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An Analysis of Economic Efficiency in Bean Production: Evidence from Eastern Uganda

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Abstract
Bean has emerged to be an important cash crop as well as a staple food in Uganda; however, the country's bean productivity per unit area cultivated has been on the decline for the past ten years. This study estimated the economic efficiency levels and assessed the factors influencing economic efficiency among bean farmers in Eastern Uganda, by applying a stochastic frontier cost function and a two-limit Tobit regression model, based on a random sample of 580 households. Findings revealed that the mean economic efficiency level was 59.94% and it was positively influenced by value of assets, off-farm income, credit and farmers' primary occupation. Based on the findings from this study, there is need for government and stakeholders to train farmers on entrepreneurial skills so that they can divest their farm profits into more income generating activities which would harness more farming capital. Finally, there is a need for initiatives geared towards enhancing farmers' access to adequate credit for farming at affordable interest rates and using groups as collateral, so that they could invest more in farming to increase their economic efficiency and farm productivity.
Key words: stochastic frontier approach, smallholder farmers, Tobit regression model

1. Introduction

Uganda's economy is predominantly agricultural and it employs about 70.8% of the population. At the rural household level, the proportion of the population directly involved in agricultural activities is high with crop production accounting for more than 70% of the employment within the sector itself. However, about 68.1% depend on agriculture for subsistence, while the rest practice farming for commercial purposes (FAO 2009). Overall, the sector accounts for 25% of the Gross Domestic Product (GDP), (UBOS 2010) and serves as an important provider of inputs for the other production activities, especially the manufacturing sector. Moreover, 80% of the Ugandan population live in rural areas and depend almost entirely on Agriculture for their livelihoods; hence the sector serves as a basic source and provider of food self-sufficiency and security for majority of the population.

Beans are the most widely grown pulses and second only to maize as a food crop and a major source of food security in East Africa (Mauyo et al. 2007). It is readily available and a popular food to both the urban and rural population in Uganda. It also provides about 25% of the total calories and 45% of the protein intake of the diets of many Ugandans (NARO 2000). The crop is also a staple food of more than 300 million diets worldwide. In fact, Uganda's bean consumption has been increasing since the 1980's. In 1987, Food and Agriculture Organization (FAO) estimated Uganda's bean consumption at 29.3 kg per capita (Kirkby 1987). However, recent studies show that the country's per capita consumption has increased to over 58 kg (Soniia and Sperling 1999). This compares with Rwanda and parts of western Kenya with some of the highest consumption levels in the world at 66 kg per capita per year. Beans are also valued by the poor because all parts of the plant can be consumed: the grain is eaten fresh or dried, the leaves are used as vegetables and the stalk is used to make soda ash (Soniia et al. 2000).

In Uganda, consumers prefer large seeded red-mottled bean grain types, followed by the purple and red types, while the pale and white colours are not popular. Large red-mottled varieties comprise some of the traditional types such as *K20*, a determinate variety developed by the national research program in the 1960's (Rubaihayo et al. 1981) and the semi climbers referred to as *Nambale*. However, the new improved varieties developed by the national agricultural research organization have also received high market reception especially *K132, K131* and *NABE 2* (Kalyebara 2008). Other important grain types available in the country include the medium size types such as the red-medium type (*Kayinja*) and the brown-red oval types (*Kanyebwa).* The small-seeded *Lango* beans are usually black or cream coloured bUSH bean varieties and are popular in Northern Uganda. Several other bean seed types are cultivated in Uganda, with definite regional differences in preferences for production and consumption (Hidalgo 1991).

Beans are also important source of income for many Ugandan farmers and traders due to the increasing demand both in the domestic and export markets, such as Kenya. According FAO statistics (2009), beans accounted for 6.1% of the total national agricultural GDP and ranked fifth behind banana, cassava, indigenous cattle meat and cattle milk in terms of value of output. This implies that harnessing the bean yield potential through increased investment in bean research could lead to significant improvements in the health and wellbeing of many Ugandans.

Uganda's bean production is common in the central, eastern and western regions. It is mainly dominated by small scale farmers who have limited resources and produce the crop under unfavourable conditions (such as little use of inputs, marginal lands and intercropping with competitive crops). The average plot size for these farmers ranges from 0.1 to 0.5 hectares per household (Hoogendijk and Soniia 1997). Therefore, the greater percentage of beans is usually grown for household consumption with a small percentage sold to the market or through other venues (Wortmann et al. 2004).

