	0.000	0.001	0.000	0.000	-0.035	0.032
Household size	-0.001	0.003	0.001	0.003	0.002**	0.001	-0.011	0.013
Farmer experience	0.009	0.006	0.009*	0.005	0.002	0.001	-0.063	0.047
Crop diversification	-0.007	0.017	-0.015	0.014	-0.013***	0.004	0.543**	0.161
FBO membership	-0.306***	0.098	-0.284***	0.079	-0.038**	0.016	0.495***	0.398
Off farm activity	-0.218***	0.040	-0.200***	0.035	-0.027***	0.010	3.540	0.364
Farm size	-0.023**	0.011	-0.024**	0.009	-0.008***	0.003	0.228*	0.117
Land tenure system	-0.108*	0.055	-0.093*	0.048	-0.008	0.014	-0.412	0.408
Distance to the market	-0.020	0.031	0.043	0.045	0.021	0.001	0.057***	0.019
Credit	-0.143***	0.035	-0.008	0.026	0.015*	0.008	-0.918***	0.310
Extension	0.042	0.044	-0.134***	0.038	-0.001	0.021	1.208**	0.509
Training	0.125	0.213	0.012	0.312	-0.020	0.023	0.564	0.609
Education	0.042	0.032	0.040	0.028	0.008	0.008	0.810***	0.209
1.CF	0.367***	0.117	0.352***	0.094	0.061***	0.018		
Constant	0.745***	0.087	0.630***	0.076	0.836***	0.022	-0.098	0.329
/athrho	0.698	0.7837	-0.8068	0.3245	-0.698	0.1743		
/lnsigma	-2.758	0.0385	-1.4924	0.0466	-2.758	0.0398		
Rho	-0.6028***	0.7763	-0.6679***	0.1797	-0.6028***	0.1109		
Sigma	0.063	0.0096	0.2248	0.0105	0.063	0.0025		
Lambda	-0.038	0.1928	-0.1501	0.0450	-0.038	0.0077		
Log likelihood	-75.4264		-24.9271		448.8637			
Wald test $\chi2$ (15)	82.87***		80.36***		46.57***			
LR test of independent equations $\chi2$ (0)	0.01***		5.10***		7.32***			

Note: *** 1% level of significance; **5% level of significance; *10% level of significance

Source: Field survey, 2019

Contract production has an estimated average treatment effect (ATE) of 0.25 of the TE, as indicated in Table 6.8. According to Khai and Yabe (2011), Mishra et al. (2018), Dube and Mugwagwa (2017), and Le Ngoc (2017), CF can help farmers boost their TE by 25%. The estimated correlation between treatment assignment errors and outcome errors (rho) is (-0.60) in Table 6.7, implying that unobservables that enhance TE are also likely to influence CF participation (self-selection occurred in CF participation). A positive bias implies that, farmers with higher-than-average TE are more likely to participate in CF and prefer to produce under contract.

The null hypothesis of no correlation between CF and AE can also be rejected using the Wald test of independence of the CF participation and AE equations. This suggests that CF and AE have a relationship. According to Table 6.8, contract production has an estimated ATE of 0.30 of AE, meaning that CF has a 0.30 influence on AE. This suggests that farmers who participate in CF have a 30% more allocatively efficient soybean crop than those who do not. As shown in Table 6.7, the estimated correlation between treatment assignment errors and outcome errors (rho) is (-0.67), showing that unobservables that increased AE also tend to occur with unobservables that promote CF (the study found self-selection in CF participation). A positive bias is indicated by the minus sign, which suggests that farmers with higher-than-average AE are more likely to contract.

Finally, the Wald test of selection and outcome equation independence shows that the null hypothesis of no correlation between CF and EE may be dismissed. This suggests that CF and EE are positively related.

Participating in contract production has an estimated ATE of 0.10 on the EE, as indicated in Table 6.8. The impact of CF on EE is 0.10. Farmers who participate in CF are around 10% more economically efficient in their soybean output than those who do not.

