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REGULAR ARTICLE

ECONOMETRICS OF ENVIRONMENTAL VALUATION: THE BAYESIAN INFERENCES ON WILLINGNESS TO PAY ESTIMATIONS

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ABSTRACT

This study applied the Bayesian approach to estimate people's willingness to pay (WTP) for mitigation of environmental hazards in oil producing areas in Nigeria. The Bayesian approach enabled estimation of the mixed logit model employing the normal and log-normal distributions of WTP parameters. The model estimate indicating a negative WTP values for the status quo (STAQUO) attribute suggests that people in oil producing areas in Nigeria do not like the current welfare situation and environmental condition which are characterised by environmental problems, affecting adequate use of resources and ecosystem services. The results also show a comparatively higher WTP for food safety (FOODSAF), poverty rate (POVERTY) and unemployment rate (UNEMP) respectively, suggesting people's desire for mitigation of undesirable livelihood (welfare) impacts of resource exploitation. On the other hand, the results also indicate positive WTP coefficients for land and water pollution from oil spills (SPILL), gas flaring (GFLARE) and land occupied by oil and gas pipelines (LOCC), suggesting that majority of the people are in support of mitigation strategies or policy change that would ensure significant reduction in environmental pollution, gas flaring, and land-take by oil and gas companies. Oil and gas companies are encouraged to ensure mitigation of environmental and livelihood impacts of the crude oil and gas extraction, including reduction in gas flaring, based on environmental laws and global best drilling practices. The study further recommends application of the willingness to pay approach as an important strategy for assessing the values of environmental resources and the impact of resource use.

Keywords: Environmental valuation, Bayesian approach, willingness-to-pay, choice experiment, Nigeria
JEL: Q1, Q4, Q5

INTRODUCTION

Environmental valuation enhances efficient use of resources. Environmental resources can be valued based on people's preferences as may be revealed by individual choices. The choices may be based on the market value (market price), or the utility (stated preference) which an individual derive from the use or mere existence of the resource. The revealed preference techniques to environmental resource valuation considers the demand for environmental resources or its value by examining the value of the related goods in the private market. In other words, it considers the value of a particular resource with reference to the prevailing market value of related goods or services. Moreover, apart from using direct market values where these are provided to estimate the value of a particular resource, the revealed preference method also uses other known methods such as the hedonic price method and the travel cost methods (**Garrod & Willis, 2001**; **van Berkel & Verburg, 2014**). The hedonic price method considers the value of a given resource as may be decomposed into the value of its individual characteristics and has been widely used in estimating the value of a house, recreational centre or a resource where surrounding characteristics are also valued to make up the whole value of the resource. The travel cost method is a demand estimating technique, where the value of a given resource is estimated based on the value of transport expenses incurred by the consumers to visit the site of the resources (**Loomis & McTernan, 2014; Fuleky *et al.*, 2014**). The revealed preference method of measurement also considers valuation methods based on surrogate market scenarios. It is, however, an indirect approach which assesses the market value of a particular environmental resource as well as, change in environment quality (**Zeneli, 2014**).

On the other hand, the expressed preference or stated preference method of environmental valuation considers the estimation of an individual value of an environmental resource or willingness to pay for a particular resource or its change. It is also market-based but depends on hypothetical or constructed market scenarios (**Akujuru & Ruddock, 2014**). The technique enhances derivation of the demand curve without recourse to complementary or substitute resource (**Garrod & Willis, 2001**). The stated preference method captures the utility gained upon the use or existence of a given environmental resource, hence, people are often asked to value a given resource based on the utility they claim upon it. In other words, while the revealed preference technique relies on actual, observed–market information revealed indirectly by purchases of market goods and services related to the environmental resource, the stated preference technique captures directly the value of a resource through market simulation such that individuals are allowed to state their willingness to pay or accept for the resource or changes in its quality (**Nijkamp, 2008**). The stated preference techniques include the conjoint analysis (CA), contingent valuation (CV) and choice experiment (CE) techniques (**Bachmann & van der Kamp, 2014**).

The conjoint analysis (CA) is a choice based experiment designed to collect data consistent with the random utility theory. It enables individuals to score a set of alternatives with each having random varied attributes (**Hainmueller *et al.*, 2014**). It also enables the prediction of choices made by a group of individuals and measures people's preferences and trade-off decisions (**Acosta *et al.*, 2014**). The CA is a useful technique in marketing research and provides the convenience of assessing price sensitivity to price differences, and ease in assessing the competitive effect on choice, and the use of the estimated model to predict real market place choices (**Rao, 2014**).

The Contingent valuation (CV) methods have been widely used in valuing non-market environmental resources with specific applications in environmental accounting and the benefit-cost analysis (**Piriyapada, & Wang, 2014; Jang, *et al.*, 2014**), and changes from the status quo are often tested for acceptance using consumer (people) willingness to pay and WTA (**Lienhoop & MacMillan, 2007**). Apart from its application in determining people's willingness to pay, the CV has been useful in evaluating people's willingness to accept (WTA) compensation for specific environmental resources or changes in the status of the resource (**Zhen *et al.*, 2014; Amigues, *et. al*., 2002**). Contingent valuation techniques are often constructed based on hypothetical market scenarios to reflect people's willingness to pay for environmental benefits or avoidance of cost. Also, contingent valuation enables estimation of the values placed on a particular environmental good or service by an individual, by creating a hypothetical market place; which enables the people to directly report their willingness to pay for such goods or services. The CV considers measuring the value of an environmental good or service holistically, by describing the resources to be valued and specifying what needs to change or protected (**Garrod & Willis, 2001**), hence, nothing is revealed about the specific attributes of the resource. However, people's behaviour or their choice for change in a given environmental scenario, can be influenced by their difficulty to express their judgement or inability to understand how public policies actions are evaluated as captured by the questionnaire (**Basili *et al*., 2006**). Unlike the choice experiment (CE) method where an individual is given an array of options to choose, the CV method considers the dichotomous choice questions where people are asked to choose or make their choice based on two already specified options.

In this study, as specified in the choice experiment, the status quo is characterized by bad scenarios including high unemployment rate, pollution from oil spills, pipeline explosions, food safety risks and poverty, but without any payment cost (tax) on the people. By this experiment, people have the discretion to choose suitable trade-offs that would be better than the status quo, with improvements in the environment and their livelihood. In view of this background, this study aimed to draw econometric inferences from the willingness to pay (WTP) approach of environmental valuation. The study applied the Bayesian approach to estimate people's willingness to pay (WTP) for mitigation of environmental hazards in oil producing areas in Nigeria. The specific objectives of the study include the following to:

- design a choice experiment to enable resource valuation using selected environmental and welfare attributes.
- design a choice experiment to enable determination of WTP method of resource valuation for mitigation of undesirable impacts of resource exploitation as a result of crude oil extraction.
- determine WTP estimates using the Bayesian approach.
- make suggestions towards enhancing policy formulations and strategies to promote mitigation of environmental and livelihood impacts of resource exploitation in Nigeria.

DATA AND METHODS

The study was carried out in Southern Nigeria, involving 446 respondents selected from fifteen communities in the oil producing areas of the Niger Delta region of Nigeria. Five communities were selected in each of the states. An appropriate sampling frame was difficult to decide for this study because of lack of adequate data on local population of the study areas within the period of the research, thus, sampling was fairly pragmatic to enable getting a good sample size for the study. Selection of communities for the study was not entirely random. The three states were selected because of the presence of major oil and gas companies and history of negative impacts of the oil industry especially pollution. In other words, selection of the communities was guided by this information and was based on prejudice as communities selected for the study were mainly oil producing communities, communities with oil and gas facilities such as oil wells, oil and gas pipelines, and communities with reported environmental and livelihood impacts of oil and gas extraction. Also, logistical convenience was considered as the three states are close to each other and share adjoining boundaries. These communities were selected from three out of the nine oil producing states of the Niger Delta region in Southern Nigeria. These include: Akwa Ibom State: *Edo, Iko, Mkpanak, Unyenge, and Ukpenekang*. Bayelsa State: *Odi, Imiringi, Etiama, Okotiama-Gbarain, and Ogboibiri*. Rivers State: *Chokota community, Igbo-Etche, Alesa-Eleme, Obigbo, and Biara*.

At most thirty (30) people were interviewed in each of the communities using the Choice Experiment (CE) methodology involving choice sets. Data were collected through semi-structured survey questionnaires consisting the choice experiments; the choice cards. The choice cards were incorporated in a survey questionnaire such that each respondent responded to eight (8) choice cards. Choice sets (choice cards) were designed to include nice (9) attributes (eight including environmental and welfare attributes) and the status quo (representing current environmental and welfare situation in the study area). The choice sets consist attributes, varying levels of the attributes, and different payment options from which respondents chose based on their preferences. The Bayesian approach was used to estimate the willingness to pay values using the Mixed Logit model, as briefly described in the subsequent section. The study relied on inferences from the results of the WTP estimates in proffering suggestions toward mitigating environmental and welfare problems caused by the oil and gas industry.

The Model Specification

The model specification was guided by the assumption that majority of the people in the study area do not like the prevailing environmental and livelihood conditions. As would further be explained, the status quo was assumed to be characterised by negative impacts of the oil and gas industry with consequent environmental and livelihood problems in the study area. Hence, it was assumed that an individual would not like to pay for the status quo, rather would support a change in policies or pay for a change that would enhance mitigation of these impacts or an improvement to the status quo. Environmental problems identified in this study against which the WTP study was proposed include land-take by oil firms and occupied by various oil and gas facilities such as pipelines, which reduces the size and proportion of land available for agriculture, oil spill which causes land and water pollution, gas flaring with its accompanying health effects, as well as pipeline explosion. The welfare and livelihood issues include unemployment, poverty and food safety issues. With reference to the choice experiment designed for this study, the model was specified with the assumption that individuals would make a choice from which they would receive Utility (Eq. 1).

$$U_{j,s,n} = X_{j,s,n} g(\beta_j) + \varepsilon_{j,s,n} \quad (1)$$

Where,
$U_{j,s,n}$ denotes the Utility received by an individual, j (jth individual), from the sth choice in the nth choice set. $X_{j,s,n}$ indicates the (K x 1) vector of attributes presented to the jth individual (where, j = 1, …,J) in the sth option (where, s = 1, …, S) of the nth choice set (where, n = 1, …, N). Otherwise, $y_{j,s,n}$ denotes an indicator variable that equals 1 if the jth individual indicates that they would choose the sth option within the nth choice set, and 0 if they would not. β_j is a (K x 1) vector indicating the preferences of the jth individual and $g(.)$ is a transformation of the parameters from and to the space of k vectors. $\varepsilon_{j,s,n}$ denotes the error which is uncorrelated across individuals and choices, and independent of $X_{j,s,n}$. For simplicity of this piece, specification of priors and misreporting are not reported, nevertheless, for reference purposes, an in-depth description of the Utility model, with specifications of priors and misreporting under the mixed logit model with Bayesian estimation are presented by **Balcombe *et al.* (2009).**

RESULTS AND DISCUSSION

Description of Attributes

Eight attributes were used in the choice experiment (CE), these include; tax, land, unemployment, land and water pollution by oil spill, gas flaring, poverty, food safety and pipeline explosion. The status quo was introduced as the ninth attributes as a control variable in the model. A summary description of the attributes is presented in Table 1.

Table 1 Description of attributes used in the Choice Experiment

Attributes	Labels	Description	Levels
TAX	Tax	A payment plan proposed in the form of tax or a compulsory levy to enhance government policies proposed to regulate the operations of the O&G industry, toward achieving a change to mitigate the impacts of the industry.	0,100,200,300,400,500 (0)*
LANDOCC	Land occupied by O&G pipelines	Proposed reduction in the area of land occupied by O&G pipeline.	0,10,20,30,40,50 (4500km)*
UNEMP	Unemployment	Proposed reduction in unemployment rate.	20,25, 30, 35 (20%)*
SPILL	Land and water pollution by oil spill	Proposed reduction in oil spills cases.	0,10,20,30,40,50,60 (320)*
GFLARE	Amount of gas flared per year	Proposed reduction in gas flaring.	0, 5, 10, 15, 20, 25 (2.5)*
POVERTY	Poverty	Proposed reduction in poverty rate.	63, 65, 68, 70, 75 (63%)*
FOODSAF	Food Safety	Proposed reduction in the percentage of contaminated (unsafe) food in the market.	1,2, 3, 5, 7, 10 (10%)*
PEXPLO	Number of Pipeline explosions per year	Proposed reduction in the number of pipeline explosions.	2, 5,7,9,11, 15 (15)*
Status Quo	STATQUO	A hypothetical base level or current scenario from which the changes are prescribed. The levels of the status quo remain the same in all the choice sets.	

NB: All attributes were assigned levels and payment options from which mitigation was proposed. *Figures in parentheses are base levels for the respective attributes.

In this study, the status quo represents a hypothetical base level or prevailing scenario from which the changes or deviations in other attributes were proposed. The levels of the status quo remained the same in all the choice sets. It was assumed that people do not like the prevailing situations (the status quo), hence would prefer a change that would bring about mitigation of the negative impacts of resource exploitation with regards to the environment and people's livelihood.

Willingness to pay estimations

The Bayesian approach was used to estimate the mixed logit model employing the normal and log-normal distributions of the parameters. The normal distribution allows the assumption that the distribution though not known, but assumed to be normally distributed, and the variables are within any two real number limits. Under the lognormal distribution, the parameters were modelled and restricted to assume positive real values with the assumption that the mean and variance are fixed. The results were generated after 10,000 iterations (simulations), to ensure reduction in error variance. The WTP estimates based on the Bayesian approach are presented in Table 2.