Uganda's total bean output was increasing rapidly between 1997 and 2002 as indicated by FAO statistics (2011). These statistics correspond with the introduction of improved and more disease resistant varieties by NARO during the same period (Kalyebara 2008). In fact, during this period the productivity per hectare was also increasing every year. However, subsequent years (from 2002 to 2006) saw a series of fluctuations in bean output, resulting in a general decline in domestic food supply per capita during the same period. Even as the statistics for 2006 to 2011 reveal an upward trend in bean output, the country's productivity per hectare has been on the decline trend since 2001 (Table 1). The average bean yield in the country has been recorded as 0.6-0.8 Mt Ha^{-1}, which depicts a major shortfall from the potential yield of 1.5-2.0 Mt Ha^{-1} realized with improved varieties and good crop husbandry under farm level conditions (Kalyebara 2008).

Various Government and non-governmental organizations (such as CIAT[1] and PABRA[2]) have designed interventions, in Eastern Uganda, to intensify the application of soil enhancing technologies with the aim of boosting productivity levels. However, the impact of such intervention in improving efficiency levels of the smallholder farmers is not clearly understood. Therefore, this study compared the economic efficiency levels of smallholder farmers who used (treated) and those who did not use (non-treated) soil enhancing technologies. The factors influencing economic efficiency among bean farmers in Eastern Uganda were also assessed. Economic efficiency is the ability of a bean farmer to employ a cost minimizing combination of farm inputs while still producing the maximum possible output, given the available technology. Findings from this study provide evidence as to whether bean farmers were utilizing available resources in a cost effective manner.

The rest of this paper is organized as follows: section two discusses the materials and methods, section three presents' results and discussions, while section four entails the conclusions and policy recommendations of the study.

2. Materials and methods

2.1 Study area

This paper is based on a study conducted in the Eastern region of Uganda which focused on four districts namely: Mbale, Tororo, Busia and Budaka. Bean production is high in these districts (over 80% of households grow beans). The study area covered two agro-ecological zones: the Montane agro-ecological zone, in which Mbale falls, is found at higher elevations between 1500-1700 metres above sea level and receives high and effective rainfall. In addition, the soils in this zone are majorly volcanic with medium to high productivity (Mwebaze 1999). The Banana-millet-cotton agro ecological zone covers Tororo, Busia and Budaka districts and is found at lower elevations, receiving less evenly distributed rainfall ranging between 1000-1500mm p.a. The soils in the banana-millet zone are a mixture of volcanic and alluvial with low to medium productivity. The major staple crops grown in the study area include: bananas, sweet potatoes, cassava, Irish potatoes and beans. Other crops grown include coffee, wheat, barley, maize, millet, peas, simsim, sunflower, cotton, rice, onions and carrots (Mwebaze 1999).

The population in the districts was also found to be very high (the lowest being Busia at 287,800 and the highest being Tororo at 493,300). In addition, population growth in the districts was relatively high ranging between 2.5-3.5% per year (CIA World Fact book 2011). However, the total land area in Uganda is 241,548 Km^2 of which 75% is available for cultivation. Therefore the capacity of this land resource to sustain the livelihoods of Ugandans given this rapidly increasing population largely depends on how well edaphic (soil related), climatic and biotic factors can be managed to increase and sustain its productivity.

2.2 Data

The population of interest constituted smallholder producers of beans in Eastern Uganda; the sampling unit was the farm household; while the unit of analysis was the household head. A multistage sampling technique was used which involved a purposive sampling of four districts in Eastern Uganda; after which a simple random sampling procedure was used at the district, sub-county, parish and village levels for each district. A sample of 580 households was randomly selected using a list of farmers in the village. The sample size was then

[1] CIAT: International Center for Tropical Agriculture;
[2] PABRA: Pan-Africa Bean Research Alliance

proportionately disaggregated as follows for the four districts, based on the intensity of bean production: Busia (343), Mbale (112), Tororo (85) and Budaka (40). Primary data was collected in November 2012 for the main cropping season using personally administered structured questionnaires and through observation.