Table 6.8: A Summary of the Impact of CF on Technical, Allocative, and Economic Efficiencies.

Study Unit	Efficiency type	Impact (ATE)	Significance level
CF	TE	0.25	5%
	AE	0.30	10%
	EE	0.10	1%

Source: Field survey, 2019

As indicated in Table 6.7, the estimated correlation between treatment assignment errors and outcome (rho) is (-0.60), implying that unobservables that increase EE are similarly likely to occur with unobservables that favor contract participation (self-selection occurred in CF participation). A positive bias is indicated by the minus sign, indicating that farmers with higher-than-average EE are more likely to contract.

CHAPTER SEVEN

SOYBEAN PRODUCTION CONSTRAINTS IN THE NORTHERN REGION

7.1 Introduction

This section discusses the challenges soybean producers are confronted with in the soybean production in the study area.

7.2 Challenges Associated with Soybean Production among Producers

The Kendall's Coefficient of Concordance ranking approach is used to rate the constraints faced by contract and non-contract soybean farmers in the Northern region. The analysis was done separately for the two categories of farmers because the constraints were ranked differently. The details as shown on Table 7.1 reveal a high concordance strength *(W)* of 0.652 and significant at 1%, thereby allowing us to reject the null hypothesis that there was no agreement among the raters.

Table 7.1: Ranks of constraints by contract and non-contract soybean farmers

Contract farmers			**Non-contract farmers**		
Constraint	**Mean value**	**Rank**	**Constraint**	**Mean value**	**Rank**
Inadequate equipment and infrastructure for farming soybean	1.82	1	Inadequate equipment and infrastructure for farming soybean	1.75	1
Poor harvesting techniques	3.27	2	Inadequate rainfall	3.02	2
Inadequate rainfall	4.05	3	Poor soil condition	3.56	3
Poor soil condition	4.74	4	Pests and diseases affecting the crop	4.15	4
High cost of inputs	5.12	5	High cost of inputs	4.65	5
Pests and diseases affecting the crop	5.35	6	Low price of output	5.27	6
Low price of output	5.92	7	Poor harvesting techniques	5.86	7
Method of sowing	6.28	8	Limited or lack of market for produce	6.40	8
High cost of rent for farming	6.94	9	Method of sowing	7.10	9
Limited or lack of market for produce	7.56	10	High cost of rent for farming	7.48	10
Kendall's(W^a)	0.652***		df	7	
Chi-Square	126.914				

Source: Field survey,2019

Results of the study indicated that, the three topmost challenges facing contract soybean farmers in the region are lack of equipment and infrastructure for soybean farming, poor harvesting techniques and inadequate rainfall (drought). For the non-contract farmers, the three topmost challenges were; lack of equipment and infrastructure for soybean farming, inadequate rainfall and poor soil conditions were the three top most challenges.

Lack of equipment and infrastructure for farming soybeans production was ranked highest by both contract and non-contract soybean farmers The reason espoused unanimously by both categories of farmers for this ranking is that, during land preparation, it is difficult to get access to the right equipment to prepare their fields for ploughing. Land preparation with simple implements such as hoes and cutlasses is cumbersome. Another point mentioned by farmers in this regard is the lack of tractor services during the period of ploughing. This problem is attributed to the high demand for tractor services for the purposes of ploughing during this period. The high demand for these tractor services with little supply results in delay in the cultivation of soybean leading to shortage of water for the crop because the rains would have stopped before the crop matures leading to bad yields.