Table 2 presents the WTP estimates based on the distributions of the parameters under normal and log-normal distributions. The results presented are the median WTPs unlike the classical approach where the mean WTPs were presented (Table 3). It was observed that the median WTPs under the Bayesian approach are more stable than the mean WTPs over various stimulations. Comparatively, the WTP estimates under the Log-normal distribution appear higher than that of the normal distribution and the classical approach. The result also shows people's willingness to pay a high amount of tax for a reduction in the percentage of unsafe food in the markets (FOODSAF), reduction in poverty rate (POVERTY) and unemployment rate (UNEMP). With a negative WTP estimate for the status quo (-6.07 under the normal distribution and -9.95 under the log-normal distribution), the results indicate people's willingness to pay for an improvement in the status quo, which indicates an indication of people's willingness to avert environmental problems and poor welfare conditions. On the other hand, the result also indicates positive WTP coefficients for reduction in pipeline explosion (PEXPLO), reduction in land and water pollution from oil spills (SPILL), reduction in displacement of land by oil and gas pipelines (LOCC), and reduction in gas flaring (GFLARE), suggesting that majority of the people are willing to pay to ensure reduction in pollution, gas flaring and land take by oil and gas companies. Most of the rural oil producing communities depend largely on land for farming, and water resources for fishing, thus, farming and fishing households face avoidable risks of poor income, food insecurity and poverty, in the event of an oil spill. Pipeline explosion has been the cause of most oil spills and fire outbreaks, especially in the event of sabotage, and it is known to have resulted in massive destruction of farms, forest and human settlements, coupled with severe environmental pollution affecting air, land and water. **Anifowose (2014)** also shares the views that oil pipeline constructed across Nigeria most of which are within the Niger delta region, has made the region vulnerable to explosions and oil spills as a result of deliberate damaging of the pipelines in the acts of vandalism and sabotage or due to faulty obsolete pipes. Pipeline explosion is a severe hazard of the oil and gas industry, which in most cases, causes death and injury to both animals and human beings, and a wide range of damage to the environment and people's sources of livelihood (**Han & Weng, 2010**). These environmental impacts pose serious setback on agricultural production and food security among rural households in the oil producing areas in Nigeria (**Ukpong, & Obok, 2018**). In fact, majority of the rural households in Nigeria depend largely on subsistent agriculture, fishing and forestry activities (**Ekpebu & Ukpong, 2013**).

On the whole, the results suggest that if the O&G companies provide livelihood improvements (such as employment, poverty reduction, and reduction in food safety risks), the people might be willing to bear some of the negative impacts of the industry. In particular, WTP coefficients for these attributes were comparatively higher compared to WTP for reduction in gas flaring. Beside the implications of the negative impacts of the O&G industry whereby people are willing to pay to promote mitigation measures, the comparatively low WTP coefficients for gas flaring might suggests poor awareness of the negative effects of flaring (particularly, long-term impacts including health problems), despite being one of the major environmental problems of global concerns.

For the purpose of comparison, the mean WTPs are presented in Table 3.

Recall that median WTPs were reported in Table 2, which show a slide variance from the mean WTPs presented in Table 3. Despite the slide difference in the means and medians WTPs, the results seem to corroborate with WTP results reported by **Balcombe *et al*. 2009**, where the means and medians WTPs are almost identical. The close similarity in the mean and median values for WTPs suggests the normality of the WTP distributions, nevertheless, the difference between the mean WTPs and median WTPs may be attributed to simulation error, also the influence of outliers and misreporting cannot be underestimated.

Like the result of the WTP estimates presented in Table 2, the results in Table 3, above shows the mean WTP in Nigerian currency, Naira (N), for each of the attributes specified in the choice experiment. The result shows a negative but a high mean WTP for the status quo, suggesting people's willingness to pay less to maintain the status quo, but a higher premium (N7.91) either to avoid the status quo or achieve an improved scenario. The mean WTP for FOODSAF is comparatively the highest, indicating that on the average, people are willing to pay as much as N23.12 for a reduction in the number of unsafe food (or contaminated food) in the market. Poverty rate and unemployment rate also have high WTPs, indicating that on the average, the people are willing to pay as much as N12.88 and N11.78 respectively to promote at least a 1% reduction in poverty rate and unemployment rate in the study area.

Table 2 WTP Estimates (Bayesian Approach)

Variable	Normal Distribution			Log-Normal Distribution		
	Median	Lower Quartile	Upper Quartile	Median	Lower Quartile	Upper Quartile
TAX (Price)	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
LOCC	2.37980	-0.00312	4.95505	2.63809	0.18793	5.36962
PEXPLO	5.90083	1.30506	13.72184	8.92944	2.34030	23.25713
SPILL	2.42151	0.85201	4.26765	2.64103	0.95431	4.62023
GFLARE	0.12732	-0.86885	1.18112	0.23928	-0.86846	1.57384
UNEMP	10.27993	4.75074	20.60551	14.96370	6.31858	32.71921
POVERTY	10.44142	6.35686	18.33676	14.69053	7.11321	29.82153
FOODSAF	19.82191	8.98767	34.67057	25.55135	14.15675	43.39659
STATQUO	-6.07222	-11.0203	-3.67492	-9.94515	-18.5842	-5.32510

Table 3. Means, Standard Deviations and Standard Errors for Marginal Utilities

Attribute	Mean WTP	Coefficient (β)	Standard Deviation	Standard Error
TAX (Price)	1.0000	0.0511	0.0360	0.0033
LOCC	2.1460	0.1100	-0.0179	0.0029
PEXPLO	9.4530	0.4830	-0.0449	0.0076
SPILL	2.5510	0.1300	-0.0182	0.0027
GFLARE	0.2960	0.0150	0.0003	0.0037
POVERTY	12.8811	0.6580	-0.0925	0.0099
UNEMP	11.7754	0.6010	0.0002	0.0167
FOODSAF	23.1231	1.1800	-0.1109	0.0117
STATQUO	-7.9077	-0.4369	0.5652	0.3051

The result also suggests that people are also willing to pay as much as N2.15, to ensure at least a 1% reduction in the size of land occupied by oil and gas pipeline, while the mean WTP for SPILL was estimated at N2.55, suggesting people's willingness to pay to secure at least a 1% reduction in oil spill resulting in land and water pollution. In summary, the government and oil industry are encouraged to come up with technology, or a mitigation plan or policy that would promote the use of less area of land for construction of oil and gas pipelines and other facilities. Also, the result further indicates that the least attribute the people would be willing to pay for is gas flaring, with the estimated mean WTP of N0.30, indicating a comparatively low payment for gas flaring which may be due to poor awareness of the dangers of gas flaring among majority of the people.

CONCLUSIONS

Most rural population in Southern Nigeria depend largely on the natural environment for their livelihood, engaging in agriculture, fishing and forestry activities. In particular, apart from those in the coastal and forested areas, majority of the households are largely engaged in crop farming and small-scale animal production. Located in oil and gas producing areas, the environment and indeed people's sources of livelihood face persistent limitations posed by impacts of crude oil extraction and transportation. The study aimed to draw econometric inferences from the willingness to pay (WTP) approach to environmental valuation and applied the Bayesian approach to estimate people's willingness to pay (WTP) for mitigation of environmental hazards in oil producing areas in Southern Nigeria. The model estimates indicating a negative WTP for the STAQUO indicates that people do not like the prevailing environmental problems and poor welfare situation in the area which is as a result of oil and gas extraction. The results also show a comparatively higher willingness-to-pay to achieve food safety, poverty reduction and reduction in unemployment rate respectively, suggesting people's desire for mitigation of undesirable livelihood and welfare impacts of resource exploitation. The results also indicate high WTP values for reduction in pipeline explosion, oil spill, land occupied by O&G pipelines and gas flaring, suggesting that majority of the people are willing to support mitigation measures and policies that would ensure such reductions. By inference, the literary significance of 'pay' depicts the readiness to be involved in the process that will bring about a change in the current undesirable condition (the status quo) caused by resource exploitation. This does not only suggest a non-tax protest scenario, but also a rejection of the negative effects associated with O&G extraction, and the extent to which the people place value for improvements in the environment and their livelihood. In other words, it suggests the need for a change from the status quo (characterized by pollution and negative livelihood impacts), and the high values attached by individuals to promote mitigation measures that would enhance reduction in pollution, poverty and unemployment, as well as, improvement in food safety in the oil producing areas. Beyond the issue of impact mitigation in the context of this study, findings on people's WTP may also be useful to the government and policy makers in the bid to achieve a viable and feasible construct for Nigeria's tax system.

With regards to the comparatively low WTP coefficients reported for gas flaring, there is a need for public awareness on the impacts of gas flaring to help the people protect themselves from avoidable exposures. Oil and gas (O&G) companies are encouraged to ensure mitigation of environmental and livelihood impacts of crude oil and gas extraction with reference to environmental laws and global best drilling practices. These should include reduction in gas flaring as Nigeria seems to flare more gas than other oil producing nations. The study also recommends increased investment in research and technology to promote efficient use of supposed flared gas by the O&G industry. On the other hand, with regards to the environment and human livelihood, agriculture remains a vital economic leverage for the people, thus effective mitigation measures would promote environmental productivity and sustainably improve human livelihoods. The study further recommends application of the willingness to pay approach as an important strategy for assessing the values of public resources. In addition, this study also recommends application of other model forms such as the Bayesian Infinite Mixture Logit (BIML), Fixed Parameter Logit model (FPL) and Hierarchical Bayes Logit Model (HBL) to enable comparisons with the Mixed Logit model applied in this study.

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REGULAR ARTICLE

TECHNICAL, ALLOCATIVE AND ECONOMIC EFFICIENCIES OF SMALL-SCALE SESAME FARMERS: THE CASE OF WEST GONDAR ZONE, ETHIOPIA

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ABSTRACT

In Ethiopia, sesame is mainly cultivated as a cash crop, important source of foreign exchange and income for many smallholders. Thus, improvement in production efficiency of sesame is crucial for Ethiopian economy and for smallholder farmer's livelihood. Socioeconomic, demographic and institutional factors were collected from randomly selected 385 sample households using multi-stage sampling techniques and interviewed using semi-structured questionnaire. The Cobb-Douglas stochastic frontier production function result shows that all input variables except land was positive and significant effect on sesame production efficiency. Labour inputs have the highest elasticity, followed by sesame seed, pesticides/herbicides and fertilizer accordingly. The model result shows that across all mean technical, allocative, and economic efficiencies estimates are 72, 49 and 35 percent respectively, implies that a substantial level of inefficiency in sesame production. Improvement of production efficiency requires availability of enough labour particularly during harvesting because of its shattering problem. Therefore, the local and regional government needs to devise mechanisms for hired labour availability in the area. Moreover, the econometric model result indicates that sesame production efficiency was positively and significantly influenced by age, education level, livestock ownership, association membership, off/non-farm income, extension contact, credit access, mobile phone ownership and training participation. The key policy implication therefore is that promoting farmer's cooperatives, address farmers in formal and informal education programs, enhancing farmer's access to financial resources through providing easy and affordable credit services, strengthen the extension services in terms of promoting livestock and crop production improving technologies are crucial.

Keywords: Technical, allocative and economic efficiencies, double-hurdle and PSM models
JEL: D13, D24, E23, M11

INTRODUCTION

The oilseeds sector in Ethiopia have been growing fast and the more useful sectors in terms of country's economy as well as income sources for more than 3.7 million smallholders (**CSA, 2014**). The previous study reports indicated that Ethiopia has been ranking 5th in sesame production after Myanmar, India, China and the Sudan until 2010 and recently, some African countries such as Tanzania, Mozambique and Mali have increased their sesame production aggressively by rapidly increasing their area and yield which consequently, Ethiopia gave way its rank to Tanzania since 2011 mainly because of decline in area (**FAOSTAT, 2015**). According to **CSA, (2014)** report on sesame production extent by smallholders and medium/large commercial farms, a total of 420,495 hectares of land devoted for sesame cultivation by about 867,347 smallholder farmers, while 276,701 hectares were cultivated by medium and large commercial farms in 2014. Sesame production was estimated about 95% have been grown mainly for the export market and only 5% is believed to be consumed locally (**CSA, 2014; FAOSTAT, 2015**).

Amhara, Oromiya, Tigray and Benshangul-Gumuz are the major sesame producer regions in Ethiopia with the dominant specific producer areas of *Humera, Gondar and Wollega* (**Wijnands *et al*., 2007; Dawit and Meijerink, 2010; CSA, 2011**). The three well known types of sesame in the international market that have been grown in the country are: the *Humera*, *Metema* and *Wellega* types. Their names are derived from the areas in which they are produced (**Mbwika, 2003**). The *Wellega* type is used for oil extraction due to its high oil contents. The *Humera* and *Metema/Gondar* types are preferred mainly for confectionery purposes due to the whitish colour, purity, and good taste (**Zerihun, 2012**). In *Amhara* region, sesame is one of the major and economically important commodity crop produced by small-scale and medium/large-scale farmers. According to **CSA (2015)**, the highest proportion of the country's total sesame production comes from the *Amhara* regional state accounts 48.84%, while 24.52% from *Tigray* and 16.59% from *Oromiya* region. Out of the region, West Gondar zone is the main sesame producing area at small-scale and medium large-scale levels. In West Gondar zone particularly in *Metema* and *Quara woredas*, smallholder sesame farming usually involves an area of one to ten hectares per household, however, the average productivity levels estimated by the local *woreda* offices was at between 300 and 500 kg/hectare which shows poor performance as compared to yield potential per hectare under good management condition that reaches as high as 3000 kg/ha (**SBN, 2014; Abadi, 2018**). Despite sesame is the most important crop, its productivity remains too low that might be resulted from production inefficiency. The previous empirical studies conducted on the area of sesame production efficiency, for instance by **Kostka and Scharrer (2011), SBN, (2014)**, **Ermiyas *et al.* (2015), and Abadi, (2018)** focused on volume of sesame production, challenges and opportunity, but no empirical study attempt in the study area. Thus, research in the area of technical, allocative and economic efficiencies of sesame and its determinants are vital for understanding the problems related to sesame production efficiency. Therefore, this study provides knowledge and information for policy makers, extension service providers and helps to share experiences among sesame producers.

DATA AND METHODS

Study area

The *Amhara* National Regional State of Ethiopia is divided into 13 administrative zones and 139 districts. The study conducted in the West Gondar zone located in the north–western part of the *Amhara* national regional state, 360 km far from the capital of the region, Bahir Dar. The elevation of the study area ranges between 550 and 1600 meters above sea level. West Gondar zone comprises 2 rural districts namely *Quara and Metema* where the study was conducted. These districts are located along the border of Sudan characterized by higher temperatures and fragile soils. The area is categorized under lowland that contains some of the largest tracts of semi-arid natural forest remaining in Northern Ethiopia. According to the projected evidence from the official census of 2007, the two sample districts population reaches about 2,606,963 which male is 50.6% and female is 49.4%. The study area is largely characterized by mixed farming system. The major crops that have been producing by smallholder farmers are sesame, sorghum and cotton used for sale and home consumption. Moreover, the major livestock species kept in the study areas are cattle, goats, sheep, and equine which serves as a source of draught power, transport, income, food, fuel and manure. Despite sesame is the major cash crop in the area, its productivity is very low as compare to the national average. This might be due to farmer's inefficiency of practices. However; there was no a study attempt on sesame production efficiencies and their determinants in the study area. Therefore, this study aimed to obtain information in terms of technical, allocative and economic efficiencies and the factors influencing these efficiencies in order to decide on the mechanisms to improve sesame production.