The data included information on bean farming operations such as: quantities of seeds, planting and topdressing fertilizer, pesticides, herbicides, fungicides, manure, land area and labour man-days. Corresponding information on average input prices was also collected from the respondents. The land area under beans (in hectares) was then used to standardize the rest of the inputs in terms of the quantities per hectare. Data was also collected on household socio-economic and institutional characteristics such as the farmer's age, gender, years of schooling, farming experience, main occupation, household size, income and asset profiles, distance to the market, extension contacts, group membership and credit.

2.3 Model specification: Review of approaches for measuring efficiency

Since Farrell (1957), there has been a series of studies in the analysis of efficiencies in all fields. In the field of agriculture, the modeling and estimation of the stochastic function, has been proposed by Aigneir et al. (1977) and Meeusen and van den Broeck (1977). A critical review of the frontier literature dealing with farm level efficiency in developing countries conducted by Battese (1992), Coelli (1995) and Thiam et al. (2001) indicated that there were wide-ranging theoretical issues that had to be dealt with in measuring efficiency in the context of frontiers which included selection of functional forms and the relevant approaches to use.

Two approaches that can be used in measuring efficiency are the parametric and non-parametric models, which differ in two ways. First, they differ on assumptions of the distribution of the error term that represents inefficiency. Second, they differ in the way the functional form is imposed on the data. Parametric methods use econometric approaches to impose functional and distributional forms on the error term whereas the non-parametric methods do not (Hyuha et al. 2007). Parametric models suffer from the same criticism as the frontier deterministic models, in a sense that they do not take into account the possible influence of measurement errors and other noises in the data as do stochastic frontier models (Thiam et al. 2001). The results can also be misleading because they do not allow for a random error as is the case with stochastic parametric approaches. Besides, non-parametric methods also lack statistical tests that would tell us about the confidence of the results. For this reason, this study adopts the stochastic frontier model to measure and explain economic inefficiencies of farmers.

2.4 Stochastic Frontier Model

Afriat (1972) was the first to propose the formulation and application of a deterministic production frontier model (Taylor and Shonkwiler 1986). The basic structure of the model is as shown in equation 1:

$$Y = f(x,\beta)e^{-\mu} \qquad (1)$$

Where f (x, ß) denotes the frontier production function and μ is a one-sided non-negative distribution term. This model imposes a constraint of $\mu \geq 0$, which implies that actual output is less than or equal to the potential, given the input and output prices. According to Taylor and Shonkwiler (1986), the model is in full agreement with production theory, but the main criticism against it is that all the observed variations are accounted for by the management practices as pointed out earlier. No account is taken of statistical noise such as random errors, omitted variables and shocks.

On the other hand, the history of stochastic models began with Aigneir and Chu (1968) who suggested a composite error term and since their work, much effort has been exerted to finding an appropriate model to measure efficiency. This resulted in the development of a stochastic frontier model (Aigner et al. 1977). The model improved the deterministic model by introducing 'ν' into the deterministic model to form a composite error term model (stochastic frontier).

The error term in the stochastic frontier model is assumed to have two additive components namely: a symmetric component which represents the effect of statistical noise (e.g. weather, topography, distribution of supplies and measurement error). The other error component captures systematic influences that are unexplained by the production function and are attributed to the effect of inefficiency (Tijani 2006). The model is specified as:

$$Y = f(x,\beta)e^{(\mathrm{V}-\mu)} \qquad (2)$$

Where f (x, ß), is as defined in (1) and ν-μ is error term, The V_i's are random variables which are assumed to be iid[1] $N(0,\delta V^2)$ and independent of the U_i's which are non-negative random variables assumed to account for inefficiency in production and are often assumed to be iid $(N(0, \delta u^2)$. Assuming that equation 2 is a self-dual production frontier such as the Cobb-Douglas function, then the dual cost frontier can be expressed as:

$$C_i = g(P_i;\alpha)e^{(V+\mu)} \qquad (3)$$

Where C_i is the minimum cost incurred by the i^{th} farmer to produce output Y; g is a suitable function (C-D); P_i represents a vector of prices of labour (wage), fertilizer, seeds, chemical inputs and manure employed by the i^{th} farmer in bean production; α is the parameter to be estimated; V_i's and U_i's are as specified above.

