ECONOMIC ANALYSIS OF LEGUME PRODUCTION IN KANO STATE, NIGERIA: A GENDER PERSPECTIVE

BY

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SPS/14/MEX/00022

APRIL, 2019

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION, FACULTY OF AGRICULTURE, BAYERO UNIVERSITY, KANO, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (M.SC) IN AGRICULTURAL ECONOMICS

APRIL, 2019

DECLARATION

I hereby declare that this work is the product of my research efforts; undertaken under the supervision ofProf. A. Mustapha and Prof. M.M. Ahmad and has not been presented anywhere for the award of degree certificate. References made to published literatures have been duly acknowledged.

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Signature and Date
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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write- up of the dissertation by Rafiat Yusuf Idris(SPS/14/MEX/000022) were carried out under our supervision.

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APPROVAL PAGE

This is to certify that, this dissertation titled "Economic Analysis of Legume Production in Kano State, Nigeria: A Gender Perspective" Prepared by Rafiat Yusuf Idris (SPS/14/MEX/000022) has been examined and approved in accordance with the regulations governing the award of Master of Science in AGRICULTURAL ECONOMICS, in the Department of Agricultural Economics and Extension, Faculty of Agriculture, Bayero University, Kano.

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This project is dedicated to my beloved son, Irfan Ahmad Auwal.

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ABSTRACT

This study analyses legume productionamong small scale farmers in Kano State. Multi-stage sampling technique was appliedto interview 120 farmers which comprised of both male (84) and female (36) through the use of structured questionnaires. The analytical tools used include descriptive statistics, Harvard analytical analysis, gross margin analysis and stochastic production frontier model. The results showed that the mean age of male and female farmers were 46 and 43 years with an average farm size of 0.84 and 0.59 respectively. Further, the result revealed that approximately 65% of farm activities were carried out by males while 35% were done by females.The gross margin analysis revealed thatlegumes production was profitable among the gender, giventhereturn on investmentfor cowpea and groundnut of 0.80 and 0.41 for the males and females, 0.99 and 0.78 respectively.The results also revealed that average economic efficiencies for cowpea and groundnut farmers for the male were 0.17 and 0.14 while the female had 0.15 and 0.14 respectively. The major constraints identified by males and females were, input sourcing (95.2%, 94.4%), marketing (91.7%, 58.3%), pest and diseases (83.3%, 88.8%) and land ownership (39.3%, 91.6%). Evidence from the study suggests that male and female farmers in the study area should collaborate in other to learn and adopt best production practices to increase profitability and efficiency. Also, sourcing for inputs can be addressed by established farmer cooperatives to assist in timely and cheaper procurement.Appropriate measures should be taken on eradicating pests and diseases in the study area and land tenure system should be relaxed and reviewed. Major recommendation emphasized that farmers should be trained on better production techniques for efficient utilization of resources.

CHAPTER ONE

1.0 INTRODUCTION

1.1BACKGROUND OF THE STUDY

Legumes have been cultivated since the earliest of civilizations. It has been part of the human diet since the early ages of agriculture and many legume species such as cowpea, soybean among others are still irreplaceable source of dietary proteins for humans as well as animals. Fresh immaturepods and grains provide green vegetable and dry seeds are cooked in making various choice dishes. The protein-rich legumes complement cereals to make one of the best solutions to protein-calorie malnutrition, particularly in developing countries (Burstin, Gallardo, and Varshney, 2011).Besides nutritional role of legumes; they are also useful in crop rotations that improve soil fertility through nitrogen fixation. According to Mpepereki and Pompi, (2002), nitrogen remains the single most limiting nutrient for crop growth in most developing countries; hence exploitation of biological nitrogen fixation offers a unique opportunity to harness “free” fertilizer from a relatively low cost technology.

Legumes complement cereals in both production and consumption. In the production process legumes improve soil fertility status, require less water than cereals, and their rotation with cereals helps control diseases and pests. On the consumption side, legumes are the cheapest source of protein in the vegetarian diet and supplement mineral and vitamin requirements.Grain legumes are a key source of nitrogen-rich edible seeds, providing a wide variety of high-protein products and constituting the major source of dietary protein in the diets of the poor in most parts of sub-Saharan Africa. Largely grown as subsistence food crops in Africa, they are predominantly crops grown by women and used within the family, with an annual per capita consumption of about 9kg and providing 88kcal/capita/day, (www.N2Africa.org). Legumes such as groundnut are also major sources of edible oil and other industrial by-products.

Ayoola and Odiaka (2004), described gender as a socio-economic parameter that is useful in analysing the roles, responsibilities, opportunities and constraints of both men and women along different ethnic, religion and ecological lines. Gender in agriculture focuses on the relationship between men and women with regards to their roles, access to and control of resources, division of labour and needs (Ojo,Nwosu and Omeje, 2013). In almost all societies, women and men differ in their activities and undertakings, regarding access to and control over resources and participation in decision-making. Women make essential contributions to the agricultural and rural economies in all developing countries. Their roles vary considerably between and within regions and are changing rapidly in many parts of the world, where economic and social forces are transforming the agricultural sector. Their activities typically include producing agricultural crops, tending animals, processing and preparing food, working for wages in agricultural or other rural enterprises, collecting fuel wood and water, engaging in trade and marketing, caring for family members and maintaining their homes. Many of these activities are not defined as "economically active employment" in national accounts but they are essential to the wellbeing of rural households (The Food and Agriculture Organization of the United Nations (FAO), 2011). Studies have shown that increasing womens' agricultural inputs and education to the same level as men can increase national agricultural output by 2.5 – 4 %, reducing the number of undernourished people in the world by 12-17% (Mary and Jeannette, 2011).

Cowpea (*Vignaunguiculata (L.)Walp*), is a crop which is grown in many parts of Nigeria. It provides protein to rural as well as urban dwellers as a substitute or supplement for animal protein. Cowpea contains 20-25% of protein and 64% of carbohydrate (Modu 2009). In addition, the crop is also an important companion crop in most cereal-legume cropping systems because the benefit from its nitrogen fixing ability and the residual nitrogen originating from the decay of its leaf litter, roots and root nodules (Okereke *et al*., 2006). Cowpea plays several key roles in the nutrition and economic life of many people in the developing world. According to a report by Thomas Jefferson Agricultural Institute (TJAI, 2009), cowpea has a protein content of about 23 % making it good source of plant protein. This has an implication in its ability to cover the gap created by the inadequacy of animal protein in the diet of common people in Nigeria due to the shortage of supply and low level of income of most people in the region (International Journal of Development and Sustainability (IJDS, 2014).

Groundnut (*Arachis hypogea L*), is an annual plant herb (legume) that comes from the pea family of *Fabaceae*. It is also known as peanut, earthnut, monkey-nut and goobers in U.S. and British terms (Kumar, 2007). It is the 13th most important crop and the 4th most important oilseed crop of the world. Groundnut seeds contain 40-50% fat, 20-50% protein and 10-20% carbohydrate (Kumar, 2007). Thus, nutritionally, it is a good source of vitamins and essential minerals. Groundnut seeds are consumed directly as raw, roasted or boiled (meal) and the oil extracted from the seeds is used as culinary oil. The oil is used in making margarine, crackers/cookies, candy, salted groundnut, salad oils nut chocolates, sandwiches and soaps. Furthermore, groundnut plants are used as animal feed (oil pressings from seeds, green material and straw) and industrial raw material (oil cakes and fertilizer). These multiple uses of the groundnut plant make it a good cash crop for domestic markets as well as for foreign trade in several developing and developed countries (Ani, Umeh and Weye, 2013).

1.2 STATEMENT OF THE PROBLEM

The 2008 World Development Report showed that agriculture is a critical source of livelihoods for women in many developing countries, and a key pathway out of poverty. Women make up a substantial majority of the agricultural workforce and produce most of the food that is consumed locally while shouldering a big chunk of the family responsibility.However, these women in many rural societies are especially constrained by lack of access to inputs, productive resources, and services. They also, often lack incentives to invest given the greater vulnerability and proportionately greater exposure to risk, and the very real likelihood that once their niche in the value chain becomes commercially profitable it will be expropriated by men (World Bank, 2008).

The 1996 World Food Summit observed that sub-Saharan Africa is the remaining region in the world with decreasing food production per capita. Soil fertility, according to Gruhn *et al*., (2000) is one of the primary constraints to agricultural production in Sub-Saharan Africa. The reduced ability to use traditional soil fertility management practices such as fallow and rotation to restore soil fertility limits farmers to the main other option, that of increased soil fertility inputs. These include organic inputs (either green manure, or livestock manure) and inorganic chemical fertilizer. Unfortunately, inorganic fertilizers are highly expensive and in most cases inaccessible to the poor local farmers. CIAT, (2006) underlined that Nitrogen (N) and phosphorus deficiencies are widespread in Sub-Saharan Africa, with Nitrogen being the most frequently deficient nutrient in agricultural systems. Thus, the need for nitrogen fixation into the cropping system becomes pertinent.

Legumes, a nitrogen fixation crop, are generally considered as women's crops because of their relatively greater contribution in production and marketing of legume vegetable products, seed and cottage industry food processing (Kumar 1985, as sited in FAO 2007). In well-developed legume value chains such as cowpea, women are increasingly involved in cowpea production, processing and producing food products such as, *kosai* (fried fritter) and*moin-moin*(beans pudding) among others, (FAO 2007), to generate income and provision of food for the family.

However, even in their roles as cultivators and processors, women face severe challenges in accessing farm inputs and services. They have been found to be more constrained in accessing production resources compared to their male counterparts. This is been reflected in having less access to information, technology, inputs and credit, resulting in women having more depressed productivity than men (Ojo *et al.*, 2013). One reason is because men (and institutions comprised largely of men) tend to control the decisions that affect women's access to these resources. For instance, men frequently allocate poor-quality lands to women, yet after women's hard work to restore soil fertility, men sometimes repossess those lands for their own use(Ojo *et al.*, 2013). Credit access is also a major constraint: in Africa women receive less than 10% of the credit issued to smallholder farmers (Consultative Group on International Agricultural Research (CGIAR, 2015).

In line with the above constraints affecting legumes production, the study intends to analyse gender participation in selected legumes production in Kano State. The study seeks to answer the following research questions:

1. What are the socio-economic characteristics of legume farmers in the study area?
2. What is the nature of access and control of resources among gender members in the study area?
3. Are there differences in profitability among male and femalelegume farmers in the study area?
4. Are the male and female farmers efficient in the production of legumes in the study area?
5. What are the constraints militating against legumes production in the study area?

1.3 OBJECTIVES OF THE STUDY

The broad objective of the study is toanalyse legume production in Kano State from a gender perspective. The specific objectives are to;

1. describe the socio-economic characteristics that influence legumes production,
2. determine the nature of access and control of resources among gender members in the study area,
3. determine the profitability of legume productionamong male and female farmers,
4. estimate resource use efficiency among male and female legume farmers; and,
5. identifythe constraints militating against legume production in the study area.

1.4 JUSTIFICATION OF THE STUDY

Since the 1990s, policy makers and development practitioners have emphasized the critical importance of gender in the implementation, evaluation, and effectiveness of programs across a range of social and economic sectors. Further, World Bank*et al*. (2008) cautioned that "the failure to recognize the roles, differences and inequities (between men and women) poses a serious threat to effectiveness of the agricultural development agenda". In addition, gender inequalities in agricultural development contribute to low productivity, and higher levels of poverty as well as under nutrition (World Bank *et al*., 2008).

This study is intended to stimulate gender participation in legumes production and involvement in agricultural activities so as to boost development in the economy. It is important to note that gender equality in the society iskey to social development of any country. Gender equality not only gives women their inalienable rights, but it benefits humanity as a whole. It gives women the opportunity to be involved in decision-making that helps to tackle poverty, illiteracy, mortality and issues that affects them the most including maternal health care, abuse, childcare, etc.

Further, this study will provide basis to encourage legume production so as toboost soil fertility, income generation and food security in the study area. It is also expected to provide valuable information to legume producers, researchers, policy makers and other stakeholders. Also, adding to the existing knowledge, it will provide new orientation in resource management needed to improve economic understanding on legume production, as it may result in according more attention to gender issues in the quest for development.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CONCEPTUAL FRAMEWORK

2.1.1 Importance of Legumes in Farming Systems

The primary role that legumes play is to fix atmospheric N_2 through their symbiotic relationship with *Rhizobium* spp., usually associated with the host's root system. This contributes nitrogenous compounds to the soil, either directly, by nodule excretion, or indirectly, by decomposition of root nodules and tissues. Nitrogen is also passed to the soil from the top growth through litter fall, through leaching by rain from above-ground parts and by deposition of excretory materials from herbivores both above and below the ground.

This primary role of fixation of atmospheric N_2 leads to two dependent or consequential roles of legumes: (1) their capacity to increase soil fertility and (2) the generally high levels of protein in the herbage and hence its high forage or mulching quality.

It is unlikely to be by chance that most legumes have acquired their ability to fix Nitrogen. If we examine the ecological basis for the natural distribution of legumes in the world's floras, one very seldom finds them at all common or highly productive in climax vegetation. However, they are frequently common and vigorous in successional situations, particularly where soil fertility or the availability of plant nutrients is low (Norris, 1964). Thus legumes are often strongly associated with disturbed sites (e.g. road-sides). As a result of this disturbance, when nutrients other than N_2 are likely to be more available than usual, legumes compete effectively against those species that cannot fix N_2. This is presumably why most legumes retain their capacity to respond to such important secondary nutrients as P. since this is critically important for effective symbiosis.

2.1.2 Cowpea Production in Nigeria

Nigerian agriculture is dominated by small-scale farms which constitute an important and invaluable production component of the Nigerian economy. Food consumption expenditures accounts for a high proportion of total households' expenditure in Nigeria and food demand has been growing at the rate of 3.5% per annum with food production growing at a rate of 2% per annum in recent years, while, the annual rate of population growth has been as high as 2.9 per cent, thereby, creating a serious food deficit (Shaib *et al*., 1999). The ability of Nigeria's agriculture to perform its role in development has been declining thus creating wide gap between the demand for and supply of food (Alabi and Esohawan,2006). It is the desire of most countries (Nigeria inclusive) to be self-sufficient especially in food production. The country has potentials for production of different cereal and legume crops which include cowpea. Cowpea is an important grain legume (Singh *et al.,* 2002) and the crop is also an important companion crop in most cereal-legume cropping systems because of the benefit from its nitrogen fixing ability and the residual nitrogen originating from the decay of its leaf litter, roots and root nodules (Okereke *et al.,* 2006). Cowpea is gradually attaining higher economic importance status in Nigeria, particularly in the southern states of Nigeria, even though the bulk of the production is done in the semi-arid zone of Northern Nigeria (PetuIbikunle and Smith, 2008).The crop therefore, has a great potential in contributing to the alleviation of malnutrition among resource-poor farmers.

Cowpea plays several key roles in the nutrition and economic life of many people in the developing world. According to a report by Thomas Jefferson Agricultural Institute (TJAI, 2009), cowpea has a protein content of about 23 % making it good source of plant protein. This has an implication in its ability to cover the gap created by the inadequacy of animal protein in the diet of common people in Nigeria due to the shortage of supply and low level of income of most people in the region.

However, according to the research by Shaba and Kilani (2014) cowpea is generally produced by small-scale farmers using rudimentary implements. The average land holding is less than two hectares for most farmers; family labour remains the essential input. Ownership of land is on communal basis, inherited or rented; cases of outright purchase of land are rare. Capital is a major limitation in agriculture, only few farmers have access to rural credit (Shaba and Kilani, 2014).

2.1.3 Groundnut Production in Nigeria

Groundnut (*Arachis hypogaea* L.) is the 6th most important oil seed crop in the world. It contains 48-50% oil, 26-28% protein and 11-27 % carbohydrate, minerals and vitamin (Mukhtar, 2009). Groundnut is grown on 26.4 million hectare worldwide, with a total production of 37.1 million metric tons and an average productivity of 1.4 metric tons /ha. Developing countries constitute 97% of the global area and 94% of the global production of this crop (FAO, 2011). The production of groundnut is concentrated in Asia and Africa, where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs). Nigeria was the third highest producer of groundnut in the world after China and India with a production of 16,114,231, 6,933,000 and 2,962,760 tons respectively in 2011. In Nigeria, the crop is presently grown throughout the country with the exception of the riverine and swampy areas. Groundnut occupies between 1.5 and 2 million ha of land of the country's land (Olurunju, 2000). Groundnut is either cultivated sole or in mixtures with other crops like maize, sorghum, millet or cassava. Fifty five percent of the groundnuts produced in Nigeria are in mixtures. In Nigeria, the leading producing states include Niger, Kano, Jigawa, Zamfara, Kebbi, Sokoto, Katsina, Kaduna, Adamawa, Yobe, Borno, Taraba, Plateau, Nasarawa, Bauchi, and Gombe States (NAERL, 2011).

In the Northern part of Nigeria, apart from being consumed whole, edible groundnuts are processed into or included as an ingredient in a wide range of other products which includes groundnut paste which is fried to obtain groundnut cake (*kuli kuli)*, salted groundnut (*gyada mai gishiri)*, a gruel or porridge made with millet and groundnut (*kunun gyada)*, groundnut candy *(kantun gyada)* and groundnut soup (*miyar gyada)*.The shells are used for fuel by some local oil factories or they are sometimes spread on the field as a soil amendment. They could also be used as bulk in livestock rations or in making chipboard for use in joinery (Mukhtar, 2009). Groundnut pod yields from farmers‟ field are low, averaging about 800 kg ha-1, less than one-third the potential yield of 3000 kg ha-1. This large gap between actual and potential yields is due to several factors, including non-availability of seeds of improved varieties for a particular ecology, poor soil fertility, inappropriate crop management practices, pests and diseases (Ahmed *et al.,* 2010).

However, government on its part equally shifted its attention from agriculture as a whole to the oil industry. Nonetheless, one of the major problems of groundnut production is low yield. This is attributed to poor production techniques used by small scale farmers, and inadequate supplies of inputs. Inter-cropping is also to be considered as another factor contributing to low yield. This is as a result of small plant population of groundnut crop and the initial shading imposed by other crops such as sorghum and guinea corn varieties (Ntare *et al.*, 2005). The low output realized by smallholder farmers is an indication that resources needed in the production of crops are not at optimal levels (Nweze, 2002; Panwal *et al.*, 2006; Adinya *et al*, 2008). There is need to increase crop production using resources efficiently, that allows sustainable levels of food production (Owa *et al.*, 2006). As a result, there is need to reverse the foregoing scenario with a view to improving the productivity and efficiency of resource use among groundnut farmers through the investigation of the nature of productivity and efficiency in their production (Taru *et al.*, 2008).

2.1.4 Concept of Gender

Gender refers to the roles and responsibilities of men and women that are created in our families, our societies and our cultures. The concept of gender also includes the expectations held about the characteristics, aptitudes and likely behaviours of both women and men (femininity and masculinity). Gender roles and expectations are learned. They can change over time and they vary within and between cultures. Systems of social differentiation such as political status, class, ethnicity, physical and mental disability, age and more, modify gender roles. The concept of gender is vital because, applied to social analysis; it reveals how women's subordination (or men's domination) is socially constructed. As such, the subordination can be changed or ended. It is not biologically predetermined nor is it fixed forever, (UNESCO, 2003).

Despite increased attention to gender issues in the international development arena, since the rise of feminism in the 1970s, few International or National agricultural research organizations have integrated gender as a central element of problem diagnosis and technology development; as such, gender issues have not always been taken into account in research, technology development, dissemination and policy formulation processes. The recently released State of Food and Agriculture by FAO, that focuses on Women in Agriculture reveals that increasing women‘s agricultural inputs and education to the same level as men‘s can increase national agricultural output significantly (FAO, 2011).

Although increased utilization of participatory approaches has led to greater involvement of men and women in research and development, there are many places in the world where women and other marginalized groups like youth remain excluded from decisions that impact on their lives and livelihood. This may be responsible for the prevailing low level of adoption of innovations. Reflecting on a growing international concern and the need to address inequalities in development efforts, the United NationsMillennium Development Goals underscores the need to include gender issues in development. The Mid Term Assessment of MDG Progress reported that, gender equality and women‘s empowerment have large multiplier effects on all MDGs" (ALIN, 2010). A desktop study revealed that little information on gender in legume production. However because gender is a cross cutting theme, background information including examples have been cited from the agricultural literature to illustrate the rationale for and strategies on how to enhance gender in this projects‘ work with legumes.

Roles of Women in Agriculture

According to a research conducted by FAO (2011) on the roles of women in agriculture,it revealed that agriculture can be an important engine of growth and poverty reduction. But the sector is underperforming in many countries because women, who are often a crucial resource in agriculture and the rural economy, face constraints that reduce their productivity. This research draws on the available empirical evidence to study in which areas and to what degree women participate in agriculture. Aggregate data shows that women comprise about 43 per cent of the agricultural labour force globally and in developing countries. But this figure masks considerable variation across regions and within countries according to age and social class. Time use surveys, which are more comprehensive but typically not nationally representative, add further insight into the substantial heterogeneity among countries and within countries in women's contribution to agriculture. They show that female time-use in agriculture varies also by crop, production cycle, age and ethnic group. A few time-use surveys have data by activity and these show that in general weeding and harvesting were predominantly female activities. Overall the labour burden of rural women exceeds that of men, and includes a higher proportion of unpaid household responsibilities related to preparing food and collecting fuel wood and water. The contribution of women to agricultural and food production is significant but it is impossible to verify empirically the share produced by women. Women's participation in rural labour markets varies considerably across regions, but invariably women are over represented in unpaid, seasonal and part-time work, and the available evidence suggests that women are often paid less than men, for the same work. Available data on rural and agricultural feminization shows that this is not a general trend but mainly a sub-Saharan Africa phenomenon, as well as observed in some sectors such as unskilled labour in the fruit, vegetable and cut-flower export sector. FAO (2011) re-affirms that women make essential contributions to agriculture and rural enterprises across the developing world. But there is much diversity in women's roles and over-generalization undermines policy relevance and planning. The context is important and policies must be based on sound data and gender analysis.

Gender Involvement in Agriculture

In Nigeria of about 140 million people, men constitute about 50.4% and women 49.6% (NPC, 2006). Both sexes are responsible for producing the nation's food and one of the major problems confronting mankind in recent times is food crisis. Gender has often been misunderstood as being about the promotion of women only, but gender focuses on the relationship between men and women, their roles, access to and control over resources, division of labour and needs. Gender relations also determine household security, well-being of the family, planning, agricultural production and many other aspects of rural life (Frischmuth, 1997). Ayoola and Odiaka (2004) described gender as a socio-economic parameter that is useful in analyzing the roles, responsibilities, opportunities and constraints of both men and women along different ethnic, religion and ecological lines. The term "gender" can also be viewed as economic, social and cultural attributes and opportunities associated with being male or female (UN-Habitat, 2006). In almost all societies, women and men differ in their activities and undertakings, regarding access to and control over resources and participating in decision-making. Riley (1997) identified gender as a social institution, cultural construct and power tool. There is a danger to confuse "gender" with "women". Sen (1999) posited that the concept of gender is not limited to the male or female species, but goes further to assess the relations between them; as are constantly being renegotiated in the context of changing political, economic, social and cultural environments at the local, national and supra national levels. Gender analysis entails having knowledge of both women and men's roles and responsibilities, as it is the comparative analysis between these that will highlight the gender inequalities of any society. Gender inequality does not imply that all women are worse off than all men; rather, gender (being male or female) is an important social division characterized by inequality. Being a woman or a man influences people's perspectives and their social expectations. Gender equality means that women and men enjoy the same status and have equal opportunities for realizing their full human rights and potential to contribute to national, political, economic, social, and cultural development, and to benefit from the results. The concept of gender equality acknowledges that different treatment of women and men sometimes required to achieve sameness of results, because of different life conditions or to compensate for past discrimination. UN-Habitat (2006) states that gender analysis must take into consideration and address differentials in control over and access to land and other resources. Gender roles may be productive and social in nature.

Men and women are affected differently in their operation in factors like markets and socio-cultural environments. Women are more constrained than their male counterparts in terms of access to information technology, inputs, credits, etc. Some crops are even classified as man's crop while others are regarded as woman's crop which has an effect on food production. At times, female sex is only restricted to child – bearing and other domestic chores, while their male counterparts do almost all agricultural operations on the farm. Women are responsible for carrying out 70% of agricultural labour, 50% of animal husbandry related activities and 60% of food processing activities (Annon, 2006). Table 1 shows gender participation in some field activities in Nigeria. The table shows that activities differ in relations to task involved. Men performed major role in physical activities like land clearing and tilling, while women major roles were in planting and marketing with almost equal task in weeding operations. In agriculture, men are generally presumed to be the chief actors in agricultural production and, as such, are often the main participants in and/ or recipients of programme – related supports. Although men and women participate in agriculture, the task may be sex specific but they are complementary and reciprocal.