Sampling techniques and the data

The study applied cross-sectional data of 2017/18 production year. A multi-stage sampling procedure was used. At the first stage, all districts of the zone *Metema*, and *Quara* districts were taken as censured survey. At the second stage, six *kebeles* namely *Shinfa, kokit, Das Michael, Dubaba, Bambaho and Fershaho* were selected randomly out of 48 sesame producer *kebeles*. At the third stage, the list of sesame producers was obtained from respective agriculture development office, and then stratified according to their adoption category. Finally, a total of 385 households selected based on probability proportional to sample size technique.

Analytical methods

Stochastic Frontier Model was introduced by **Aigner *et al.* (1977)** and **Meeusen and Van den Broeck (1977)**; the method takes into account the random error and the inefficiency component simultaneously that technical, allocative, and economic efficiency scores derived by estimating the stochastic production frontier. This study followed the general stochastic production frontier functional form represented by:

$$lny_i = \beta_0 + \sum_{j=1}^{n} \beta_i \, lnX_i + v_i - u_i \qquad (1)$$

Where: y is the total quantity of sesame produced in kilogram; X_1 represents the land under sesame cultivation in hectare on the ith farm; X_2 represents family and hired labour used for sesame production (man/days) on the ith farm; X_3 denotes chemical fertilizer in kilogram applied to land for sesame production of the ith farm; X_4 denotes the amount of sesame seed used in kilogram and X_5 represents chemical such as pesticide and herbicide in litters applied for sesame production of the ith farm; β_j j = 1, 2, ...5 are parameters to be estimated; v_i is a symmetric random error which represents random variations, or random shocks assumed to be independent and identically distributed N (0, σ^2). The error term u_i is a one-sided non-negative variable which measures technical inefficiency of the ith household, the extent to which observed output falls short of the potential output for a given technology and input levels.

Followings the above estimated Cobb-Douglas production function in Equation (1), explain Technical Efficiency (TE) of sesame farming. TE is the ability of a farmer to obtain maximum (optimal) output from a given set of inputs and technology. Estimation of TE for individual farm is predicted by obtaining the ratio of the observed production values to the corresponding estimated frontier values. The TE for the ith farm can be computed as Eq. 2.

$$TE = \frac{actual\ output}{potential\ output} = \frac{y}{y_i^*} = \frac{\exp(X_i\,\beta + v_i - u_i)}{exp\ (X_i\ \beta + v_i)} = \exp(-u_i) \qquad (2)$$

Where: TE is technical efficiency, the inefficiency term u_i is always between 0 and 1, When u_i is equal to zero, then production is on the frontier $y_i^* = exp\ (X_i \beta + v_i)$ and TE = 1, therefore a farmer is technically efficient, when u_i is greater than zero ($u_i > 0$), the farmer is technically inefficient (TE < 1), since production is below the frontier. Similarly, based on the estimated production frontier in Equation (2), the study computed the dual cost frontier in Equation (3) and this forms the basis of computing the EE and AE of sesame production. The dual cost frontier was computed as Eq. 3.

$$lnTC = \beta_0 + \sum_{i=1}^{n} \beta_i\, lnX_i + v_i + u_i \qquad (3)$$

Where: TC is total cost of production in ETB, X_i are prices of land, labour, chemical fertilizer, seed and pesticides, while β_0 and β_i are parameters to be estimated. v_i and u_i are as specified earlier but with positive sign of the inefficiency term since inefficiency factors raise the cost of production. The technical efficiency (TE) and allocative efficiency (AE) can be combined to give the economic efficiency (EE) (Eq. 4)

$$EE = TE * AE \qquad (4)$$

The effect of demographic, socio-economic and institutional factors on sesame production efficiency was analysed using OLS regression model (Eq. 5).

$$y_i = \beta_0 + \beta_{1j} X_{1j} + _{...}\beta_{nj} + X_{nj} + e_i \qquad (5)$$

Where, y_i is the efficiency score of sesame production,
β_0 is the intercept
β_{1-n} is the coefficient of jth explanatory variable to be estimated and
ε_i is the error term assumed mean zero and constant variance.

Definition of variables, measurement and hypotheses

With regard to this study, the level of sesame production efficiencies is hypothesized to be influenced by a combined effect of demographic, socio-economic and institutional factors. Summary statistics of variables used in the OLS model depicted in Table 1.

RESULTS AND DISCUSSION

Table 2 shows the coefficient of land, labour, fertilizer, seed (improved and local), and chemicals (pesticides and herbicides) of stochastic frontier model of Cobb-Douglas production function in sesame production process. Except land, the signs of all the slope coefficients of the production function are positive and significant. This implies that most inputs (labour, fertilizers, seed and pesticides) have turned out to be significant in determining sesame output; that is, sesame output is responsive to inputs utilization. The coefficients associated with the inputs measure the partial elasticity of output with respect to the respective inputs.

The sum of elasticities of the five inputs (land, labour, fertilizers, sesame seed and chemicals) were 1.229 i.e. scale elasticity is greater than one. The result indicated that sesame production function exhibits increasing returns to scale that the first stage economic region of production function which implies that increasing input utilization is advisable because the proportionate increase in all inputs results less than proportionate increase of sesame output.

The maximum likelihood estimate shows that sesame output elasticities associated with labour, chemical fertilizer, seed (improved and local) and chemicals (pesticides and herbicides) were positive and significant in sesame production, while land size allocated for sesame production was not significant in the overall respondents.

The elasticity of output due to labour input was the highest (0.565) indicating that there was relatively more proportionate change in output due to proportionate change in supply of labour, followed by elasticity of output due to sesame seed (0.271), pesticide and insecticide chemicals (0.145) and fertilizer (0.028) accordingly.

Table 1: Description of the variables hypothesized to influence sesame production efficiency

Variable	Variable description	Measurement	Sign
Demographic characteristics			
Age	Age of the household head	Years	+/-
Household size	Person per household	Adult equivalent	+
Education level	Education level	Years	+
Farming experience	Sesame farming experience	Years	+
Socio-economic characteristics			
Livestock holding	Livestock owned	TLU	+
Oxen	Oxen owned	Number	+
Off/non-farm income	Off and/or non-farm income	ETB	+/-
Soil fertility	Farm land soil fertility	Poor/good	+/-
Mobile cell-phone	Mobile phone ownership	Dummy (1 own, 0 otherwise)	+
Association membership	Association membership	Dummy (1 member, 0 otherwise)	+
Institutional characteristics			
Extension contact	Extension contact	Frequency	+
Training participation	Training participation	Dummy (1 participate, 0 otherwise)	+
Market distance	Market distance from residence	km	-
Farm distance	Distance of farm from agent office	km	-
Access to formal credit	Credit access	Dummy (1 has got credit, 0 otherwise)	+

Table 2: Maximum likelihood estimates of elasticities of output

Variable	ML estimates Coefficient	St.err	OLS estimates Coefficient	St.err
Constant	3.928***	0.136	3.517***	0.241
Ln(land)	0.220	0. 198	0.210	0.201
Ln(labor)	0.565***	0. 109	0.585***	0.111
Ln(fertilizer)	0.028***	0. 007	0.026***	0.008
Ln(Improved and local seed)	0.271***	0. 081	0.265***	0.088
Ln(chemicals)	0.145***	0.030	0.147***	0.032
Wald $\chi2$ statistic	1356.68***			
Sigma2 (total error variance)	0.254***	0.033		
Lambda	2.130***	0.069		
Log-likelihood	-132.75			

Source: Model result

The overall mean technical efficiency were 71.8 percent with minimum and maximum technical efficiency of 32.2 and 93 percents respectively. Therefore, given the current state of technology and input levels, there is an opportunity of the scope of increasing sesame output by up to 23 percents on average. The estimated lambda value is the estimate of variance parameter and shows significant at one percent level of significance implying that there is a high variation in sesame output due to the presence of production inefficiency. This result is confirmed by conducting a likelihood ratio test to compare OLS model versus frontier model in representing the surveyed data. Wald chi-square test statistic provided a statistic of 1356.68, which is significant at one percent level of significance implying that the model is well fitted and rejecting the adequacy of the OLS model in representing the data.

Allocative Efficiency

To maximize the profit of sesame production, farmers have to choose the best combination of inputs given the prices of inputs and output. With the optimal combination of inputs, output could be produced at a minimal cost. Thus, for this study, allocative efficiency was estimated from a single sesame output and input variables such as land, labour, chemical fertilizers, sesame seed and pesticides/herbicides. These all variables were transformed into natural logarithms, and Stochastic Frontier Cobb-Duglas cost function was estimated by maximum likelihood method.

The cost of production was measured in Birr, price of land was estimated based on the rental value of land in Birr per hectare per year, daily wage rate was used to value labour, and average prices of DAP and UREA fertilizers are in Birr per kilogram. Average price of improved and local sesame seed and average price of pesticides per kilogram was used. Standing from the estimated parameters, the basis of computing AE (allocative efficiency) is the dual cost frontier given by Eq. 6.

$$LnC_i = 3.321 + 0.297lnC_{land} + 0.465lnC_{labour} + 0.326lnC_{fertilizer} + 0.019lnC_{seed} + 0.032lnC_{chemical} + 0.017lnY_{prod} \quad (6)$$

Where: C_i is the cost of sesame production for the i[th] farmer, C_{Land} is the rental price of land per hectare, C_{Labour} is the price of labour per day, $C_{Fertilizer}$ is the price of chemical fertilizer per kg, C_{seed} is average price of improved and local seed per kg, $C_{chemical}$ is average price of pesticide and herbicide per kg and Y_{prod} is total sesame output in kg of the i[th] farm.

Table 3: Maximum likelihood estimates of inputs

Variable	Coefficient	St.err	z-value	p >z
Ln (land rent)	0.2972***	0.0144	20.60	0.000
Ln (wage)	0.4656***	0.0302	15.41	0.000
Ln (fertilizers price)	0.3260	0.2250	1.45	0.147
Ln (seed price)	0.0192*	0.0116	1.66	0.098
Ln (chemical price)	-0.0321	0.0265	-1.21	0.227
Ln (output)	0.0176**	0.0087	2.02	0.043
Constant	3.321***	0.6076	5.47	0.000
Wald $\chi2$ statistic	788.05***			
Sigma2 (total error variance)	0.1009	0.0075		
Lambda	29.645	0.0127		
Log-likelihood	152.745			

****, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.
Source: Model results

The Wald test gives significant chi-square statistic (788.05) and proves the rejection of the null hypothesis that the coefficients are equal to zero. This means, the effects of the coefficients are significantly different from zero (Table 3). The maximum likelihood estimates of allocative efficiency revealed that the coefficients of Cobb-Douglas stochastic frontier cost function. Across all sample respondents, except chemical fertilizer and pesticide/herbicide chemicals, all input coefficients are statistically significant at 1 and 5 percent significance levels. The effects of prices (rent) of land, labour wage, prices of sesame improved and local sesame varieties and output were positive on the cost of production. However, the effects of chemicals (pesticide or herbicide) prices were negative but insignificant that indicates when price of chemical inputs increase, farmers tend to use less of them and allocate resources for other inputs (labour, land, improved sesame varieties). The mean allocative efficiency of sample farmers' is estimated at 49% with a minimum of 29.9% and maximum of 90.4%. The calculation of allocative efficiency in the study indicates that, farmer reveals 46 percent increase in output by improving allocative efficiency, with the existing inputs and technology level.

Economic Efficiency

The combined effects of technical and allocative efficiencies provide economic efficiency, that is economic efficiency is determined on multiplying technical efficiency by allocative efficiency. Based on this, the average economic efficiency was 35% with a minimum of 14.3% and a maximum of 83.1%. This result shows that if the average farmer can reach to the economic efficiency level of the most efficient counterpart, then the average farmer could obtain 58% increase in output by improving both economic and allocative efficiencies with the existing technology. In general, the analyses show that the sample households are inefficient technically, allocatively and economically in sesame production. Thus, there is a potential to improve households' sesame output with the existing technology level.

Factors Affecting Technical, Allocative and Economic Efficiency

Using STATA version 13, the coefficients of the factors hypothesized to affect efficiency were estimated along with the elasticities of sesame output with respect to inputs. The efficiency scores were dependent variables while the independent variables were demographic, socio-economic and institutional factors that can affect the efficiency of sesame production. These factors include age, education level, sesame farming experience, family size, livestock holding size (TLU), number of oxen, off/non-farm income, soil fertility, mobile phone ownership, association membership, extension contact, training participation, distance from nearest market, sesame farm distance from development agent office and access to formal credit. Before running the regression model, the multi-collinearity problem was tested using variance inflation factor (VIF) and no problem of multicollinearirty.

The model result shows that age of the household head, education level, livestock owned in TLU, off/non-farm income, mobile phone ownership, association membership, extension contact, training participation and credit access were significantly and positively/negatively affect efficiency of sesame production at 1%, 5% and 10% significance levels (Table 4). Therefore, the significant variables were the main factors affecting household's sesame production efficiency. The positively related factors to efficiency indicate a yield improving effects and raise the level of observed output of the household. On the other hand, the negatively related factors to efficiency indicate yield reducing effects on level of observed output of the household.