In a focused group discussion session with a group of non-contract soybean farmers in Zagbang in the Yendi Municipality, a farmer said:

"*Our soybeans did not do well last season and this was because it did not get enough water, the rains stopped before the beans ripened leading to poor output. This happened because we did not get tractors to plough for us on time"*

During another session in Borido in the Chereponi District, a contracted soybean farmer said:

"*I finally had to get a tractor outside the contractual arrangements with the sponsors to plough my field because the season was running out and tractor services were not coming from them.*"

Contract soybean farmers also complained about lack of equipment for harvesting soybean. There is no known farm machinery or equipment for harvesting soybeans in Ghana and for that matter Northern Region. Harvesting of the crop is mainly by uprooting with the hands when it is fully matured and dried. Unfortunately, soybean plants are thorny when dry and this makes it difficult to handle with the hands. Loss of output is quite common amongst farmers cultivating soybeans in the Northern Region because of this challenge.

One farmer in Zang poured out her frustration about this situation when she was interviewed. She said:

"*What I hate most about cultivating soybeans is the harvesting, my soybean can fruit very well only for me to lose almost everything during harvesting especially when it is not harvested early. I don't like uprooting the crop at all, it always cuts my hands*".

There were many narrations of similar stories by both contract and non-contract farmers, making this the most pressing problem.

The second most pressing challenge confronting contract soybean farmers in the Northern Region of Ghana is harvesting techniques. This challenge is directly related to the topmost challenge of lack of equipment and infrastructure for farming as explained earlier. Respondents complained about huge post-harvest losses due to their inability to properly harvest their soybeans. A contract farmer in Takoroyili summarized the challenge of harvesting in one sentence when she said: "*Using our hands to uproot the ripened soya with the plant without hand gloves and threshing it to remove the beans is the most difficult aspect in farming soybeans."*

On the part of the non-contract soybean farmers, the second most pressing constraint was inadequate rainfall (drought). This constraint is directly linked to the delay in procuring the services of tractors for ploughing. Mohammed et al., (2016) also found inadequate rainfall to be the second most pressing problem in the cultivation of soybean in the Northern region of Ghana. This sentiment was expressed by a non-contract farmer in Zagbang when he said:

"Once there is a delay in ploughing and planting, the rains will stop before the crop is fully matured. This leads to poor output."

Contract farmers ranked inadequate rainfall as the third most pressing problem in their cultivation of soybeans. The reason for their ranking is consistent with that of their non-contract counterparts which is expressed earlier. Poor soil condition was the third challenge strongly expressed by non-contract farmers in the region. Respondents attributed their low outputs to this problem. This finding is consistent with the findings of Salayman (2014) who ranked poor soil conditions third most pressing problem in the cultivation of rice in Gambia. When compared to their outputs to years ago when the soil was so rich, farmers could harvest 10 bags or more from a hectare of soybeans which is far less than the case now. According to them, they can only harvest 5 bags or less per hectare. When quizzed about the reasons for the reduction in the fertility of the soil, farmers gave reasons as continuous cropping, bush fires, overgrazing, and non-application of fertilizer to the crop. It is interesting to note that, farmers in the study area do not apply fertilizer to their soybeans. This is because the soybean crop, like many legumes, is able to supply its own nutrients like nitrogen which the plant utilises. When asked about the conditions of the soils, a farmer in Borido said:

"Our soils are now very poor and not suitable for the cultivation of soybeans again, I think we should start applying fertilizer to the crop."

The fourth ranked constraint by contract farmers was poor soil conditions in which soybean is being cultivated on. As expressed by non-contract farmers when they ranked it as the third most constraining factor, contract farmers also attributed their poor yields to the conditions of their soil. This finding is consistent with that of Ofori-Appiah (2018) when he ranked the constraints of pineapple in the Akwapim South District of Ghana. Non-contract farmers ranked pests and diseases as the fifth most pressing issue consistent with the findings of Mohammed et al., (2016).