Why pay attention to gender in agriculture?

The rationale for integrating gender in agricultural research relates to agricultural productivity, food security, nutrition, poverty reduction, and empowerment. Female farmers play a vital role in sub-Saharan African (SSA) agriculture and produce up to 80 percent of basic foodstuffs for household consumption and sale but often their roles is under-recognized and face greater constraints than men (Meinzein-Dick *et al*., 2010). Recognizing this sets the stage for identifying ways that the agricultural research system can redress these problems and contribute to productivity and equity. Considerable evidence exists that households do not act in a unitary manner when allocating resources (Alderman, *et al*., 1996). This means that men and women within households do not have the same preferences nor pool their resources. This has important implications for productivity; several empirical studies have found that redistributing assets between men and women in the household has the potential for increasing productivity (Udry, 1996). Not only do gender disparities in control over assets exist, but increasing women‘s control over assets has positive effects on a number of important development outcomes, including food security, child nutrition, and education (Quisumbing and Maluccio, 2003). Women play a crucial role in the distribution of food and non-food household resources that determine the food security of the household. Increases in the resources that women control have been shown to improve child health and nutrition and increase allocations toward education (Quisumbing and Maluccio, 2003). Sustainability in agricultural development calls for passage of knowledge across generations. However, involvement of gender and youth in agriculture has been noted to be on the decline and their involvement should be included in the gender work (Njenga *et al*., 2007)

Consequently, agricultural development toward increasing agricultural production must address gender issues in order to achieve significant impact in the reduction of hunger and poverty as well as to increase productivity and output (ALIN, 2010). Alderman, *et al*., (1996) estimate that reducing inequalities in human capital, physical capital, and current inputs between male and women farmers in sub-Saharan Africa could potentially increase agricultural productivity by 10-20 percent. Interventions which enhance women‘s capacity to make their own decisions and build their skills have been shown to promote children‘s welfare and education, diversify household livelihoods, increase returns on women‘s productive labour, and contribute to economic growth and nutrition. Similarly, women‘s participation in farmer and other types of community organisations has been shown to increase overall cooperation, collective action and impact (ALIN, 2010; World Bank *et al*., 2008). Thus, agricultural research and development that target gender in legumes production can play an important role in reducing gender inequality in these key areas when it works to enhance women‘s assets or improve the productivity of the resources that women do control. A large body of evidence shows that, in many parts of the world, men and women spend money differently: women are more likely to spend the income they control on food, healthcare, and education of their children. Increasing household income does not necessarily improve the nutritional and health status of women and children when that income is controlled by men. Women‘s relative bargaining power within the household is likely to influence whether gains in income translate into nutritional improvements (Meinzein-Dick *et* *al*., 2011). It is also very important to realize that alliances between men and women are the most effective ways of engineering positive change and increase the profitability in legumes production as women do not exist in isolation either from each other or from men in their society. Legumes are mainly women‘s crops grown for home consumption and as such women‘s active and meaningful involvement in legumes production, processing, marketing, commercialization is crucial.

Gender in selection of best fits legume varieties and technologies

It is important to recognize the specific expertise of women farmers in participatory legume variety selection processes. This is illustrated in a case where the International Centre for Tropical Agriculture (CIAT) convened a panel of female farmers in Rwanda to evaluate its new crop varieties, which paid significant dividends. The varieties selected by women had production increases of up to 38 per cent over breeder-selected varieties and outperformed local mixtures 64-89 per cent of the time (Sperling and Scheidegger, 1997). A study carried out in Malawi, over a five yearperiod and more than 3,000 farmers tested legumes and gained knowledge of their contributions to child nutrition and soil productivity. The results showed that legume systems expanded on an average area of 862 square meters in 2005 (772 square meters for women and 956 square meters for men, indicating a gender dimension to legume adoption). Farmers chose edible legume intercrops such as cowpea and groundnuts over the *Mucuna* spp. green manure system. Women in particular preferred the edible species to meet their combined goals of food security and soil improvement (Kerr *et al*., 2007).

<u>Gender responsive monitoring and evaluation (M&E)</u>

Interventions which enhance women‘s capacity to make their own decisions and build their skills have shown that increasing women‘s agricultural inputs and education to the same level as men‘s can increase national agricultural output by 2.5 - 4 %, reducing the number of undernourished people in the world by 12-17% . This would effectively reduce the hungry of the World by 100 - 150 million people (FAO, 2011)

Gender issues should be taken into account to mitigate against any risks that might occur in men‘s acquisition of control of income at the expense of women once the N2Africa‘s target legumes are commercialized. Situations like this have occurred for example in Kenya, where the development of export horticulture has led to an erosion of women‘s control over their produce, as men realised the benefits of vegetable production (Dolan, 2005). In Uganda, strong demand for leafy vegetables (traditionally a women‘s crop) in Kampala markets caused men to take over their cultivation (World Bank,*et al*., 2008). The design of agricultural projects can have positive or negative impacts on seasonal workloads and the distribution of income, especially for women. Adverse seasonality is most severe for smallholder families that depend on single rainy season agriculture for their livelihood (Devereux and Longhusrt, 2010). The use of seasonal calendars show activities undertaken in different periods of the year and men, women and children‘s involvement while indicating times of labour surplus and shortages. Seasonality in household income from agriculture and other sources will inform the project on periods of the year when households receive more or experience shortages in income and food from legumes compared to other agricultural and non-agricultural activities.

Intended beneficiaries are sometimes sceptical and cautious about interventions, but their voices are rarely heard by researchers or their sponsors (Scoones and Thompson, 2009) a challenge that could be addressed through M&E. Knowledge and adaption of agricultural technologies is gendered, and the success of improvement of legume production by N2Africa will depend on the degree to which it incorporates knowledge of women and men on what, how, where and why it works, and makes adjustments accordingly. This approach is in line with empowerment of women and men in making their decisions on what is best for them rather than merely adopting the recommendations of others. Structures are constituted by rules, norms, beliefs and practices that define social relationships between different groups in a society (Kabeer, 2010). Farmers are knowledgeable about their farming systems,and men and women have different perceptions and knowledge about different aspects of theirbiophysical and socio—economic situations. Researchers need to learn from this indigenous knowledge, and farmers may need to be encouraged to tap into their own knowledge (World Bank *et al*., 2008). Because N2Africa‘s identification of best fits, technology delivery and dissemination strategies involve working with farmer groups, changes in gender relations in decision making should be assessed to ensure that as legumes become commercialized, women‘s power to exercise choice over their interest is enhanced. When designing and implementing any community based project it is important that tools, methods and approaches take into consideration women and men including other stakeholders‘ views and active contribution to decisions making processes so that agricultural research and development is more effective in reducing hunger and alleviating poverty.

Since gender issues are so linked to cultural values, social attitudes and perceptions, it is important to use qualitative as well as quantitative methods. When facilitated in a participatory mode in groups and with methods that are visual and tangible, farmers - whether literate or not - can count, measure, estimate, rank, score, value, and compare and generate numbers (Chambers, 2010). Quantitative participatory methods, such as ranking and scoring matrices can quantify the qualitative, and the numbers can be analysed like other statistics. Participatory approaches can empower farmers to analyse and present to policy makers the complexity and diversity of their farming systems and inform scientists and implementers through timely information and insights. To ensure gender responsiveness in data generation, experienced gender-sensitive facilitators and approaches such as men-only and women-only focus group discussions should be applied. People-centred M&E need to be embedded in project cycles to ensure that projects are addressing their pre-set objectives and interventions are being informed by local people‘s preferences and priorities at every stage of the project while promoting gender equality. This process serves several purposes which include holding implementers accountable to donors and beneficiaries; providing feedback loops from project implementers, men and women beneficiaries and other stakeholders; and learning and refining of strategies where necessary. Systematically asking farmers about their priorities and what is and is not working is vital to achieving sustainable and equitable improvements in agricultural productivity while achieving accountability to donors and intended beneficiaries (Chambers, 2010).

Programmes that aim to increase overall income and nutrition should take into account measuring progress and impact in regard to gender dimensions where for example a well-designed programme that aims to increase household well-being will pay attention to who is generating the income, how the income is used and who makes decision over its use. Evidence shows that income is often unevenly distributed amongst family members, adversely affecting nutrition objectives. For example in SouthWestern Kenya, for a given household income level, female-controlled income share was shown to have a positive and significant effect on household calorie consumption, while male-controlled income had a negative effect (Quisumbing and Maluccio, 2003).M&E should be done well so that it make projects work better, assess impact, steer strategy, increase stakeholder ownership, build the capacity of stakeholders to hold programme financiers and implementers to account and share learning more widely (Chambers, 2010).

2.2 THEORETICAL FRAME WORK OF PRODUCTION

Production theory is the study of production or the economic process of producing outputs from the inputs. Production in economics, in common parlance the term production is used for an activity of making something material. The growing of cowpea, groundnut or any other agricultural crop by farmers is often referred to as production. But in economics the word production is used in a wider sense. In economics, by production, we mean the process by which man utilises or convert resources of nature working upon them so as to make them satisfy human wants. In other words, production is an economic activity which is directed towards the satisfaction of the wants of people by converting physical inputs to physical output. Production is the organised activity transforming resources into finished products in the form of goods and services, and the objective of production is to satisfy the demand of such transformed resources.

Production function relates physical output of a production process to physical inputs or factors of production. It is a mathematical function that relates the maximum amount of output that can be obtained from a given number of inputs, generally capital labour.

2.2.1 The Law of Variable Proportion

If one input is variable and all other inputs are fixed the firms production function exhibits the law of variable proportions. If the number of units of variable factors is increased, keeping other factors constant, how output changes is the concern of the law. Suppose land equipment are fixed factors and labour are variable factor, when the number of labour is increased successfully to have large output, the proportion between fixed and variable factors is altered and the law of variable proportion set in. the law states as the quantity of a variable input is increased by equal dose keeping the quantity of other inputs constant, total product will increase, but after a point at a diminishing rate. It is also known as diminishing returns.

Assumption

Only one factor is variable while others are held constant, all units of the variable factors are homogenous, it is possible to vary the proportion in which different inputs are combined, it assumes a short- run situation for in the long run all factors are variable, the product is measured by physical units i.e. tonnes.

2.3 REVIEW OF EMPIRICAL MODELS

2.3.1 Gross Margin Analysis

Gross Margin Analysis involves evaluating the efficiency of an individual enterprise so that comparison can be made between enterprises on the farm. It is a very useful tool in situations where fixed capital is a negligible portion of the farming enterprise as is the case in subsistence farming (Olukosi and Erhabor, 1988) as cited in Henry (2014) The gross margin per hectare or per head for crops and livestock can be compared with 'standards (published averages of what might be typically possible in average conditions).obtained from other farms. Gross margins, however, should only be compared with figures from farms with similar characteristics and production systems. Gross Margin analysis involves determining all variable costs and revenue associated with an enterprise. The difference between revenue and total variable costs is the gross margin for the enterprise and in essence, this is the return to capital, management and risk. Henry (2014) summarized the usefulness of gross margin as being easy to compute, interpret and highly applicable to subsistence system of farming involving small fixed capital component. Also it is useful where the same capital items are used in many different enterprises in a given farm, used to determine net farm income, serves as a guide to the selection of enterprises by comparing their margins, helps the farm manager to critically examine the variable cost components in production and helps in building partial budgets for the farm. The gross margin is derived when total variable Cost (TVC) is deducted from Total Revenue (TR)

According to Henry (2014) on a study carried out on analysis of soya bean production under Sasakawa-Global 2000 Kaduna State, Nigeria. It showed that the Total Variable Cost (TVC) incurred by the respondents averaged N115,448.80/ha, with an average Gross Income (GI) of N356,400, which resulted in a Gross Margin (GM) of N240,951.90/ha.

Muhammad (2014), in a study on economic analysis of watermelon production in some selected local government area of Kano state, Nigeria, indicates that watermelon farmers obtained a net income of N25, 422.98k per hectare which implies that watermelon production in the study area is profitable. The average returns per naira invested (RNI) was calculated to be 0.46. This implied that*ceteris peribus,*for every naira invested, there was a profit of 46k.

2.3.2 Stochastic Frontier Model

For a long time, econometricians have estimated average production functions. It is only after the pioneering work of Farrell (1957) that serious considerations were given to the possibility of estimating the so-called frontier production functions in an effort to bridge the gap between theory and empirical work (Aigner *et al*, 1977).

The modeling, estimation and application of stochastic frontier production functions to economic analysis assumed prominence in econometrics and applied economic analysis during the last two decades. Early applications of stochastic frontier production functions to economic analysis include those of Aigner *et al*., (1977) in which they applied the stochastic frontier production functions in the analysis of the United States agricultural data.

Mohammed (2015) in his research “Comparative Analysis of Farmers’ Efficiency of IAR Developed Groundnut Varieties for Poverty Alleviation in North Western Nigeria” used the stochastic frontier model. His study revealed that the mean economic efficiency of the adopters in the study area was 0.59 which indicated that groundnut farms were economically efficient.

Consequently, in a study carried out by Henry (2014) on economic analysis of soya bean production under Sasakawa Global 2000 project in Kaduna State, the stochastic frontier estimates results showed the gamma statistics of 0.98, implying that 98% of the changes in the output are attributable to respondents' differences in their technical efficiencies.

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY AREA

The study was conducted in Kano State. The state was created in May 1967 and has a total of 44 local government areas with a population of approximately 9.4 million based on the 2006 census, and current estimates at 12 million with a population growth rate of approximately 3.5% per annum (KSIH, 2013). Kano State is situated in Sudan savannah; it lies between latitude 13^0N to the North and 11^0N to the South and longitude 8^0E in the West and 10^0E in the East. The total land area of the state is 20,760 square kilometres (NPC, 2006). The state is bordered to the West and Northwest by Katsina State, to the East and Northeast by Jigawa State, to the South by Bauchi and to the Southwest by Kaduna State (KNSG, 2006). The state is divided into three agricultural zones by the Kano State Agricultural Rural Development Authority (KNARDA, 2011). They are zone I, zone II, and zone III.

There are over 1,754,200 hectares of cultivable land in Kano State (KSIH, 2013). The state has been a commercial centre and agricultural state predominantly known for the production of groundnut and other crops like maize, millet, sorghum, cowpea, rice, soybean, tomato and alsorearing animals such as goat, sheep, cattle and poultry. Kano State has two seasonal periods categorized on the basis of moisture as dry (October – April) and wet (May – September) seasons. The soil in most of Kano State is light or moderately leached, yellowish brown and sandy just like most other Savannah parts of Northern Nigeria. The temperature of Kano usually ranges between a maximum of 33^0C and a minimum of 15.85^0C. Annual rainfall ranges between 787mm and 960mm (KNARDA, 2011). This provides a favourable atmosphere to grow legumes.

Kano State is administratively classified into three (3) agricultural zones by the Kano State Agriculture and Rural Development Authority, (KNARDA, 2011). The zones according to the bulletin are as follows:-

1. **Zone I:** With headquarters at Rano, it comprises fifteen (15) Local Government Areas namely; Rano, Bebeji, Tudun wada, Rogo, Gwarzo, Madobi, Kura, Kumbotso, Kiru, Kabo, Karaye, Kibiya, Garin Malam, Doguwa and Bunkure LGAs.

2. **Zone II:** With headquarters at Danbatta, it comprises twelve (12) LGAs which are: Tofa, Danbatta, Ungoggo, Tsanyawa, Shanono, Rimin-Gado, Minjibir, Makoda, Kunchi, Dawakin-Tofa, Bichi and Bagwai LGAs.

3. **Zone III:** With headquarters at Gaya, it comprises seventeen (17) Local Government areas namely: Albasu, Ajingi, Dawakin-kudu, Dala, Fagge, Gwale, Garko, Gabasawa, Gaya, Gezawa, Municipal, Nassarawa, Sumaila, Takai, Tarauni, Warawa and Wudil LGAs.

3.2 SAMPLING PRODEDURE

A multi-stage sampling technique was adopted for this study. The first stage involvedthe purposive selection of two (2) local governments within the Zone II area which were Danbatta and Makoda LGAs respectively. These LGAs were considered due to the high concentration of cowpea and groundnut farmersin the area and also availability of male and female farmers that are engaged in legumes farming, so as to achieve the gender based research.

Danbatta and MakodaLGAs were classified into several blocks by Kano State Agriculture and Rural Development Authority (KNARDA). According to KNARDA's classification, Danbatta LGA is divided into four (4) blocks, namely; Gwanda block, Sansan block, Danbatta block and Fagwalawa block. In a bid to carry out the research work we realised that women are prohibited to farm in the communities under Fagwalawa block, therefore the three (3) other blocks were male and femaleparticipate in farming activities were purposively chosen for the research work.Also, Makoda L.G.A is classified into three (3) blocks by KNARDA, namely; Makoda, Koguna and Mai Tsaidau Block, where both gender participate in farming activities.

Stratified random sampling was used for the next stage which involved the selection of two farmer groups,a male and a female where available and/or male and female group where there was no specific female registered group of farmers.From the sampling frame, twenty-five per cent (25%) of the farmers were selected using simple random sampling techniques,which gave a totalsample size of 120 respondents for this study.

Table 1: Summary of the sampling frame of legume producers in Kano State

Zone	**LGAs**	**Blocks selected**	**Farmers' Group**	**Sample frame**	**Sample size (25%)**
		Gwanda	2	80	20
	Danbatta	Danbatta	2	88	22
		Sansan	2	78	20
Zone II					
		Koguna	2	75	19
	Makoda	Mai Tsaidau	2	80	20
		Makoda	2	76	19
		Total	6	477	120

Source: Field survey, 2017.

3.3 METHOD OF DATA COLLECTION

Primary data were used for the study. The data was obtained using semi-structured questionnaires which captured information on the following aspects; socio-economic characteristics of legume producers, land size, type of crop production, sources of income, input and labour use, access to finance and constraint militating against legumes production in the study area.

3.4 ANALYTICAL FRAMEWORK

To achieve the earlier stated objectives, the following tools of analysis were employed.

a. Descriptive statistics
b. Harvard Gender Analytical Framework
c. Gross Margin Analysis
d. Stochastic Frontier Production Function

3.4.1 Descriptive Statistics

Descriptive statistics was used to achieve objective (1) and (4). These include the use of frequency distribution, mean and percentages.

3.4.2 Harvard Analytical Framework

The Harvard Gender Analytical Framework was used to achieve objective (2).It is also known as the Gender Roles Framework or the Gender Analysis Framework. It is primarily use for academic research or desk based studies. The framework consists of a matrix for collecting data. It has four interrelated components:

- the ‘activity profile’, which answers the question, "who does what?", including gender, age, time spent and location of the activity
- the ‘access and control profile’, which identifies the resources used to carry out the work identified in the activity profile, and access to and control over their use, by gender

- the analysis of 'influencing factors', which charts factors that influence gender differences in the above two profiles
- the'project cycle analysis', which examines a project or intervention in light of gender-disaggregated information. This consists of a series of questions which serves as a checklist.

Table 2: Activity Profile Tool

ACTIVITY	Men / boys	Women / girls
Legume Production		
Clearing of field		
Ploughing of field		
Ridging of farm land		
Planting		
Application of fertilizer		
Weeding		
Harvesting		
Income Generating		
Sale of output		

Table 3: Access and Control Profile

	Access		**Control**	
	Men/boys	Women/girls	Men/boys	Women/girls
Resources				
Land				
Equipment				
Labour				
Cash/Credit				
Benefits				
Education/training				
Additional Income				
Asset ownership				
Basic needs (food, clothing, shelter, etc.)				

3.4.3 Gross Margin Analysis

The gross margin for a farm enterprise is one measure of profitability that is a useful tool for cash flow planning and determining the relative profitability of farm enterprises. Gross margin profit is the difference between the annual gross income for that enterprise and the variable costs directly associated with the enterprise (David, Jim and Daniel, 2013). Gross Margin can also be defined as the gross income from an enterprise less the total variable costs incurred in achieving it. Variable costs are those costs directly attributable to an enterprise and which vary in proportion to the size of an enterprise. For example: If the area of wheat or sorghum sown doubles, then the variable costs associated with growing it, such as seed, chemicals and fertilizers, will roughly double. If the number of breeding cows' doubles, then the variable costs associated with carrying the additional stock, such as drench and vaccination costs, will also roughly double. In constructing gross margins, fixed (overhead) costs are ignored, as it is considered that they will be incurred regardless of the level of the enterprise undertaken. It doesn't change with the level of output.

Hence, Gross Margin was used to achieve objective (3). A gross margin for an enterprise is its financial output minus its variable cost.

Profitability Analysis for Cowpea

GM = TR – TVC

Where:

GM = Gross margin (₦)

TR = Total revenue (₦) which is;

Total output of cowpea (kg/ha) × Unit Price of cowpea (₦/kg)

Total variable cost (TVC) = $C_1 + C_2 + C_3 + C_4 + C_5$

Where:

C_1 = Cost of seeds (₦/kg) = Quantity of seed × unit price of seed

C_2 = Cost of fertilizer (₦/kg) = Quantity of fertilizer × unit price of fertilizer

C_3 = Cost of manure (₦/kg) = Quantity of manure × unit price of manure

C_4 = Cost of pesticides (₦/litres) = Quantity of pesticides × unit price of pesticides

C_5 = Cost of labour (₦/man-days) = Quantity of labour × unit price of labour

C_6 = Cost of bags and bagging (₦/bag) = Quantity of bags × unit price of bag

Profitability Analysis for Groundnut

GM = TR – TVC

Where:

GM = Gross margin (₦)

TR = Total revenue (₦) which is;

Total output of groundnut (kg/ha) × Unit Price of groundnut (₦/kg)

Total variable cost (TVC) = $C_1 + C_2 + C_3 + C_4 + C_5$

Where:

C_1 = Cost of seeds (₦/kg) = Quantity of seed × unit price of seed

C_2 = Cost of fertilizer (₦/kg) = Quantity of fertilizer × unit price of fertilizer

C_3 = Cost of manure (₦/kg) = Quantity of manure × unit price of manure

C_4 = Cost of pesticides (₦/litres) = Quantity of pesticides × unit price of pesticides

C_5 = Cost of labour (₦/man-days) = Quantity of labour × unit price of labour

C_6 = Cost of bags and bagging (₦/bag) = Quantity of bags × unit price of bag

3.4.4 Stochastic Frontier Production Function

Estimating the stochastic production frontier function and predicting individual farm's technical efficiency, determine production efficiency. In a stochastic frontier production model, output is assumed to be bounded from above by a stochastic production. The essential idea behind the stochastic frontier model is that the error term is composed of two parts, a systematic and a one sided component. Stochastic frontier is an econometric analytical technique, which allows for variation of output of individual producers from the frontier of maximum achievable level to be accounted for by the firm (Battese, *et al*., 1997).

The stochastic frontier production function was used to achieve objective 4.

The model in its implicit form is as follows:

$$Y = f(X_i; \beta) + e_i \quad \ldots\ldots (1)$$

$$e_i = V_i - U_i \quad \ldots\ldots (2)$$

Where:

Y = quantity of output (kg)

X_i = vector of the inputs used by the ith farm

β = a vector of the parameter to be estimated

e_i = composed error term

V_i = random error beyond the control of producers

U_i = technical inefficiency effects

$f(X_i; \beta)$ = appropriate functional form of the vector.

Therefore the model is explicitly shown as follows;

$$lnY_i = \beta_0 + \sum \beta_j lnX_{ji} + V_i - U_i \quad \ldots\ldots (3)$$

The stochastic frontier model for estimating the technical efficiency of legume farmers is specified by the Cobb- Douglas frontier production function, which is defined by:

$$lnYi = \beta_0 + \beta_1 Inx_1 + \beta_2 Inx_2 + \beta_3 Inx_3 + \beta_4 Inx_4 + \beta_5 Inx_5 + v_i - u_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where:

ln = natural logarithm to base e

Y_i = Output of legume (kg/ha)

β_0 = constant or intercept

β_1 - β_5 = parameters to be estimated

x_1= farm size (ha)

x_2= labour used (₦ /man days)

x_3= quantity of seeds (kg/ha)

x_4= quantity of fertilizers used (kg/ha)

x_5= quantity of agrochemicals (litres/ha)

v_i = random errors

u_i = Technical inefficiency effects predicted by the model

Technical Inefficiency Model

To further enhance the results of the study, it will go a long way in identifying the socioeconomic determinants of the technical inefficiency. For this study, the model used is specified explicitly as follows;

$$Ui = Y_0 + Y_1 W_1 + Y_2 W_2 + Y_3 W_3 + Y_4 W_4 + Y_5 W_5 + e_i$$

Where;

U_i = Technical inefficiency of the ith farmer

W_1 = Age of the legume farmer (years)

W_2 = Years of experience in legume production (years)

W_3 = Education Level (No formal Education, Primary Edu., Secondary Edu. or Tertiary Edu.)