[1] iid-Independent and Identically distributed random errors

In this case, U_i captures the level of farmer-specific economic inefficiency. The maximum likelihood estimates of the parameters in the stochastic frontier cost function defined by equations 2 & 3 are obtained using STATA computer software. We then apply Shepherd's Lemma in partially differentiating the cost frontier with respect to each input price to obtain the system of minimum cost input demand equations as:

$$\frac{\partial C}{\partial P_i} = X_{di} = f(P_i Y_i; \varphi) \quad (4)$$

In equation 4 φ is a vector of parameters to be estimated. We can then obtain the economically efficient input quantities (X_{ie}) from input demand equations, by substituting the farms' input prices P and output quantity Y^* into equation 4. Further, it is now possible to calculate the cost of the actual or observed input bundle as $\sum X_i * P_i$ while the cost of economically efficient input bundle associated with the farmers' observed output is $\sum X_{ie} * P_i$. Hence we calculate economic efficiency estimates based on these cost measures as follows:

$$EE_i = \sum_i X_{ie} * P_i \Big/ \sum_i X_i * P_i = \frac{cost\ of\ EE\ input\ bundle}{cost\ of\ observed\ input\ bundle} \quad (5)$$

2.5 Tobit model

The economic efficiency estimates obtained by the methods described above are regressed on some farm and household specific attributes using the Tobit model. This approach has been used widely in efficiency literature (Nyagaka et al. 2010; Obare et al. 2010). The farm and household specific factors regressed here include gender, age, education, main occupation and farming experience of the farmer; as well as farm size, off-farm income, value of assets, distance to the market, group membership and credit. The choice of these variables was intuitive although they have been found to have an effect on the level of efficiency among smallholder farmers. The structural equation of the Tobit model is therefore given as:

$$y_i^* = X_i\beta + \varepsilon_i \quad (6)$$

Where Y_i^* is a latent variable for the i[th] bean farmer that is observed for values greater than τ and censored for value less than or equal to τ. The Tobit model can be generalized to take account of censoring both from below and from above. X is a vector of independent variables postulated to influence efficiency. The β's are parameters associated with the independent variables to be estimated. The ε is the independently distributed error term assumed to be normally distributed with a mean of zero and a constant variance. The observed y is defined by the following generic measurement equation:

$$y_i = y^* \ if\ y^* > \tau$$
$$y_i = \tau_y \ if\ y^* \leq \tau \quad (7)$$

Typically, the Tobit model assumes that τ = 0 which means the data is censored at zero. However, efficiency scores for the bean farmers range between 0-1. Thus we substitute τ in equation 7 as follows:

$$y_i = y^* \ if\ 0 < y^* < 1$$
$$y_i = 0 \ if\ y^* \leq 0$$
$$y_i = 1 \ if\ y^* \geq 1 \quad (8)$$

Therefore the model assumes that there is an underlying stochastic index equal to ($X_i\beta + \varepsilon_i$) which is observed only when it is some number between 0 and 1; otherwise Y_i^* qualifies as an unobserved latent (hidden) variable. The dependent variable is not normally distributed since its values range between 0 and 1. The empirical Tobit model for this study therefore takes the following form:

$$y_i^* = \beta_0 + \sum_{n=1}^{11} \beta_n Z_i + \varepsilon_i \quad (9)$$

It is important to mention that estimating the model using Ordinary Least Squares (OLS) would produce both inconsistent and biased estimates (Gujarati 2004). This is because OLS underestimates the true effect of the parameters by reducing the slope (Goetz 1995). Therefore, the maximum likelihood estimation is recommended for Tobit analysis.

3. Results and discussion

3.1 Farmer-specific efficiency scores

Predicted farmer-specific economic efficiency scores in Eastern Uganda are summarized in Table 2. The scores were predicted after estimating the stochastic frontier cost function. The findings showed that the mean economic efficiency score among all the sampled farmers was 59.94%, with treated farmers having a higher mean (62.09%) than the overall; compared to non-treated farmers which had a lower mean (57.82%) than the overall. The t-test results also revealed that the mean difference was statistically significant at 5% level, which indicates that the mean economic efficiency score for treated farmers was significantly greater than the mean for non-treated farmers.