Both contract and non-contract farmers mentioned high cost of inputs as one of the constraints of cultivating soybean (fifth ranked constraint). They complained that these high costs increase their total cost of production thereby eroding their profits. This finding is consistent with that of Adabe (2017). In his words a contract farmer said: "*Every season, there is an increase in the prices at which we buy inputs for the crop and even by-day, meanwhile the price of our soya has not been increasing, this erodes our gains."*

With increasing pressure on agricultural lands for crop production with its accompanying decrease in fertility of these lands, it has become more compelling to use more inputs in our production processes and soybeans is not an exception. Using more inputs in the production process means spending more money to buy them, unfortunately prices of these inputs are not stable, they increase every farming season. Farmers lamented over the high cost of production because of high input costs which makes up about 70% of the total costs of production. Higher cost of production with lower price for outputs implies lower profits. This reduces the benefits of soybeans production in the region. This point was echoed by another non-contract farmer in Zagbang when he said: *"These days farming is all about buying weedicides, pesticides, hiring by day for labour purposes when in the past we used to help each other on ourselves; these days you have to pay for everything including labour. All these things increase our cost of production. Meanwhile the prices for our soybeans remain stagnant. We are really suffering."*

Contract farmers ranked pests and diseases invasion as the sixth most difficult challenge affecting their production. Mohammed et al., (2016) also ranked pests and diseases as the sixth most pressing problem is soybean production.

Low output prices were ranked as the sixth most limiting factor affecting soybean production in the region affecting non-contract farmers. NCF who wish to sell their soybeans especially during the harvesting period often get very poor prices for their produce unlike their CF counterparts who can get good prices even at harvesting time because prices are negotiated before production is even done. However, NCF who store their soybeans awaiting better prices often gain more because prices of soybeans are higher later in the lean season when there is less of the produce in the market. CF do not have the luxury of doing same because their produce is often bought by their sponsors immediately after harvest. A farmer in Yakansia in the Chereponi District could not have put it better when she said:

"*I don't know why the prices of soybeans keep going down even though the prices of inputs keep going up. For instance, last year I sold my soybeans at GHS 80.00 per bag (100kg) during the harvesting period and this year it is GHS75.00 at the same time. Meanwhile, a bottle of 'condemn' (weedicide) was GHS15.00 and this year it is GHS20.00. So, you see, the price of 'condemn' went up and that of my soya has come down. That is not fair.*"

Another constraint reported by soybean farmers in the region is limited or no market access for their produce. This challenge is only peculiar to some NCF. These farmers mostly complain about this problem only when there is a bumper harvest of soybeans for a particular year. It is not a pressing problem for farmers in the region because there were no reports of soybeans cultivated that was not purchased over the years. Market access for CF is not a problem at all because they are guaranteed market by the sponsors.

Method of sowing was ranked eighth by CF. Even though sowing is done manually, this was not deemed as a serious problem because the labour involved in sowing is not limited to male adults only but cut across adults, women, and children; of which they have enough, hence its rank. These findings were corroborated by a female farmer in Wapuli in the Saboba district when she said: "*I have many children and sowing of* *soybean seeds can be done by them, I only need to teach them how to do it and they will sow. It usually takes only a day to sow 2 acres of soybean farm, so it not so difficult as compared to other farming activities"*

The least ranked constraint, which is in the tenth position was high rent on the part of NCF. This is not surprising at all because traditionally agricultural lands for farming in the Northern Region are mostly inherited and not rented. For CF, the least reported constraint was limited or lack of market for their soybean. This was reported as the least because these categories of farmers have ready market for their produce from the contracting firms.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FOR POLICY

8.1 Introduction

This chapter summarizes the study, draws conclusions from the research, and makes policy recommendations.

8.2 Summary

The value of CF in boosting smallholder farmers' performance in terms of increased productivity and revenue has been documented in numerous studies. However, only a few studies have investigated the efficiency effects of CF, to the best of the researcher's knowledge. The objective of this study was to measure CF participation on EE in soybean farming in Ghana's Northern Region. It attempted to do so by examining the factors that influence farmers' decisions to engage in soybean CF. Another objective was to compare the Technical, Allocative, and Economic Efficiencies of contractual and non-contractual soybean producers. The research also looked at the socioeconomic factors that influence soybean producers' efficiency. The challenges facing both contract and non-contract soybean farmers were identified and ranked using the Kendall's coefficient of concordance ranking technique.