W_4 = Extension agent (No Contact, Weekly, Twice a week, Monthly, Quarterly or Annually)

W_5 = Off-farm income (₦)

e_i = Error term

$\gamma_0 - \gamma_5$= Parameters to be estimated

Specification of the Stochastic Frontier Cost Model (Allocative Efficiency)

This would be used to measure the cost efficiency (allocative efficiency) of legume producers in the study sites, this will be employed to achieve part of objective iv and it is explicitly given as;

$lnCi = \alpha + \alpha_1 lnP_1 + \alpha_2 lnP_2 + \alpha_3 lnP_3 + \alpha_4 lnP_4 + \alpha_5 lnP_5 + (V_i + U_i)$

Where;

ln = Natural logarithm

Ci = Total cost for the ith legume farmer (₦/ha)

P_1 = Cost of rentings legume field (₦/ha)

P_2 = Cost of legume seeds (₦/ha) = Quantity of seed × unit price of seed

P_3 = Cost of fertilizer used (₦/ha) = Quantity of fertilizer × unit price of fertilizer

P_4 = Cost of labour used (₦/ha) = Quantity of labour × unit price of labour

P_5 = Cost of pesticides used (₦/ha) = Quantity of pesticides × unit price

$\alpha_1 - \alpha_5$ = Parametres to be estimated

Vi = Random error independent of Ui

Ui = Non-negative error

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 SOCIO ECONOMIC CHARACTERISTICS OF LEGUME PRODUCERS

In this section, the result of socio-economic characteristics of legumes farmers in Kano State is presented. The variables are discussed under the quantitative and qualitative socio-economic factors. The socio-economic variables include: age, gender, marital status, farm income, household size, farm size, educational status, major occupation, farming experience, membership of cooperative society, and access to credit facilities. The results are presented in the Tables 4 and 5.

Table 4: Farmers Age, Household Size, Farm size and Farming Experience

Variables	Male Frequency	Percentage	Female Frequency	Percentage
Age				
24 – 33	16	19.05	3	8.33
34 – 43	27	32.14	7	19.44
44 – 53	15	17.86	21	58.33
54 – 63	15	17.86	5	13.89
64 – 73	11	13.00	0	0
Total	84	100.00	36	100.00
Minimum	24		30	
Maximum	73		60	
Mean	46		43	
S.D	11.953		11.561	
Household size				
1 – 6	33	39.29	13	36.11
7 – 13	23	27.38	18	50.00
14 – 20	18	21.43	4	11.11
21 – 27	7	8.33	1	2.78
28 – 34	3	3.57	0	0
Total	84		36	100.00
Minimum	1		2	
Maximum	30		25	
Mean	11		9	
S.D	7.041		7.022	
Farming exp.				
3 – 14	14	16.67	11	30.56
15 – 26	22	26.19	10	27.78
27 – 38	23	27.38	13	36.11
39 – 50	21	25.00	2	5.55
51 – 62	4	4.76	0	0
Total	84	100.00	36	100.00
Minimum	3		5	
Maximum	60		40	
Mean	29		22	
S.D	13.801		12.46	
Farm size (ha)				
0.1-0.5	42	50.00	23	63.88
0.6-1.0	30	35.71	10	27.77
1.1-1.5	5	5.95	3	8.33
1.6-2.0	6	7.14	-	-
2.6-3.0	1	1.19	-	-
Total	84	100.00	36	100.00
Minimum	0.20		0.20	
Maximum	3.0		1.50	
Mean	0.84		0.59	
S.D	0.542		0.474	

Source: Field survey, 2017

4.1.1 Age Distribution of the Respondents

Age is measured by the number of years an individual farmer spent on earth at the time of the survey. Age is a very important factor in considering the adoption of innovation and the overall production of farmers in the field. In Table 4 the results of the study reveal that the minimum age of male farmers was 23, the maximum was 75 years and the average was 46. While the results of female farmers show that minimum was 30 years, maximum was 60 years and mean age is 43. This is an indication that majority of the respondents both male and female in the study area were within their active youthful ages and that may give them opportunity for participating in legume production for a long period to come. This result is similar to Modu *et al*., (2009) who reported that majority of female cowpea farmers are within the age bracket of 41-50 years.

4.1.2 Household Size of the Respondents

According to Ogungbile (2002), household size is the total number of individuals who live within and feed in the same house. It plays two vital roles, depending on composition of the family numbers. The more the number of adult in a family the more the family labour contribution in agricultural production but on the contrary, the larger number of dependents in a family affects it productivity, and therefore increased the need to provide more food for the members of the family. The result of household size of male farmers shows that the average number of household size was 11 and the minimum was 1 while the maximum were 30. However, in the result of Female respondent it shows that the average number of household size was 9, with the minimum number of 2 and maximum of 25 household sizes. This implies that larger family size lead to high personal consumption with consequent effects in marketable surplus especially under subsistence farming. Muhammad *et al.*, (2013) reported that farmers are saddled with the responsibility of caring for household in terms of food and other requirements and therefore any increase in their production would potentially increase their food security and basic income.

4.1.3 Farming Experience of the Respondents

Farming experience refers to the number of years an individual respondent has engaged in farming. Farming experience influences producers understanding of the advance production techniques explain during training and also affects their decision and performance. Experienced farmers would be more efficient, will have better knowledge of climatic conditions, special production techniques and thus is expected to run more efficient and profitable enterprise (Adeoye *et al*., 2009). Descriptive statistics in Table 5 shows that the male farmers in the study area had a mean farming experience of 29 years; with minimum farming experience of 3 years and maximum of 50 years. While the female farmers mean farming experience was 22 years, with a minimum of 5 years and maximum of 40 years farming experience. This shows that the respondents had an experience in legumes production which influences their participation into legumes production and understanding of climatic and socio-economic policies and other factors that affect farming in the area.

4.1.4 Farm Size of the respondents

Farm size in agricultural production refers to the portion of land cultivated by a farmer. Result in Table 5 shows that most of the male farmers were having average farm sizes of 0.84ha, with the minimum of 0.20 ha and maximum of 3.0ha while with the female farmers, the mean farm size was 0.59ha, with a minimum of 0.20ha and maximum of 1.50ha size. About 80% of male and female farmers majorly own and operate less than one hectare. This agrees with Olayide (1982) as sited in Halliru (2015), who reported that majority of Nigerian farmers were usually small-scale farmers. This implies a low level of productivity, given that there is a positive relationship between farm size and productivity. The larger the farm size of the household, the higher the expected level of production.

Table 5: Farmers Marital Status, Occupation, Education, Cooperative Membership and Access to credit

Variables	Male		Female	
Marital status	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Single	8	9.50	-	-
Married	76	90.50	25	69.40
Divorced	-	-	6	16.70
Widow	-	-	5	13.90
Total	84	100.00	36	100.00
Major occupation				
Farming	35	41.66	17	47.22
Civil servant	25	29.76	2	5.55
Livestock rearing	10	11.90	12	33.33
Trading	14	16.66	5	13.88
Total	84	100.00	36	100.00
Educational level				
Non-formal	46	54.80	19	52.80
Primary	20	23.80	12	33.30
Secondary	10	11.90	4	11.10
Tertiary	8	9.5	1	2.80
Total	84	100.00	36	100.00
Cooperative membership				
Member	83	98.80	36	100.00
Non-member	1	1.20	-	-
Total	84	100.00	36	100.00
Access to credit				
Yes access	18	21.40	5	13.90
No access	66	78.60	31	86.10
Total	84	100.00	36	100.00

Source: Field survey, 2017.

4.1.5 Marital Status

Marital status refers to one's situation with regard to whether the respondent is single, married, separated, divorced or widowed. The distribution of respondents according to marital status is presented in Table 7. The result of the study revealed the majority of male farmers in the study area90.5% were married and only 9.5% were single, however, in the category of female farmers, the study revealed that majority 69.40% were married, while 16.70% were divorced and only 13.90% were widowed. Early marriage was a very common practice in this part of the country especially in the study area, and this must have been responsible for the majority of the respondents being married. This is in line with Victor, (2004) who assertedthat marital status influences the size of the farmers' family and availability of labour for farm production because the marriage institution poses some restriction as regard to which member of the family should practice farming or the role/activity he or she performs in the household.

4.1.6 Major Occupations

Occupation refers to what one does to earn a living. Occupations of the population are largely influenced by the setting of their environment as well as their local economy as is often the case in most rural African countries were livelihood strategies usually involve mixture of activities including on-farm and off-farm employment (Haruna, 2002). Table 7 shows the distribution of respondents according to their major occupation in the study area. The result shows that most of the respondents both male and female were engaged in farming as their major occupation represented as 41.66% for male farmers and 47.22% for female farmers, followed by civil servant which were 29.76% for male and 5.55% for female, then 11.90% for male and 33.33% for female were engaged in livestock rearing, and only 16.66% for male and as well as 13.88% for females were traders. This implies that the respondents have diversified means of income generation to support their households' livelihood strategies and the women are predominantly (80%) farmers who engage in both crop and livestock production.

4.1.7 Educational Background of the Respondents

This explains the ability of respondents to read and write whether through formal or informal means. The result in Table 7 also revealed that 54.80% of the male farmers had acquired non formal education, 23.80% had acquired up to primary level, 11.90% had acquired up to secondary school and only 9.50% of the male farmers acquired up to tertiary education. Similarly, in the case of female farmers, 52.80% acquired non formal education, and then 33.30% acquired primary school, while 11.10% and 2.80%acquiredsecondary and tertiary education respectively. This shows that majority of the farmers in the study area acquired non-formal education only. This also agrees with the UNESCO (2013) reports that one-third of sub-Saharan Africans failed to complete primary school. The implication of this to the study is that it reduces the ability of farmers to easily embrace modern technology that could help them use resources more efficiently.

4.1.8 Cooperative membership

A cooperative is an autonomous association of persons united voluntarily to meet their common goal. These farmer organizations are normally formed to provide certain services that assist members of the group for improved productivity. Table 7 shows that majority 98.80% of male farmers were cooperative members with only 1.20% who were not member of any cooperative society. While for the female farmers, the study revealed that all 100.00% of them were members of cooperative society. This implies that majority of the farmers in the study area are united and share ideas among themselves. Hence, it will be easy for extension agents to reach out to the farmers and introduce new farming techniques.

4.1.9 Access to Credit

Table 5 of the study shows that there is limited access to credit in the study area; result of this research shows that it is only 21.40% of male respondents and 13.90% of the female respondents have access to credit, while 78.60% of the male respondents and 86.90% of the female respondents mentioned that they do not have access to credit. This shows that access to new technology may be difficult to farmers, thus there is need to enhance the access to credit in the study area in order to boost the legume production and improve the living standard in the area. The implication of this to the study is that limited access to credits restricts farmers from expansion and this is the reason most of them in the study area operates on a rather small scale.

4.2 GENDER ANALYSIS OF LEGUME PRODUCERS

This section presents how farm activities were carried out in relation to gender differences and also shows who has more accessand control of farm resources and outside benefits. The farm activities include land clearing, ploughing of field, ridging, planting, application of fertilizer, weeding, harvesting and sale of output.

4.2.1 Gender Participation in Labour Activities on Legume Production

Table 6 shows the distribution of various activities carried out on the farm. The result revealed that men, women and children were all involved in labour activities in the farm. Further, men contribute higher man-days of labour participation as compared to women and children. These were given by 56.9%, 93%, 97%, 47.2%, 44.4%, 63.2%, 40.5% and 77.6% for land clearing, ploughing of field, ridging, planting, application of fertilizer, weeding, harvesting and sale of output respectively. The results also show the major areas men dominate in farm production of legumes are on land clearing, ridging, ploughing and weeding, while women and children contribute substantially in planting, fertilizer application and harvesting. This is perhaps due to the extent of heavy duty labour demands in field works. It implies that men do most of the work on the field regardless of whether they were family or hired. However, this result contrastswith World Bank*et al*., (2008) findings that reported women make up a substantial majority of the agricultural workforce and produce most of the food that is consumed locally.

Table 6: Gender participation inlabor activities on legume production

Variable	Male	Female	Children
Land clearing			
Frequency	111	40	44
Percentages	56.9	20.5	22.6
Ploughing of field			
Frequency	120	2	7
Percentages	93.0	1.6	5.4
Ridging			
Frequency	117	3	
Percentages	97.5	2.5	
Planting			
Frequency	101	82	31
Percentages	47.2	38.3	14.5
Application of fertilizer			
Frequency	103	74	55
Percentages	44.4	31.9	23.7
Weeding			
Frequency	110	23	41
Percentages	63.2	13.2	23.6
Harvesting			
Frequency	106	92	64
Percentages	40.5	35.1	24.4
Sale of output			
Frequency	104	26	4
Percentages	77.6	19.4	3.0
Multiple response			

Source: Field survey, 2017.

Table 7: Nature of access and control of resources and benefits based on gender distribution

Resources	Male		Female	
	Frequency	%	Frequency	%
LAND				
Access	109	68.6	50	31.4
Control	90	70.9	37	29.1
FARM TOOLS				
Access	112	61.9	69	38.1
Control	94	70.1	40	29.9
LABOUR				
Access	114	55.3	92	44.7
Control	93	68.4	43	31.6
CREDIT				
Access	115	49.8	116	50.2
Control	98	50.3	97	49.7
Benefits				
TRAINING				
Access	115	51.3	109	48.7
Control	115	89.8	13	10.2
ADDITIONAL INCOME				
Access	106	52.2	97	47.8
Control	101	65.2	54	34.8
ASSET OWNERSHIP				
Access	113	63.5	65	36.5
Control	101	76.5	31	23.5
BASIC NEEDS (food, clothing and shelter)				
Access	113	49.8	114	50.2
Control	104	69.3	46	30.7
Multiple response				

Source: Field survey, 2017.

4.2.2 Access and Control of Resources

Table 7reveals that there is variation in terms of who has more access to and control of resources among men and women in the study area.

Access to and control of land

Land is one of the most important productive resources in agricultural production, therefore understanding who has more access and control among legume producers between men and women is important in determining the productivity and efficiency of legume production in the study area. The result showed that men have 68.6% of access to land compared to women 31.4% access. The study also revealed that 70.9% of these lands were controlled by men. This implies that not only do men have more access to land than women, but they have even more control over the lands cultivated by women. This result indicatesthat men have more access to and control of land resources compared to women in general. It also shows that the percentage of women in control of land 29.1% is less than proportion 31.4%that has access to it. This means that even though women have access to land, they have certain limitation over its control. This may be due to some level ofsocietal perception of women to participate in farming in some of the communities due to some reasons. This result agrees with Ojo *et al*., (2013) who reported that men (and institutions comprised largely of men) tend to control the decisions that affect women's access to these resources.

Access to and control of Farm tools

Farm tools such as hoes, cutlass etc., are also important material resources that are used in legume production. Result in Table 7 shows that 61.9% of male farmers have access to these tools while women 38.1% have access to them. On the control side once again the men has higher control with70.1% as compared to female with 29.9%. This is also in line with Ojo et al., (2013) in their study "Determinants of gender productivity among smallholder cowpea farmers in Baga", where it is reported that men control most decisions. The implication of this finding is that men have more access and exert more control of farm tools and equipment and this can affect their productivity performance.

Access to and Control of Labour

Labour is an important factor of production which is necessary for any production activities. Result of the study show that access to and control of labour among men and women in legumes production differs. Though both men and women in the study area haveaccess to family and hired labour,there is slight difference in their percentages as shown in Table 7, with 55.3% for men and 44.7% for women.However the men still had more control over labour with 68.4 %, and women 31.6%. The implication of this to the study is that, labour is generally available to both genders in the study area. For the heavy duty activities on the farm, the women hired men that assisted with it, hence the result in Table 6 that shows more men participation in farm activities.

Access to and Control of Cash/Credit

Result of access and control of cash among men and women in legumes production shows that there is approximatelyequal (49.8% and 50.2%) access and control of cash between men and women in the study area as shown in table 7. This implies that almost equally credit is available to both men and women. This could be because the farmers belong to individual farmers' groups, and been a registered member of such groups it is easier to get loan through the association.

Training/Education

The result shows that both men and women in the study area have access to training, given by the respective proportions of 51.3% and 48.7%.However, given by the result for control, with 89.8 % the men have more control over the decision of who should attend training or acquire education in the study area, as compared with women. This is logical especially in this part of the control where women do not usually attend public gatherings, except of course with the permission of their husbands in the study area.

Additional income

Additional income refers to extra earnings of respondents in addition to sales of farm produce from alternative sources. This could be from services rendered or other activities that brought receipt of funds. These activities include trading, plaiting, artisans, among others. Table 7 reveals 52.2% of male farmers have access to additional income, and 47.8% of the female have access to additional income. Given bythe results, men have higher control of these extra earnings with 65.2% and women with 34.8%. The implication of this result is that even though women brings in extra income from their side jobs, the men have more power over the decision on how these earnings are to be used in the household.

Basic needs

The result revealed that both men and women have access tobasic needssuch as food, clothing and shelter, with 49.8% and 50.2% respectively. However 69.3% of these basic needs are controlled by men and women have 30.7% control over these basic needs.The implication of this result to this study is that legume production has been profitable enough in the study area that most of the respondents have access to basic needs, which is essential for sustenance.

4.3 PROFITABILITY OF LEGUMES PRODUCTION

Legumes production like other agricultural production entails incurring of cost and generation of revenue. The return from legumes production and cost of input and labour were obtained for cowpea and groundnut in the study area. The profitability analysis using gross margin approach was used in comparing the profitability of legumes production of men and women in the study area.

Table 8a: Profitability of Cowpea for Male Producers Per ha

Variables	Quantity	Unit price	Total price	%
Seed	33kg	330	10890	19.65
Pesticides	3litres	1200	3600	6.5
Fertilizer	1.5 bags/50kg	6000	9000	16.24
Manure	6 *mangala*/200kg	600	3600	6.5
Bags/bagging	4bags	170	680	1.23
Labour			27650	49.9
TVC			55420	
TR	4 bags/100kg	25,000	100,000	
GM			44580	
RNI			0.80	

Source: Field survey, 2017

Table 8b: Profitability of Cowpea for Female Producers Per ha

Variables	Quantity	Unit price	Total price	%
Seed	30kg	300	9000	20.52
Pesticides	2.5litres	1200	3000	6.84
Fertilizer	1.5 bag/50kg	6000	9000	20.52
Manure	4 *mangala*/200kg	600	2400	5.47
Bags/bagging	4bags	150	600	1.37
Labour		340	19850	45.27
TVC			43850	
TR	3.5bags/100kg	25000	87,500	
GM			43650	
RNI			0.99	

Source: Field survey, 2017

4.3.1 Profitability of Cowpea Production

Table 8a and 8b shows the average cost incurred for variable inputs such as labour, fertilizer, chemicals and seed and revenue generated from the sales of the output generated at the end of production.

The total variable cost of production, as indicated in Table 8a was ₦55,420per hectare for the male producers and ₦43,850per hectare for the female producers. The breakdown of the TVC as indicated in Table 8a and 8b shows that cost of labour constitutes the highest proportion of the cost with 49.9% of the TVC which equals ₦27,650for the male respondents and ₦19,850for women amounting to 45.27% of the TVC. This is followed by seeds which cost

₦10890and accounted for 19.65% of the TVC for the male respondents and ₦9000per hectare for the female producers and account 20.52% of the TVC of female producers. The average cost of fertilizer for the male is ₦9000/ha which constitutes 16.24% of the total variable cost (TVC) while the cost of fertilizer for the female was ₦9000/ha and it constitute 20.52%. This is followed by the cost of manure for the male producers and is found to be ₦3600 and represent 6.5% of the male TVC and it cost ₦2400 for the female producers and account for 5.47% of the TVC of female producers. The cost of pesticides for the male respondents were ₦3,600/ha and it represent 6.5% of the male TVC while the cost of pesticides for the female producers was found to be ₦3, 000/ha and constitute 6.84% of the TVC. In any production process, costs are incurred in producing output and income or returns are earned from the sales of such outputs produced. Therefore the revenue generated was ₦100,000 for the male farmers, from the sale of cowpea at an average yield of 4(100kg)bags/ha and average price of₦25,000. Hence the gross margin for the male cowpea producers was found to be ₦ 44,580 with the return per naira invested of 0.8 which implying that for every naira spent in cowpea production for the male respondents 80 kobo was returned as profit. While the revenue generated from the sale of cowpea for the female farmers was ₦87,500, with a gross margin of ₦43,650 and a return per naira invested of 0.99 which implies that for every naira spent in cowpea production 99 kobo was returned as profit. The implication of this result is that cowpea production is profitable in the study area. And more profits can be generated if costs are minimized, especially costs of labour. This result is similar to the findings of Isah *et.al* (2013) that revealed cowpea production among small holder farmers in Nigeria is profitable.

Table 9a: Profitability of Groundnut for Male Producers Per ha

Variables	Quantity	Unit price	Total price	%
Seed	30kg	280	8400	19.79
Pesticides	2 litres	1200	2400	5.65
Fertilizer	1.5 bags/50kg	6500	9750	22.96
Manure	6 *mangala*/200kg	600	3600	8.48
Bags/bagging	3bags	200	600	1.41
Labour			17700	41.70
TVC			42450	
TR	3bags/100kg	20000	60000	
GM			17550	
RNI			0.41	

Source: Field survey, 2017

Table 9a: Profitability of Groundnut for Female Producers Per ha

Variables	Quantity	Unit price	Total price	%
Seed	27kg	270	7290	25.95
pesticides	1.5litres	1200	1800	6.41
fertilizer	1 bag/50kg	6000	6000	21.36
Manure	4 *mangala*/200kg	600	2400	8.54
Bags/bagging	2bags	150	300	1.1
Labour			10300	36.67
TVC			28090	
TR	2.5bags/100kg	20000	50,000	
GM			21910	
RNI			0.78	

Source: Field survey 2017

4.3.2 Profitability of Groundnut Production

From the results in Table 9a, the study revealed that the TVC for male groundnut farmers is ₦42,450, with labour having the highest percentage of 41.7%, followed by inorganic fertilizer,seed, FYM,pesticides and bagging with 22.96%, 19.79%, 8.48%, 5.65% and 1.41% respectively. The result also shows that TR for the male groundnut farmers was ₦60,000; thus, arriving at a gross margin of ₦17,550 with an RNI of ₦0.41. Which imply that for every naira spent on groundnut production, 41kobo was returned as profit. On the other hand, the TVC for female groundnut farmers is ₦28,090, with labour also having the highest percentage of 67.29%, followed by seed, inorganic fertilizer, FYM, pesticides and bagging with 25.95%, 21.36%, 8.54%, 6.41% and 1.1% respectively. The result shows that TR for the female cowpea farmers was ₦50,000, arriving at a gross margin of ₦21,910 with an RNI of ₦0.78 implying that for every naira spent on groundnut production 78kobo was returned as profit. Therefore the result revealed that both parties are profitable in the study area, this is in line with Halliru (2015) that revealed that groundnut production is profitable in Kano State. However, female producers seem to be more profitableas compared to their male counterparts in the study area, this may be due to the cost management strategies and ability to bargain imbibed in the nature of women.