The maximum economic efficiency scores were 91.10% and 89.17% for the treated and non-treated farmers respectively. On the other hand, the minimum economic efficiency scores were 0.31% and 3.07% for treated and non-treated farmers respectively. Thus, the most economically efficient farmer as well as the least economically efficient farmer was found among the treated farmers. This also shows that if an average bean farmer were to attain the level of economic efficiency shown by the most efficient treated farmer, then they would realize a saving of 34.20% [(1-(59.94/91.10)) x 100] in terms of total production costs while maximizing their bean productivity. The findings also reveal that there is a huge gap between the least economically efficient and the most economically efficient farmer in the study area. But it is promising to find that 78.51% of the treated farmers and 72.62% of non-treated farmers have economic efficiency scores above 50%.

Across the districts focused in the study, the ANOVA results (Table 3) revealed that economic efficiency levels did not vary significantly across districts. However, mean results indicate that, Tororo district had the highest average economic efficiency levels (67.54%) among bean farmers, whereas Mbale showed the lowest average economic efficiency of 54.78%. Economic efficiency is concerned with costs of production; therefore, the fact that bean farms in Tororo district were located closer to the input markets than all the other districts may have been responsible for the higher levels of economic efficiency in Tororo. In addition, the mean farm sizes in Mbale were the smallest compared to those in the other three districts, which suggests that it is less economical to produce beans in Mbale and this explains why the least economic efficiency levels were registered there.

3.2 Determinants of economic efficiency

The results in Table 4 show estimates of the two-limit Tobit regression of selected socio-economic and institutional-support factors against farmer-specific economic efficiency scores. The model was correctly specified since its chi-square was 48.82 and it was strongly significant at 1% level. In addition, the pseudo R^2 was 72.2%, thus it implies that the independent variables chosen for the model were able to explain 72.2% of the variations in farmer economic efficiency. Among the selected variables, four were found to contribute significantly to economic efficiency namely: main occupation, off-farm income, value of assets and credit.

The *farmer's primary occupation* showed a negative influence on economic efficiency as hypothesised and it was significant at 5% level. The results revealed that farmers whose main occupation was employment, business or any other income generating activity (other than farming) had significantly higher economic efficiency by 0.1% compared to those who were full time farmers. This is attributed to the fact that in farms where the household head was involved in non-farm occupations, the farmer had more funds coming in from such external sources which were used to improve farming activities. The results are consistent with those reported by Mulwa et al. (2009) among maize farmers in Kenya; and also Tijani (2006) among rice farms in Nigeria. In their findings, the authors observed that farmers who entirely depended on farming were disadvantaged in that they did not have regular sources of income to finance their farming; rather, they had to wait until harvest time. In fact, in most cases the proceeds from the farm are not always reinvested back to the farm, due to other household needs or accumulated debts, so that farm productivity decreases over time.

Further findings indicate that *off-farm income* had a positive effect on economic efficiency as hypothesised and it was significant at 5% level. The results indicate that an increase in off-farm income by a unit increased the level of economic efficiency by 2.1%. This suggests that the more income a farmer obtained from off-farm sources the more economically efficient he became. The positive relationship is attributed to the fact that off-farm income provides extra capital that is invested in farming in form of purchasing inputs and hiring labour; hence farmers with such earnings reflect higher farm productivity. Similar findings were reported by Lopez (2008) among selected farms in the USA. However, Kibaara (2005) in a study of maize producers in Kenya observed that efficiency was reduced when farmers had higher off farm income. This may be the case if the type of off-farm activity totally deprives the farmer time to attend to his or her farm.

The other factor influencing economic efficiency was the *value of assets*, which showed a positive effect on economic efficiency as was hypothesised. The coefficient was also strongly significant at 1% level. The results indicate that an increase in the value of assets owned by a unit increased the level of economic efficiency by 3.4%. The results are similar to those by Tchale (2009) among smallholder crop farmers in Malawi, who observed that assets (like livestock units, a radio and a bicycle) owned by the farmers improved their liquidity position thereby ensuring that they were able to purchase inputs promptly. Tchale also mentioned that radios were important for accessing production and market information through the media, while bicycles made it less costly for farmers to transport items to and from the market. As such, asset ownership collectively improved the level of economic efficiency of the bean farmers in the study area.