To achieve its goals, the study used stochastic frontier models. The models were specified with the goal of determining soybean farmers' technical, allocative, and EE levels in the research area.

Three Hundred and Seventy-four (374) respondents were chosen using a multi-stage sampling procedure (200 contract farmers and 174 non-contract farmers). Face-to-face interviews were done to obtain primary data using a semi-structured questionnaire.

To estimate the efficiency levels and coefficients of efficiency, the LIMDEP version 11 and STATA version 14 were employed in the analysis. The validity of the model was tested using hypotheses testing. To identify which model had the best fit for the analysis, the generalized was utilized.

According to the findings, the gender of the respondents, education, off-farm business, FBO membership, farm size, access to agricultural extension service, and distance from farm to market center all had positive impacts on CF participation. However, experience in soybean production and production credit had negative impacts on participation.

Gender, crop diversification, farm-market distance, FBO membership, farm size, and participation in CF all had negative impacts on economic inefficiency, according to the findings. Also, the variables that influenced technical inefficiency negatively included education, FBO membership and farm size. Finally, crop diversification, education, FBO membership and farm size were the variables that positively influenced cost inefficiency.

At the 1% level, the CF of soybeans had a positive coefficient and was statistically significant. This indicates that farmers who took part in the soybean CF were more economically efficient in their soybean production than those who did not. Also, the

ATE results show that, soybean farmers who participated in CF have 25%, 30% and 10% efficient respectively in TE, AE and EE than their counterparts who did not.

The three topmost challenges facing contract soybean farming in the region are equipment and infrastructure for farming soybean, harvesting techniques and poor soil conditions. Lack of equipment and infrastructure for farming soybeans production was ranked highest. The three least challenges ranked were access to land, method of sowing and cost of rent.

8.3 Conclusions

The main goal of the study was to investigate CF participation and EE of soybean farmers in Ghana's Northern Region. The findings imply that CF has the potential to increase soybean production in the study area. Even though the values for the TE, AE and EE are higher for both categories of farmers, none of them is operating on 100% efficiency score in all the efficiency categories. There is room for improvement in their output. Contract farmers are allocatively and economically more efficient than their non-contract counterparts, however, non-contract farmers are more technically efficient.

8.4 Policy Recommendations

The study's findings show that CF participation can help farmers become more economically efficient. However, soybean producers in the region are not producing at maximum efficiency, therefore the actions that cause these inefficiencies should be identified and reduced. Soybean farmers can be taught more efficient farming methods to help increase their efficiency through a collaborative effort of the government, MoFA, and NGOs. To reduce farmer inefficiency, MoFA, contracting firms, NGOs, and other agricultural stakeholders should build the capacity of soybean farmers through frequent extension visits and workshops.

There is a disparity in the efficiency of male and female farmers; male farmers are more economically efficient than their female counterparts; therefore, gender-oriented initiatives should not only target men but also women, equipping and building their capacity to produce more and with greater efficiency.

Farm size was directly proportional to higher outputs per the results in the analysis, therefore, stakeholders in the agricultural sector should equip farmers with the requisite support in a form of loans to expand their farm sizes to increase their output. There should be timely delivery of inputs especially tractor services by contracting firms to farmers to plough the farms. This will address the situation where there is a shortage of rainwater for the crop because of delay in cultivation.

The three major challenges facing soybean production in the area include equipment and infrastructure for soybean farming, poor soil conditions and harvesting techniques. Attention should be focused on these areas to make soybean farmers more productive and efficient. There should be a deployment of machinery in performing some of the activities such as harvesting. Farmers complained bitterly about these two activities and that require attention. The study also revealed that farmers hardly apply inoculants (fertilizer) to the soybean even though the soils are poor. This leads to lower output per acre. The study recommends that MoFA, contracting firms and other stakeholders should put in efforts to facilitate easy access to inoculants (fertilizer) which has a higher impact on productivity.