4.4 EFFICIENCY IN LEGUME PRODUCTION

Table 10: Technical Efficiency Estimates for Cowpea Production in Kano State

		Male			Female		
Variables	parameters	Coeff.	St.Error	t-value	Coeff.	St. error	t-value
Constant	β_0	6.619	0.233	28.457***	4.239	0.683	6.210***
Seed	β_1	-0.039	0.018	-2.154**	0.076	0.043	1.758*
Pesticides	β_2	-0.126	0.048	-2.623***	0.250	0.052	4.856***
Inorg. Fer	β_3	0.005	0.013	0.398	0.004	0.009	0.392
Fym	β_4	0.022	0.025	0.877	0.002	0.004	0.544
Labour	β_5	-0.016	0.032	-0.497	0.413	0.153	2.691***
Farm size	β_6	0.838	0.051	16.385***	0.336	0.079	4.255***
Inefficiency							
Delta 0	δ_0	3.269	1.683	1.943**	1.301	1.321	0.985
Age	δ_1	-0.085	0.043	-1.986**	-0.244	0.105	-2.336***
Marital	δ_2	-1.862	1.243	-1.498	2.445	0.803	3.046***
Hh	δ_3	0.323	0.058	5.607***	0.122	0.181	0.678
Edu	δ_4	-1.413	0.489	-2.891***	-0.781	1.188	-0.657
Exp	δ_5	0.002	0.036	0.053	-0.338	0.125	-2.713***
Ext Contact	δ_6	-1.602	0.862	-1.858*	2.085	1.424	1.465
Sigma square	σ^2	0.14584	0.283	5.160	0.4541	1.406	3.231
Gamma	Γ	0.994	0.004	276.987	1.000	0.000	49776236.000
log likelihood		858260.000				698130.000	
LR test		0.12850116				0.84653857	

Source: Field survey, 2017.*** = 1% significant, ** = 5% significant, * = 10% significant

From Table 10, the maximum likelihood estimates of the parameters are presented, the estimate of gamma (Γ) ratio indicates the relative magnitude of the variance σ2, associated with technical inefficiency effects and it ranges from 0 to 1. From the table, Γ is estimated to be 0.994 which can be interpreted that 99% of random variation in male cowpea farmers output is due to differences in their technical efficiencies. While for the female Γ is estimated to be 1.000 which implies 100% of random variation in the output of female cowpea farmers is due to differences in their technical efficiencies. The variance parameter of Sigma (σ^2) was 0.14584for male and 0.4541 for female which indicates good fitness and correctness of the distributional form assumed for the composite error term.

The value of estimated coefficient for farm size indicates that male cowpea producer is 0.838 and 0.336 for female. This positive effect of farm size on cowpea output implies that an increase in the size of farm holding by 1% will lead to an increase in output of cowpea by 0.838% for male and 0.336% for female. This implies that large farm size gives opportunity for expansion which can lead to higher output. The coefficient of farm size is significant at 1% level of probability, indicating the relevance of farm size on cowpea production in the study area.

The coefficient of seed for male is negativewith a value of 0.039, while female has a positive value of 0.076 and both are significant at 5% and 10%. The implication of this positive effect is that if quantity of seed used increases by 1%, output will rise by 0.076% of cowpea produced, while the negative coefficient for male implies that there will be decrease in output for male cowpea producers by 0.039%. The significance of seed implies that seed is an important factor that influences output of cowpea.

The estimated coefficient for labour for male was negative (-0.016) and not significant. The negative effect of labour on output is against *a priori* expectation. The sign indicates that as labour used in the production of cowpea increases, quantity of cowpea produced decreases. Labour used was not significant. This may be attributed to greater accessibility of farmers to labour input in the study area, hence over-utilization. While for the female cowpea producer, the coefficient was 0.413 and has positive relationship with output. It implies a unit increase in labour would lead to 0.413kg increase in output of cowpea produced by female in the study area.

The coefficient for volume of pesticides was negatively signed (-0.126) and significant for the production of cowpea by male producers. The implication of the result is that as the volume of pesticides used for the production of cowpea increases by a litre, the quantity of cowpea produced decreases. The sign was not as expected because use of pesticides reduces drudgery in farm operations such as weeding and clearing as well as increase quantity of output produced stemming from control of pests and diseases while coefficient for female cowpea producer is 0.052 and significant at 1%.It suggests overuse or misuse of pesticide.

The technical inefficiency in the model is explained as follows:

The estimated coefficient (-1.413),for education is significant but negative.The negatively estimated coefficient for education in cowpea production implies that respondents with greater years of schooling tend to be more efficient, because as schooling years increases, technical inefficiency tend to reduce. Technical inefficiency tends to decrease by -1.413 for male producers as schooling years rise by 1%. It could be plausible to say that respondents with considerable years of education respond readily to effective decision making in agriculture whilethe female cowpea farmers have a negative coefficient of -0.781. This finding is supported by findings obtained by Battese and Coelli (1995) in their study on model for technical inefficiency effect, in stochastic frontier production function for Panel Data. Educational level was statistically significant at 10% probability level.

Household size coefficient (0.323) had a positive sign in the model. An increase in the number of people in a household will lead to an increase in technical inefficiency of the cowpea male farmers, while for female cowpea producer has coefficient of (0.122). Therefore, respondents with larger household sizes tend to be more technically efficient than households with smaller number of people. This could be as a result of the fact that large household size translates into cheaper and availability oflabour which can reduce cost of production.

Coefficient of age (-0.085) has negative effect on male cowpea respondents' technical inefficiency implying that it has positive effect on technical efficiency. This suggests that the older the respondents, the lower the technical inefficiency while for female cowpea producers has coefficient of -0.244. As the respondents' age increases by 1% the technical inefficiency decreases. The positive effect of age on technical efficiency indicates that the agility and energetic capability of the respondents contribute to the production of cowpea, this is as expected. If young and virile farmers engage in the production of cowpea, output will increase thereby leading to higher income and standard of living. As farmers' age increases their experience in cowpea production is increased. This is in line with the findings of Amos (2007), who found that age increases technical efficiency

This variable had negative and significant coefficient of -0.338, implying that respondents with higher farming experience tend to be more technically efficient in the production of cowpea for female. A rise in farming experience by one year of the respondents enhances the skill of the farmers which in turn increase their efficiency but for the male cowpea producer has coefficient of 0.002 implying that farmers with low farming experience tend to be less efficient. Farming experience was significant at 1% level of probability indicating the relevance of accumulation of experience in a farming activity.

Table 11: Allocative Efficiency Estimates for Cowpea Production

Variable	para.	Male Coeff.	St. error	t-value	Female Coeff.	St. error	t-value
Constant	β_0	6.901	0.655	10.539	4.382	0.712	6.150
Cost of seed	β_1	0.010	0.012	0.775*	-0.009	0.034	-0.264*
Costof pesticides	β_2	0.096	0.044	2.194***	0.097	0.025	3.836
Cost of inorganic fertilizer	β_3	0.015	0.013	1.179*	-0.003	0.020	-0.167*
Cost of farm yard manure	β_4	-0.052	0.037	-1.410*	0.082	0.040	2.017**
Cost of labour	β_5	0.313	0.039	8.004	0.451	0.145	3.100
Sigma-squared	δ^2	0.9652829	0.122	7.89	0.128968	0.812	1.588
Gamma	Γ	1.000	0.003	291.348	1.000	0.032	31.597
Log likelihood		5796800			2757900		
LR test of the one-sided error =		0.157885			0.935073		

Source: Field survey, 2017. *** = 1% significant, ** = 5% significant, * = 10% significant

The estimated parameters for the male cowpea producers revealed that δ^2 is 0.96 and Γ is 1.00. The ratio of sigma square (0.96) indicates the good fitness and correctness of the distribution form the composite error term. The gamma estimation shows the variation in total cost of production resulting from the differences in allocative efficiencies of the farmers. For the female cowpea producers the sigma-squared (δ^2) is 0.12 and gamma (Γ) is 1.00.

The coefficient estimate for cost of seed, cost of inorganic fertilizer, cost of pesticides and cost of farm yard manure are significant. This means the cost of these inputs affect cowpea production.

The cost coefficient of cost of seed for male cowpea producers is positive and statistically significant, which implies that a rise in cost of seed will lead to increase in cost of total production, which indicate the relevance of seed in production, but for the female counterpart the coefficient of cost of seed is negative and statistically significant, which implies that the female cowpea farmers are over utilizing the resources, based on the findings there is need to reduce over utilization of resources to achieve optimal resource allocation.

Cost of pesticides for male cowpea producers is significant and positive; it implies an increase in cost of pesticides will lead to increase in cost of total production, if the cost of production is increased, invariably the revenue is affected.

Cost of organic fertilizer for male cowpea producers is positive and statistically significant, which implies that an increase in cost of inorganic fertilizer lead to increase in total cost of production, if the cost of fertilizer increase, total production is increased, which means fertilizer increase fertility of the soil which affect output positively. But the cost of inorganic fertilizer for female cowpea producers is negative and significant, which implies that a decrease in cost of fertilizer will lead to decrease in total cost of production, invariable it lead to increase in revenue of the female cowpea producer because less was spent on fertilizer input.

Cost of farm yard manure for male farmers is negative and significant at 10% level of probability. This implies that the farmers were not only inefficient in the allocation of productive resources but grossly over utilized farm yard manure. But for the female counterpart, the costof farm yard manure is significant and positive, which implies thatfarm yard manure directly affects production and as such an increase in its cost will lead to increase in total cost of production.

Table 12: Frequency Distribution of Technical, Allocative and Economic Efficiency of cowpea male producers

Efficiency level	Technical efficiency		Allocative efficiency		Economic efficiency	
	Freq.	**Percent. (%)**	**Freq.**	**Percent. (%)**	**Freq.**	**Percent. (%)**
0.00-0.25	1	1.2	62	73.8	72	85.7
0.26-0.50	7	8.3	19	22.6	10	11.9
0.51-0.75	17	20.2	2	2.4	2	2.4
0.76-1.00	59	70.3	1	1.2	0	
Total	84	100	84	100	84	100
Mean	0.78		0.22		0.17	
Minimum	0.01		0.10		0.00	
Maximum	0.97		0.91		0.74	

Source: Field survey, 2017.

Table 12 shows the efficiency levels between the ranges 0.00 – 1.00, along with mean, minimum and maximum values. It was observed from the study that 9.5% of the male cowpea farmers possess technical efficiency levels between the range of 0.00 – 0.50, while 91.5% of the farmers were able to achieve technical efficiency level above 0.50. The mean technical efficiency score is 0.78, while the best and worst farmer demonstrated a technical efficiency of 0.97 and 0.15 respectively. 96.4% of the respondents had allocative efficiency score within the ranges 0.00 – 0.50, with a mean score of 0.22. This results show that the farmers in this category are more technically efficient, though not at 100% level.

The combined effect of technical and allocative factors shows that, the average economic efficiency level was 0.17. The best farmer demonstrated an economic efficiency of 0.74 while the worst farmer had an economic efficiency of 0.00. Hence, on average, economic efficiency of the male cowpea farmers can be improved by 83% using the available resources and technology.

Table 13: Frequency Distribution of Technical, Allocative and Economic Efficiency of female cowpea producers

Effien. level	Technical efficiency		Allocative efficiency		Economic efficiency	
	Freq.	Percent. (%)	Freq.	Percent. (%)	Freq.	Percent. (%)
0.00-0.25	1	2.8	29	80.6	30	83.3
0.26-0.50	7	19.4	6	16.7	5	13.9
0.51-0.75	13	36.1	1	2.8	1	2.8
0.76-1.00	15	41.7	0		0	
Total	36	100	36	100	36	100
Mean	0.71		0.20		0.15	
Minimum	0.01		0.10		0.01	
Maximum	1.00		0.53		0.52	

Source: Field survey, 2017.

The distribution of female cowpea farmers' technical efficiency score is presented in the Table 13 which shows the minimum value of 0.01, maximum of 1.00 with average of 0.71. The obtained mean technical efficiency of the respondents indicates that an average female cowpea farmer in the study area have 29% chances for improving production efficiency using the existing technology of the best farmer. Therefore, there is need to increase production by utilizing available resources to operate at the frontier efficiency level.

The allocative efficiency mean, minimum and maximum values were 0.20, 0.10 and 0.56 respectively. This shows a wide distribution of allocative efficiency among the respondents, though, none of the respondents had attained the cost frontier level of 100%.

Economic efficiency which is the product of technical and allocative efficiencies shows that the average economic efficiency level was about 0.15, with a minimum of 0.01 and a maximum of 0.52.

Table 14: Technical Efficiency Estimates for Groundnut Production

Variables	parameters	Male Coeff.	Male St.Error	Male t-value	Female Coeff.	Female St.error	Female t-value
Constant	β_0	6.116	0.413	14.813	5.209	0.129	40.384
Seed	β_1	-0.021	0.057	-0.365	0.093	0.001	171.272***
Pesticides	β_2	0.024	0.551	0.044	-1.460	0.014	-101.853***
Inorg. Fer	β_3	0.000	0.041	-0.007	-0.014	0.003	-5.621***
FYM	β_4	-0.039	0.057	-0.687	0.029	0.003	10.495***
Labour	β_5	0.103	0.098	1.648*	0.168	0.035	4.833***
Farm size	β_6	0.029	0.114	6.254***	0.559	0.003	181.589***
Inefficiency							
Delta 0	δ_0	-3.411	3.575	-0.954	-1.629	1.329	-1.226
Age	δ_1	0.063	0.093	0.680	-0.356	0.112	-3.188***
Marital	δ_2	-3.443	1.359	-2.533	6.466	2.292	2.821***
Hh	δ_3	-0.360	0.156	-2.303	-0.732	0.359	-2.039
Edu	δ_4	-0.474	0.585	-0.811	-0.266	0.946	-0.281
Exp	δ_5	0.094	0.078	1.215	0.235	0.128	1.842*
Contact	δ_6	4.128	2.006	2.058***	-5.338	2.941	-1.815*
Sigma squa.	σ^2	0.2285024	1.342	1.702	0.73976235	1.710	4.326
Gamma	Γ	0.897	0.084	10.731	1.000	0.000	8299309
log likelihood		5051500				2812200.000	
LR test		0.50596				0.79164139	

Source: Field survey, 2017. *** = 1% significant, ** = 5% significant, * = 10% significant

FromTable 14, the technical efficiency estimates of the parameters are presented,the estimate of gamma (Γ) ratio indicates the relative magnitude of the variance σ2, associated with technical inefficiency effects and it ranges from 0 to 1. From the table, Γ is estimated to be

0.897 and this can be interpreted that 89% of random variation in farmers output is due to differences in their technical efficiencies. The variance parameter of Sigma (δ2) was 0.228 which is significant at 10% indicating good fitness and correctness of the distributional form assumed for the composite error term.

The estimated coefficient of farm size for male groundnut producer is 0.029 and 0.559 for female. This positive effect of farm size on groundnut output implies that increasing farm size by 1 hectare will lead to an increase in output of groundnut by 0.029kg for male and 0.559kg for female. This implies that large farm size lead to higher output. The coefficient of farm size is significant at 1% level of probability, indicating the relevance of farm size on groundnut production in the study area. This is in line with the findings of Mohammed (2015) that the fact that farm size determines to a large extent the output obtained.

The estimated coefficient (0.093) of seed used by female producers was positive and significant at 1% level. The implication is that increasing seed by 1kg will lead to an increase groundnut output by a magnitude of 0.093 kg. This is in line with the findings of Mohammed (2015) who observed that the estimated coefficient of seed was positive as expected and significant at ($p<0.01$) level and implies that the more seed is applied the better the output of groundnut.

The estimated coefficient of labour for the male producers was positively (0.103) related to output. The sign indicates that as labor used in the production of groundnut increases, output of groundnut increases. This implies that a unit increase in the use of labour would increase output by 0.103kg. While for the females, the coefficient was 0.168 and also positive. It implies a unit increase in labour would lead to 0.168kg increase in output of groundnut produced by female in the study area.

For the female groundnut producers, the estimated coefficient for pesticides is -1.460 which is negative and statistically significant at 1% level. This shows a negative relationship between pesticide and output; and the implication of this result is that if the volume of pesticides used for the production of groundnut increases by aliter, the output of groundnut will decrease by 1.460 kg.This is not as expected because the use of pesticides reduces drudgery in farm operations such as weeding and clearing as well as increase quantity of output produced stemming from control of pests and diseases. The result obtained could be because of misuse or over utilizationof pesticides. On the other hand the coefficient for male groundnut producer is 0.024 but not significant.

The estimated coefficient of fertilizer is -1.460 and statistically significant for the females. This implies that a unit increase in fertilizer will lead to decrease in output by 1.460kg.

The technical inefficiency in the model is explained below:

The negatively estimated coefficient (-0.356) for age in female groundnut producersimplies that, an increase in age decreases inefficiency in groundnut production and thus increases output by 0.356 kg.

Household size coefficient (-0.360) had a negative sign in the model. A decrease in the number of people in a household will lead to a increase in technical inefficiency of the groundnut male farmers, while for female groundnut producer has coefficient of (-0.732) . Therefore, respondents with larger household sizes tend to be more technically efficient than households with smaller number of people. This could be as a result of the fact that large household size translates into cheaper and available labor which can reduce cost of production.

Coefficient of age (0.063) has negative effect on male groundnut respondents' technical inefficiency implying that it has negative effect on technical efficiency. This suggests that the older the respondents, the lower the technical inefficiency while for female groundnut producers has coefficient of -0.356, but not significant. The negative effect of age on technical efficiency indicates that the agility and energetic capability of the respondents to contribute to the production of groundnut is reduced.

Farming experience had positive and significant coefficient of 0.235, implying that respondents with higher farming experience tend to be more technically efficient in the production of groundnut for female. A rise in farming experience of the respondents could enhance the skill of the farmers which in turn increase their efficiency but for the male groundnut producer has coefficient of 0.094 implying that farmers with low farming experience tend to be less efficient. Farming experience was significant at 1% level of probability indicating the relevance of accumulation of experience in a farming activity.

Table 15: Allocative Efficiency Estimates for Groundnut Production

Variable	**para.**	**Male Coeff.**	**St. error**	**t-value**	**Female Coeff.**	**St. error**	**t-value**
Constant	β_0	7.187	0.665	10.803***	4.161	0.706	5.890***
Cost of seed	β_1	0.000	0.014	0.014	0.054	0.016	3.377***
Cost of pesticides	β_2	-0.019	0.024	-0.814	0.026	0.034	0.772
Cost of inorganic fertilizer	β_3	-0.002	0.011	-0.217	0.027	0.027	0.987
Cost of farm yard manure	β_4	0.022	0.051	0.424	0.068	0.057	1.193
Cost of labour	β_5	0.313	0.042	7.449***	0.475	0.059	8.068***
Sigma-squared	δ^2	0.75912564	0.144	5.255	0.981273	0.185	5.291
Gamma	Γ	0.976	0.022	44.742	1.000	0.000	11662
Log likelihood		9023500			9386300		
LR test of the one-sided error =		0.1477017			0.79722472		

Source: Field survey, 2017. *** = 1% significant, ** = 5% significant, * = 10% significant

The estimated parameters for the groundnut production presented revealed that δ^2 (0.75) and Γ(0.97) were significant. The sigma squared (0.75) which indicate the fit and correctness of the distribution form the composite error term. The gamma estimation shows the variation in total cost of production resulting from the allocative efficiencies of the farmer. For the female groundnut producers the sigma-squared (0.98) and gamma (1.00) were significant. The sigma squared indicates the fitness of the distribution. The gamma estimation revealed the total cost of production resulting in allocative efficiencies.

The coefficient for the cost of seed for female producer is positive and significant, which implies an increase in cost of seed lead to increase in total cost of production, an increase in total cost of production decrease revenue of the farmers.

The cost of labour coefficient estimates for male groundnut producers is positive and statistically significant, which implies an increase in cost of labour lead to increase in total cost of production.an increase in cost of labour reduce the revenue base of the producers. For the female producers the same is applicable.

Cost of Fertilizer,the estimated coefficient for males is -0.002 and 0.027for female groundnut producers, however they are both not significant.

Cost of pesticidesis also not significant for both male and female groundnut producers.

Table 16: Frequency Distribution of Technical, Allocative and Economic Efficiency of groundnut male producers

Effien. level	Technical efficiency		Allocative efficiency		Economic efficiency	
	Freq.	Percent. (%)	Freq.	Percent. (%)	Freq.	Percent. (%)
0.00-0.25	2	2.4	61	72.6	78	92.9
0.26-0.50	3	3.6	21	25.0	5	5.9
0.51-0.75	46	54.7	1	1.2	1	1.2
0.76-1.00	33	39.3	1	1.2	0	1.19
Total	84	100	84	100	84	100
Average	0.70		0.20		0.14	
Minimum	0.21		0.11		0.01	
Maximum	0.89		0.76		0.66	

Source: Field survey, 2017.

Table 16 shows the efficiency levels between the ranges 0.00 – 1.00, along with mean, minimum and maximum values. It was observed from the study that 6% of the male groundnut farmers possess technical efficiency levels between the range of 0.00 – 0.50, while 94% of the farmers were able to achieve technical efficiency level above 0.50. The mean technical efficiency score is 0.70, while the best and worst farmer demonstrated a technical efficiency of 0.89 and 0.21 respectively. 97.6% of the respondents had allocative efficiency score within the ranges 0.00 – 0.50, with a mean score of 0.11. This results show that the farmers in this category are more technically efficient, though not at 100% level efficiency.

The combined effect of technical and allocative factors shows that, the average economic efficiency level was 0.14. The best farmer demonstrated an economic efficiency of 0.66 while the worst farmer had an economic efficiency of 0.01. Hence, on average, economic efficiency of the male groundnut farmers can be improved by 86% using the available resources and technology.

Table 17: Frequency Distribution of Technical, Allocative and Economic Efficiency of female groundnut producers

Effien. level	Technical efficiency		Allocative efficiency		Economic efficiency	
	Freq.	Percent. (%)	Freq.	Percent. (%)	Freq.	Percent. (%)
0.00-0.25	3	8.3	28	77.8	29	80.6
0.26-0.50	6	16.7	7	19.4	6	16.7
0.51-0.75	11	30.6	1	2.8	1	2.8
0.76-1.00	16	44.4	0		0	
Total	36	100	36	100	36	100
Mean	0.69		0.22		0.16	
Minimum	0.01		0.11		0.00	
Maximum	1.00		0.64		0.59	

Source: Field survey, 2017.

The distribution of female groundnut farmers' technical efficiency score is presented in the Table 17 which shows the minimum value of 0.20, maximum of 1.00 with average of 0.69. The obtained mean technical efficiency of the respondents indicates that an average female groundnut farmer in the study area have 31% chances for improving production efficiency using the existing technology of the best farmer. Therefore, there is need to increase production by utilizing available resources to operate at the frontier efficiency level.

The allocative efficiency mean, minimum and maximum values were 0.22, 0.11 and 0.64 respectively. This shows a wide distribution of allocative efficiency among the respondents.

Economic efficiency which is the product of technical and allocative efficiencies shows that the average economic efficiency level was about 0.16, with a minimum of0.00and a maximum of 0.59.

4.5 CONSTRAINTS MILITATING AGAINST LEGUMES PRODUCTION

This component examined constraints militatingagainst legumes production in the study area. The constraints identified incudes; input sourcing, marketing, pest and diseases, damage due to pastoralist activities, climate change, theft, land ownership and fire.They are presented in Table 18.

Table 18: Constraint to legumes production

	Male			**Female**		
Variables	**Frequency**	**(%)**	**Rank**	**Frequency**	**(%)**	**Rank**
Input sourcing	80	95.2	1st	34	94.4	1st
Marketing	77	91.7	2nd	21	58.3	5th
Pest and disease	70	83.3	3rd	32	88.8	3rd
Pastoralistactivities	60	71.4	4th	10	27.8	7th
Climate Change	49	58.3	5th	13	36.1	6th
Theft	35	41.7	6th	24	66.6	4th
Land Ownership	33	39.3	7th	33	91.6	2nd
Fire outbreak	25	29.8	8th	7	25.0	8th
Multiple response						

Sources: Field survey, 2017

The result revealed that for the male farmers, input sourcing is the major constraints affecting legume production in the study area with 95.2%, whilefor the female farmers it represents 94.4% both ranking 1stin the list of constraints. In the course of the research work, the farmers stressed their inability to get inputs at required time and prices. These includeimproved seeds, fertilizers etc. Also distance to input source contributed to the problems.

Marketing is very important because if the right channel of selling is not followed, it will lead to reduction in profit. Marketing of output is another constraint of legume productionranking 2ndwith 91.7% for the male and 58.3% for the female counterpart ranking 5th.

Incidence of pest and diseases is a very serious constraint, because the outbreak of disease can lead to loss in output of farmers. From the study it revealed that 83.3% of the male affirmed that pest and diseaseoutbreak ranking 3rd in their list of constraintsled to reduction in output and ranking third for female with 88.8%.

The issue of pastoralists is another challenge experience by mostly the male farmers with 77.4% and ranking 4th.Farmers' pastoralist conflict is a very important aspect to be taking into cognisance because most farmers lose crops and sometimes lives when it occurs. Both male and female farmers could be affected by these pastoralist activities. However,from the results only 27.8% of female in the study area reported pastoralist activities as a constraint ranking 7th.

Climate change is another important aspect in production, because its effect can lead to low yield for the farmers. 58.3% of the male revealed that climate change affect production ranking 5th, while 36.1% of the female reported that climate change is a constraint in legume production.

Most farmers lost harvested crops to theft. From the result, it shows that 41.7% and 66.6% representing both male and female farmers lose crops to theft.