Finally, economic efficiency was also influenced by the amount of *credit*. The results showed that credit had a positive influence on economic efficiency and it was significant at 5% level. Specifically, it was found that an increase in the amount borrowed by a unit increased economic efficiency by 0.5%. The positive effect suggests that credit is a major contributor of economic efficiency among bean producers in the area. The findings are similar to those reported by Hyuha et al. (2007) among rice producers in Uganda; and also Goncalves et al. (2008) among milk producing farms in Brazil. In these studies, it was observed that access to credit is important in production in the sense that it improves farmers' ability to purchase the otherwise unaffordable farm inputs; and consequently it significantly improves their level of efficiency. There are innovative credit facilities currently coming up that integrate credit providers, producers and traders in such a way that farmers who borrow loans are linked to a ready market for their produce; which in turn enables them to be able to repay the farming loans. On the other hand, the introduction of crop insurance has lessened uncertainties associated with agriculture and boosted confidence among lenders to provide farming loans. Therefore credit has a great potential for improving economic efficiency in Uganda in coming years.

4. Conclusions and policy implications

The main objective in this study was to estimate the economic efficiency levels and assess the factors influencing economic efficiency among bean farmers in Eastern Uganda. It was established that the mean economic efficiency among bean farmers was 59.94% with treated farmers showing a significantly higher mean than the non-treated farmers. However, there was a large discrepancy between the most efficient and the least efficient farmer. It was also encouraging that at least half of the farmers had economic efficiency scores exceeding the 50% limit and could easily improve to the level of the most efficient farmer. Finally, the Tobit regression model estimation revealed that economic efficiency was positively influenced by value of assets at 1% level and off-farm income and credit at 5% level. However, farmers' primary occupation negatively influenced economic efficiency at the 5% level.

Based on the findings from this study, there is need for the government and NGOs concerned with Agriculture to organize seminars where farmers would be trained on entrepreneurship. This will sensitize the farmers to invest their farm profits into more farming equipment and income generating assets that would enable them harness more farming capital for buying farming inputs to improve their productivity. This initiative will also reduce over-dependence on farm produce and provide alternative employment to the young people in the area. The government of Uganda through the Ministry of Agriculture, Animal Industry and Fisheries and other development partners should also come up with more initiatives through which farmers can access adequate credit facilities at affordable interest rates and using groups as collateral, so that smallholder farmers can invest more in farming to increase their economic efficiency and farm productivity.

5. References

Afriat S.N. (1972): Efficiency estimation of production function. International Economic Review, 13: 568-598.

Aigner D.J., Chu S.F. (1968): On estimating the industry production function. American Economic Review, 58: 826-839.

Aigner D.J., Lovell C.A.K., Schmidt P. (1977): Formulation and estimation of stochastic frontier production models. Journal of Econometrics, 6: 21-37.

Battese G.E. (1992): Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics. Agricultural Economics, 7: 185-208.

CIA World Factbook (Uganda country profile) (2011). Available at www.cia.gov/library/publications/the_world_ factbook/geos/ug.html (accessed July 2011).

Coelli T.J. (1995): Recent development in frontier modeling and efficiency measurement. Austrarian Journal of Agricultural Economics, 39: 219-245.

Farrell M.J. (1957): The measurement of productivity efficiency. Journal of Royal Statistical Society Series, 120: 253-290.

Food and Agricultural Organization (FAO) (2007): Conservation Agriculture in Africa. Sustainable agriculture and rural development (SARD), Policy brief (18).

Food and Agricultural Organization (FAO) (Uganda's country profile) (2009). Available at www.fao.org/es/ess/top/country.html (accessed August 2010).

Food and Agricultural Organization (FAO) (Uganda's country profile) (2011). Available at www.fao.org/es/ess/top/country.html (accessed April 2011).

Goetz S.J. (1995): Markets, transaction costs and selectivity models in economic development, Prices, Products and People: Analysing Agricultural Markets in Developing Countries', Boulder, London: Lynne Rienner Publishers.

Gonçalves R., Lima M., Wilson V.C., Eustáquio J.L., Gomes S.T. (2008): Analysis of technical efficiency of milk-producing farms in Minas Gerais. Econ. aplic., São Paulo, 12(2): 321-335.