A negative and statistically significant relationship between age of the farmer and EE at 10 percent level of significance indicates that when a one year increase in age of household head, the probability and level of economic efficiency (EE) decreased by about 0.16 percent. The variable education level of the household head has a positive and significant relationship with the AE and EE of sesame production at 1% significant level. The result implies that better educated household heads are expected easily understand the effect of agricultural technologies and have higher tendency to adopt improved farm inputs that leads to better efficiency than less educated ones. Thus, a one year increase in educational level of the household head could bring an overall increase in the levels of AE and EE efficiencies by 0.67 and 0.6 percents respectively. The number of livestock owned in TLU has also positive and significant effect on AE in sesame production at 10 percent level of significance. The result shows that farmers who owned more livestock are economically more efficient than those who owned less livestock ownership in sesame production. This might be due to farmers who owned more livestock could generate additional income, able to buy farm inputs and able to have a source of power for traction. Therefore, a unit increase in TLU increases the level of AE by 0.18 percent. The relationship of off/non-farm income has a positive and significant effect on TE at 10 percent significance level. Hence, a farm household generating additional income from other sources in sesame production would increase TE by 0.31 percent than those have income from farm activities only. Moreover, the variable association membership with TE in sesame production is positive and significant at 10% level of significance. This is because farmers who are a member of association will have a chance to obtain current information, opportunity to receive credit for purchase of farm inputs, etc. that makes a producer to be more technically efficient in sesame production. Being a member of an association would increase an overall increase in level of TE efficiency by 3 percent. This result is similar with the study done by **Gashaw *et al*. (2014)** used household survey data from Ethiopia and evaluated the impact of agricultural cooperatives on smallholder's technical efficiency in crop production.

The relationship of extension contact with AE and EE in sesame production is positive and significant at 1% and 5% level of significances respectively. That is, farmers who had more number of extension contact during the cropping and marketing period were allocatively and economically more efficient than those who had less number of extension contact during similar period. Thus, extension contacts have contributed significantly to AE and EE of sesame production in the study areas. Increase in the frequency of extension contact by one would increase level of allocative and economic efficiencies by 0.77 and 0.49 percent respectively. Similar finding was registered by **Aye and Mungatana (2011)**, who found that extension agents provide farmers with new information on improved agricultural technologies, thus, farmers who had more number of contacts with such agents improved their access to improved inputs and farming management practices thereby increased their production efficiencies. With regard to the effect of the dummy variable training on sesame farming efficiency, a positive and significant effect was observed on AE and EE at significance level of 5% that implies farmers who participated in training performs better in sesame farming than non-participants. Thus, participation in training increases the levels of AE and EE by 4.3% and 3.5% respectively.

The unexpected results such that the negative and statistically significant effect of credit access and mobile phone ownership at five and one percent significance levels on TE, AE and EE was interesting. With regard to credit access, the reason might be the existing bureaucratic and long process to obtain credit service that causes waste of working time might lead to inefficient in production. Hence, access to formal credit decreases the levels of AE and EE by 3 percent and 2.7 percent respectively. Similarly, the negative effect of mobile phone ownership might be due to lack in analysing and interpreting the inflow of information through the mobile phone. Thus, use of unprocessed data might cause for the wrong decisions and lead to inefficiency of production. Therefore, ownership of mobile phone decreased TE, AE and EE by 4.1, 5.1 and 6.2 percents respectively. This finding is not consistent with the research results of **Sisay *et al.* (2015)**, studied efficiency of maize production and its determinants using parametric stochastic frontier production function applying Cobb- Douglas production function and Tobit model respectively for smallholder maize producing farmers in Jimma zone of south western Ethiopia.

CONCLUSION AND POLICY IMPLICATION

The study found the existence of substantial technical, allocative and economic inefficiency in sesame production in the study area. The Cobb-Douglas stochastic frontier production function result shows that all input variables except land was positive and significant effect on sesame production. Labour inputs have the highest elasticity, followed by sesame seed, pesticides and fertilizer inputs accordingly. The model result shows that the overall mean technical, allocative, and economic efficiency estimates were 72, 49 and 35 percent respectively. This implies that sesame production can be increased on average by 52 percent through improving efficiencies with the existing technology.

The estimated regression model result indicates that technical efficiency (TE) of sesame production was positively and significantly influenced by the variables such as association membership and off/non-farm income and negatively and significantly by mobile phone ownership, while allocative efficiency (AE) was affected positively and significantly by education level, livestock ownership, extension contact and training participation, but negatively and significantly by credit access and mobile phone ownership factors.

Table 4: Regression results on technical, allocative and economic efficiency

Variable	Technical efficiency		Allocative efficiency		Economic efficiency	
	Coefficient	Std.error	Coefficient	Std.error	Coefficient	Std.error
Age	-0.0000	0.0011	-0.0016	0.0011	-0.0016*	0.0009
Education	-0.0023	0.0026	0.0067**	0.0026	0.0060***	0.0023
Experience	-0.0010	0.0011	-0.0002	0.0011	-0.0002	0.0010
Family size	0.0005	0.0059	-0.0022	0.0058	-0.0020	0.0051
Livestock	-0.000	0.0010	0.0018*	0.0010	0.0014	0.0009
Oxen	0.0042	0.0034	-0.0037	0.0033	-0.0010	0.0029
Off/non-farm income	0.0031*	0.0017	0.0007	0.0017	0.0016	0.0015
Soil fertility	0.0031	0.0149	0.002	0.0146	0.0181	0.0128
Mobile phone	-0.0414**	0.0174	-0.0514***	0.0170	-0.0624***	0.0150
Association	0.0308*	0.0178	-0.0284	0.0174	-0.0049	0.0153
Extension contact	0.0014	0.0028	0.0077***	0.0027	0.0049**	0.0024
Training	0.0129	0.0163	0.0431***	0.0159	0.0359**	0.0140
Market distance	-0.0020	0.0012	0.0007	0.0012	0.0010	0.0010
Farm distance	-0.0011	0.0010	0.0005	0.0010	-0.0001	0.0009
Credit access	-0.0075	0.0163	-0.0337**	0.0150	-0.0273**	0.0132
Constant	0.7298***	0.0444	0.6440***	0.0434	0.4948***	0.0382

****, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.
Source: Model results

The economic efficiency (EE) was also influenced by age of the household head, credit access and mobile phone ownership negatively, while positively and significantly by education level of the household head, extension contact and training participation variables. In view of the study results, smallholders were inefficient in sesame production in the study areas that needs attention as it provides significant source of enhancement in sesame output. Therefore, in order to raise sesame production and improve the livelihood of smallholders towards food security, the attention of policy makers should give due attention on improving the existing level of the inefficiencies of sesame producer farmers besides improved farm inputs. These inefficiencies, however, can be improved if major factors that determine sesame production efficiencies are identified.

The significant positive effect and higher elasticity of production inputs indicates the importance of production inputs in sesame production. This implies that enhanced access and better use of production inputs could lead to higher sesame production in the study areas. Therefore, the key policy implication is providing easy or free of bureaucratic and affordable credit services as the high cost of hired labour, improved sesame variety and chemical fertilizer are most frequently mentioned problems. Sesame farming requires availability of enough labour particularly during harvesting period because of seed shattering problem. Therefore, among the production inputs, labour input was the first crucial and very important factor in order to improve farm efficiency. Thus, local and regional government needs to plan in facilitation of hired labour availability in the area using different mechanisms.

Moreover, education level is an important factor in AE and EE improvement. Creation of education opportunity for all farmers and encourage them to attend formal and informal education is the key policy issue in the study area. Thus, farmers can change their perception towards the benefit of current information, able to search and use it properly. Household's livestock holding size affected AE of sesame producing farmers positively. Therefore, the study suggested that enhancing the existing livestock production system by providing improved health service and skill training on livestock management leads to improved efficiency. Similarly, association membership of a household plays a positive role in affecting the TE. This need strengthening the existing association structures and organizing new farmer's associations such as farmers marketing groups and cooperatives for common benefits that can improve efficiency.

The positive effect of extension service on AE and EE requires strengthening the existing extension service provision mechanism in terms of providing technical support through applying frequent visit of development agents to the farmer's sesame farming fields. The significant influence of training on AE and EE needs policy focus in terms of providing skill training particularly on sesame farming like improved farm inputs and information utilization techniques.

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REGULAR ARTICLE

LAND DEALS AND SMALL-SCALE INTENSIVE FARMING DECISIONS

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ABSTRACT

The upsurge of land deals in Northern Ghana is a concern to many stakeholders. In order to reduce the effects of land deals on livelihoods, farmers resort to adopting semi-intensive, intensive or low intensive farming systems. Using a multinomial logit model, this study assessed how land deals influence the decision of a farm household to choose any of the farming regimes. Factors that influence farmers' decision to choose intensive as against semi-intensive methods of farming are farm size, awareness of land grabbing, intension of cultivating part of grabbed land, number of adults, household expenditure, location, remittances and land grabbed investment type. On the other hand, households' engagement in low intensive as compared to semi-intensive methods of farming are influenced by age, fallowing period, education, remittances, and household expenditure. Land deals must be accompanied by efforts to diversify livelihoods of smallholder farmers away from land-based systems. This would require skills training for rural peasant farmers to enable them take up emerging livelihood opportunities. In order to safeguard the interests and livelihood of rural peasants, agricultural investment programmes must make community-investor partnership a key condition for gaining access to government and donor incentives.

Keywords: Land deals, semi-intensive, intensive, low intensive system
JEL: R52, R58, H41

INTRODUCTION

In developing countries, rural farm households derive income from foraging the forests (**Wunder *et al.*, 2014**). The increasing dependence of rural farm households on land and other land-based resources like forest means that activities that impact on land and forest would have direct implications on rural farm households and their livelihoods. Biodiversity loss in itself has a direct influence on forest-livelihood linkages which are increasingly exposed to risk as human activities continue to diminish habitat for other flora and fauna. An example of risk to biodiversity and forest ecosystems is the increasing demand on land for commercial agricultural purposes (**Somorin, 2010**). Human activity is affecting the existence and inter-dependence of the environment and mankind**,** as habitats are continually transformed for agriculture, managed forest or urban development (**Polasky *et al.*, 2005**).

Farm households make decisions against risk factors towards achieving the best outcomes as they guard against events and incidences that reduce their perceived incomes and/or increase their cost of production. Such undesired events and incidences (i.e. escalating cost of inputs, high climate variability, land loss, etc.) constitute farmers' risk. Onset and persistent land grabbing increase the farmers' likelihood of losing their productive lands.

The risk is much pronounced when rural people are deprived of usufruct rights and access to the benefits of land under customary tenure systems. Hardship on rural households is exacerbated when access to important livelihood assets such as water bodies, wild fruits, herbs, game, timber and economic trees is curtailed. This situation diminishes the livelihood options of rural farm households (**Kranjac-Berisavljevic, 2015**). Reduced livelihood assets have direct forward linkage to increased migration, diversification and the intensification of farm lands as evident from the livelihood framework developed by **Scoones (1998)**. Land deals by domestic and transnational corporations have been shown to have profound effects on land relations and access to land for smallholders as they contribute to reduced livelihood assets, which in turn have direct effect on livelihood strategies. Many people have become alarmed of the spate and upsurge of land acquisition in developing counties especially in African continent.

Within the framework of Goldstein and **Udry (2008)**, increasing demand for land is a source of risk. A risk that limits usufruct land right holders' ability to fallow land in an optimal manner. There is a risk to the farming system in that gaining access to more land for extended fallowing to regenerate depleted land is limited. Land deals by domestic investors and transnational corporations is a source of risk to smallholder farmers and has a bearing on their livelihood and farming system choices.

There has been outcry against the selling of land by chiefs and other customary authorities in Ghana as land commercialization spreads across the length and breadth of the country over the past three decades **(Yaro and Tsikata, 2014)**. The widespread appropriation of land by chiefs and major clan heads has implications on smallholder inclusive development **(Jayne *et al.*, 2014)** and the ability of households to acquire land to build and develop sustainable livelihood systems around agriculture.

Despite arguments that much of the land grabs in Ghana occur in "so-called open lands," **Yaro and Tsikata (2014)** argue that grabbed lands include bush lands and common lands, which are the sources of valuable resources which supplement other agrarian livelihood activities and protect the long term survival of smallholder agriculture. **Yaro and Tsikata (2014)** pointed that there is the risk to the survival of smallholder farming systems thus threatening the livelihood alternatives for smallholders as a result of land acquisition. The effects of land deals on farmer risk perception and response behaviour is the main focus of this study. While there is documented evidence by **Kranjac-Berisavljevic (2015)** and **Schoneveld *et al.* (2011)** on medium and large scale land grabs across Ghana, the study of its impact on farm households as agricultural risk and a livelihood choice decision making remains less explored.

This study explores how land deals in Northern Ghana influence agricultural livelihood choice decisions (intensive, semi intensive and low intensive method of farming). Based on **Pressman (2011)**, a farm household method of farming is intensive if the farm household engages in two or more of the following: mechanized land preparation, use of improved seed, application of chemical fertilizer, use of weedicide and pesticides. Also, he defined semi-intensive farm household as a farm household who engages in two or more of the following: mechanized land preparation, use of improved or local seed, application of partial organic fertilizer as well as chemicals whereas a low intensification farm household is a farm household who engages in two or more of the following: partial or no mechanized land preparation, use local seed, application of no chemical fertilizer and chemicals. Policy makers can rely on the determinants (especially land deals factors) of farmers' livelihood choice decisions in the midst of medium and large scale land acquisitions explored by this study to factor into decisions (intensive, semi intensive and low intensive method of farming) and directions on the dimensions of land grabbing and the overall effect it would have on the agricultural sector of the Ghanaian economy.

The objective of our study was to assess how land deals influence the decision of a farming household to choose any of the farming regimes: intensive, semi-intensive or low intensive systems of farming. This will help researchers make actionable policy recommendations for stakeholders to implement so as to minimise the effects of dealing on livelihoods of rural peasant farmers.

DATA AND METHODS

Description of Study Areas

The study was conducted in Northern Ghana. Northern Ghana mainly comprises Upper East region, Upper West region, Northern region and some portions of Volta and Brong-Ahafo regions. Its land size covers about 41 % of the total land area of the country, with about 20% inhabitation of the people of Ghana. The specific districts selected for the study are Gushiegu and Kassena Nankana East (KNE) of Northern and Upper East regions of Ghana respectively. Data from the Lands Commission of Ghana shows that most of the acquisitions in Northern Ghana occur within the Northern and Upper East Regions. The data further confirms that 21 different parcels of land ranging between 10.12 ha to 24.28 ha have already been acquired and registered in the Kassena Nankana East Municipality in the Upper East Region alone. In the Northern Region, 27 different parcels of land ranging between 20.00 ha to 50.00 ha are also registered in the Gushiegu District. This study takes special interest in these high recording areas within the two regions for a better appreciation of the land grab situation in Northern Ghana.