Land ownership is very important in agricultural production.In Africa, women lack access to most livelihood resources such as land. From the study, 91.6% of the women lack access to land for production, this ranked 2nd in the list of their constraints. One the other hand39.3% of male affirmed to lack access to land, ranking 7th in the list. By comparison with both genders, it revealed that most females do not have access to land for cowpea production.

Fire outbreak lead to loss of crops and in turn reduce profitability, 29.8% and 25.0% of both male and female reported that fire outbreak is also a constraint faced by the farmers, ranking 8th in their list of constraints.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The research analysed legume productionin Kano State in respect to gender classification. Primary data were collected from a total of 120 farmers which comprised of both male (84) and female (36) through the use of structured questionnaires.Multi-stage sampling techniques consisting of purposive and random sampling were used in selection of the farmers. The analytical tools employed for the study include descriptive statistics, Harvard gender framework, gross margin analysis and stochastic production frontier. Descriptive statistics of the farmers shows that there are slight differences between the male and female farmers in terms of socio economic characteristics such as age, household size, farming experience and farm size, with mean 45.9, 10.64, 29.3 and 0.84 for the male farmers and the female 42.78, 8.72, 21.83 and 0.59 respectively.

The results revealed that men, women and children actively carried out labour activities in the farm, with men having higher percentages (56.9%, 93%, 97.5%, 47.2%, 44.4%, 63.2%, 40.5% and 77.6%) in land clearing, ploughing of field, riding, planting, application of fertilizer, weeding, harvesting and sales of output. Alsomen have more access and control over available resources and benefits as compared with women.

The gross margin analysis revealed that the TVC for male cowpea farmers was ₦55,420, with labour having the highest percentage of 49.9%, followed by seed,inorganic fertilizer, FYM, pesticides and bagging with 19.65%, 16.24%, 6.5%, 6.5% and 1.23% respectively. The result also shows that TR for the male cowpea farmers was ₦100,000, thus, arriving at a gross margin of ₦44, 580with an RNI of ₦0.8k. On the other hand, the TVC for female cowpea farmers was ₦43, 850, with labour also having the highest percentage of 45.27%, followed by inorganic fertilizer, seed, pesticides, FYM and bagging with 20.52%, 20.52%, 6.84%, 5.47 and 1.37% respectively. The result shows that TR for the female cowpea farmers was ₦87, 500, arriving at a gross margin of ₦43, 650 with an RNI of ₦0.99k.

The study revealed that the TVC for male groundnut farmers is ₦42,450, with labour having the highest percentage of 41.7%, followed by inorganic fertilizer,seed, FYM,pesticides and bagging with 22.96%, 19.79%, 8.48%, 5.65% and 1.41% respectively. The result also shows that TR for the male groundnut farmers was ₦60,000; thus, arriving at a gross margin of ₦17,550 with an RNI of ₦0.41. On the other hand, the TVC for female groundnut farmers is ₦28,090, with labour also having the highest percentage of 67.29%, followed by seed, inorganic fertilizer, FYM, pesticides and bagging with 25.95%, 21.36%, 8.54%, 6.41% and 1.1% respectively. The result shows that TR for the female cowpea farmers was ₦50,000, arriving at a gross margin of ₦21,910 with an RNI of ₦0.78.

The technical efficiency estimatesfor cowpea production were presented, the estimate of gammaΓ is estimated to be 0.994 which can be interpreted that 99% of random variation in male cowpea farmers output is due to differences in their technical efficiencies. While for the female Γ is estimated to be 1.000 which implies 100% of random variation in the output of female cowpea farmers is due to differences in their technical efficiencies. The variance parameter of Sigma (σ^2) was 0.14584 for male and 0.4541 for female which indicates good fitness and correctness of the distributional form assumed for the composite error term.The estimated coefficients of parameters of the production function such as seeds, pesticides, labour and agrochemical were significant and had effect on output. Whereas age, education and farming experiences reduces inefficiency level.

The technical efficiencyestimate of the parameters for groundnut farmers were presented, Γ is estimated to be 0.897 and this can be interpreted that 89% of random variation in farmers

output is due to differences in their technical efficiencies. The variance parameter of Sigma (δ2) was 0.228 which is significant at 10% indicating good fitness and correctness of the distributional form assumed for the composite error term.
Lastly, the study highlights the constraints militating against legumes production in the study area. Input sourcing was reported to be the major challenge facing both male and females farmers in the study area. Marketing, pest and diseases and climate change are alsocommon problems/ constraints by both parties. However, land ownership issue seems to be more severe on the female farmers and the issues concerning pastoralists activities were reported only by the male farmers. Theft as well as fire outbreakwere not left out amongst other constraints faced by legume producers in the study area.

5.2 CONCLUSION

The study concluded that both male and female legume farmers in the study area share similar socio economic characteristics. It also revealed that men, women and children actively engage in activities on the farm. Also, from the research it is concluded that men have more access and control over land resource, farm tools and labour as compared with women in the area particularly for legume production.

Legumes are profitable in the study area, though women seem to be more profitable than men in both cowpea and groundnut production enterprise. This may be due to the cost management strategies adopted by females in inputs procurement, which contribute to minimize their TVC. Hence record higher gross margin than the male counterparts.

Also, the study concludes that there were over utilization of resource inputs, hence, the negative relationships existing as shown by the production function analysis in some major inputs. Both male and female farmers were not very efficient in the production of cowpea and groundnut. These might likely be due to lack of training and exposure to farm management skills and expertise, as well as challenges in sourcing and using of key inputs.

On a final note, the study concludes that the major problems facing legume producers are input sourcing, marketing of farm output, issues of pest and diseases and access to finance to expand production.

5.3 RECOMMENDATIONS

Based on the objectives and the findings of this study, the following recommendations are suggested:

1. Women empowerment strategy should be implemented so as to encourage more female participationin legumes production, considering the low participation by females (36) as compared to their male counterparts (84) in the study area.
2. Access to land need to be addressed to enable both categories of farmers increase their land holdings for improved output. Perhaps land tenure system need to be reviewed and relaxed to facilitate access especially to the females.
3. To reduce over utilization of resources in the study area, cooperative members and cooperative agencies including agricultural extension agenciesshould organize seminars where extension agents can enlighten farmers on proper farm resources allocation and management especially efficient utilization of labour resources, pesticides and fertilizers. Also, adequate training on production techniques is recommended for efficient productivity
4. There is the need for sustainable input supply policy that will ensure availability, affordability and timely delivery of agricultural inputs for better profitability in legume production in the study area.

5. Proper infrastructures such as good roads and market facilities should be put in place to enhance flexibility among input and output markets.

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APPENDIX I
QUESTIONNAIRE

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION
FACULTY OF AGRICULTURE, BAYERO UNIVERSITY KANO

RESEARCH QUESTIONNAIRE

Enumerators Name: ………………………………………………………………………..
Interview Date: ……………………….... **Questionnaire Id: …………………….**

Dear Respondent,

I am Rafiat Idris Yusuf, a student of Bayero University Kano from the Department of Agricultural Economics and Extension, Faculty of Agriculture conducting a research on the topic titled **"Gender Analysis on Selected Legume Producers in Kano State, Nigeria"**. Please, you are demanded to respond accordingly as any information provided would be used strictly for academic purpose.

Thank You.

Section A: Socioeconomic Information

1. L.G.A…………………… Village…………………
2. Respondent's Name ……………………………….………………… Mobile No……………………………....
3. Sex a. Male { } b. Female { }
4. Marital status a. Single { } b. Married { } c. Divorced { } d. Widowed { }
5. Household size ……………..
6. Household composition related to farm-plots defined in labour, consumption e.t.c

Respondent (starting with household head)	Male=1 Female=2	Age (yrs)	**Occupation** 1=farming 2=civil service 3=livestock rearing 4=trading 5=others(specify)	**Farming experience** (in years)	**Education level** 1=no formal education 2=primary education 3=secondary education 4=tertiary education	**Labour participation** 1=full time farmer 2=part-time farmer 4=others(specify)
Household head						

7. Crops: Legume: 1)………………..2)………………….3)……….......... Cereal: 4)…………………
8. Household Average income per harvest season (in naira) ……………..
9. Household total land(ha)

Asset name	Number of hectares (ha)	Ownership 1= male 2= Female
Total cultivable land area		
Total cultivated area		
Total area fallow		
Area planted with cowpea		
Area planted with groundnut		
Area planted with cereals		

10. Membership of cooperative society a. Member { } b. Non-member { }
11. If non-member, state reason(s)……………………………………………………
12. If member, state name of the cooperative group………………………………………
13. Are those cooperatives functioning? a Yes { } b. No { }
14. Where do you source agricultural information?
    a. Extension agent { } b. Media { } c. fellow farmers { }
15. Do you have contact with extension agent? Yes { } No { }
16. If yes, what is the frequency of your contact to extension agents?
    a. Daily { } b. weekly { } c. Fortnightly { } d. Monthly { } d. others { }
17. How useful is the contact?
    a. very useful { } b. useful { } c. not useful { } d. can't tell { }
18. Do you have access to credit? a. Yes { } b. No { }
19. If yes; from where?
    a. ADPs { } b. Banks { } c. Cooperatives { } d. Financial institution { }
    f. Others (specify)……………....................
20. If no; have you ever sourced for credit? a. Yes { } b. No { }

SECTION B: Inputs Procurement

21. Use the table below to complete information on inputs used in legumes production

Inputs	**Quantity (kg)**	**Unit Price (₦)**	**Total Price (₦)**	**Source*****
Cowpea				
Seeds: Local Seeds				
Improved seeds				
Agro-chemicals				
Pesticides				
Herbicides				
Fungicide				
Fertilizers				
In organic fertilizer				
Compost				
Farm Yard Manure (FYM)				
Poultry				

Inputs	Quantity (kg)	Unit Price (₦)	Total Price (₦)	Source***
Groundnut				
Seeds: Local Seeds				
Improved seeds				
Agro-chemicals				
Pesticides				
Herbicides				
Fungicide				
Fertilizers				
In organic fertilizer				
Compost				
Farm Yard Manure (FYM)				
Poultry				

Source *:** 1=Research institutes 2= Govt/ADPs 3=open markets 4=Input companies 5=Agro dealers 6=others (specify)

22. What kind of labour is used on the farm?
    a) Family { } b. Hired { } c. Family and hired { }

23. Complete the table regarding labour used in legume production

		Paid labour				**Family labour**			
S/n	Operation	No. of labourers	No. of hours/day	No. of days spent	Unit cost (₦)	No. of labourers	No. of hrs spent/day	No. of days spent	Unit cost (₦)
1.	**Land preparation**								
	Land Clearing								
	Adult male								
	Adult female								
	Children								
	Harrowing/Ridging								
	Adult Male								
	Adult female								
	Children								
2.	**Planting**								
	Adult male								
	Adult female								
	Children								
3.	**Fertilizer app.(1st&2nd)**								
	Adult male								
	Adult female								
	Children								
4.	**Weeding(1st&2nd)**								
	Adult male								
	Adult female								

	Children								
5.	**Harvesting**								
	Adult male								
	Adult female								
	Children								
6.	**Threshing**								
7.	**Bagging**								
8.	**Transportation**								

24. Do you own farm implements a. Yes { } b. No { }

25. If yes, provide the following information:

S/n	Type	Qty	Unit cost (₦)	Years of purchase	life span	Total cost(₦)
1.	Hoe					
2.	Cutlass					
3.	Sprayer					
4.	Others ……….					

26. Did you borrow/hired any type of agricultural equipment this year? Yes { } No { }

27. If yes, specify the equipment below:

s/n	Type	Source	Purpose	Condition of working	Rate (₦/hr)
1.					
2.					
3.					

Condition: 1= Good, 2=Fair, 3=Poor

Source: 1=ADP, 2=Ministry, 3=LGA, 4=Private, 5=Others

SECTION C: Information on Output

28. Did legume production increase in the last 2 – 3 years? a. Yes { } b. No { }

29. Provide information on Legume harvested in 2 years by household.

Crops	Variety	2015				2016			
		Area (ha)	Production			Area (ha)	Production		
			Quantity	Unit (Code X)	Price (₦)		Quantity	Unit (Code X)	Price (₦)
Cowpea									
G/nut									

Code X: 1= kg, 2= Kwano, 3= 50kg Bag, 4= 100kg Bag, 5= Ton, 6= Other Unit (Specify)

30. How do you distribute your output?

S/N	Distribution	Cowpea Quantity (kg)	Groundnut Quantity (kg)
1.	Sold immediately after harvest		
2.	Kept for future sale		
3.	Seeds		
4.	Family consumption		
5.	Gift		

31. Where do you usually sell the crops?
    a. Farm gate { } b. village market { } c. urban market d. others (specify)…………………
32. Who are your buyers?
    a. Rural assemblers { } b. rural wholesalers { } c. urban wholesalers { } d. others…........

SECTION D: Information on Gender related issues

Activity Profile Tool

ACTIVITY	**Men**	**Women**	**Children**
Legume Production			
Clearing of field			
Ploughing of field			
Ridging of farm land			
Application of inoculants			
Planting			
Application of fertilizer			
Weeding			
Harvesting			
Income Generating			
Sale of cowpea			
Sale of groundnut			

Table 3: **Access and Control Profile**

	Access Men Women	**Control** Men Women
Resources		
Land		
Equipment		
Labour		
Cash		
Education/training		
Others		
Benefits		
Outside Income		
Asset ownership		
Basic needs (food, clothing, shelter, etc.)		
Education		

Table 4: **Influencing Factor Tool**

Influencing Factors	**Constraints**		**Opportunities (%)**	
Demographic Character	Men	Women	Men	Women
• Age				
• Marital statues				
• Gender				
• Household size				

• Level of education				
• Poverty level • No. of dependent				

Code for constraints: A = affect D = does not affect

Code for opportunity by 10% = 1, 20% = 2, 30% = 3, 40% = 4, 50% = 5, >50% = 6

SECTION E: Legume Production Constraints

33. Identify the major problems affecting legume production

a. Input sourcing ( )
a. Climate change ( )
b. Production techniques ( )
c. Pest and diseases ( )
d. Legumes marketing ( )
e. Land ownership problem ( )
f. Risk factors (i)…………………………. (ii)…………………….
(iv)…………………..
g. Others (specify)
…………………………………………………………………………………….

APPENDIX II

Output of Stochastic Frontier Production Model

COWPEA

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file = male.txt

Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.28717712E+01	0.53003901E+00	0.54180373E+01
beta 1	0.14167357E+00	0.62409139E-01	0.22700773E+01
beta 2	-0.13099863E+00	0.13941274E+00	-0.93964610E+00
beta 3	0.49419197E-01	0.44189582E-01	0.11183450E+01
beta 4	0.25934127E+00	0.48194284E-01	0.53811623E+01
beta 5	0.67264986E+00	0.17620237E+00	0.38174847E+01
beta 6	0.31569444E+00	0.94185228E-01	0.33518467E+01
sigma-squared	0.34962797E+00		

log likelihood function = -0.71399160E+02

the estimates after the grid search were :

beta 0	0.33925607E+01
beta 1	0.14167357E+00
beta 2	-0.13099863E+00
beta 3	0.49419197E-01
beta 4	0.25934127E+00
beta 5	0.67264986E+00
beta 6	0.31569444E+00
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00
sigma-squared	0.59171407E+00
gamma	0.72000000E+00

iteration = 0 func evals = 20 llf = -0.67722975E+02

0.33925607E+01 0.14167357E+00-0.13099863E+00 0.49419197E-01 0.25934127E+00
0.67264986E+00 0.31569444E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.59171407E+00
0.72000000E+00

gradient step

iteration = 5 func evals = 46 llf = -0.52338275E+02
0.34483802E+01 0.82591061E-01-0.55390669E-01 0.81349522E-01 0.19932714E+00
0.68218713E+00 0.33466523E+00-0.24401182E-02-0.79698595E-01-0.34724025E-02
0.15089759E+00-0.39795277E-01 0.37543568E-01-0.10745304E-01 0.57167677E+00
0.76704899E+00

iteration = 10 func evals = 67 llf = -0.43986760E+02
0.47631151E+01 0.50554434E-02 0.18297303E+00 0.25655537E-01 0.72317423E-01
0.46262888E+00 0.24957333E+00 0.55572539E-01-0.74050832E-01 0.10361279E+00
0.17858627E+00-0.33446525E+00 0.16782711E-01-0.10132018E+00 0.72681065E+00
0.89922928E+00

iteration = 15 func evals = 108 llf = -0.27416074E+02
0.63901505E+01-0.55642268E-01-0.92252178E-02-0.49511662E-02 0.31912611E-01
0.79458077E+00 0.22787718E-01 0.38245941E+00-0.74748842E-01 0.61944726E+00
0.18576189E+00-0.79160255E+00 0.98117027E-02-0.44313113E+00 0.55599836E+00
0.98461506E+00

iteration = 20 func evals = 146 llf = -0.13160896E+02
0.64792442E+01-0.43461049E-01-0.11022056E+00-0.74948452E-04 0.35737003E-01
0.82562069E+00 0.80201838E-03 0.11100526E+01-0.82787205E-01 0.55744057E+00
0.20955082E+00-0.10509046E+01 0.10418201E-02-0.13188549E+01 0.89277914E+00
0.98719323E+00

iteration = 25 func evals = 207 llf = -0.72020548E+01
0.66159275E+01-0.38351020E-01-0.12597296E+00 0.52555055E-02 0.22157664E-01
0.83712053E+00-0.15476364E-01 0.32065410E+01-0.85405694E-01-0.18123959E+01
0.32099252E+00-0.13970675E+01 0.25822352E-02-0.15944689E+01 0.14457311E+01
0.99348905E+00

iteration = 29 func evals = 251 llf = -0.71485822E+01
0.66192041E+01-0.38930948E-01-0.12631019E+00 0.51657140E-02 0.22128741E-01
0.83800570E+00-0.15691871E-01 0.32694380E+01-0.84978788E-01-0.18619183E+01
0.32280501E+00-0.14126745E+01 0.19106820E-02-0.16018178E+01 0.14584241E+01
0.99353273E+00

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.66192041E+01	0.23260086E+00	0.28457351E+02
beta 1	-0.38930948E-01	0.18075480E-01	-0.21537988E+01
beta 2	-0.12631019E+00	0.48149123E-01	-0.26233124E+01
beta 3	0.51657140E-02	0.12989309E-01	0.39768967E+00
beta 4	0.22128741E-01	0.25223134E-01	0.87731927E+00
beta 5	0.83800570E+00	0.51144371E-01	0.16385101E+02
beta 6	-0.15691871E-01	0.31594444E-01	-0.49666550E+00
delta 0	0.32694380E+01	0.16829650E+01	0.19426655E+01
delta 1	-0.84978788E-01	0.42787971E-01	-0.19860439E+01
delta 2	-0.18619183E+01	0.12430088E+01	-0.14979123E+01

delta 3 0.32280501E+00 0.57573758E-01 0.56068080E+01
delta 4 -0.14126745E+01 0.48859138E+00 -0.28913209E+01
delta 5 0.19106820E-02 0.36101293E-01 0.52925584E-01
delta 6 -0.16018178E+01 0.86223074E+00 -0.18577600E+01
sigma-squared 0.14584241E+01 0.28266243E+00 0.51595968E+01
gamma 0.99353273E+00 0.35869236E-02 0.27698742E+03

log likelihood function = -0.71485826E+01

LR test of the one-sided error = 0.12850116E+03
with number of restrictions = 8
[note that this statistic has a mixed chi-square distribution]
number of iterations = 29
(maximum number of iterations set at : 100)
number of cross-sections = 84
number of time periods = 1
total number of observations = 84
thus there are: 0 obsns not in the panel

covariance matrix :

0.54103159E-01 -0.14232008E-02 0.43494703E-03 -0.79016991E-03 -0.45326539E-02
-0.79951604E-03 -0.50847478E-02 0.68117064E-01 0.11846521E-02 -0.35886112E-01
0.82606328E-03 -0.15585783E-01 -0.12113156E-02 -0.26240799E-01 0.80207828E-02
0.32356087E-04
-0.14232008E-02 0.32672298E-03 -0.27598234E-03 0.66574933E-05 0.59570619E-04
0.19168321E-03 0.92678525E-04 -0.57731991E-02 0.11144252E-03 0.30818953E-02
-0.19448194E-03 -0.49089386E-03 -0.18774102E-04 0.71871412E-03 -0.72479628E-03
-0.50804581E-05
0.43494703E-03 -0.27598234E-03 0.23183381E-02 -0.17746203E-03 -0.24160662E-03
-0.13791901E-02 0.14327953E-03 -0.62615511E-02 -0.77382012E-03 0.58752561E-02
0.58184455E-03 0.71992453E-02 0.42948760E-03 -0.26276107E-02 0.88464137E-03
-0.58959415E-05
-0.79016991E-03 0.66574933E-05 -0.17746203E-03 0.16872215E-03 0.25590676E-05
-0.55240731E-04 0.83431695E-04 -0.50244636E-03 -0.14635749E-04 0.18687648E-04
0.15269339E-04 0.48801651E-03 0.35662186E-04 -0.53716293E-03 -0.15931010E-03
0.96356470E-05
-0.45326539E-02 0.59570619E-04 -0.24160662E-03 0.25590676E-05 0.63620648E-03
0.34819181E-03 0.14597945E-03 -0.43881535E-02 -0.87034758E-05 0.28272808E-02
-0.20263682E-03 -0.51006837E-03 0.36501229E-04 0.41005866E-02 -0.56317638E-03
0.41424529E-05
-0.79951604E-03 0.19168321E-03 -0.13791901E-02 -0.55240731E-04 0.34819181E-03
0.26157467E-02 0.47186111E-04 0.11874689E-01 0.44726700E-03 -0.73372875E-02
-0.29936623E-03 -0.62203111E-02 -0.28245281E-03 0.36062454E-02 0.29275564E-03
0.81463339E-05
-0.50847478E-02 0.92678525E-04 0.14327953E-03 0.83431695E-04 0.14597945E-03
0.47186111E-04 0.99820891E-03 -0.35129955E-02 -0.25751665E-03 0.14939137E-02
0.12961846E-03 0.33091483E-02 0.18005732E-03 0.12581444E-02 -0.58623496E-03
-0.75873225E-05
0.68117064E-01 -0.57731991E-02 -0.62615511E-02 -0.50244636E-03 -0.43881535E-02

0.11874689E-01 -0.35129955E-02 0.28323712E+01 0.13948179E-02 -0.16468553E+01
0.57182596E-01 -0.47133900E+00 -0.14577994E-01 -0.44274484E+00 0.36906394E+00
0.17941548E-02
0.11846521E-02 0.11144252E-03 -0.77382012E-03 -0.14635749E-04 -0.87034758E-05
0.44726700E-03 -0.25751665E-03 0.13948179E-02 0.18308104E-02 -0.66416554E-02
-0.83396401E-03 -0.15604476E-01 -0.12380127E-02 -0.53471965E-02 0.75170021E-03
-0.13948183E-04
-0.35886112E-01 0.30818953E-02 0.58752561E-02 0.18687648E-04 0.28272808E-02
-0.73372875E-02 0.14939137E-02 -0.16468553E+01 -0.66416554E-02 0.15450710E+01
-0.48289170E-01 0.34366388E+00 0.50817610E-02 -0.33749803E-01 -0.28688074E+00
-0.11904145E-02
0.82606328E-03 -0.19448194E-03 0.58184455E-03 0.15269339E-04 -0.20263682E-03
-0.29936623E-03 0.12961846E-03 0.57182596E-01 -0.83396401E-03 -0.48289170E-01
0.33147376E-02 -0.57666713E-03 0.12191997E-03 -0.12758952E-01 0.12445735E-01
0.58727823E-04
-0.15585783E-01 -0.49089386E-03 0.71992453E-02 0.48801651E-03 -0.51006837E-03
-0.62203111E-02 0.33091483E-02 -0.47133900E+00 -0.15604476E-01 0.34366388E+00
-0.57666713E-03 0.23872153E+00 0.12586008E-01 0.27152765E-01 -0.76419806E-01
-0.36849550E-03
-0.12113156E-02 -0.18774102E-04 0.42948760E-03 0.35662186E-04 0.36501229E-04
-0.28245281E-03 0.18005732E-03 -0.14577994E-01 -0.12380127E-02 0.50817610E-02
0.12191997E-03 0.12586008E-01 0.13033034E-02 0.93178108E-02 -0.25197964E-02
-0.87159966E-07
-0.26240799E-01 0.71871412E-03 -0.26276107E-02 -0.53716293E-03 0.41005866E-02
0.36062454E-02 0.12581444E-02 -0.44274484E+00 -0.53471965E-02 -0.33749803E-01
-0.12758952E-01 0.27152765E-01 0.93178108E-02 0.74344185E+00 -0.67902990E-01
-0.64923482E-04
0.80207828E-02 -0.72479628E-03 0.88464137E-03 -0.15931010E-03 -0.56317638E-03
0.29275564E-03 -0.58623496E-03 0.36906394E+00 0.75170021E-03 -0.28688074E+00
0.12445735E-01 -0.76419806E-01 -0.25197964E-02 -0.67902990E-01 0.79898048E-01
0.41605869E-03
0.32356087E-04 -0.50804581E-05 -0.58959415E-05 0.96356470E-05 0.41424529E-05
0.81463339E-05 -0.75873225E-05 0.17941548E-02 -0.13948183E-04 -0.11904145E-02
0.58727823E-04 -0.36849550E-03 -0.87159966E-07 -0.64923482E-04 0.41605869E-03
0.12866021E-04