Grain Sub-sector Analysis (2007): Report on beans, groundnuts, sorghum and upland rice. Submitted to FIT (U) Ltd, Kampala, Uganda.

Gujarati D.N. (2004): Basic Econometrics, 4th Ed. New Delhi: Mc-Graw Hill.

Hidalgo R. (1991): CIAT's world of *Phaseolus* collection. In Van Schoonhoven A and Voysest O (Eds). 'Common beans: Research for crop improvement'. Wallington, UK: C.A.B International, pp.163-189.

Hoogendijik M., Soniia D. (1997): Bean production systems in Mbale district, Uganda with emphasis on varietal diversity and adoption of new climbing varieties. Network on Bean Research in Africa, Occasional Paper Series (32). Kampala, Uganda: CIAT.

Hyuha T.S., Bashaasha B., Nkonya E. Kraybill D. (2007): Analysis of profit inefficiency in rice production in Eastern and Northern Uganda. African Crop Science Journal, 15(4): 243-253.

Kalyebara R. (2008): The impact of improved bush bean varieties in Uganda. Network on Bean Research in Africa, Occasional Publication Series (43). Kampala, Uganda: CIAT.

Kibaara B.W. (2005): Technical efficiency in Kenyans' maize production: An application of the stochastic frontier approach. Colorado State University.

Kijima Y., Otsuka K. Sserunkuuma D. (2010): An inquiry into constraints on a green revolution in sub-saharan Africa: The case of Nerica rice in Uganda. World Development, 20(10).

Kirkby R.A. (1987): Assessing the impact of bush bean varieties on poverty reduction in Sub-Saharan Africa: Evidence from Uganda', Workshop proceedings on Bean Research in Eastern Africa, Mukono, Uganda, June 22-25, 1987, African Workshop Series (2). Kampala, Uganda: CIAT.

Lopez A.M. (2008): Studies on the economic efficiency of Kansas farms. An unpublished doctoral dissertation. Department of Agricultural Economics. Kansas State University, Manhattan, Kansas.

Mauyo L.W., Okalebo J.R., Kirkby R.A., Buruchara R., Ugen M., Mengist C.T., Anjichi V.E. Musebe R.O. (2007): Technical efficiency and regional market integration of cross-border bean marketing in western Kenya and eastern Uganda. African Journal of Business Management, 077-084.

Meeusen W., Van Den Broeck J. (1977): Efficiency estimation from a Cobb-Douglas production function with composed error. International Economic Review, 8: 435-444.

Mulwa R., Emrouznejad A., Muhammed L. (2009): Economic efficiency of smallholder maize producers in Western Kenya: A DEA meta-frontier analysis. International Journal of Operational Research, 4(3).

Mwebaze M.N.S., Suttie J.M., Reynolds S.G. (ed.) (1999): Country pasture/ Forage Resource Profiles for Uganda. Department of animal production and marketing of the MAAIF. Entebbe, Uganda.

National Agricultural Research Organization (NARO) (2000): Annual Report. Entebbe, Uganda.

Nyagaka D.O., Obare G.A., Nguyo W. (2009): Economic efficiency of smallholder Irish potato producers in Kenya: A case of Nyandarua North District. A contributed paper prepared for presentation at the international Association of Agricultural Economists' conference, August 16-22, 2009. Beijing, China.

Obare G.A., Nyagaka D.O., Nguyo W., Mwakubo S.M. (2010): Are Kenyan smallholders allocatively efficient? Evidence from Irish potato producers in Nyandarua North district. Journal of Development and Agricultural Economics, 2(3): 078-085.

Reardon T., Kelly V., Crawford E., Jayne T., Savadogo K., Clay D. (1997): Determinants of farm productivity in Africa: A synthesis of four case studies. Sustainable development bureau of Africa: SD Publication series.

Rubaihayo P., Muindwa D., Sengooba T., Kamugira K. (1981): Bean production in Uganda. In: Allen D. (Ed.). Potential for beans in Eastern Africa: Proceedings of a regional workshop in Lilongwe, Malawi, March 9-14. Cali, Columbia: CIAT.