Kassena Nankana Municipal has been reported by the **Ghana Statistical Service (GSS) (2014a)** to have 82.7 percent of households engaging in agriculture. In the rural localities, 93.1 percent of households are agricultural households while in the urban localities, 56.8 percent of households are into agriculture. Most households in the Municipality (96.1 %) are involved in crop farming with poultry (chicken) as the dominant animal reared in the municipality. Gushiegu District on the other hand is one of the twenty-six (26) administrative districts of the Northern Region of Ghana. According to **Ghana Statistical Service (2014b)**, about 91.8 % of the households in the district are engaged in agriculture. It is estimated that 96.9 % are agricultural households while in the urban localities, 75.2 percent of households are into agriculture with most of these households (98.0 %) involving in crop farming **(Ghana Statistical Service, 2014b).**

Data Collection and Instrumentation

The basic unit of analysis was the household. This means that data and observations were collected at the household level and the source of the data was primary. Household is defined by the GSS as; individuals and groups who agree to share pooled resources irrespective of the degree of its tangibility in order to earn a living **(GSS, 2012)**. Such people may at most times share the same compound. The study focused on the head of the farm household who is in control of almost all economic resources available to the household for the general upkeep of the entire members of the household. The household head is therefore assumed to be in the best position to offer an account of the various degrees of opportunities, shocks and treats to the entire household. Using a semi-structured questionnaire with closed-ended and open-ended questions, data were gathered from household heads through face-to-face interview.

Sampling Technique

To effectively achieve the aim of this research, the study grouped the communities under two broad strata (Affected and Non-affected) using stratified random sampling technique. Affected communities are communities with one or more commercialized land parcels acquired within its defined boundaries whilst non-affected communities are communities with no grabbed land parcel within its defined boundaries. Within the affected community, a sub-division was further used to define individual respondents as those who lost one or more farm lands to the activities of commercial land acquisitions within the community and those who did not lose any farm land to the activities of commercial land acquisitions within their community. Systematic random sampling was then used to select respondents.

Sample Size Determination

According to **Ghana Statistical Service (2014)**, the total population of Kassena Nankana East (KNE) and Gushiegu Districts are 107,435 and 110,039 respectively. The census report also shows that Gushiegu District has a total household count of 19,790 as against 11,150 of the KNE Municipal. Furthermore, the report indicated that in the two districts lies the fact that 82.7 % of the households in KNE are engaged in agriculture whilst 91.8 % of the farm households in Gushiegu are engaged in agriculture. The household survey embarked by this study relied on the respective percentage of agricultural household out of the total household count as the sample frame for the determination of appropriate sample size. The mathematical formula adopted for the estimation of the sample size in this study is given as;

$$n = \frac{NZ^{*} \times P(1-P)}{e^2(N-1) + Z^{*}P(1-P)} \tag{1}$$

Where:

n Sample size; N Sample frame; $Z*$ Z-score; P Standard deviation; e Margin of error.

Substituting a 95 % confidence level, standard deviation of 0.5 and a 10 % margin of error to the sample frame of KNE gives,

$$n = \frac{9221 \times 1.96[0.5(0.5)]}{0.1^2(9921) + 1.96[0.5(0.5)]} = 48.75 \approx 49$$

Whereas for Gushiegu Districts gives,

$$n = \frac{18167 \times 1.96[0.5(0.5)]}{0.1^2(18167) + 1.96[0.5(0.5)]} = 48.87 \approx 49$$

Based on the specific interest of this study, it was very necessary to have more respondents. Hence a scale factor of 2 was used to get a sample size of 97.5 and 97.74 from KNE and Gushiegu Districts respectively. Meanwhile, at the end of the data collection, 94 and 108 household heads were interviewed in KNE and Gushiegu Districts respectively.

Multinomial Logit Model: Effects of Land Deals on Farm Livelihood Choice Decisions

This segment examined factors influencing farm household's livelihood choice decisions (intensive, semi intensive and low intensive method of farming) within affected communities in the study area. The study employed multinomial logit regression analysis in identifying how land deals factors influence farm households' choice of intensive, semi intensive and low intensive method of farming. The variable of interest has three categories which are mutually exclusive and hence the appropriate model is multinomial logistic regression as noted by **Greene (2012)**. Thus, each alternative regime has an associated utility.

According to **Greene (2012),** the general model for examining the factors influencing a farm households' probability of choosing j^{th} farm livelihood strategy for i^{th} farmer (P_{ij}) is specified with reference to Equation (2).

$$P(Y_i = j) = \frac{exp(X_i' \beta_J)}{\sum_{j=1}^{n} exp(X_i' \beta_J)} \tag{2}$$

Where: $j = 1, 2, 3$ which represent outcomes for intensive, semi-intensive and low intensification; X socio-economic characteristics of farm household; β unknown parameter estimates of explanatory variables; P probability of choosing a livelihood strategy.

Equation (2) specified above is not identified; it is only identified when one of the coefficients is arbitrarily set to zero. This study therefore equates the coefficient of semi-intensive to zero, hence becomes the base outcome of the probabilities corresponding to each outcome. The coefficients thus denote the marginal effect in the probability of engaging in either high intensive or low intensive farming. The model fits well with the estimation because it also allows for the investigation of explanatory variables for the chosen alternative over the other alternatives. Following the work of **Torres et al. (2018)** and **Mwaura and Adong (2016)**, empirical models for each of the livelihood intensive decision making are specified below.

$$P(Y_i = Semi - intensive) = \frac{1}{1 + expW\delta(1) + expW\delta(2) + expW\delta(3)} \tag{3}$$

For the base outcome semi-intensive

$$P(Y_i = Intensive) = \frac{1}{1 + expW\delta(1) + expW\delta(2) + expW\delta(3)} \tag{4}$$

$$P(Y_i = Low\ intensive) = \frac{1}{1 + expW\delta(1) + expW\delta(2) + expW\delta(3)} \tag{5}$$

Modifying from the work of **Mwaura and Adong (2016),** the empirical model used in this paper shows socioeconomic factors that influence the livelihood intensive decision making of smallholder farmers and it is expressed in Equation 6.

$$\begin{aligned} Y_{ji} = {} & \delta_0 + \delta_1 Ag_i + \delta_2 Edyrs_i + \delta_3 FmSz_i + \\ & \delta_4 AwLanGb_i + \delta_5 Cult\_Int_i + \delta_6 NoAdult_i + \\ & \delta_7 Fallowyrs_i + \delta_8 EnoughLan_i + \delta_9 HHSz_i + \\ & \delta_{10} Remit_i + \delta_{11} EduExp_i + \delta_{12} OthHHExp_i + \\ & \delta_{13} Dist_i + \delta_{14} AcqBushLand_i + \delta_{15} AcqFalloLand_i + \\ & \delta_{16} InvestTyp_i + \delta_{17} GrabScale_i + \delta_{18} GrabYrs_i + \\ & \delta_{19} LostLand_i + \delta_{20} FalloLength_i + e_i \end{aligned} \tag{6}$$

Where: δ unknown parameter estimates; W explanatory variables and e represents the error term.

The exponent of coefficient in a multinomial logistic regression can be viewed as the probability of choosing alternative regime j of farm livelihood over the base category. The Relative-Risk Ratios (RRR) is the measure of the probability of choosing an alternative over the base outcome.

$$RRR = \frac{Pr(Y_i=j)}{Pr(Y_i=Semi-intensive)} = expW\delta \qquad (7)$$

In order to establish the relationship between land acquisitions and livelihood strategy of farm households in the study area, socio-economic characteristics and grab-specific variables were captured. Table 1 shows the definition and measurements of explanatory variables used in the multinomial logit model. The variables are explained as follows.

Age: This variable was measured as a continuous variable, thus the number of years of the farmer. Age of household head has been used in many livelihood studies but the direction of its effects on the dependent variables has been varying and this may depend on many factors. **Yizengaw *et al*. (2014)** found age to have no significant influence on choice of livelihood strategy. However, it is expected that older household heads would most likely choose intensive farm livelihood strategy ahead of their younger counterparts because older household heads have better access and control over economic resources.

Years in Education: This variable is measured as the number of years a household head has spent in school. Educated household heads are most likely to be engaged in other formal occupations as found out by **Hatlebakk (2012)**; **Gecho *et al.* (2014)** and **Rahman and Akter (2014)**. This study hypothesizes years in schooling to positively influence the decision of a farmer to choose non-intensive farming strategy because household heads with higher education are most likely to engage in formal occupations.

Farm size: This is measured as the total land area under food crop cultivation of a given farmer. Farmers with larger farm sizes are usually wealthier as compared to their counterparts with smaller farm sizes and so there is the likelihood that they would readily choose intensive farming strategy. **Rahut and Micevska (2012)** and **Gecho *et al.* (2014)** found that farm size had positive influence on farmer's choice of non-farm livelihood; this notwithstanding it is expected that farm size will positively influence a farmers' choice of intensive farming strategy.

Knowledge on other grab lands: This variable is measured as a count variable, thus the number of commercial acquisitions a household head is aware of. The study expects that, the more commercial sites a farmer is aware of, the more his likelihood of choosing intensive farming strategy. This variable is therefore hypothesized to positively influence a farmer's choice of an intensive farming strategy.

Future intention: This is measured as a dummy, thus '1' if a farmer had a future intention of cultivating part of an acquired land prior to the take over and '0' if otherwise. A farmer who had a future intention of farming on an acquired land will most likely choose intensive farming strategy. As a result of this, the study expects this variable to have positive influence on intensive farming strategy.

Recent Fallow: This is measured as the most recent fallowing engaged by a farmer and it is recorded as number of years. The last time a farmer fallowed can either have a positive or negative influence on the type of farming strategy he chooses. Therefore, it is postulated that recent fallow would have an indeterminate effect on the choice of farming strategy.

Fallow period: This variable is measured as the length of time (years) a farmer allowed fallowing before revisiting the farm land. The fallow period may either have a positive or negative influence on a farmer's choice of farming strategy. This therefore means that the study postulates this variable to be indeterminate.

Adults: This is measured as the number of people in the households who are 18 years and above. The study hypothesizes that a farm household with more adults would most likely be positively influenced to engage in an intensive farming strategy.

Enough land: This is measured as a dummy. Thus '1' if a farmer concedes to having enough land for cultivation and '0' if otherwise. It is expected that a farmer who has enough land for cultivation and is therefore not affected by land grabs is expected to engage in a semi-intensive farming system ahead of an intensive farming strategy.

Amount spent on Education: This is measured as the total monthly expenditure spent on wards' education in Ghana Cedis (GH¢). The study assumes that the more a farm household spends on education, the less likely they would choose intensive farming strategy. The study therefore postulates this variable to have a negative relationship with the choice of intensive farming strategy.

Other total monthly expenditure: This variable is measured as the amount of money a farm household spends on food, medical bills among others in a month. A farm household that has higher total monthly expenditure is most likely to engage in an intensive farming strategy. Abimbola and Oluwakemi (2013), and Yizengaw *et al.* (2015) found total household income to have a positive influence on farmers' choice of livelihood strategy. As such the study hypothesizes total monthly expenditure to positively influence the choice of intensive farming strategy.

Remittance: This is a continuous variable measured as the total yearly amount of money received by the household head from relatives and well-wishers outside his community of residence. The influence of remitted amount in this study is indeterminate.

Location: This variable is measured as a dummy, thus '1' if the farmer is located in KNEM and '0' if the farmer is located in the Gushegu District. A farmer located in KNEM is assumed to have a positive and strong preference for intensive farming strategy than a farmer in Gushegu District. This is because it is believed that there are larger lands acquired in KNEM than in Gushegu District. The study therefore hypothesizes location to positively influence a farmer's choice of intensive farming strategy.

Land type acquired: This is as an indicator variable which was censored as '1' if acquired land was a bush and '0' if not; '1' if acquired land was a fallowed land and '0' if not; '1' if acquired land was under cultivated and '0'if not. With cultivated land as reference category, the study expects that farmers within an area where fallowed lands were acquired would most likely choose intensive farming.

Grab investment: This variable is measured as dummy, thus '1' if a grab land is used for the cultivation of arable crop and '0' if the grab land is used for the establishment of a tree crop plantation. The *a priori* expectation of this variable on a farmer's choice of farming strategy is indeterminate.

Grab scale: Grab-scale is measured as dummy, thus '1' for large scale and '0' for medium scale. The assumption is that larger scale acquisitions have high potential of influencing farmer's farming strategy. This implies that the larger the grab land, the more likely farmers would want to intensify their farming. Therefore, Grab-scale is expected to have a positive influence on the choice of intensive farming strategy.

Grab years: This variable is measured as dummy, thus '1' if the land had been grabbed for a longer period and '0' for a shorter period. Farmers who find themselves in communities that have been affected by longer years of grab lands may have a greater incentive to choose intensive farming strategy than their counterparts. The study therefore predicts Grab-years to have positive influence on a farmer's choice of intensive farming strategy.

Grab status: This variable is measured as dummy, thus '1' if a farmer's land has been lost to land acquisitions (DI) and '0' if a farmer has not lost land (NI). It is assumed that farmers whose lands have been grabbed, are most likely to choose intensive farming strategy ahead of semi-intensive farming strategy. The study therefore hypothesizes victim to have a positive influence on a farmer's choice of intensive farming system.

RESULTS AND DISCUSSION

Effect of Land Deals on Livelihood Choice Decisions of Farm Households

The key argument by governments in Sub-Saharan Africa in support of commercial acquisition of land for agriculture is economic development through positive agrarian change. The interface between the 'modern' investors acquiring land for commercial agriculture and rural peasants' improvement is that, the latter is expected to be achieved through the creation of jobs, improvement of incomes and technology transfer that would improve indigenous farming systems. The effect of land grabbing on local farming systems has therefore become a key indicator in assessing the impact of commercial scale agricultural land deals. In this section, the study undertakes an econometric estimation of the effects of land deals on livelihood choice decisions of farm households and this answered the question of finding the relationship that exists between land deals and livelihood decisions, using a multinomial logit regression model. The results for the multinomial logit regression model are shown in Table 2.

From the results, the likelihood-ratio (LR) test of the joint hypothesis shows that the coefficients of all the explanatory variables are significantly different from zero as indicated by the LR Chi-squared = 119.15 with $p<0.01$, suggesting that the estimated model is highly significant. The Pseudo R^2 (0.4847) means that the model variables were able to predict at least 48.47% of the probability of farm households' choice of intensive and low intensification farm livelihood regimes ahead of semi-intensive. The interpretation of all significant explanatory variables is based on ceteris paribus assumption.