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.16382584E-02
2	1	0.97008576E+00
3	1	0.53671532E+00
4	1	0.91030537E+00
5	1	0.37030994E+00
6	1	0.92872113E+00
7	1	0.85518191E+00
8	1	0.37035570E+00
9	1	0.61949862E+00
10	1	0.89214838E+00
11	1	0.72796850E+00

12	1	0.77465109E+00
13	1	0.91716461E+00
14	1	0.89159853E+00
15	1	0.92944832E+00
16	1	0.86873983E+00
17	1	0.85261300E+00
18	1	0.89407625E+00
19	1	0.63124823E+00
20	1	0.62869095E+00
21	1	0.89394560E+00
22	1	0.95796421E+00
23	1	0.36964570E+00
24	1	0.88951929E+00
25	1	0.90834614E+00
26	1	0.81181417E+00
27	1	0.82271774E+00
28	1	0.91808783E+00
29	1	0.92060275E+00
30	1	0.94925572E+00
31	1	0.91272676E+00
32	1	0.73425036E+00
33	1	0.92560628E+00
34	1	0.79156479E+00
35	1	0.78388796E+00
36	1	0.91967254E+00
37	1	0.35372275E+00
38	1	0.91967254E+00
39	1	0.72351889E+00
40	1	0.62730716E+00
41	1	0.79748973E+00
42	1	0.95633670E+00
43	1	0.95480567E+00
44	1	0.92906713E+00
45	1	0.94593864E+00
46	1	0.68174268E+00
47	1	0.78787560E+00
48	1	0.53593808E+00
49	1	0.86861796E+00
50	1	0.91530061E+00
51	1	0.78314179E+00
52	1	0.83231270E+00
53	1	0.94790292E+00
54	1	0.77652592E+00
55	1	0.84820259E+00
56	1	0.93268363E+00
57	1	0.64803689E+00
58	1	0.92280008E+00
59	1	0.62089750E+00
60	1	0.93823481E+00
61	1	0.34906321E+00

62	1	0.67692267E+00
63	1	0.89711472E+00
64	1	0.92530158E+00
65	1	0.83091311E+00
66	1	0.78314179E+00
67	1	0.74913375E+00
68	1	0.79510342E+00
69	1	0.81853450E+00
70	1	0.81171576E+00
71	1	0.40163553E+00
72	1	0.78101026E+00
73	1	0.81089534E+00
74	1	0.34212407E+00
75	1	0.93404270E+00
76	1	0.71472945E+00
77	1	0.80836861E+00
78	1	0.81234084E+00
79	1	0.62261116E+00
80	1	0.90669311E+00
81	1	0.85910162E+00
82	1	0.71793308E+00
83	1	0.90991059E+00
84	1	0.81853450E+00

mean efficiency = 0.77863948E+00

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file =   lll.txt

Tech. Eff. Effects Frontier (see B&C 1993)
The model is a production function
The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.38798920E+01	0.27316563E+01	0.14203441E+01
beta 1	-0.11185651E+00	0.20749970E+00	-0.53906831E+00
beta 2	0.48491052E+00	0.39056211E+00	0.12415708E+01
beta 3	-0.25656161E-01	0.10137165E+00	-0.25309009E+00
beta 4	-0.99240729E-01	0.12112238E+00	-0.81934260E+00
beta 5	0.57522321E+00	0.53732999E+00	0.10705213E+01
beta 6	-0.60231580E-01	0.54526800E+00	-0.11046234E+00
sigma-squared	0.12346475E+01		

log likelihood function = -0.50983910E+02

the estimates after the grid search were :

beta 0	0.51135833E+01
beta 1	-0.11185651E+00
beta 2	0.48491052E+00
beta 3	-0.25656161E-01
beta 4	-0.99240729E-01
beta 5	0.57522321E+00
beta 6	-0.60231580E-01
delta 0	0.00000000E+00
delta 1	0.00000000E+00
delta 2	0.00000000E+00
delta 3	0.00000000E+00
delta 4	0.00000000E+00
delta 5	0.00000000E+00
delta 6	0.00000000E+00
sigma-squared	0.25165714E+01
gamma	0.95000000E+00

iteration =   0 func evals =   20 llf = -0.43562054E+02
0.51135833E+01-0.11185651E+00 0.48491052E+00-0.25656161E-01-0.99240729E-01
0.57522321E+00-0.60231580E-01 0.00000000E+00 0.00000000E+00 0.00000000E+00
0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.25165714E+01
0.95000000E+00

```
gradient step
iteration =     5  func evals =     61  llf = -0.29328674E+02
   0.50630990E+01-0.63053338E-01 0.46004183E+00-0.14125906E-02-0.76202336E-01
   0.34416633E+00 0.46521481E-01 0.69265643E-02 0.10863603E-01 0.47522090E-01
   0.10098891E-01-0.24817125E-03-0.21650929E+00 0.17751073E-01 0.25353389E+01
   0.98394966E+00
iteration =    10  func evals =     86  llf = -0.24399860E+02
   0.49251311E+01-0.49165468E-01 0.35749260E+00-0.18321901E-03-0.23007339E-01
   0.32294943E+00 0.20626581E+00 0.13312864E+00-0.82054101E-01 0.72334428E+00
   0.48580007E+00 0.46211691E-01-0.33387318E+00 0.28589013E+00 0.26729390E+01
   0.99215303E+00
iteration =    15  func evals =    124  llf = -0.13258602E+02
   0.46704299E+01 0.13624607E-01 0.25847341E+00-0.81608181E-02-0.47712250E-02
   0.37502249E+00 0.31698724E+00 0.48105931E+00-0.17765485E+00 0.23073216E+01
   0.21354814E+00-0.11526399E+00-0.29570440E+00 0.10793791E+01 0.33048393E+01
   0.99999999E+00
iteration =    20  func evals =    366  llf = -0.11045056E+02
   0.46488566E+01 0.38627341E-01 0.25766216E+00 0.12447951E-02-0.31717108E-02
   0.34997562E+00 0.33524938E+00 0.49511500E+00-0.16769580E+00 0.20320994E+01
   0.25079802E+00-0.17542380E+00-0.31446368E+00 0.10299272E+01 0.34102018E+01
   0.99999999E+00
iteration =    25  func evals =    459  llf = -0.98860538E+01
   0.45158867E+01 0.56440967E-01 0.26806710E+00 0.68260524E-02 0.14772285E-02
   0.35224639E+00 0.31014114E+00 0.52326573E+00-0.16393930E+00 0.19300921E+01
   0.25243149E+00-0.19794639E+00-0.32132740E+00 0.10382325E+01 0.34599638E+01
   0.99999999E+00
iteration =    30  func evals =   1613  llf = -0.95895389E+01
   0.44633740E+01 0.61666269E-01 0.26677716E+00 0.66109389E-02 0.16304558E-02
   0.36151842E+00 0.31050197E+00 0.63422035E+00-0.17543268E+00 0.20071827E+01
   0.22774466E+00-0.28807717E+00-0.32221312E+00 0.11919387E+01 0.36199549E+01
   0.99999999E+00
iteration =    35  func evals =   1680  llf = -0.86575111E+01
   0.42395172E+01 0.76173467E-01 0.25043459E+00 0.35865082E-02 0.22271721E-02
   0.41261136E+00 0.33562337E+00 0.13003189E+01-0.24427987E+00 0.24446322E+01
   0.12247757E+00-0.78049573E+00-0.33838060E+00 0.20851467E+01 0.45409848E+01
   0.99999999E+00
iteration =    40  func evals =   1698  llf = -0.86569806E+01
   0.42394479E+01 0.76177927E-01 0.25042971E+00 0.35855700E-02 0.22273313E-02
   0.41262718E+00 0.33563085E+00 0.13006167E+01-0.24430188E+00 0.24447874E+01
   0.12247016E+00-0.78075796E+00-0.33840987E+00 0.20854948E+01 0.45414132E+01
   0.99999999E+00
```

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.42394479E+01	0.68272216E+00	0.62096239E+01
beta 1	0.76177927E-01	0.43339382E-01	0.17577068E+01
beta 2	0.25042971E+00	0.51570175E-01	0.48560958E+01
beta 3	0.35855700E-02	0.91528031E-02	0.39174556E+00

```
 beta 4         0.22273313E-02  0.40964232E-02  0.54372587E+00
 beta 5         0.41262718E+00  0.15335278E+00  0.26907056E+01
 beta 6         0.33563085E+00  0.78877176E-01  0.42551073E+01
 delta 0        0.13006167E+01  0.13210656E+01  0.98452095E+00
 delta 1       -0.24430188E+00  0.10459785E+00 -0.23356299E+01
 delta 2        0.24447874E+01  0.80264773E+00  0.30459033E+01
 delta 3        0.12247016E+00  0.18070836E+00  0.67772273E+00
 delta 4       -0.78075796E+00  0.11877437E+01 -0.65734547E+00
 delta 5       -0.33840987E+00  0.12472124E+00 -0.27133299E+01
 delta 6        0.20854948E+01  0.14236312E+01  0.14649123E+01
 sigma-squared  0.45414132E+01  0.14057503E+01  0.32305974E+01
 gamma          0.99999999E+00  0.20089908E-07  0.49776236E+08

log likelihood function =  -0.86569813E+01

LR test of the one-sided error =   0.84653857E+02
with number of restrictions = 8
 [note that this statistic has a mixed chi-square distribution]

number of iterations =     40
(maximum number of iterations set at :   100)
number of cross-sections =     36
number of time periods =      1
total number of observations =     36
thus there are:      0  obsns not in the panel

covariance matrix :

  0.46610955E+00 -0.29587488E-01  0.35195375E-01  0.62478959E-02 -0.26621894E-02
 -0.10469196E+00 -0.53830330E-01 -0.21324152E+00  0.15638458E-01 -0.76518234E-01
  0.92522178E-02  0.22700509E+00  0.13357522E-01 -0.25738628E+00 -0.28120520E+00
  0.12536838E-08
 -0.29587488E-01  0.18783021E-02 -0.22336777E-02 -0.39661808E-03  0.16851600E-03
  0.66461593E-02  0.34163647E-02  0.13742377E-01 -0.10104043E-02  0.49893364E-02
 -0.60170046E-03 -0.14564571E-01 -0.86340795E-03  0.16592405E-01  0.18121620E-01
 -0.80210517E-10
  0.35195375E-01 -0.22336777E-02  0.26594830E-02  0.47177557E-03 -0.20254311E-03
 -0.79035160E-02 -0.40676607E-02 -0.15535996E-01  0.11399046E-02 -0.54257344E-02
  0.65730920E-03  0.16623515E-01  0.95490796E-03 -0.18755658E-01 -0.20350996E-01
  0.10026648E-09
  0.62478959E-02 -0.39661808E-03  0.47177557E-03  0.83773805E-04 -0.35621756E-04
 -0.14034475E-02 -0.72156538E-03 -0.28803855E-02  0.21259093E-03 -0.10456599E-02
  0.12388443E-03  0.30605147E-02  0.17987428E-03 -0.34783056E-02 -0.37986056E-02
  0.17731623E-10
 -0.26621894E-02  0.16851600E-03 -0.20254311E-03 -0.35621756E-04  0.16780683E-04
  0.59604144E-03  0.30983472E-03  0.65220718E-03 -0.38883699E-04  0.50986045E-04
 -0.75016289E-05 -0.84575049E-03 -0.36331692E-04  0.76616943E-03  0.80713009E-03
 -0.49814072E-11
 -0.10469196E+00  0.66461593E-02 -0.79035160E-02 -0.14034475E-02  0.59604144E-03
  0.23517076E-01  0.12088138E-01  0.48576831E-01 -0.35770441E-02  0.17664877E-01
```

-0.21301536E-02 -0.51508263E-01 -0.30439931E-02 0.58664349E-01 0.64096042E-01
-0.28765535E-09
-0.53830330E-01 0.34163647E-02 -0.40676607E-02 -0.72156538E-03 0.30983472E-03
0.12088138E-01 0.62216089E-02 0.23826575E-01 -0.17466397E-02 0.83248485E-02
-0.10005537E-02 -0.25467673E-01 -0.14701187E-02 0.28754364E-01 0.31179116E-01
-0.15204444E-09
-0.21324152E+00 0.13742377E-01 -0.15535996E-01 -0.28803855E-02 0.65220718E-03
0.48576831E-01 0.23826575E-01 0.17452142E+01 -0.78921742E-01 0.35457210E+00
-0.31715492E-01 -0.63132361E+00 -0.62783106E-01 0.88587689E+00 0.10730086E+01
-0.31628406E-08
0.15638458E-01 -0.10104043E-02 0.11399046E-02 0.21259093E-03 -0.38883699E-04
-0.35770441E-02 -0.17466397E-02 -0.78921742E-01 0.10940711E-01 -0.65241058E-01
-0.76809355E-03 0.31878759E-01 0.16198281E-02 -0.91564178E-01 -0.10289302E+00
0.36642126E-09
-0.76518234E-01 0.49893364E-02 -0.54257344E-02 -0.10456599E-02 0.50986045E-04
0.17664877E-01 0.83248485E-02 0.35457210E+00 -0.65241058E-01 0.64424338E+00
-0.14623422E-01 -0.43150909E+00 -0.70791245E-02 0.31166960E+00 0.78693972E+00
-0.10570370E-08
0.92522178E-02 -0.60170046E-03 0.65730920E-03 0.12388443E-03 -0.75016289E-05
-0.21301536E-02 -0.10005537E-02 -0.31715492E-01 -0.76809355E-03 -0.14623422E-01
0.32655510E-01 0.23781051E-01 -0.48431879E-02 -0.11690760E-01 -0.47164423E-01
-0.19916996E-09
0.22700509E+00 -0.14564571E-01 0.16623515E-01 0.30605147E-02 -0.84575049E-03
-0.51508263E-01 -0.25467673E-01 -0.63132361E+00 0.31878759E-01 -0.43150909E+00
0.23781051E-01 0.14107352E+01 0.38530192E-01 -0.77952411E+00 -0.88814211E+00
0.69405310E-09
0.13357522E-01 -0.86340795E-03 0.95490796E-03 0.17987428E-03 -0.36331692E-04
-0.30439931E-02 -0.14701187E-02 -0.62783106E-01 0.16198281E-02 -0.70791245E-02
-0.48431879E-02 0.38530192E-01 0.15555388E-01 -0.73327582E-01 -0.10853488E+00
0.30666951E-10
-0.25738628E+00 0.16592405E-01 -0.18755658E-01 -0.34783056E-02 0.76616943E-03
0.58664349E-01 0.28754364E-01 0.88587689E+00 -0.91564178E-01 0.31166960E+00
-0.11690760E-01 -0.77952411E+00 -0.73327582E-01 0.20267258E+01 0.13263911E+01
-0.36721517E-08
-0.28120520E+00 0.18121620E-01 -0.20350996E-01 -0.37986056E-02 0.80713009E-03
0.64096042E-01 0.31179116E-01 0.10730086E+01 -0.10289302E+00 0.78693972E+00
-0.47164423E-01 -0.88814211E+00 -0.10853488E+00 0.13263911E+01 0.19761338E+01
-0.65771092E-09
0.12536838E-08 -0.80210517E-10 0.10026648E-09 0.17731623E-10 -0.49814072E-11
-0.28765535E-09 -0.15204444E-09 -0.31628406E-08 0.36642126E-09 -0.10570370E-08
-0.19916996E-09 0.69405310E-09 0.30666951E-10 -0.36721517E-08 -0.65771092E-09
0.40360440E-15

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.46414452E+00
2	1	0.99976324E+00
3	1	0.99969526E+00
4	1	0.82633511E+00

5	1	0.97121186E+00
6	1	0.17884164E-02
7	1	0.69595742E+00
8	1	0.52121732E+00
9	1	0.66371907E+00
10	1	0.70594318E+00
11	1	0.99961736E+00
12	1	0.80606197E+00
13	1	0.63077321E+00
14	1	0.62790375E+00
15	1	0.43059872E+00
16	1	0.32779005E+00
17	1	0.72323261E+00
18	1	0.66056909E+00
19	1	0.46135627E+00
20	1	0.43921418E+00
21	1	0.99945038E+00
22	1	0.99367726E+00
23	1	0.73128284E+00
24	1	0.65825138E+00
25	1	0.99945038E+00
26	1	0.28482147E+00
27	1	0.99951034E+00
28	1	0.98551512E+00
29	1	0.99969529E+00
30	1	0.42952291E+00
31	1	0.55692736E+00
32	1	0.85332723E+00
33	1	0.69526661E+00
34	1	0.87666726E+00
35	1	0.79439201E+00
36	1	0.71455620E+00

mean efficiency = 0.70914463E+00

Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file =   buy.txt

Tech. Eff. Effects Frontier (see B&C 1993)
The model is a cost function
The dependent variable is logged

the ols estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.88074919E+01	0.51621524E+00	0.17061666E+02
beta 1	-0.13901491E-02	0.21760110E-01	-0.63885208E-01
beta 2	0.30930530E-01	0.39230330E-01	0.78843409E+00
beta 3	0.32512703E-01	0.18311462E-01	0.17755383E+01
beta 4	0.70071647E-02	0.36813126E-01	0.19034419E+00
beta 5	0.19961823E+00	0.24942638E-01	0.80030924E+01
sigma-squared	0.28975627E+00		

log likelihood function = -0.64052263E+02

the estimates after the grid search were :

beta 0	0.81825990E+01
beta 1	-0.13901491E-02
beta 2	0.30930530E-01
beta 3	0.32512703E-01
beta 4	0.70071647E-02
beta 5	0.19961823E+00
sigma-squared	0.65955049E+00
gamma	0.93000000E+00

```
 iteration =     0  func evals =     20  llf = -0.60548080E+02
    0.81825990E+01-0.13901491E-02 0.30930530E-01 0.32512703E-01 0.70071647E-02
    0.19961823E+00 0.65955049E+00 0.93000000E+00
 gradient step
 iteration =     5  func evals =     41  llf = -0.58860292E+02
    0.81774888E+01 0.10072070E-01 0.16531833E-01 0.25658291E-01-0.40375778E-01
    0.24236792E+00 0.66112998E+00 0.95813718E+00
 iteration =    10  func evals =     98  llf = -0.57385990E+02
    0.72816700E+01 0.67641998E-02 0.60031236E-01 0.22135527E-01-0.28764157E-01
    0.28427843E+00 0.80965591E+00 0.99483853E+00
 iteration =    15  func evals =    169  llf = -0.56157968E+02
    0.69007646E+01 0.95991229E-02 0.96452096E-01 0.15299339E-01-0.52313544E-01
    0.31336281E+00 0.96528489E+00 0.99999999E+00
 iteration =    16  func evals =    174  llf = -0.56157908E+02
```

0.69007754E+01 0.95990389E-02 0.96451437E-01 0.15299416E-01-0.52313177E-01
0.31336199E+00 0.96528295E+00 0.99999993E+00

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.69007754E+01	0.65477731E+00	0.10539118E+02
beta 1	0.95990389E-02	0.12385699E-01	0.77500988E+00
beta 2	0.96451437E-01	0.43957956E-01	0.21941748E+01
beta 3	0.15299416E-01	0.12979282E-01	0.11787567E+01
beta 4	-0.52313177E-01	0.37094653E-01	-0.14102619E+01
beta 5	0.31336199E+00	0.39152883E-01	0.80035482E+01
sigma-squared	0.96528295E+00	0.12220945E+00	0.78985947E+01
gamma	0.99999993E+00	0.34323260E-02	0.29134759E+03

log likelihood function = -0.56157968E+02

LR test of the one-sided error = 0.15788589E+02
with number of restrictions = 1
[note that this statistic has a mixed chi-square distribution]

number of iterations = 16

(maximum number of iterations set at : 100)

number of cross-sections = 84

number of time periods = 1

total number of observations = 84

thus there are: 0 obsns not in the panel

covariance matrix :

0.42873333E+00 -0.27733696E-02 -0.17353062E-01 -0.13372212E-02 -0.71359352E-02
-0.20479646E-01 0.39357257E-03 -0.48412531E-03
-0.27733696E-02 0.15340554E-03 0.19619428E-03 -0.10070221E-03 -0.13857961E-03
0.20262436E-03 -0.32710801E-03 0.96567605E-05
-0.17353062E-01 0.19619428E-03 0.19323019E-02 -0.66415257E-04 -0.49776569E-03
0.57151617E-03 0.17702299E-02 0.60507957E-04
-0.13372212E-02 -0.10070221E-03 -0.66415257E-04 0.16846177E-03 0.17243146E-03
-0.12511343E-04 -0.48678746E-03 -0.25772732E-04
-0.71359352E-02 -0.13857961E-03 -0.49776569E-03 0.17243146E-03 0.13760133E-02
-0.78173238E-04 -0.11852516E-02 -0.18916311E-04
-0.20479646E-01 0.20262436E-03 0.57151617E-03 -0.12511343E-04 -0.78173238E-04
0.15329483E-02 0.23265198E-03 0.29413098E-04

0.39357257E-03 -0.32710801E-03 0.17702299E-02 -0.48678746E-03 -0.11852516E-02
0.23265198E-03 0.14935151E-01 0.13991024E-03
-0.48412531E-03 0.96567605E-05 0.60507957E-04 -0.25772732E-04 -0.18916311E-04
0.29413098E-04 0.13991024E-03 0.11780862E-04

cost efficiency estimates :

firm	year	eff.-est.
1	1	0.11543789E+01
2	1	0.38265028E+01
3	1	0.29772263E+02
4	1	0.23452430E+01
5	1	0.20504754E+01
6	1	0.20202204E+02
7	1	0.24640440E+01
8	1	0.15474472E+01
9	1	0.12023174E+01
10	1	0.42913684E+01
11	1	0.26676812E+01
12	1	0.20540674E+01
13	1	0.15995094E+01
14	1	0.38941521E+01
15	1	0.16842837E+01
16	1	0.13381416E+01
17	1	0.10179363E+01
18	1	0.15769462E+01
19	1	0.25975509E+01
20	1	0.10424243E+01
21	1	0.33613616E+01
22	1	0.11811643E+01
23	1	0.16755847E+01
24	1	0.17517297E+01
25	1	0.44940421E+01
26	1	0.24092260E+01
27	1	0.27625286E+01
28	1	0.13797978E+01
29	1	0.24432836E+01
30	1	0.11984241E+01
31	1	0.21360208E+01
32	1	0.25244890E+01
33	1	0.18947795E+01
34	1	0.22845518E+01
35	1	0.26448852E+01
36	1	0.13729733E+01
37	1	0.38805496E+01
38	1	0.69442787E+01
39	1	0.12107802E+01
40	1	0.16097694E+01
41	1	0.17462243E+01
42	1	0.14071212E+01
43	1	0.33833991E+01
44	1	0.13673020E+01