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APPENDICES

Appendix 1: Research Questionnaire

UNIVERSITY FOR DEVELOPMENT STUDIES, TAMALE

Department of Agriculture and Food Economics, Faculty of Agriculture, Food and Consumer Sciences,

TOPIC: CONTRACT FARMING PARTICIPATION AND ECONOMIC EFFICIENCY OF SOYBEAN FARMING IN THE NORTHERN REGION OF GHANA

Hello, my name is................ I am from the University for Development Studies, and we are here to conduct research on the topic of 'CF participation and EE of Soybean Farming in Ghana's Northern Region. In this regard, we would like to ask you to participate in a 30-minute interview. This study may not benefit you right now, but it will be useful as information to inform the public, NGOs, and government institutions working on agricultural development about contractual soybean farming and farmer efficiency.

Then, policy recommendations will be made to the government, NGOs, and others in order to improve the rural farmer's living conditions. Please feel free to end the interview at any time, and you are not required to answer all of the questions if you do not wish to. If you believe the questions are unclear, please ask us to repeat them or paraphrase them in a simple word. Please keep in mind that all of your responses will be kept completely confidential, will never be shared with anyone outside of this research, and will only be used for this research study.

Do you wish to take part in this interview? Yes No

A. ADMINISTRATIVE INFORMATION

A1. Enumerator's name …………… A2. Date of interview……………………….

A3. Community/Village……….. A4. District …………………………………

B. PERSONAL AND HOUSEHOLD CHARACTERISTICS

B1. Gender of respondent

1=Male [ ] 0=Female [ ]

B2. Age of respondent……………………years

B3. Marital status

1=Married [ ] 2=Single [ ] 3=Window [ ] 4=widower [ ]

B4. Education

1=Primary [ ] 2=Secondary [ ] 3=Tertiary [ ] 4=None [ ]

(i)Number of years in formal education: ………………………………… years

B5. Religion

1=None [ ] 2=Christian [ ] 3=Muslim [ ] 4=Traditionalist [ ]

5=Others (Specify)…………………………………………….

B6. How many members are you in your household? ....

B7. How many years have you been cultivating soybeans …………………

B8. (i) Do you cultivate other crops?

1=Yes [ ] 0=No [ ]

(ii) What other crops do you grow?.......................................

(iii) What are the sizes of the various crops that are grown? ....

B9 (i) Do you engage in any other income generating activities?

1=Yes [ ] 0=No [ ]

(ii) What other income generating activities do you do? ....

B10. (i) Are you a member of any farmer's organization or cooperative?

1=Yes [ ] 0=No [ ]

(ii) If yes, which farmer/s organization? ....……………………

(iii) What are some of the benefits you derive from FBO membership?............................…………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

………………………………………………………………………………

C. FARM RESOURCES (Land, Labour, Capital and Management)

(C) (i) Land:

C1. How many plots of soybean land did you cultivate in 2016 cropping season? ....

Table 2: Plots of soybean cultivated

	Size(acres)	**Ownership**	**Suitability**	**Cost per acre**
Plot 1				
Plot 2				
Plot 3				
Plot 4				
Plot 5				

Ownership: 1= Owner, 2= Tenant   Suitability: 1= Very suitable, 2= Suitable, 3= Not suitable

C2. How far is your farm to the nearest market? ....km

(C)(ii) Labour:

C3. Indicate the type and number of labour used in soybean production and rate paid (Man-days) during the production period.

Table 3: Labour cost:

Farm Operation	Type of labour						Cost of hired labour	Unit of hired labour
	Family labour		Hired labour		Communal labour			
	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	Labour (GH₵)	
Land preparation								
Planting								
Weeding								
Fertiliser application								

Applying chemicals like Herbicides								
Harvesting/bagging								
Others (specify)								
Others (specify)								
Total								

Unit codes: 1= per day; 2= per acre; 3= others (specify)……………………………….