Table 1: Description of variables

Variable	Definition and measurement	Mean
Ag	Age of household head in years	46.29
Edyrs	Number of years spent in school	3.13
FmSz	Farm size of household in acres	2.74
AwLanGrb	Awareness of land grabbing by household head in the community (1=aware, 0= not aware)	68.22%
Cult_Int	If household head had intention of cultivating part of the area grabbed (1=yes; 0=no)	32.45%
NoAdult	Number of adults in a household	4.52
Fallowyrs	Most recent year of fallowing farm land	3.23
EnoughLan	If the household head is satisfied with current size of farm land (1=yes; 0=no)	28.82%
HHSz	Household size (count)	11.91
Remit	Remittances (GH¢)	235.65
EduExp	Yearly amount spent on wards' education (GH¢)	580.50
OthHHExp	Other monthly household expenditure (GH¢)	365.04
Dist	District of household (1 for KNE; 0 for Gushiegu)	46.53%
AcqBushLand	Acquired bush land by investors (1=yes, 0=otherwise)	22.32%
AcqFalloLand	Acquired fallow land by investors (1=yes, 0=otherwise)	21.32
LandInvTyp	Agricultural investment that acquired land has been put into (1 for arable crop; 0 for tree crop)	35.64%
GrabScale	Scale of land acquired (1 for large; 0 for medium)	55.94%
GrabYrs	Years of acquisition (1 for longer; 0 for shorter)	45.54%
LostLand	If household head has lost land to investors (1=yes; 0=no)	68.32%
FalloLength	Perception about length of fallow (1=long, 0=short)	24.34%

Table 2: Multinomial logistic estimation: effects of land deals on livelihood choices

	Intensive		Low intensive	
	RRR	Std. Err.	RRR	Std. Err.
Ag	0.014	0.021	0.193*	0.112
Edyrs	0.034	0.060	0.376	0.255
FmSz	0.043**	0.019	-0.103	0.123
AwLanGrb	3.569***	0.841	2.088	2.655
Cult_Int	1.272*	0.674	-13.56	146.932
NoAdult	0.199**	0.094	-0.019	0.339
Fallowyrs	0.237	0.200	1.556**	0.786
EnoughLan	-0.305	0.758	29.096	160.667
HHSz	0.009	0.045	0.117	0.244
Remit	-0.00016	0.0004	-0.009*	0.005
EduExp	-0.002**	0.0008	0.019**	0.009
OthHHExp	0.0012*	0.0007	-0.015*	0.008
Dist	7.165***	2.199	4.959	776.201
AqBushLand	-1.115	0.764	4.787	3.758
AqFalloLand	-14.971	630.389	0.817	7.312
LandInvTyp	3.538*	1.871	2.558	244.798
GrabScale	-4.216	2.589	-1.735	864.501
GrabYrs	3.547**	1.784	-9.132	206.166
LostLand	-1.158	0.763	9.703	8.434
Fallolength	-0.285	0.231	-1.495**	0.705
Const	-11.270	2.757	-46.283	161.339

Pseudo R^2 (0.4847); Prob > chi2 = 0.01; Log likelihood = 119.15; Number of obs = 302.

Farm households' choice of intensive farming regime was positively influenced by farm size. The risk ratio of farm size is 0.043 ($p<0.05$) suggesting that, a marginal increase in farm size would result in a 0.043 probability of a household to choose an intensive farming system over semi-intensive. This contradicts the work of **Rahut and Micevska (2012)**, and **Gecho *et al*. (2014)** who found that farm size had positive influence on farmers' choice of non-farm livelihood. This result meets the *a priori* expectation in the sense that farm households with larger farm sizes are endowed with either social or financial capital and could intensify their faming activities within affected communities in the wake of commercial land deals.

Farm households having knowledge on more than one existing acquisitions within their community had a risk ratio of 3.569 at 1 % significant level and a positive relationship with choosing intensive farming strategy. This means that knowing other acquisitions increases the likelihood of a farm household choosing intensive over semi-intensive regime of farm work. A farm household's knowledge on more than one land acquisition has a direct correlation with reduced community lands. Therefore, respondents intend to make the best use of the available land at their disposal which accounts for their engagement in intensive farming.

Farm households with future intensions of cultivating part of grabbed lands had a positive and significant influence on choosing intensive farming strategy at a risk ratio of 1.272 and a 10 % significance level. This shows that farm households who had future intension are 1.272 times more likely to choose intensive over semi-intensive regime of farm work. This result may be due to the fact that, individual farm households who had the intention of cultivating parts of acquired lands are having the capacity to extend their farming activities and have channelled those resources to intensification.

Total number of adults in a household was positive and significant at 5 % with the choice of intensive farming. Showing that at a 0.199 risk ratio, households with higher number of adults are more likely to choose intensive over semi-intensive regime of farm work. This result meets the *a priori* expectation because, adults are of the working class and can contribute either labour or capital to intensive farming within the household.

Amount spent on ward's education influences the risk ratios of farm households engaging in the intensive and low intensification regimes of farm work. The risk ratio of intensive was -0.002 showing a negative relationship with education amount but for low intensification the risk ratio was 0.019. This result indicates that farm households with higher amounts spent on wards education are 0.002 times less likely to engage in intensive farming and are 0.019 more likely to choose low intensification ahead of semi-intensive farming. The cost of taking wards through school has direct influence on financial capability of a farm household, hence households with increasing bills on schooling are more likely not to engage in intensive farming. This is because intensive farming requires the purchase of agrochemicals, improved seeds, fertilizer and the use of farm machines. On the other hand, the reverse of this reason is valid in explaining the positive effect of amount spent on wards' education on low intensification.

Also, total monthly expenditure of farm household influences positively the risk ratio of engaging in intensive farming whilst negatively influencing the risk ratio of low intensification. This result indicates that, farm households with higher monthly expenditures are 0.0012 times more likely to engage in intensive farming and are 0.015 less likely to choose low intensification ahead of semi-intensive farming. Total monthly expenditure encompasses all expenditures made by the household within a calendar month and reflects a good economic standing of such household. In light of this, it is not surprising that farm households with higher monthly expenditure do engage in intensive farming because they can afford. The result is consistent with the findings of **Abimbola and Oluwakemi (2013)** and **Yizengaw *et al*. (2014)** that total household income has positive influence on farmers' choice of livelihood strategy. This inversely explains the negative effect of higher monthly expenditure on low intensification.

Location of respondents on the other hand shows a positive and significant (1 %) relationship with the choice of intensive farming at a risk ratio of 7.165. This shows that, given the districts considered in this study, residing in KNEM increases the likelihood of choosing intensive farming ahead of semi-intensive farming, over residing in the Gushiegu District. This may be due to the fact that sizes of land that are grabbed in KNEM are larger in scale as compared to acquisitions in the Gushiegu District. This confirms the study by **Yaro (2006)** in Kassena Nankana East as farmers engage intensive farming as a result of difficulty in accessing arable land in the area due to land grabbing.

At 10 % significance level, affected communities with acquired lands used for arable crop investments showed positive relationships with the choice of intensive farming. This means that at a risk ratio of 3.538 farm households within such communities are more likely to choose intensive farming ahead of affected communities with tree crop investments. This result may be due to the fact that acquired lands used for arable crop investments are most likely to have irrigation facility which can be taken advantage of by farmers within the catchment area. Therefore, it is not surprising that these farmers engage in intensive farming.

Longer years of grabbing also, showed a positive and significant (5 %) relationship with the choice of intensive farming. This gives an indication that, at a risk ratio of 3.547 farm households residing in a community which has been affected for longer years are of higher likelihood of choosing intensive farming ahead of communities with shorter years of acquisition. This result also may be due to the fact that longer years of acquisition has contributed to the reduction in farmers' per capita land access, hence the need to adopt intensive farming regime.

Age was positively significant with the choice of low intensification. The risk ratio of age is 0.193 which indicates that at 10 % significant level, farm household with older heads are about 0.193 times more likely to choose low intensification over semi-intensive regime of farm work. Increased age has direct correlation with strength reduction in humans, therefore it is expected that as farmers age increases they are more likely to engage in low intensified farming.

Recent fallow showed a positive relationship with choosing low intensification at 5 % significance level. The risk ratio of recent fallow is 0.237 which indicates that farm household with longer years of recent fallow is about 0.237 times more likely to choose low intensification over semi-intensive regime of farm work. This result is not consistent with the *a priori* expectation and may be due to the fact that, farmers who have not fallowed their farm lands for a longer period of time are not highly incentivized to farm, hence do not put much investment into farming. Land fallowing has been proven to improve soil fertility, therefore it is expected of motivated farmers to either engage in fallowing or intensify their farming routine.

The results also show a negative relationship between fallow period and the choice of low intensification at 5 % significance level. This means that, with a risk ratio of -1.495 farm households that experiences shorter fallow periods are more likely to choose semi-intensive over low intensification regime of farm work. Farmers with longer fallow period are most likely to sustain soil fertility. This result supports the fact that such farmers do engage in semi-intensive farming ahead of low intensification as they partly complement their farm work with farm inputs and machinery.

Remitted amount received by farm households showed a significance level of 10 % was found to have a negative relationship with the choice of low intensification. This shows that, at a risk ratio of -0.009 farm households that receive lower amounts of remittance are more likely to choose semi-intensive farming ahead of low intensification. The reasoning behind this could be that farm households with low income support from family and well-wishers do rely more on farming activities than their counterparts who receive support.

CONCLUSION

This study focused on analysing how land deals affect livelihood alternatives for smallholder farm households (intensive, semi-intensive and low intensive methods of farming). The study concludes that, large farm size, household heads' awareness of land grabbing in the community, households having interest of cultivating part of grabbed land, households having more adults, households who have higher total monthly expenditure and households located in KNE municipality have higher probability of using intensive method of farming. Households living in communities where grabbed lands are used for cultivating arable crops and longer number of years of land grabbing prefer intensive to semi-intensive methods of farming. Those who have low propensity to farm under intensive system are households who spend more on education and those who receive higher amount of remittances.

Also, households who have higher probability of engaging in low intensive method of farming as compared to semi-intensive method of farming are older households, households who allow longer period of fallowing and households who spend more on education. Lastly, households are likely to engage in semi-intensive method of farming as compared to low intensive method of farming when they receive high amount of remittances, spend more money on food, medical bills among others, and when they live in communities where grabbed land have been left to fallow for longer period of time.

Land deals must be accompanied by efforts to diversify livelihoods away from land-based systems. This would require skills training for rural peasants to enable them take up emerging livelihood opportunities. This is necessary because local peasants who are disposed by commercial land deals have limited options for livelihood. In order to safeguard the interests and livelihood of rural peasants, agricultural investment programmes must make community-investor partnerships a key condition for gaining access to government and donor incentives. Such policies would help reduce elite capture and ensure lands and funds acquired by urban elites translate into investments and livelihood opportunities.

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REGULAR ARTICLE

DOES FARMER GROUP MEMBERSHIP ENHANCE TECHNOLOGY ADOPTION? EMPIRICAL EVIDENCE FROM TOLON DISTRICT OF GHANA

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ABSTRACT

The low adoption of improved technologies by farmers has been identified as one of the major factors affecting agricultural production and food security in many developing countries including Ghana. Farmer-based organizations have been identified as important channels for information and technology dissemination to farmers. The effect of these groups on farmers' adoption decisions has important implications for agricultural production and food security in many developing countries. This study therefore sought to examine the effect of farmer group membership on improved variety adoption by smallholder maize farmers in the Tolon District of Ghana using cross-sectional data from a sample of 160 farmers. A recursive bivariate probit (RBP) model was used to estimate the effect of group membership on adoption. The results indicate that membership in farmer groups is associated with lower adoption of improved maize varieties, which is contrary to generally held view that farmer groups promote adoption by farmers. Adoption is higher for the married and farmers with access to agricultural extension but decreases with size of herd size and cultivated land. The results underscore challenges confronting farmer-based organizations such as increasing politicization, decreasing effectiveness, and lack of support from both public and private institutions. Incentivizing farmer groups, including the apex body responsible for supervision of these groups will enhance effectiveness of farmer groups.

Keywords: Adoption, farmer-based organization, productivity, recursive bivariate probit model, Tolon district
JEL: C21, D24, Q12

INTRODUCTION

Agriculture plays a major role in the development of Ghana's economy. According to **ISSER (2016)**, the agricultural sector contributes about 20.3% to the country's gross domestic product (GDP) while more than 60% of the population depend on the sector for their livelihood **(Government of Ghana, 2017)**. Despite the important role agriculture plays in the national economy, there has been a consistent decline in the sector's contribution to gross domestic product (GDP) in recent years. As a result, there have been several efforts towards revamping the agricultural sector to promote growth and development, especially productivity growth and overall agricultural development. These efforts include promotion and establishment of farmer-based organizations (FBOs) especially among rural farmers and measures to enhance adoption of improved agricultural technologies such as improved seeds, inorganic fertilizers, agricultural mechanization and irrigation technology.

As emphasized by **Gatzweiler and von Braun (2016)**, one way to improve the welfare of rural people is to ensure agricultural productivity growth through technological innovations. Agricultural technology may be defined as enhancing farming activities by the use of new methods and innovations. Technology encapsulates the scientific application of knowledge to real situations while adoption is the integration of new concepts into farmers' common farming practices over a period of time **(Feder *et al*. (1985)**. Adoption of improved agricultural technology is a tool for increasing agricultural production as well as increasing farm income, reducing poverty, improving standard of living and increasing food security **(Mwangi and Kariuki, 2015)**.