45	1	0.10011598E+01
46	1	0.17339042E+01
47	1	0.15119014E+01
48	1	0.15082982E+01
49	1	0.12960503E+01
50	1	0.10672113E+01
51	1	0.19611191E+01
52	1	0.13778504E+01
53	1	0.11170560E+01
54	1	0.26859356E+01
55	1	0.13970857E+01
56	1	0.16913659E+01
57	1	0.25397562E+01
58	1	0.11075367E+01
59	1	0.60240418E+01
60	1	0.29900008E+01
61	1	0.26001462E+01
62	1	0.17142383E+01
63	1	0.29726297E+01
64	1	0.17474410E+01
65	1	0.14169825E+01
66	1	0.22144334E+01
67	1	0.19913986E+01
68	1	0.28376062E+01
69	1	0.21120875E+01
70	1	0.24818993E+01
71	1	0.18301123E+01
72	1	0.11860167E+01
73	1	0.42055043E+01
74	1	0.15705457E+01
75	1	0.10666461E+01
76	1	0.10889433E+01
77	1	0.21279595E+01
78	1	0.12149217E+01
79	1	0.18119520E+01
80	1	0.11030436E+01
81	1	0.17533293E+01
82	1	0.13956290E+01
83	1	0.28093039E+01
84	1	0.90600766E+01

mean efficiency = 0.27466229E+01

```
Output from the program FRONTIER (Version 4.1c)
instruction file = terminal
data file =        cowp.txt
 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a cost function
 The dependent variable is logged
the ols estimates are :
              coefficient     standard-error    t-ratio
  beta 0         0.80691813E+01  0.87264281E+00  0.92468317E+01
  beta 1        -0.85584821E-02  0.36639916E-01 -0.23358356E+00
  beta 2         0.30381621E-01  0.29458709E-01  0.10313290E+01
  beta 3        -0.17336910E-01  0.47524590E-01 -0.36479873E+00
  beta 4         0.91820004E-01  0.43157279E-01  0.21275670E+01
  beta 5         0.20060064E+00  0.54399921E-01  0.36875172E+01
  sigma-squared  0.30972870E+00
log likelihood function =  -0.26702945E+02
the estimates after the grid search were :
  beta 0         0.75382406E+01
  beta 1        -0.85584821E-02
  beta 2         0.30381621E-01
  beta 3        -0.17336910E-01
  beta 4         0.91820004E-01
  beta 5         0.20060064E+00
  delta 0        0.00000000E+00
  sigma-squared  0.54000522E+00
  gamma          0.82000000E+00
 iteration =     0  func evals =     20  llf = -0.25841627E+02
    0.75382406E+01-0.85584821E-02 0.30381621E-01-0.17336910E-01 0.91820004E-01
    0.20060064E+00 0.00000000E+00 0.54000522E+00 0.82000000E+00
 gradient step
 iteration =     5  func evals =     42  llf = -0.25586434E+02
    0.75249113E+01-0.23008662E-01 0.20801415E-01-0.30799524E-01 0.10012345E+00
    0.22566608E+00-0.90502848E-02 0.53199674E+00 0.83161127E+00
 iteration =    10  func evals =     99  llf = -0.23923798E+02
    0.55363517E+01-0.42332248E-02 0.63724303E-02 0.34683654E-01 0.11073713E+00
    0.35496213E+00-0.51172747E+00 0.90038337E+00 0.96725930E+00
 iteration =    13  func evals =    146  llf = -0.22027462E+02
    0.43816343E+01-0.89538135E-02-0.33316549E-02 0.81612533E-01 0.97389076E-01
    0.45092369E+00-0.11449834E+01 0.12896868E+01 0.99999999E+00
the final mle estimates are :
              coefficient     standard-error    t-ratio
  beta 0         0.43816343E+01  0.71247991E+00  0.61498355E+01
  beta 1        -0.89538135E-02  0.33968259E-01 -0.26359353E+00
  beta 2        -0.33316549E-02  0.19979587E-01 -0.16675294E+00
  beta 3         0.81612533E-01  0.40454751E-01  0.20173782E+01
  beta 4         0.97389076E-01  0.25387857E-01  0.38360495E+01
  beta 5         0.45092369E+00  0.14543592E+00  0.31004973E+01
  delta 0       -0.11449834E+01  0.14485093E+01 -0.79045637E+00
```

```
 sigma-squared  0.12896868E+01  0.81190087E+00  0.15884782E+01
 gamma          0.99999999E+00  0.31648669E-01  0.31596905E+02
```

log likelihood function = -0.22027579E+02
LR test of the one-sided error = 0.93507308E+01
with number of restrictions = 2
[note that this statistic has a mixed chi-square distribution]
number of iterations = 13
(maximum number of iterations set at : 100)
number of cross-sections = 36
number of time periods = 1
total number of observations = 36
thus there are: 0 obsns not in the panel
covariance matrix :

```
 0.50762762E+00 -0.14013825E-01 -0.35440992E-01  0.43084816E-02 -0.61347943E-01
 0.13780151E+00 -0.16207051E+01  0.97544235E+00  0.15069690E-01
-0.14013825E-01  0.11538426E-02  0.18946043E-03  0.26282011E-03  0.14398804E-03
 0.12046404E-03  0.74758264E-03 -0.12492897E-02  0.67640524E-04
-0.35440992E-01  0.18946043E-03  0.39918390E-03  0.93931346E-03 -0.20469044E-02
 0.47501412E-02 -0.48220609E-01  0.28188241E-01  0.14302229E-03
 0.43084816E-02  0.26282011E-03  0.93931346E-03  0.16365869E-02  0.12439562E-02
-0.37794643E-02  0.39239653E-01 -0.23459807E-01 -0.54032404E-03
-0.61347943E-01  0.14398804E-03 -0.20469044E-02  0.12439562E-02  0.64454327E-03
 0.74546222E-02 -0.68377790E-01  0.39088373E-01  0.26615025E-03
 0.13780151E+00  0.12046404E-03  0.47501412E-02 -0.37794643E-02  0.74546222E-02
 0.21151608E-01  0.22970044E+00 -0.13590743E+00 -0.14351634E-02
-0.16207051E+01  0.74758264E-03 -0.48220609E-01  0.39239653E-01 -0.68377790E-01
 0.22970044E+00  0.20981792E+01  0.12416360E+01  0.99725636E-02
 0.97544235E+00 -0.12492897E-02  0.28188241E-01 -0.23459807E-01  0.39088373E-01
-0.13590743E+00  0.12416360E+01  0.65918302E+00 -0.65799058E-02
 0.15069690E-01  0.67640524E-04  0.14302229E-03 -0.54032404E-03  0.26615025E-03
-0.14351634E-02  0.99725636E-02 -0.65799058E-02  0.10016383E-02
```

cost efficiency estimates :

firm	year	eff.-est.
1	1	0.10019432E+01
2	1	0.15527551E+01
3	1	0.20055969E+01
4	1	0.14155194E+01
5	1	0.14582789E+01
6	1	0.15662598E+01
7	1	0.38239392E+01
8	1	0.14578179E+01
9	1	0.19324478E+01
10	1	0.14674796E+01

11	1	0.16926934E+01
12	1	0.15080386E+01
13	1	0.11918861E+01
14	1	0.16006352E+01
15	1	0.15297826E+01
16	1	0.11129441E+01
17	1	0.44454372E+01
18	1	0.12636774E+01
19	1	0.11950437E+01
20	1	0.21442635E+01
21	1	0.52541214E+02
22	1	0.38740057E+01
23	1	0.18493912E+01
24	1	0.20130545E+01
25	1	0.26986548E+01
26	1	0.12367017E+01
27	1	0.16914934E+01
28	1	0.15353843E+01
29	1	0.20055969E+01
30	1	0.13517683E+01
31	1	0.26470272E+01
32	1	0.11876859E+01
33	1	0.10019432E+01
34	1	0.11714512E+01
35	1	0.48562472E+01
36	1	0.17542064E+01

mean efficiency = 0.32995074E+01

GROUNDNUT

Output from the program FRONTIER (Version 4.1c)

```
instruction file = terminal
data file =        gmale.txt

 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a production function
 The dependent variable is logged

the ols estimates are :

                coefficient     standard-error    t-ratio

  beta 0         0.58625206E+01  0.61075306E+00  0.95988395E+01
  beta 1        -0.60482738E-02  0.74650924E-01 -0.81020749E-01
  beta 2        -0.38511961E+00  0.75230393E+00 -0.51192025E+00
  beta 3         0.31080472E-01  0.51309831E-01  0.60574107E+00
  beta 4        -0.37102563E-01  0.81318354E-01 -0.45626309E+00
  beta 5         0.42183217E-01  0.17562735E+00  0.24018592E+00
  beta 6         0.32900839E-01  0.12872344E+00  0.25559323E+00
  sigma-squared  0.74991494E+00

log likelihood function =  -0.10344895E+03

the estimates after the grid search were :

  beta 0         0.68613544E+01
  beta 1        -0.60482738E-02
  beta 2        -0.38511961E+00
  beta 3         0.31080472E-01
  beta 4        -0.37102563E-01
  beta 5         0.42183217E-01
  beta 6         0.32900839E-01
  delta 0        0.00000000E+00
  delta 1        0.00000000E+00
  delta 2        0.00000000E+00
  delta 3        0.00000000E+00
  delta 4        0.00000000E+00
  delta 5        0.00000000E+00
  delta 6        0.00000000E+00
  sigma-squared  0.16850909E+01
  gamma          0.93000000E+00

 iteration =     0  func evals =     20  llf = -0.92701534E+02
    0.68613544E+01-0.60482738E-02-0.38511961E+00 0.31080472E-01-0.37102563E-01
    0.42183217E-01 0.32900839E-01 0.00000000E+00 0.00000000E+00 0.00000000E+00
    0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.16850909E+01
```

```
   0.93000000E+00
 gradient step
 iteration =     5  func evals =     43  llf = -0.87209179E+02
   0.68311958E+01-0.12052661E-02-0.37768439E+00 0.14879547E-01-0.76319266E-01
   0.34367295E-01 0.13432169E-01-0.51140859E-02-0.78034183E-02-0.89508700E-02
  -0.13725934E+00-0.88234256E-02 0.17218892E-01 0.18126297E-01 0.17051791E+01
   0.89865347E+00
 iteration =    10  func evals =     67  llf = -0.83019115E+02
   0.62897819E+01-0.79923826E-02-0.96322971E-02 0.23262893E-01-0.24637361E-01
  -0.72528010E-01 0.47356245E-01-0.35239992E+00-0.16338660E-01-0.50214580E+00
  -0.18586716E+00-0.41756673E+00 0.28682980E-01 0.11007296E+01 0.24979004E+01
   0.93732150E+00
 iteration =    15  func evals =    134  llf = -0.78281108E+02
   0.61134730E+01-0.20205913E-01 0.43534230E-01 0.33470739E-03-0.39134613E-01
   0.28561924E-01 0.10372297E+00-0.32725739E+01 0.60823378E-01-0.33905458E+01
  -0.35348407E+00-0.45188590E+00 0.92413319E-01 0.40274952E+01 0.22902993E+01
   0.89710898E+00
 iteration =    20  func evals =    165  llf = -0.78153212E+02
   0.61156182E+01-0.20797906E-01 0.24634831E-01-0.26660038E-03-0.39256945E-01
   0.28955374E-01 0.10299472E+00-0.34081959E+01 0.62974866E-01-0.34424757E+01
  -0.35950542E+00-0.47388962E+00 0.94226211E-01 0.41264557E+01 0.22854085E+01
   0.89663950E+00
 iteration =    25  func evals =    192  llf = -0.78150530E+02
   0.61156321E+01-0.20811436E-01 0.24472827E-01-0.27768358E-03-0.39258104E-01
   0.28956869E-01 0.10298256E+00-0.34111244E+01 0.63018190E-01-0.34433417E+01
  -0.35962381E+00-0.47418121E+00 0.94262602E-01 0.41282851E+01 0.22850288E+01
   0.89661392E+00
 iteration =    30  func evals =    214  llf = -0.78150515E+02
   0.61156320E+01-0.20811518E-01 0.24472298E-01-0.27775092E-03-0.39258105E-01
   0.28956859E-01 0.10298251E+00-0.34111406E+01 0.63018431E-01-0.34433451E+01
  -0.35962441E+00-0.47418241E+00 0.94262792E-01 0.41282942E+01 0.22850244E+01
   0.89661365E+00
```

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.61156320E+01	0.41284735E+00	0.14813301E+02
beta 1	-0.20811518E-01	0.57032713E-01	-0.36490494E+00
beta 2	0.24472298E-01	0.55136032E+00	0.44385308E-01
beta 3	-0.27775092E-03	0.41265832E-01	-0.67307723E-02
beta 4	-0.39258105E-01	0.57110379E-01	-0.68740753E+00
beta 5	0.28956859E-01	0.11389798E+00	0.25423506E+00
beta 6	0.10298251E+00	0.98265232E-01	0.10480055E+01
delta 0	-0.34111406E+01	0.35752836E+01	-0.95408953E+00
delta 1	0.63018431E-01	0.92735907E-01	0.67954726E+00
delta 2	-0.34433451E+01	0.13593445E+01	-0.25330923E+01
delta 3	-0.35962441E+00	0.15613189E+00	-0.23033374E+01
delta 4	-0.47418241E+00	0.58454330E+00	-0.81120152E+00
delta 5	0.94262792E-01	0.77611200E-01	0.12145514E+01

delta 6 0.41282942E+01 0.20062977E+01 0.20576678E+01
sigma-squared 0.22850244E+01 0.13424519E+01 0.17021276E+01
gamma 0.89661365E+00 0.83551244E-01 0.10731302E+02

log likelihood function = -0.78150515E+02

LR test of the one-sided error = 0.50596863E+02
with number of restrictions = 8
[note that this statistic has a mixed chi-square distribution]

number of iterations = 30
(maximum number of iterations set at : 100)
number of cross-sections = 84
number of time periods = 1
total number of observations = 84
thus there are: 0 obsns not in the panel

covariance matrix :

0.17044293E+00 -0.20644794E-02 -0.51309422E-02 -0.49346076E-03 -0.90982090E-02
0.62204731E-03 -0.22097089E-01 0.23968603E+00 0.38824319E-02 0.42690978E-01
0.79972302E-02 -0.27102153E-01 -0.10126344E-01 -0.18062783E+00 0.11877766E+00
0.47466910E-02
-0.20644794E-02 0.32527303E-02 0.65764914E-02 0.68980677E-03 -0.12388548E-02
0.52029313E-03 0.81478816E-03 0.72153836E-01 -0.18664359E-02 0.22061839E-01
0.30667714E-02 0.41716394E-02 -0.60130879E-03 -0.35123643E-01 0.23317461E-01
0.15993921E-02
-0.51309422E-02 0.65764914E-02 0.30399820E+00 -0.53767448E-03 -0.50633503E-02
0.14427342E-01 0.54920236E-02 0.37095538E+00 -0.14607265E-01 0.11833217E+00
-0.31256329E-03 -0.59057530E-01 0.33552973E-02 0.16831162E-01 0.18386523E+00
0.10099696E-01
-0.49346076E-03 0.68980677E-03 -0.53767448E-03 0.17028689E-02 0.79786596E-04
-0.26215677E-03 -0.30937424E-03 0.56963079E-01 -0.12127263E-02 0.81422483E-02
0.26514817E-02 0.66098072E-02 -0.46470207E-03 -0.31924498E-01 0.22648749E-01
0.15429355E-02
-0.90982090E-02 -0.12388548E-02 -0.50633503E-02 0.79786596E-04 0.32615954E-02
-0.10218265E-02 -0.23046286E-02 -0.70267713E-02 0.31496342E-03 0.22402619E-02
-0.38885297E-03 -0.47402880E-02 0.61963904E-04 -0.30161775E-03 -0.36437589E-02
-0.17898115E-03
0.62204731E-03 0.52029313E-03 0.14427342E-01 -0.26215677E-03 -0.10218265E-02
0.12972749E-01 0.24538018E-02 0.15202848E-01 -0.11937343E-02 -0.71470966E-03
0.20242102E-03 0.35445025E-02 0.92430700E-03 -0.27274573E-02 0.12537170E-01
0.66586862E-03
-0.22097089E-01 0.81478816E-03 0.54920236E-02 -0.30937424E-03 -0.23046286E-02
0.24538018E-02 0.96560558E-02 0.34160798E-01 -0.23293655E-02 0.18843834E-02
0.16945992E-02 0.20508046E-01 0.10772018E-02 -0.38854177E-02 0.69216618E-02
0.11376658E-02
0.23968603E+00 0.72153836E-01 0.37095538E+00 0.56963079E-01 -0.70267713E-02
0.15202848E-01 0.34160798E-01 0.12782652E+02 -0.21616485E+00 0.24538962E+01
0.44589812E+00 0.63600365E+00 -0.13546493E+00 -0.64566990E+01 0.41362149E+01

0.26998955E+00
0.38824319E-02 -0.18664359E-02 -0.14607265E-01 -0.12127263E-02 0.31496342E-03
-0.11937343E-02 -0.23293655E-02 -0.21616485E+00 0.85999484E-02 -0.69660508E-01
-0.10022566E-01 -0.28748976E-01 -0.10896442E-02 0.97687823E-01 -0.71717525E-01
-0.47720180E-02
0.42690978E-01 0.22061839E-01 0.11833217E+00 0.81422483E-02 0.22402619E-02
-0.71470966E-03 0.18843834E-02 0.24538962E+01 -0.69660508E-01 0.18478174E+01
0.10783253E+00 -0.61897443E-01 -0.41170216E-01 -0.16352062E+01 0.70904603E+00
0.51600162E-01
0.79972302E-02 0.30667714E-02 -0.31256329E-03 0.26514817E-02 -0.38885297E-03
0.20242102E-03 0.16945992E-02 0.44589812E+00 -0.10022566E-01 0.10783253E+00
0.24377167E-01 0.43604010E-01 -0.55624942E-02 -0.23523983E+00 0.14694769E+00
0.10106179E-01
-0.27102153E-01 0.41716394E-02 -0.59057530E-01 0.66098072E-02 -0.47402880E-02
0.35445025E-02 0.20508046E-01 0.63600365E+00 -0.28748976E-01 -0.61897443E-01
0.43604010E-01 0.34169087E+00 0.93699569E-02 -0.35690259E+00 0.27547835E+00
0.21075776E-01
-0.10126344E-01 -0.60130879E-03 0.33552973E-02 -0.46470207E-03 0.61963904E-04
0.92430700E-03 0.10772018E-02 -0.13546493E+00 -0.10896442E-02 -0.41170216E-01
-0.55624942E-02 0.93699569E-02 0.60234984E-02 0.86365230E-01 -0.47509145E-01
-0.30388015E-02
-0.18062783E+00 -0.35123643E-01 0.16831162E-01 -0.31924498E-01 -0.30161775E-03
-0.27274573E-02 -0.38854177E-02 -0.64566990E+01 0.97687823E-01 -0.16352062E+01
-0.23523983E+00 -0.35690259E+00 0.86365230E-01 0.40252305E+01 -0.22576318E+01
-0.14880331E+00
0.11877766E+00 0.23317461E-01 0.18386523E+00 0.22648749E-01 -0.36437589E-02
0.12537170E-01 0.69216618E-02 0.41362149E+01 -0.71717525E-01 0.70904603E+00
0.14694769E+00 0.27547835E+00 -0.47509145E-01 -0.22576318E+01 0.18021771E+01
0.10640984E+00
0.47466910E-02 0.15993921E-02 0.10099696E-01 0.15429355E-02 -0.17898115E-03
0.66586862E-03 0.11376658E-02 0.26998955E+00 -0.47720180E-02 0.51600162E-01
0.10106179E-01 0.21075776E-01 -0.30388015E-02 -0.14880331E+00 0.10640984E+00
0.69808103E-02

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.89244984E+00
2	1	0.81944070E+00
3	1	0.87733359E+00
4	1	0.71274546E+00
5	1	0.63058584E+00
6	1	0.85626161E+00
7	1	0.71274546E+00
8	1	0.59830071E+00
9	1	0.83527433E+00
10	1	0.89386300E+00
11	1	0.88701431E+00
12	1	0.64042585E+00
13	1	0.54208608E+00
14	1	0.80713562E+00

15	1	0.68468541E+00
16	1	0.71316476E+00
17	1	0.52639952E+00
18	1	0.61347620E+00
19	1	0.75006813E+00
20	1	0.62234379E+00
21	1	0.70094614E+00
22	1	0.56417828E+00
23	1	0.80773593E+00
24	1	0.60425276E+00
25	1	0.66242285E+00
26	1	0.59854484E+00
27	1	0.84280294E+00
28	1	0.70327150E+00
29	1	0.86395608E+00
30	1	0.79181574E+00
31	1	0.74088923E+00
32	1	0.21560127E+00
33	1	0.84938106E+00
34	1	0.28782199E+00
35	1	0.79836496E+00
36	1	0.65814743E+00
37	1	0.76367202E+00
38	1	0.87360093E+00
39	1	0.83458833E+00
40	1	0.69427251E+00
41	1	0.79998606E+00
42	1	0.54633656E+00
43	1	0.78405238E+00
44	1	0.65869879E+00
45	1	0.71125265E+00
46	1	0.64310727E+00
47	1	0.80249913E+00
48	1	0.72667779E+00
49	1	0.52809095E+00
50	1	0.83799287E+00
51	1	0.83014404E+00
52	1	0.42060938E+00
53	1	0.65054601E+00
54	1	0.73053197E+00
55	1	0.74039950E+00
56	1	0.69000114E+00
57	1	0.71866634E+00
58	1	0.73777761E+00
59	1	0.54566656E+00
60	1	0.70669512E+00
61	1	0.77316419E+00
62	1	0.73293273E+00
63	1	0.80902940E+00
64	1	0.81198064E+00

65	1	0.78144270E+00
66	1	0.82204551E+00
67	1	0.81362016E+00
68	1	0.74493291E+00
69	1	0.60448404E+00
70	1	0.61421433E+00
71	1	0.79907894E+00
72	1	0.77759423E+00
73	1	0.48314933E+00
74	1	0.78267189E+00
75	1	0.68706464E+00
76	1	0.84996554E+00
77	1	0.57223086E+00
78	1	0.59926868E+00
79	1	0.70818387E+00
80	1	0.59905701E+00
81	1	0.84769033E+00
82	1	0.62461200E+00
83	1	0.73798946E+00
84	1	0.38614033E-02

mean efficiency = 0.70073886E+00

```
Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file =        kiv.txt

 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a production function
 The dependent variable is logged

the ols estimates are :
               coefficient     standard-error    t-ratio

  beta 0         0.29888516E+01  0.29109629E+01  0.10267570E+01
  beta 1        -0.25949135E-01  0.29139334E+00 -0.89051914E-01
  beta 2        -0.98940628E-01  0.12658341E+01 -0.78162398E-01
  beta 3         0.12847252E+00  0.19829122E+00  0.64789817E+00
  beta 4        -0.74327634E-01  0.18843107E+00 -0.39445529E+00
  beta 5         0.68825950E+00  0.66899709E+00  0.10287930E+01
  beta 6         0.32513063E+00  0.40136967E+00  0.81005281E+00
  sigma-squared  0.22908256E+01

log likelihood function =  -0.62110191E+02
the estimates after the grid search were :

  beta 0         0.46693226E+01
  beta 1        -0.25949135E-01
  beta 2        -0.98940628E-01
  beta 3         0.12847252E+00
  beta 4        -0.74327634E-01
  beta 5         0.68825950E+00
  beta 6         0.32513063E+00
  delta 0        0.00000000E+00
  delta 1        0.00000000E+00
  delta 2        0.00000000E+00
  delta 3        0.00000000E+00
  delta 4        0.00000000E+00
  delta 5        0.00000000E+00
  delta 6        0.00000000E+00
  sigma-squared  0.46693700E+01
  gamma          0.95000000E+00

 iteration =     0  func evals =     20  llf = -0.54723141E+02
    0.46693226E+01-0.25949135E-01-0.98940628E-01 0.12847252E+00-0.74327634E-01
    0.68825950E+00 0.32513063E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00
    0.00000000E+00 0.00000000E+00 0.00000000E+00 0.00000000E+00 0.46693700E+01
    0.95000000E+00
 gradient step
 iteration =     5  func evals =     95  llf = -0.44998750E+02
    0.46396928E+01 0.10910646E-01-0.10436956E+00 0.63098498E-01-0.88390778E-01
```

```
   0.50921750E+00 0.46860390E+00 0.63294830E-03-0.24530316E-02 0.70605292E-01
  -0.14146495E+00 0.12625919E-01-0.73282907E-01 0.60625757E-02 0.46739527E+01
   0.98408606E+00
 iteration =    10  func evals =    114  llf = -0.37136576E+02
   0.48278248E+01-0.16408744E-01-0.15176627E+00-0.12629249E-02 0.14582602E-01
   0.33918406E+00 0.58920727E+00-0.27062972E-01-0.15246805E+00 0.16505124E+01
  -0.25898565E+00 0.29035687E+00 0.29422028E-01-0.50552527E-01 0.45716240E+01
   0.99705837E+00
 iteration =    15  func evals =    161  llf = -0.28564194E+02
   0.55213316E+01 0.89693525E-01-0.31481502E+00-0.53552476E-02 0.17358175E-01
   0.11850775E+00 0.52656302E+00-0.24102745E+00-0.25287492E+00 0.33934723E+01
  -0.33603822E+00 0.40263504E+00 0.75371717E-01-0.72030236E+00 0.45029947E+01
   0.99999999E+00
 iteration =    20  func evals =    210  llf = -0.28380535E+02
   0.55411690E+01 0.92796247E-01-0.33016143E+00-0.63353842E-02 0.16865638E-01
   0.11196389E+00 0.52766705E+00-0.24967280E+00-0.25307351E+00 0.33990968E+01
  -0.33693370E+00 0.39924034E+00 0.74979081E-01-0.75002370E+00 0.45152294E+01
   0.99999999E+00
 iteration =    25  func evals =    246  llf = -0.27533793E+02
   0.57145539E+01 0.91715747E-01-0.43485514E+00-0.13007424E-01 0.15007945E-01
   0.75210985E-01 0.55716206E+00-0.30625528E+00-0.25332743E+00 0.34475276E+01
  -0.35685763E+00 0.36147104E+00 0.77824406E-01-0.95091425E+00 0.46015235E+01
   0.99999999E+00
 iteration =    30  func evals =    334  llf = -0.24557853E+02
   0.53561743E+01 0.92844897E-01-0.11391210E+01-0.11615003E-01 0.31853826E-01
   0.12894286E+00 0.56307753E+00-0.78199645E+00-0.26397261E+00 0.45339519E+01
  -0.56080409E+00 0.84766223E-01 0.91796703E-01-0.25390306E+01 0.55041553E+01
   0.99999999E+00
 iteration =    35  func evals =    501  llf = -0.23547572E+02
   0.52858277E+01 0.92404728E-01-0.14426933E+01-0.12793554E-01 0.30837412E-01
   0.14687634E+00 0.56104734E+00-0.97203739E+00-0.27405936E+00 0.49962081E+01
  -0.61744098E+00-0.34754433E-01 0.10387412E+00-0.31624638E+01 0.59123511E+01
   0.99999999E+00
 iteration =    40  func evals =   1423  llf = -0.22531867E+02
   0.52096838E+01 0.92582592E-01-0.14602601E+01-0.14321358E-01 0.29034117E-01
   0.16795338E+00 0.55940764E+00-0.16267023E+01-0.35566323E+00 0.64591777E+01
  -0.73134972E+00-0.26646206E+00 0.23514451E+00-0.53294366E+01 0.73938100E+01
   0.99999989E+00
 iteration =    44  func evals =   1451  llf = -0.22528117E+02
   0.52093710E+01 0.92582625E-01-0.14602637E+01-0.14327723E-01 0.29027211E-01
   0.16803865E+00 0.55940056E+00-0.16292413E+01-0.35585441E+00 0.64658810E+01
  -0.73226804E+00-0.26621221E+00 0.23523857E+00-0.53375754E+01 0.73976235E+01
   0.99999989E+00
the final mle estimates are :
              coefficient     standard-error    t-ratio

  beta 0         0.52093710E+01  0.12899674E+00  0.40383741E+02
  beta 1         0.92582625E-01  0.54056023E-03  0.17127162E+03
  beta 2        -0.14602637E+01  0.14337044E-01 -0.10185250E+03
  beta 3        -0.14327723E-01  0.25489864E-02 -0.56209492E+01
```