(C)(iii) Capital: Variable inputs:

C4. Indicate the type and number of variable inputs used in soybean production and costs last farming seasons?

Table 4: variable inputs used

Input Type	**Unit of Measurement**	**Quantity used per acre**	**Unit Cost**	**Total Coat**
Land preparation cost				
Farm size				
Seed				
Fertilizer/manure				
Herbicide				
Pesticide				
Harvesting cost				
Sacks				
Transportation				
Others				

(C) (iv) Credit:

C5. (i) Did you have access to other sources of credit for the 2016 cropping season?

1=Yes [ ] 0=No [ ]

(ii) If yes, provide the information below

Table 5: Sources of credit

Type	Sources	Amount/Quantity	Availability	
Cash				
In kind				
Others				

Source of credit: 1= Formal Bank, 2= Money Lenders, 3= Friends, 4= Family/Relatives 5= Others Specify

Availability: 1=Readily Available 2= Available 3= Scare

(C)(v) Management

C6. How long have you been producing soybeans? ....years

C7. (i) Did you have access to extension service for the 2016 cropping season?

1=Yes [ ] 0=No [ ]

(ii) If yes, what is the source of the advice?

1= Extension [ ] 2= NGOs [ ] 3= Others Specify?.............

(iii) How often were you visited by these agents last cropping year……………….?

(iv)What type of advice did you receive from these agents?

1= Agronomic [ ] 2= Pest and Diseases [ ] 3= Other Specify…………..

(v) Was the advice useful?

1=Yes [ ] 0=No [ ]

(vi) If yes how would you rate the extent of usefulness?

1=Very useful [ ] 2= useful [ ] 3=less useful

(vii) Have you received any training on soybean production?

1=Yes [ ] 0=No [ ]

(viii) As part of the training did you visit any demonstration farms?

1=Yes [ ] 0=No [ ]

(ix) If yes how would you rate the extent of usefulness of the training?

1=Very useful [ ] 2= useful [ ] 3=less useful

(xi) Which organization provided the training?...

D. CF PARTICIPATION

D1. Are you into contractual arrangements with respect to your soybean production?

1=Yes [ ] 0=No [ ]

D2. If yes why are you into this? (Select multiple)

1=ready market [ ] 2=extension [ ] 3=good prices [ ] 4=credit [ ] 5=others (specify)…………

D3. How long have you been into such contractual arrangement?

1=less than 1year [ ] 2=1 year [ ] 3=2 years [ ] 4=3 years [ ] 5=4 years [ ]

6=5 years or more [ ]

D4.With what organisation(s) are you into this contract?...

D5.What were the criteria for joining the soybean contractual production?

……………………………………………………………………………………

D6.What are the terms spelt out in the contract?

1=ready market [ ] 2=extension [ ] 3=good prices [ ] 4=credit [ ] 5=input provision [ ]

6=number of acres to be cultivated [ ]

7=price negotiation [ ]

5=others (specify)…………………………………….

D7. What are your obligations in the contract? ....

……………………………………………………………………………………

……………………………………………………………………………………

D8. What benefits do you derive from participating in contractual soybean production?

1=ready market [ ] 2=extension [ ] 3=good prices [ ] 4=credit [ ] 5=input provision [ ]

6=larger acreage [ ] 7=others (specify)………………………………….

D9. Were there any potential benefits you were promised with but you did not receive?

1=Yes [ ] 0=No [ ]

D10. If yes in D9 what were these benefits?...

D11.If yes to D9, why didn't you receive them? ....

………………………………………………………………………………………

D12.Since entering into contractual arrangements would you say that your soybean output/revenue/cost/profit levels have increased, decreased or remained the same?

Table 6: effects of contractual arrangements

Item	**Increased**	**The same (unchanged)**	**Decreased**
Output			
Revenue			
Cost			
Profit			

D12. What challenges do you face in contractual soybean production? …………………...............