Hazell *et al*. (2010) argued that institutional innovations play relevant role in achieving agricultural growth and development as they can assist farmers to overcome market failures. The term farmer groups, farmers' associations, farmers' cooperatives and farmer's societies can be used interchangeably **(Asante *et al*., 2011; DENIVA, 2005; Uliwa and Fisher, 2004)** and refers to a group of farmers with common interest who share experience to enhance their common objective. From a lay man's perspective, a farmer-based organization may be defined as an organization owned and controlled by the members with the aim of rendering services for mutual benefit of all its members. Several organizations, both governmental and non-governmental, support the development of FBOs in Africa on the premises that FBOs enhance access to credit, extension services, marketing of produce and farm inputs, as the nature of agriculture in Africa is on small scale **(Barham and Chitemi 2009; Bernard *et al*. 2008; Bernard and Spielman 2009)**. Establishment of FBOs is encouraged by several governments to enhance poverty reduction and economic growth, improve rural access to extension delivery and credit as well as the welfare of the people **(Stockbridge *et***

***al*., 2003; World Bank 2007)**.

Farmer groups are anticipated to enhance the adoption of improved agricultural technologies by members which is expected to increase agricultural productivity, commercialization and market access **(MAAIF, 2010)**. The influence of FBOs on crop productivity has been evaluated by several researchers worldwide. These studies give mixed results suggesting both positive and negative effects of farmer groups on productivity (see **Benin et al., 2011; Davis *et al*., 2012; Mwaura, 2014**). A study by **Debela *et al*. (2018)** indicated that farmers' cooperatives enhanced income and productivity of smallholder farmers in Eastern Oromia in Ethiopia. When farmer-based organizations are adequately resourced and incentivized to serve their members, they provide benefits to the members. These benefits include access to services and input delivery which lead to improvement in farm performance and profitability. However, farmer groups may deviate from their core mandate while free-riding behaviour of some members may also reduce the groups' effectiveness. In addition, increasing politicization of FBOs has the tendency to reduce effectiveness of these groups due to political influences, favouritism, and cronyism. Thus, the contribution of farmer groups is very much related to both its internal structures and the support from governmental and non-governmental organizations. Where such support is forthcoming, farmer groups are more likely to be effective in their operations thereby enhancing adoption of technology and farm productivity of the members.

Farmer groups are voluntary organizations; hence participation is voluntary. Nevertheless, in spite of the perceived benefits of FBOs to smallholder farmers, not every farmer is willing to join these groups. The decision to join a farmer group depends on the expected utility to be gained from participation. Hence, farmers are likely to join when the benefits of joining the group is perceived to be higher than not joining. Conversely, where farmers perceived the benefits to be gained to be lower than not joining, they are not likely to join.

Farmer-based organizations are gaining popularity in recent times and becoming common in many rural areas of developing countries. However, the impact of these groups on farm outcomes especially technology adoption and productivity, remains unclear especially in the context of smallholder farming in Ghana. The objective of this paper is therefore to assess the factors influencing the decision of smallholder maize farmers to participate in FBOs in the Tolon district of northern region of Ghana and the effect that these groups have on adoption decisions of farmers and farm productivity. The study employs a recursive bivariate probit model that accounts for both observed and unobserved heterogeneity in the binary decisions, thus accounting for selection bias. Furthermore, the model can be used to assess the impact of FBO membership on adoption. The motivation behind this study is born out of the need to ascertain the effectiveness of FBOs operating in rural areas in the country and their impact on smallholder farmers vis-à-vis adoption of improved varieties and productivity. The results of the study will highlight the strengths or weaknesses of these groups and provide insight into measures to enhance group effectiveness that will promote technology adoption and farm productivity.

DATA AND METHODS

Recursive bivariate probit (RBP) model

In modelling two jointly determined binary choices or decisions, researchers typically adopt a bivariate probit approach, where the two binary choices are determined by the same set of explanatory variables. In the situation where the two binary choices are influenced by slightly different explanatory variables, a seemingly unrelated bivariate probit (SUBP) model is assumed. However, there are situations where one of the binary choice variables is a factor influencing the other choice variable. In this case, a recursive bivariate probit (RBP) model is more appropriate for the estimation. The recursive bivariate probit model consists of two probit equations with error terms that are correlated and one of the binary dependent variables is allowed to be an endogenous explanatory variable in the other equation. In this way, the RBP model can be used to evaluate the impact of a binary choice variable on another binary decision. The dependent variables under investigation in this study are dichotomous namely farmer group membership and adoption of improved varieties. Empirical investigations of binary choice decisions typically make use of latent variables to analyse the relationship between the dichotomous variable and the set of explanatory variables. In this study, a latent variable is assumed for the analysis.

It is assumed that participation in farmer-based organizations is a latent variable represented by Y_1^*, and that Y_2^* is a latent variable measuring adoption of improved variables. Since these two latent variables are unobservable, the following specification can be used to depict the relationship between the latent variable Y_1^* and the observed choice Y_1 (Eq. 1-2)

$$Y_1^* = x_1\beta_1 + e_1 \quad (1)$$

$$Y_1 = \begin{cases} 1, & if\ Y_1^* > 0 \\ 0, & otherwise \end{cases} \quad (2)$$

Where: x_1 stands for the observed explanatory variables that explain participation in farmer-based organizations, β_1 is a vector of parameters to be estimated, and e_1 denotes a random error term.

Similarly, the decision to adopt improved varieties is modelled as a latent variable, with the following specification that represents the relationship between the latent variable Y_2^* and the observed choice Y_2 (Eq. 3-4)

$$Y_2^* = \partial Y_i + x_2\beta_2 + e_2 \quad (3)$$

$$Y_2 = \begin{cases} 1, & if\ Y_2^* > 0 \\ 0, & otherwise \end{cases} \quad (4)$$

Where: x_2 represents the observed explanatory variables explaining adoption decision, β_2 is a vector of parameters to be estimated, and e_2 denotes a random error term. The error terms in the two models, that is e_1 and e_2, are dependent and have a normal distribution so that (Eq. 5),

$E[e_i] = E[e_2] = 0 \quad var[e_1] = var[e_2] = 1$ and $cov[e_1, e_2] = \rho$ (5)

Finally, a Wald test for the null hypothesis ρ = 0 is used to test whether the two models have to be jointly estimated.

The empirical model for improved variety adoption is presented as follows (Eq.6).

$$Y_1 = \beta_0 + \beta_1 \text{age} + \beta_2 sex + \beta_3 edu + \beta_4 mar + \beta_5 exp + \beta_6 fsize + \beta_7 hsize + \beta_8 ext + \beta_9 catt + e_1 \quad (6)$$

Similarly, the empirical model for farmer group participation is presented as follows in Eq. 7.

$$Y_2 = \beta_0 + \beta_1 \text{age} + \beta_2 sex + \beta_3 edu + \beta_4 mar + \beta_5 exp + \beta_6 fsize + \beta_7 hsize + \beta_8 ext + \beta_9 catt + \beta_{10} cred + \beta_{11} subsidy + \beta_{12} cost + \beta_{13} Y_1 + e_2 \quad (7)$$

Simultaneous estimation of Equations (1) and (3) using maximum likelihood gives unbiased estimates of β and ρ.

RESULTS AND DISCUSSION

Description of the sample

Table 1 provides a description of the variables used in the study. Majority of the respondents (86%) are male while 92% are married. The respondents have a mean age of 43 years and an average of 10 household members, while farm size averaged 1 hectare. Majority of the respondents (74%) have no formal education nor access to credit (89%). Close to 54% have access to extension service while 14% own cattle. Cattle ownership was included as a wealth indicator. In addition, majority of the respondents (89%) have access to fertilizer subsidy. Technology adoption involves a cost to farmers and the decision to adopt depends on farmers' ability to pay and whether the cost of adoption is perceived to be high or low. The cost of adoption includes the cost of improved seeds and chemical fertilizers as well as farmers' perceptions of the riskiness of the technology. Majority of the respondents in this study perceive the cost of adoption to be high. The years of farming experience of the respondents averaged 17 years. Also, about 48% of the farmers participate in a farmers group while 50% adopt improved maize varieties.

The descriptive statistics of the bivariate probit model variables are presented in Table 2. Farm size, sex, age, household size, and marital status of the respondents did not differ much between FBO members and adopters of improved maize varieties. On average, 25% of FBO members had formal education while 28% of adopters of improved varieties had formal education. Furthermore, 97% of FBO members were married compared to 93% of adopters. Also, 17% of FBO members had access to credit compared to 14% of adopters of improved varieties. Farmers' low access to credit is a major concern to agricultural production in the study area. The data also shows that 87% of FBO members had access to agricultural extension compared to 66% of adopters. This indicates that FBO members participated more in extension in line with the extant literature that FBOs are conduits for extension service delivery in most rural communities. The low participation of adopters in agricultural extension is contrary to a priori expectation but may be indicative of the generally low access to agricultural extension in many rural areas. Majority of the respondents did not own cattle while similar proportion of FBO members and adopters had access to fertilizer subsidy. On the other hand, 88% of FBO members perceived the cost of adoption to be high compared to 80% of adopters. Finally, farming experience did not differ between the two groups.

Results of the recursive bivariate probit (RBP) model

The results of the recursive bivariate probit model of FBO membership and improved maize variety adoption are presented in Table 3. The likelihood ratio test of the joint equations was significant at 5% level indicating that the two equations are related. In other words, joint estimation of the two equations is appropriate, whereas individual estimation of the two models would have yielded inconsistent estimates.

Table 1 Definition and summary statistics of the variables used in the study

Variable	Definition	Mean	Min.	Max.
Adoption (Y_1)	Crop variety (1 = improved)	0.500	0	1
Farmer group membership (Y_2)	Group membership (1 = member)	0.475	0	1
Sex of farmer (*sex*)	Sex of farmer (1 = male)	0.863	0	1
Age of farmer (*age*)	Age of farmer in years	42.93	18	90
Educational status (*edu*)	Educational status (1 = educated)	0.256	0	1
Marital status (*mar*)	Marital status (1 = married)	0.919	0	1
Household size (*hsize*)	Number of household members	10.24	1	25
Farm size (*fsize*)	Farm size in hectares	0.969	0.4	5.3
Access to credit (*cred*)	Access to credit (1 = access)	0.113	0	1
Extension access (*ext*)	Access to extension (1 = access)	0.538	0	1
Cattle ownership (*catt*)	Farmer owns cattle (1 = yes)	0.144	0	1
Subsidy (*subsidy*)	Access to fertilizer subsidy (1 = yes)	0.894	0	1
Cot of adoption (*cost*)	Cost of adoption (1 = high)	0.863	0	1
Experience (*exp*)	Farming experience in years	16.88	2	50

Table 2 Descriptive statistics of the recursive bivariate probit analysis variables

Variable	FBO membership		Improved variety adoption	
	Members	Non-members	Adopters	Non-adopters
Sex of farmer (%)	0.855	0.869	0.825	0.900
Age of farmer (years)	44.61	41.42	42.85	43.01
Educational status (%)	0.250	0.262	0.288	0.225
Marital status (%)	0.974	0.869	0.925	0.913
Household size (number)	11.18	9.393	10.86	9.625
Farm size (hectare)	0.950	0.985	1.009	0.928
Access to credit (%)	0.171	0.060	0.138	0.088
Extension access (%)	0.868	0.238	0.663	0.413
Cattle ownership (%)	0.092	0.190	0.188	0.100
Subsidy (%)	0.947	0.845	0.950	0.838
Perceived cost of adoption (%)	0.881	0.845	0.800	0.925
Farming experience (years)	18.80	15.14	18.23	15.54

Table 3 RBP model estimates of FBO membership and adoption of improved varieties

Variable	FBO membership		Adoption of IMVs	
	Coefficient	Std. Dev.	Coefficient	Std. Dev.
Sex	-0.179	0.639	-0.745**	0.318
Age	0.012	0.447	-0.008	0.013
Educational status	0.485	0.116	0.391*	0.237
Marital status	1.486***	0.001	0.460	0.379
Farming experience	0.007	0.702	0.025*	0.015
Farm size	-0.607*	0.051	-0.083	0.184
Household size	0.017	0.526	0.028	0.022
Extension contact	2.040***	0.000	1.365***	0.233
Cattle ownership	-0.770*	0.053	0.017	0.288
Access to credit			0.334	0.273
Subsidy			0.711**	0.354
Cost of adoption			-0.648**	0.277
Farmer group membership			-1.514***	0.186
Constant	-2.653***	0.000	-0.311	0.673

***, ** and * indicate statistical significance at 1, 5 and 10 percent levels, respectively. Likelihood-ratio test of rho=0: chi2(1) = 5.3175, Prob > chi2 = 0.021**.**

Determinants of farmer group membership

For the FBO participation model, the results in Table 3 indicate that membership in FBOs is higher for married respondents, indicating that the choice to belong to a farmer group is influenced by the marital status of the respondent. However, **Etwire *et al.* (2013)** observed that marital status had no significant effect on farmers' decision to participate in agricultural projects in Ghana.

Furthermore, farmers with smaller farms were more likely to participate in farmer groups compared to those with larger farms. Land-constrained farmers may be relatively poorer, which may influence their decision to join farmer groups as a result of the perceived benefits. The result is however at variance with the findings of a study on the determinants and impact of farmer collective action in Kenya by **Fischer and Qaim (2012)** which showed a higher probability of farmers with larger farms to join farmer groups compared to those with smaller farms. **Asante *et al.* (2011)** also reported a positive influence of farm size on farmer group membership in Ghana.

The result also indicate that extension contact increases the probability to participate in farmer-based organizations. The result is consistent with the extant literature and a priori expectation due to the increasing role of FBOs as conduits for extension delivery among poor people in developing countries. The result agrees with the findings of **Tolno *et al.* (2015)** in a study involving potato farmers in Guinea. Extension agents interact with farmers and share information on the benefits of joining farmer groups, thus influencing farmer's decision to participate in groups. **Etwire *et al.* (2013)** also observed that the likelihood of farmers to participate in agricultural projects increased with the number of extension contacts in a study involving farmers in Ghana.

In addition, the study revealed an inverse relation between cattle ownership and participation in farmer-based organizations. This implies that owners of cattle have a lower propensity to participate in farmer-based organizations. Cattle ownership was included as a proxy variable for wealth status of the respondent. Thus, participation in farmer groups was found to be lower for wealthier household heads in the study area.

Determinants of improved variety adoption

The estimates of the determinants of improved variety adoption are presented in the 4th and 5th columns of Table 3. The results indicate that adoption of improved maize varieties is higher for female farmers. In other words, male farmers are more likely to cultivate traditional varieties. This result does not lend itself to easy interpretation. However, adoption of traditional varieties is a risk-averse behaviour of farmers, and therefore suggests that male farmers in the study area may be more risk-averse in their choice of crop varieties. The result agrees with **Mwangi *et al.* (2015)** who found that men were less likely to adopt cover crops for weed management in Kenya. The result is however contrary to the findings of **Kalinda *et al.* (2014)** which showed that male farmers adopted improved technology more than female farmers.

The results also indicate that adoption of improved varieties increased with education of the respondent. Farmers with formal education are more likely to adopt improved varieties compared to those without formal education. This result is consistent with a priori expectation because education enhances the human capital and the ability of the farmer to make informed decisions based on available information. The result agrees with **Teklewold *et al.* (2016)** and **Yimer *et al.*, (2019)** in their adoption studies involving farmers in Ethiopia.