beta 4	0.29027211E-01	0.27657721E-02	0.10495157E+02
beta 5	0.16803865E+00	0.34768131E-01	0.48331228E+01
beta 6	0.55940056E+00	0.30805898E-02	0.18158879E+03
delta 0	-0.16292413E+01	0.13293827E+01	-0.12255623E+01
delta 1	-0.35585441E+00	0.11162886E+00	-0.31878352E+01
delta 2	0.64658810E+01	0.22921128E+01	0.28209262E+01
delta 3	-0.73226804E+00	0.35921238E+00	-0.20385379E+01
delta 4	-0.26621221E+00	0.94593439E+00	-0.28142777E+00
delta 5	0.23523857E+00	0.12769219E+00	0.18422315E+01
delta 6	-0.53375754E+01	0.29407705E+01	-0.18150262E+01
sigma-squared	0.73976235E+01	0.17099482E+01	0.43262266E+01
gamma	0.99999989E+00	0.12049193E-06	0.82993099E+07

log likelihood function = -0.22528122E+02

LR test of the one-sided error = 0.79164139E+02
with number of restrictions = 8
[note that this statistic has a mixed chi-square distribution]
number of iterations = 44
(maximum number of iterations set at : 100)
number of cross-sections = 36
number of time periods = 1
total number of observations = 36
thus there are: 0 obsns not in the panel
covariance matrix :

0.16640160E-01 0.26747693E-04 0.49242480E-04 0.32513433E-03 0.34799340E-03
-0.44822284E-02 0.39152609E-03 0.10054164E+00 0.82727203E-02 -0.25271517E+00
0.32547948E-01 -0.30623186E-02 -0.63841849E-02 0.31770042E+00 -0.16228103E+00
0.13560840E-07
0.26747693E-04 0.29220536E-06 -0.13719749E-05 0.43922050E-06 0.48936790E-06
-0.69693672E-05 0.65272360E-06 -0.29439459E-04 -0.76226040E-05 0.59146397E-04
0.18723355E-04 -0.50869717E-04 0.13927908E-04 -0.11223585E-03 0.99309292E-04
0.13426366E-11
0.49242480E-04 -0.13719749E-05 0.20555082E-03 0.15843755E-05 0.16863878E-05
-0.15119637E-04 0.81436750E-06 0.12973903E-02 0.12709498E-03 -0.31879393E-02
0.31954699E-03 0.15780992E-03 -0.14231614E-03 0.42834462E-02 -0.21350539E-02
0.15206835E-09
0.32513433E-03 0.43922050E-06 0.15843755E-05 0.64973318E-05 0.69128510E-05
-0.87800206E-04 0.75850748E-05 0.20334273E-02 0.16843879E-03 -0.51296651E-02
0.63818576E-03 -0.40545924E-04 -0.12469266E-03 0.64145919E-02 -0.32536106E-02
0.27005276E-09
0.34799340E-03 0.48936790E-06 0.16863878E-05 0.69128510E-05 0.76494951E-05
-0.94458152E-04 0.79105849E-05 0.22384389E-02 0.19020030E-03 -0.56295616E-02
0.69725069E-03 -0.24651711E-04 -0.15088624E-03 0.70739395E-02 -0.36233235E-02
0.30006051E-09
-0.44822284E-02 -0.69693672E-05 -0.15119637E-04 -0.87800206E-04 -0.94458152E-04
0.12088229E-02 -0.10491001E-03 -0.27454601E-01 -0.22730870E-02 0.69006730E-01
-0.88201652E-02 0.72778124E-03 0.17656209E-02 -0.86763837E-01 0.44359424E-01
-0.36977896E-08

0.39152609E-03 0.65272360E-06 0.81436750E-06 0.75850748E-05 0.79105849E-05
-0.10491001E-03 0.94900332E-05 0.22597783E-02 0.17809544E-03 -0.56437413E-02
0.77317085E-03 -0.10353005E-03 -0.14181574E-03 0.71518052E-02 -0.36786608E-02
0.30597675E-09
0.10054164E+00 -0.29439459E-04 0.12973903E-02 0.20334273E-02 0.22384389E-02
-0.27454601E-01 0.22597783E-02 0.17672583E+01 0.46264617E-01 -0.19588328E+01
0.25246512E+00 -0.41480368E-01 -0.56560438E-01 0.24282455E+01 -0.12891859E+01
0.11025580E-06
0.82727203E-02 -0.76226040E-05 0.12709498E-03 0.16843879E-03 0.19020030E-03
-0.22730870E-02 0.17809544E-03 0.46264617E-01 0.12461003E-01 -0.18933608E+00
0.94788405E-02 -0.18578010E-01 -0.71735432E-02 0.18888902E+00 -0.14010726E+00
0.95575344E-08
-0.25271517E+00 0.59146397E-04 -0.31879393E-02 -0.51296651E-02 -0.56295616E-02
0.69006730E-01 -0.56437413E-02 -0.19588328E+01 -0.18933608E+00 0.52537809E+01
-0.57191672E+00 -0.70290097E-01 0.12512336E+00 -0.62547250E+01 0.34189110E+01
-0.27610684E-06
0.32547948E-01 0.18723355E-04 0.31954699E-03 0.63818576E-03 0.69725069E-03
-0.88201652E-02 0.77317085E-03 0.25246512E+00 0.94788405E-02 -0.57191672E+00
0.12903353E+00 0.52307643E-01 -0.23221050E-01 0.80420680E+00 -0.36081019E+00
0.32418086E-07
-0.30623186E-02 -0.50869717E-04 0.15780992E-03 -0.40545924E-04 -0.24651711E-04
0.72778124E-03 -0.10353005E-03 -0.41480368E-01 -0.18578010E-01 -0.70290097E-01
0.52307643E-01 0.89479186E+00 -0.37915749E-01 -0.12478482E+00 0.23396278E-02
0.31314041E-08
-0.63841849E-02 0.13927908E-04 -0.14231614E-03 -0.12469266E-03 -0.15088624E-03
0.17656209E-02 -0.14181574E-03 -0.56560438E-01 -0.71735432E-02 0.12512336E+00
-0.23221050E-01 -0.37915749E-01 0.16305295E-01 -0.17405550E+00 0.10421020E+00
-0.80358374E-08
0.31770042E+00 -0.11223585E-03 0.42834462E-02 0.64145919E-02 0.70739395E-02
-0.86763837E-01 0.71518052E-02 0.24282455E+01 0.18888902E+00 -0.62547250E+01
0.80420680E+00 -0.12478482E+00 -0.17405550E+00 0.86481312E+01 -0.40788303E+01
0.34977330E-06
-0.16228103E+00 0.99309292E-04 -0.21350539E-02 -0.32536106E-02 -0.36233235E-02
0.44359424E-01 -0.36786608E-02 -0.12891859E+01 -0.14010726E+00 0.34189110E+01
-0.36081019E+00 0.23396278E-02 0.10421020E+00 -0.40788303E+01 0.29239230E+01
-0.18218825E-06
0.13560840E-07 0.13426366E-11 0.15206835E-09 0.27005276E-09 0.30006051E-09
-0.36977896E-08 0.30597675E-09 0.11025580E-06 0.95575344E-08 -0.27610684E-06
0.32418086E-07 0.31314041E-08 -0.80358374E-08 0.34977330E-06 -0.18218825E-06
0.14518306E-13

technical efficiency estimates :

firm	year	eff.-est.
1	1	0.17854565E-02
2	1	0.99343374E+00
3	1	0.73046417E+00
4	1	0.62589364E+00
5	1	0.99415817E+00

6	1	0.16945135E-02
7	1	0.30323027E+00
8	1	0.25734525E+00
9	1	0.87752075E+00
10	1	0.78192954E+00
11	1	0.99700188E+00
12	1	0.99700143E+00
13	1	0.99674121E+00
14	1	0.56111035E+00
15	1	0.63113009E+00
16	1	0.14826174E+00
17	1	0.99582776E+00
18	1	0.47676421E+00
19	1	0.47340669E+00
20	1	0.45086732E+00
21	1	0.92725636E+00
22	1	0.98725485E+00
23	1	0.76893372E+00
24	1	0.99708181E+00
25	1	0.92725636E+00
26	1	0.70204342E+00
27	1	0.72974555E+00
28	1	0.98759125E+00
29	1	0.73046300E+00
30	1	0.70262446E+00
31	1	0.57806412E+00
32	1	0.82968989E+00
33	1	0.70028844E+00
34	1	0.72142251E+00
35	1	0.30827439E+00
36	1	0.81356422E+00

mean efficiency = 0.68630896E+00

```
Output from the program FRONTIER (Version 4.1c)


instruction file = terminal
data file =        game.txt


 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a cost function
 The dependent variable is logged


the ols estimates are :

              coefficient     standard-error    t-ratio

  beta 0         0.85226493E+01  0.43249301E+00  0.19705866E+02
  beta 1        -0.31526328E-02  0.19483291E-01 -0.16181213E+00
  beta 2        -0.17710269E-01  0.33868592E-01 -0.52291129E+00
  beta 3         0.29373672E-02  0.14639713E-01  0.20064377E+00
  beta 4         0.38868170E-01  0.40592604E-01  0.95751850E+00
  beta 5         0.23763115E+00  0.25597119E-01  0.92835113E+01
  sigma-squared  0.30333180E+00

log likelihood function =  -0.65975323E+02

the estimates after the grid search were :

  beta 0         0.78661203E+01
  beta 1        -0.31526328E-02
  beta 2        -0.17710269E-01
  beta 3         0.29373672E-02
  beta 4         0.38868170E-01
  beta 5         0.23763115E+00
  sigma-squared  0.71269553E+00
  gamma          0.95000000E+00


 iteration =     0  func evals =     20  llf = -0.60567950E+02
    0.78661203E+01-0.31526328E-02-0.17710269E-01 0.29373672E-02 0.38868170E-01
    0.23763115E+00 0.71269553E+00 0.95000000E+00
 gradient step
 iteration =     5  func evals =     43  llf = -0.59230707E+02
    0.78614047E+01-0.24004345E-02-0.22768275E-01-0.44357450E-02-0.54565766E-02
    0.27435138E+00 0.71120506E+00 0.96117901E+00
 iteration =    10  func evals =     96  llf = -0.58591047E+02
    0.72034199E+01 0.21353811E-03-0.19324917E-01-0.23782973E-02 0.20139726E-01
    0.31276022E+00 0.75838086E+00 0.97498859E+00
 iteration =    15  func evals =    179  llf = -0.58590235E+02
```

0.71871504E+01 0.20686223E-03-0.19144988E-01-0.23780285E-02 0.21560828E-01
0.31316274E+00 0.75912564E+00 0.97550577E+00

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.71871504E+01	0.66529481E+00	0.10802956E+02
beta 1	0.20686223E-03	0.14405462E-01	0.14359985E-01
beta 2	-0.19144988E-01	0.23513720E-01	-0.81420496E+00
beta 3	-0.23780285E-02	0.10981986E-01	-0.21653902E+00
beta 4	0.21560828E-01	0.50877218E-01	0.42378158E+00
beta 5	0.31316274E+00	0.42038392E-01	0.74494461E+01
sigma-squared	0.75912564E+00	0.14446294E+00	0.52548122E+01
gamma	0.97550577E+00	0.21802763E-01	0.44742299E+02

log likelihood function = -0.58590235E+02

LR test of the one-sided error = 0.14770177E+02
with number of restrictions = 1
[note that this statistic has a mixed chi-square distribution]

number of iterations = 15

(maximum number of iterations set at : 100)

number of cross-sections = 84

number of time periods = 1

total number of observations = 84

thus there are: 0 obsns not in the panel

covariance matrix :

0.44261719E+00 -0.14936722E-02 -0.66441680E-03 -0.12203167E-02 -0.23012497E-01
-0.22254880E-01 -0.22368726E-01 -0.58575286E-02
-0.14936722E-02 0.20751735E-03 0.63962099E-04 -0.16236281E-04 -0.18187392E-03
0.13868869E-03 0.18554059E-03 0.30168329E-04
-0.66441680E-03 0.63962099E-04 0.55289504E-03 -0.70962701E-04 -0.15088967E-03
0.10700684E-03 0.40896719E-03 0.10173138E-03
-0.12203167E-02 -0.16236281E-04 -0.70962701E-04 0.12060402E-03 0.13128373E-03
0.16269440E-05 -0.10884882E-03 -0.21674092E-04
-0.23012497E-01 -0.18187392E-03 -0.15088967E-03 0.13128373E-03 0.25884913E-02
0.28284569E-03 -0.11752283E-03 0.17335217E-04
-0.22254880E-01 0.13868869E-03 0.10700684E-03 0.16269440E-05 0.28284569E-03
0.17672264E-02 0.16624466E-02 0.44990100E-03

-0.22368726E-01 0.18554059E-03 0.40896719E-03 -0.10884882E-03 -0.11752283E-03
0.16624466E-02 0.20869542E-01 0.17970509E-02
-0.58575286E-02 0.30168329E-04 0.10173138E-03 -0.21674092E-04 0.17335217E-04
0.44990100E-03 0.17970509E-02 0.47536049E-03

cost efficiency estimates :

firm	year	eff.-est.
1	1	0.19540184E+01
2	1	0.37370887E+01
3	1	0.24564960E+02
4	1	0.18457211E+01
5	1	0.18565020E+01
6	1	0.10635415E+02
7	1	0.19876122E+01
8	1	0.13442206E+01
9	1	0.10649580E+01
10	1	0.37571032E+01
11	1	0.27399442E+01
12	1	0.13992753E+01
13	1	0.15049572E+01
14	1	0.35568633E+01
15	1	0.17273982E+01
16	1	0.12902518E+01
17	1	0.11469844E+01
18	1	0.12721382E+01
19	1	0.25833307E+01
20	1	0.12077174E+01
21	1	0.26331370E+01
22	1	0.10914358E+01
23	1	0.14727523E+01
24	1	0.17529013E+01
25	1	0.30614629E+01
26	1	0.25534102E+01
27	1	0.28911465E+01
28	1	0.13022112E+01
29	1	0.23446620E+01
30	1	0.10951736E+01
31	1	0.20149587E+01
32	1	0.27593856E+01
33	1	0.14771819E+01
34	1	0.25873709E+01
35	1	0.31470828E+01
36	1	0.14891023E+01
37	1	0.30868439E+01
38	1	0.75637101E+01

39	1	0.16390178E+01
40	1	0.15452774E+01
41	1	0.17336604E+01
42	1	0.13105944E+01
43	1	0.33884500E+01
44	1	0.13025490E+01
45	1	0.11526569E+01
46	1	0.12525988E+01
47	1	0.16025159E+01
48	1	0.16369819E+01
49	1	0.15631465E+01
50	1	0.12457640E+01
51	1	0.19975087E+01
52	1	0.16809379E+01
53	1	0.10918434E+01
54	1	0.13041950E+01
55	1	0.25435899E+01
56	1	0.13581045E+01
57	1	0.13129855E+01
58	1	0.14005060E+01
59	1	0.57131754E+01
60	1	0.12605985E+01
61	1	0.21074877E+01
62	1	0.13607535E+01
63	1	0.31117419E+01
64	1	0.18600570E+01
65	1	0.17160922E+01
66	1	0.23852791E+01
67	1	0.17992883E+01
68	1	0.28120588E+01
69	1	0.22256213E+01
70	1	0.27112696E+01
71	1	0.18950601E+01
72	1	0.11843735E+01
73	1	0.42171983E+01
74	1	0.19460712E+01
75	1	0.11396118E+01
76	1	0.11509382E+01
77	1	0.25683429E+01
78	1	0.11830446E+01
79	1	0.16304435E+01
80	1	0.11384258E+01
81	1	0.14570594E+01
82	1	0.13512040E+01
83	1	0.26436978E+01
84	1	0.35341370E+01

mean efficiency = 0.24245988E+01

```
Output from the program FRONTIER (Version 4.1c)

instruction file = terminal
data file =        book.txt

 Tech. Eff. Effects Frontier (see B&C 1993)
 The model is a cost function
 The dependent variable is logged

the ols estimates are :

                coefficient     standard-error    t-ratio

  beta 0         0.77530566E+01  0.78167880E+00  0.99184685E+01
  beta 1         0.34610893E-01  0.27501326E-01  0.12585173E+01
  beta 2         0.29308634E-02  0.32773416E-01  0.89428070E-01
  beta 3        -0.30123621E-01  0.58757792E-01 -0.51267450E+00
  beta 4        -0.35558303E-02  0.42200596E-01 -0.84260192E-01
  beta 5         0.27996428E+00  0.54753649E-01  0.51131620E+01
  sigma-squared  0.38631129E+00

log likelihood function =  -0.30679986E+02

the estimates after the grid search were :

  beta 0         0.72037320E+01
  beta 1         0.34610893E-01
  beta 2         0.29308634E-02
  beta 3        -0.30123621E-01
  beta 4        -0.35558303E-02
  beta 5         0.27996428E+00
  sigma-squared  0.62368354E+00
  gamma          0.76000000E+00

 iteration =     0  func evals =     20  llf = -0.30106999E+02
    0.72037320E+01 0.34610893E-01 0.29308634E-02-0.30123621E-01-0.35558303E-02
    0.27996428E+00 0.62368354E+00 0.76000000E+00
 gradient step
 iteration =     5  func evals =     41  llf = -0.29859383E+02
    0.71944858E+01 0.34610019E-01 0.97531895E-02-0.50901365E-01 0.46088257E-02
    0.29654604E+00 0.61763989E+00 0.76789648E+00
 iteration =    10  func evals =     83  llf = -0.28223944E+02
    0.47363072E+01 0.49237855E-01 0.26526919E-01 0.43365927E-01 0.17982713E-01
    0.44315456E+00 0.85808247E+00 0.98634896E+00
 pt better than entering pt cannot be found
 iteration =    13  func evals =    121  llf = -0.26693863E+02
    0.41605190E+01 0.53938336E-01 0.26626877E-01 0.68330307E-01 0.26253703E-01
    0.47510907E+00 0.98127368E+00 0.99999999E+00
```

the final mle estimates are :

	coefficient	standard-error	t-ratio
beta 0	0.41605190E+01	0.70641439E+00	0.58896295E+01
beta 1	0.53938336E-01	0.15973463E-01	0.33767465E+01
beta 2	0.26626877E-01	0.26968330E-01	0.98733874E+00
beta 3	0.68330307E-01	0.57295839E-01	0.11925876E+01
beta 4	0.26253703E-01	0.34017113E-01	0.77177928E+00
beta 5	0.47510907E+00	0.58886797E-01	0.80681764E+01
sigma-squared	0.98127368E+00	0.18547802E+00	0.52905118E+01
gamma	0.99999999E+00	0.85748422E-04	0.11662022E+05

log likelihood function = -0.26693863E+02

LR test of the one-sided error = 0.79722472E+01
with number of restrictions = 1
[note that this statistic has a mixed chi-square distribution]

number of iterations = 13

(maximum number of iterations set at : 100)

number of cross-sections = 36

number of time periods = 1

total number of observations = 36

thus there are: 0 obsns not in the panel

covariance matrix :

0.49902128E+00 0.57820345E-02 0.10159762E-02 -0.28232163E-01 0.18360345E-02
-0.33325601E-01 -0.48568301E-02 0.77899733E-06
0.57820345E-02 0.25515152E-03 -0.17863551E-03 -0.38423886E-03 -0.27411370E-03
-0.31824291E-03 -0.78531213E-03 -0.87120478E-08
0.10159762E-02 -0.17863551E-03 0.72729082E-03 0.35764446E-03 0.16797201E-03
-0.41212135E-03 -0.61432538E-03 -0.45770471E-08
-0.28232163E-01 -0.38423886E-03 0.35764446E-03 0.32828132E-02 0.21428666E-03
0.46294105E-03 0.60494395E-03 -0.46346485E-07
0.18360345E-02 -0.27411370E-03 0.16797201E-03 0.21428666E-03 0.11571640E-02
-0.38224825E-03 0.31083467E-03 0.25226313E-07
-0.33325601E-01 -0.31824291E-03 -0.41212135E-03 0.46294105E-03 -0.38224825E-03
0.34676549E-02 -0.26860872E-03 -0.31775753E-07
-0.48568301E-02 -0.78531213E-03 -0.61432538E-03 0.60494395E-03 0.31083467E-03
-0.26860872E-03 0.34402098E-01 -0.46649807E-07
0.77899733E-06 -0.87120478E-08 -0.45770471E-08 -0.46346485E-07 0.25226313E-07
-0.31775753E-07 -0.46649807E-07 0.73527919E-08

cost efficiency estimates :

firm	year	eff.-est.
1	1	0.16729348E+01
2	1	0.15764273E+01
3	1	0.37595926E+01
4	1	0.12295855E+01
5	1	0.19531449E+01
6	1	0.15466008E+01
7	1	0.38038207E+01
8	1	0.14661865E+01
9	1	0.25308471E+01
10	1	0.16729348E+01
11	1	0.24471086E+01
12	1	0.24471086E+01
13	1	0.14255207E+01
14	1	0.15504226E+01
15	1	0.18244243E+01
16	1	0.13110306E+01
17	1	0.47680212E+01
18	1	0.10002870E+01
19	1	0.10850706E+01
20	1	0.11443222E+01
21	1	0.63779975E+02
22	1	0.38408791E+01
23	1	0.15506257E+01
24	1	0.35795301E+01
25	1	0.28454614E+01
26	1	0.13259990E+01
27	1	0.19822677E+01
28	1	0.16394330E+01
29	1	0.37595926E+01
30	1	0.20445135E+01
31	1	0.14097414E+01
32	1	0.12273702E+01
33	1	0.16729348E+01
34	1	0.11313949E+01
35	1	0.19004158E+01
36	1	0.19042958E+01

mean efficiency = 0.37724950E+01