………………………………………………………………………………………

………………………………………………………………………………………

D12. How do you think these challenges can be resolved? ………………………………………..

………………………………………………………………………………………

………………………………………………………………………………………

E. FARM PRODUCTION

E1.What type of soybean variety/ies did you grow in 2016 cropping season? ………………………………………………………………………………

E2. Method/technology employed in soybean Production?

Table 7: method/technology used in soybean production

Farm production	Method/technology	Time of planting	Time of fertilizer application	Time of weed control	Period of harvesting
Plot 1					
Plot 2					
Plot 3					

F. RETURNS:

F1. Quantity of soybean produced and the usage in 2016 Harvest Period.

Table 8: Returns from soybean production

Plot	Quantity harvested	Sold	Consumed	Gift	Seed	Storage	Total	Price per Kg
1								
2								
3								
4								

5								

G. PROBLEMS IN SOYBEAN PRODUCTION:

G1. Rank all the following constraints under which you grow soybean?

Table 9: problems associated with soybean production

List of Constraints	**Ranking of constraints (coded 1-10)**
Pest and Disease incidence	
Poor Soil	
Inadequate rainfall	
High Cost of Inputs	
Low price of output	
Limited/Lack of Market	
High rent for land for farming	
Equipment and Infrastructures	

H. **ADDITIONAL QUESTIONS FOR NON-CONTRACTUAL FARMERS**

H14. Why are you not into CF? ……………………………………………………

……………………………………………………………………………………

H15. What do you perceive to be the benefits that contractual farmers are receiving? (Probe benefits)……………………………………………………………………………

……………………………………………………………………………………

H16. What do you think are the challenges? (Probe)…………………………………………...

………………………………………………………………………………………

H17. Would you like to join? 1=Yes [ ] 0=No [ ]

H18. Mention the organization(s) you would like to join.

H19. What do you need to help you improve your cultivation of soybeans………………………………………………………………………………

………………………………………………………………………………………

H20. What are the general problems associated with the cultivation of soybeans………………………………………………………………………………

………………………………………………………………………………………

……………………..H21. Can you suggest ways of overcoming those problems………………………………………………………………………………

I. WELFARE INDICATORS

B11. What type of house do you live in?

1= Block 2= mud 3=other (specify)

B12. Type of roof of house? (Observe)

1=Aluminium sheets 2=grass 3=other

B13. What is your source of drinking water?...

B14. Do you have money to go to the hospital/clinic when you or your family member is not well? 1=Yes [ ] 0=No [ ]

B15. What percentage of your dependants who are of school going age are going to school …………………………….

B16. How would you rate your living standard?

1= Rich 2=Average 3=poor

C17. How would you rate the following?

(a) Extent of happiness

1= Very good 2=average 3=bad

(b) Extent of security (protection)

1=Very good 2= average 3=bad

(c) Extent of health

1=Very good 2= average 3=bad

Appendix 2

First-stage regression results of determinants of Credit access and Extension

Variable	**Credit**	**Extension**
Sex|	-0.238 (0.165)	-0.146 (0.156)
Household size	-0.005 (0.019)	-0.037* (0.174)
Age	0.010 (0.007)	0.012 (0.121)
Experience	-0.071* (0.029)	-0.006 (0.033)
Crop diversification	0.287*** (0.082)	0.101 (0.124)
Off farm activity	0.746* (0.221)	0.515 (0.331)
Farm size	0.133 (0.147)	0.127 (0.160)
Education	0.316*(0.161)	0.094 (0232)
Training |	0.990**(0.424)	0.732* (0.744)
_cons |	-1.510**(0.347)	-0.241 (0.569)

***, **,* represent 1%, 5%, and 10% significance level, respectively. Values in parentheses are standard errors.

PARTICIPATION IN CONTRACT FARMING AND ECONOMIC EFFICIENCY OF SOYBEAN PRODUCTION IN THE NORTHERN REGION OF GHANA

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