Soniia D., Sperling L. (1999): Improving technology delivery mechanisms: Lessons from bean seed systems research in eastern and central Africa. Agriculture and Human Values, 16: 381-388.

Soniia D., Kikby R., Kasozi S. (2000): Assessing the Impact of bush bean varieties on poverty reduction in Sub-Saharan Africa: Evidence from Uganda. Network on Bean Research in Africa. Occasional Publication Series (31). Kampala, Uganda: CIAT.

Taylor T.G., Shonkwiler J.S. (1986): Alternative stochastic specifications of the frontier production model in the analysis of agricultural credit programs and technical efficiency. Journal of Development Economics, 21: 149-160.

Tchale H. (2009): The efficiency of smallholder agriculture in Malawi. African Journal of Agricultural Research, 3(2).

Thiam A., Bravo-Ureta B.E., Teodoro E.R. (2001): Technical efficiency in developing country agriculture: A meta-analysis. Agricultural Economics, 25: 235-243.

Tijani A.A. (2006): Analysis of the technical efficiency of rice farms in Ijesha land of Osun state, Nigeria. Journal of Agriculture Economics, 45(2).

Uganda Bureau of Statistics (UBOS) (2010): Uganda national household survey 1999/2000. Report on the crop survey module. Entebbe, Uganda: UBOS.

Wortmann C.S., Kirkby R.A., Eledu C.A., Allen D.J. (2004): Atlas of Common bean *(Phaseolus vulgaris L.)* production in Africa. CIAT Publication (297).

Table 1: Bean production information in Uganda for selected years

Year	Output ('000' Mt[1])	Harvested Area ('000'Ha)	Yield (Mt/ha)	Food supply Kg/Capita/Year
1997	221	630	0.35	9.20
1998	387	645	0.60	14.80
1999	401	669	0.60	14.80
2000	420	699	0.60	14.00
2001	511	731	0.70	17.70
2002	535	765	0.70	17.80
2003	525	780	0.67	16.90
2004	455	812	0.56	14.40
2005	478	828	0.58	13.80
2006	424	849	0.50	11.30
2007	435	870	0.50	11.80
2008	440	896	0.49	-
2009	452	925	0.49	-
2010	948	-	-	-
2011	973*	-	-	-

Source: FAOSTAT 2011; * denotes estimated figures; - denotes missing data

Table 2: Predicted economic efficiency scores between treated and non-treated farmers

Economic efficiency	Treated farmers		Non-treated farmers	
Class	Frequency	%	Frequency	%
0-24	21	8.26	13	8.28
25-49	33	13.22	30	19.11
50-74	140	55.37	67	42.68
75-100	59	23.14	47	29.94
Total	253	100.00	328	100.00
Mean		62.09		57.82
Std deviation		20.02		21.48
Maximum		91.10		89.17
Minimum		0.31		3.07
t-ratio				-2.109
Sig.				0.013**
Overall mean				59.94

** is significant at 5% level

Table 3: Farmer-specific efficiency scores in terms of districts

District	Busia	Mbale	Budaka	Tororo
Mean (%)	59.70	54.78	60.68	67.54
S.D (%)	18.88	27.36	23.45	14.55
ANOVA: F-ratio	0.393			
Sig.	0.758			

[1] Mt denotes metric tonnes, equivalent to 1000 kgs

Table 4: Tobit regression estimates of factors influencing economic efficiency

Economic Efficiency	Coefficient	t-value	P>|t|
Sex (1=Female)	0.000	0.000	1.000
Age (years)	0.000	0.220	0.830
Schooling (years)	-0.003	-0.850	0.397
Occupation (1=Farming)	-0.001	-2.470	0.014**
Farming (years)	0.000	0.130	0.900
Farm size (ha)	0.005	0.640	0.521
Off-farm Income (UGX)	0.021	2.020	0.044**
Asset value (UGX)	0.034	4.080	0.000***
Distance to market (km)	-0.004	-1.120	0.262
Extension service	0.000	0.010	0.992
Group membership	0.001	0.010	0.994
Credit (UGX)	0.005	2.280	0.023**
Constant	1.328	9.390	0.000***
Log likelihood =	58.197	48.820	
Pseudo R^2 =	-0.722	0.000	

***, **, *** is significant at 10%, 5% and 1% levels respectively**