Adoption of improved variety also increased with farming experience, which is consistent with the extant literature. Farming experience, like education and training, enhances the human capital and the ability to make informed decisions. Through learning over a long period of time and information sharing, farmers may gain knowledge of productivity-enhancing technologies which may enhance their willingness to adopt high-yielding crop varieties. However, a study by **Ebojei *et al.* (2012)** found no significant influence of farming experience on adoption.

Another important human capital variable which positively influenced farmers' decision to adopt improved maize varieties is access to agricultural extension services. The result is consistent with a priori expectation and corroborated by the extant literature. Farmers receive agricultural information from extension agents who link farmers to research centers. As a result, extension agents facilitate access to information and technology transfer to farmers and therefore play an important role in farmers' adoption decisions. The result agrees with **Yimer *et al.*, (2019)** in their study in Ethiopia. The result is also in consonance with **Mignouna *et al.* (2011)** in their study of maize technology adoption in Western Kenya and **Akudugu *et al.* (2012)** who studied technology adoption by farmers in Ghana.

The results of the study further indicate that access to fertilizer subsidy is positively related to adoption of improved maize varieties at 5% significance level. This shows that the likelihood to adopt improved maize varieties increases with access to fertilizer subsidy. The government of Ghana introduced the Fertilizer Subsidy Program (FSP) in 2008 to increase cereal production in Ghana. Technically, all cereal farmers are entitled to a subsidy. However, as with many other government interventions in the agricultural sector, not every farmer is able to access the input subsidy due to several challenges (see **Yawson *et al.*, 2010**). A subsidy reduces the cost of production and the risk of adopting improved crop varieties, thus enhancing the likelihood of adoption. Similarly, **Bezu *et al.* (2013)** found a significant positive correlation between subsidy accessibility and adoption of improved maize varieties in Malawi.

Farmers' perception of the cost of adoption had a significant relationship with the decision to adopt improved maize varieties at 5% level. The result indicates that adoption decreased with an increase in the perceived cost of adoption. The result is consistent with a priori expectation. As cost of adoption increases, many farmers are likely to choose varieties that are less costly to adopt. In a situation where the farmer faces liquidity constraints, it is unlikely that he or she will adopt a technology which is costly. However, with credit provision and adequate information on the yield potential of new varieties, farmers may be persuaded to adopt technologies which they perceive to be costlier. The result is in agreement with the findings of **Lyimo *et al.* (2014)** which stated that high cost of improved seeds hindered its adoption in Tanzania.

Finally, the variable of interest, farmer group membership portrayed a negative and significant relationship with adoption at 1% level. The result indicates that farmer group membership significantly decreases adoption of improved varieties. The result is contrary to a priori expectation because farmer groups are expected be serve as channels for extension delivery to farmers. Farmer groups also help members to acquire production inputs and credit for their members. The result however suggests that farmer groups in the study area are not effective in influencing technology adoption decisions of members. All though the result is hard to explain, **Mwangi and Kariuki (2015)** observed that social groups may have a negative impact on technology adoption in the event of free-riding behaviour by members.

CONCLUSION AND RECOMMENDATIONS

The study examined the effect of farmer group membership on improved variety adoption by maize farmers in Tolon District of northern Ghana. The study relied on cross-sectional data from 160 maize farmers and used a recursive bivariate probit model to estimate the influence of group membership on adoption. The study indicated a negative association between farmer group membership and adoption of improved maize varieties. This implies that farmer groups in the study area are not making a positive impact on their members in terms of decision to adopt improved seeds. Farmer groups in the country face challenges including politization of the groups, and lack of adequate support from both public and private institutions, which are likely to reduce their effectiveness. There is therefore the need to incentivize these groups, including the apex body responsible for their supervision so as to enhance the effectiveness of farmer-based organizations in the study area.

The results of the study also highlight the important role of agricultural extension, which is positively related to adoption decision and farmer group membership. Hence, efforts to enhance adoption of improved maize varieties and FBO membership must seek to address the specific factors influencing farmers' participation and adoption decisions, while paying particular attention to ways to enhance farmers' access to agricultural extension.

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REGULAR ARTICLE

INCOME IMPACT OF PASTORALIST WOMEN PARTICIPATION IN ALOE VERA SOAP PRODUCTION IN SOUTHERN ETHIOPIA

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ABSTRACT

Commercial opportunity for indigenous Aloe Vera products appear to be increasing as there is a sustained demand from international as well as African market with high participation of women. However, its income impact on the livelihood of household is not yet addressed. Therefore, this study evaluated the income impact of pastoralist women participation in Aloe Vera soap production in Yabello district, Borana zone of Oromia, Ethiopia. Both primary and secondary data were collected from 200 sample households using semi-structured questionnaire. To analyse the data both descriptive and inferential statistics and Propensity Score Matching model were applied. The Propensity Score Matching was applied the required matching processes, covariate balancing and sensitivity analysis tests. The result shows that participation of women in Aloe Vera soap production has insignificant result with impact on household income. However, the propensity score matching also indicates average treatment effect on treated income is 45.693 Birr. Result of sensitivity analysis further shows that the estimated effects are insensitive to unobserved selection bias within gamma level used. Thus, Aloe Vera soap production should be encouraged for the pastoralist social wellbeing.

Keywords: Aloe Vera Soap production, Propensity Score Matching, Yabello, Southern Ethiopia
JEL: B16, C21, O13

INTRODUCTION

According to many researchers commercial opportunity for indigenous Aloe Vera appear to be increasing as there is a sustained demand from international as well as regional market with high participation of women (**Wren, 2008; Wren and Mamo, 2009**). Aloe Vera is a semi-tropical plant that originated in the dry warm climate of Africa. It is a member of Lily family (liliaceae) and related to other Lily family such as the onion, garlic and turnip families. Its history dates back to the biblical times (**Council, 1996-2002**). There are about 400 species of aloe, but only five can be used as medicine. Today aloe plant is found worldwide and become high -ranking agent as an all-purpose herbal plant (**Virdi, *et al*. 2012**).

Aloe species are used as a medicine for animal and human in case of disease such as worms and internal parasites both for human and livestock's, malaria, for injured and scarred skin so as to fasten the healing process. Aloe sap also used for remedy of snack bite by mixing Aloe latex with certain proportions (1:40 ratio) of water and enforced to drink the one who have bitten as short as possible after the attack (**Asmelash, 2017**).

Internationally, the share of women in paid employment outside the agricultural sector has increased marginally. But in South Asia, North Africa and West Asia, employment opportunities remain very low. Approximately two-thirds of all employed women in developing countries work either as contributing family workers or as own-account workers, extremely vulnerable employment which lacks security and benefits. Gender difference in the labour force participation rates, unemployment rates and gender wage gaps are a persistent feature of global labour markets (**UNDG, 2010**).

In Africa participation of women in economic activities has been improving overtime. As present by **Oyekanmi *et al*., (2014**) African black soap is mostly hand crafted by village women who make the soap for themselves to support their families. This handmade African black soap which made with potash in small lots and from local materials includes alkali from cocoa pods ash, palm kernel oil, Aloe Vera and honey is found to be of high quality than the industrial produce soap. However, the production and the technique for the soap vary depending on the region of African where it is made.

According to **Livingstone and Ruhindi. (2011)**, in the pastoralist communities women's groups play a vital role in economic contribution of family. In group they can act as supporters for individual loans, to mobilize the funds to expand or start a business, help to mitigate women's time poverty and reinforce existing social capital. This is essential because restrictions on women's mobility are a major constraint on their economic participation where women need to become empowered within harmonious, well-functioning families and societies. According to **Handaragama *et al.* (2013)** in Thunkama, the economic well-being of the family is initiated by women in the families since they perform a significant role in their family economy.

In Ethiopia, there is a participation of women groups in Bio-enterprise developments in sustainable wild harvest and domestication of indigenous Aloe species and gums product of non-timber forest products (NTFPs). Aloe is one of a vast growing plant species in Ethiopia even though the commercialization of this ample resource by residents and transient communities is very low (**Demissew and Nordal, 2010**).

As **Wren and Mamo (2009)** currently a few Bio-enterprise are established at different parts of Ethiopia to utilize the natural resource in an area. Their goal is to contribute to the poverty reduction, economic empowerment and social wellbeing of pastoralists, particularly women. Example; rural women groups that participate in Aloe Vera soap production came from Tigray and Amhara region to Borana zone for cross visits organized to rural enterprises initiated by women groups for experience sharing.

As presented by **Hurst, *et al.*, *(*2012)** in Borana community, women generate income for their family by establishing women's groups or savings cooperatives. Mostly NGOs such as CARE, Gayo and SOS Sahel provide financial support to women hoping to engage in petty trade businesses. These activities are purchasing sugar, alcohol, coffee, tobacco, butter, milk and tea leaves and then returning to the village to sell these items, thus earning a small profit. Women who live in close proximity to forests or wooded areas (special in Yabello and Arero districts) may use products from the forest to supplement their incomes. Organizations such as SOS Sahel encourage forest management and teach women how to use products from the forest such as aromatic wood product that is used as perfume, collect gum from trees and sell incense/myrrh to generate profit.

The Aloe Vera soap production established by SOS Sahel Ethiopia in Borana pastoral area in 2006 after they did an assessment on natural resource found in that area. Seed money was funded by the European (**Milky union, 2017**). Before this assessment Aloe plants taken as bush clearing but the result of assessment found that aloe is one of economical and medical wild tree in an area. Their intention was utilization of wild resource like aloes which is found in an area so as to improve livelihood of local community and social wellbeing of pastoralists, particularly women in sustainable manner. Indeed, it enables local community (like women, youth and people at different economic level) to participate in economic activities by starting Aloe Vera soap production opportunity.

Even though in most pastoral community, women roles are reproductive and they mostly work in the house like fetching water, collecting firewood, cooking food, cleaning and child care (**Lasage *et al.*, 2010**), this project gives them chance to participate in productive activities to their family living. Today this project has becoming to expand into five districts of the zone.

As usually known the livelihood of pastoral and nomadic people are more relied on livestock (live animal and its product). Problem with this system in the study area is that they mostly depend on natural climate condition (rainfall).

However, the nature of rainfall becomes very erratic and there is a high drought expansion throughout the district of Borana zone including the study area. As **Tilahun (2015**), this drought causes shortage of feed and water for both livestock and human beings. Thus, severe death on livestock, and human hungry (food insure) is an end result of the drought. Therefore, what more important for this pastoral community is diversifying their basis of livelihood through utilization of available wild resource in an area with all participation of their local community without discrimination of sex and minor groups and people in all age. Aloes is one of those trees that identified as elaborated above.

Previous studies such as **Teshome (2014)** tried to address Aloe soap value chain initiatives and its effect on livelihood diversification strategy, by assessing the impact and determinants of participation in three kebele or peasant associations. Moreover, **Tesfaye (2006), Demissew and Nordal (2010), Oda and Erena (2017), and Walker (2017)** conducted study on the aloe species and distribution in different parts of Ethiopia including Yabello district. But, to the knowledge of this study the impact of Aloe Vera soap production particularly for women economic empowerment and income of household were not yet addressed. Therefore, considering aloe as one of commercial natural resource, and women as important human capital for Borana pastoral community, this study aims to fill the gaps by analysing the income impact of pastoralist women participation in Aloe Vera Soap production in Yabello district, Borana Zone of Oromia, Southern Ethiopia.

DATA AND METHODS

Description of Study Area

The study was conducted in Yabello district, Borana zone, southern Oromia State in Ethiopia. Yabello is located in the coordinates of 4°25' – 5°15'North latitude and 37°50'-38°50' East longitude. The ecology of the zone is arid and semi-arid savannah (**Beza, 2011**), with an altitudinal range of 1000 -1600 masl (**McCarthy *et al*, 2001**). Borana zone rangelands are dominated by tropical savannah vegetation with varying proportions of open grasslands and perennial woody vegetation (**Homann *et al.*, 2007**).

The mean annual daily temperature and a mean annual rainfall are around 19^0c and below 600mm respectively. It is frequently exposed to droughts that characterized as hot temperature and erratic rainfall. The erratic rainfall pattern causes vast area of the zone is not suitable for crop production. As (**JICA, 2015; Tilahun, 2015**), there are two rain season; long rainy ganna (from March to May) and short rainy Hagayya (from September to November) and the other remain months are dry season.

According to **Demissew and Nordal (2010)**, the vegetation type in Borana zone was Acaccia-Commiphora woodland and bush land with scattered remnant forests. This vegetation type is particularly rich in Aloes and other lilies including quite a few endemic or near endemic Aloe species. The natural populations taking place in study area is found in Sidamo floristic region.

Research Design

The study employed survey research of cross-sectional design. This cross-sectional survey study collected the data from study population at a single time from March to April of 2018 to examine the relationship between variables of interest. The study target population was both participant and non-participant women who are living in Yabello district of Oromia region, Ethiopia.

The study employed multi-stage sampling techniques that involve a combination of both simple random sampling and purposive sampling techniques.

In the first stage, on the basis of production of Aloe *Vera* soap out of the 12 kebeles of Yabello district , five sample kebeles were selected using stratification basis on the existence of intervention of Aloe Vera soap production in kebeles or not. The reason for this stratification is to have sample data from both kebeles of intervention and non-intervention of Aloe Vera soap production program. The first stratum was included women living in Aloe Vera soap production kebeles and a second stratum was accounted for non-participant women from the kebeles where production is not introduced yet.

Accordingly, Yabello district has only three kebeles (Dadim, Dida Yabello and Dikale) which produces Aloe Vera soap production; so that all three kebeles were selected purposively based on their production. From the other nine remain kebeles of which production is not yet started; two kebeles (Areri and Hara Awatu), for the case of taking as control group in order to reduce spillover effect for analysis of the impact of women participation in Aloe Vera soap, were selected purposively. This is because compared to others; those two kebeles are relatively more similar to intervention kebeles as they are on the same agro-ecology and on the same livelihoods basis (according to the interview of Yabello Pastoralist Development Office). Spillover is occurred due to interaction between participant and non-participant women live in the same village. Since this interaction is out of the control so taking some of the sample from the people outside the kebeles of Aloe Vera soap production is important.

On the second stage, sample respondents were selected randomly from each stratum on the basis of proportion to their population size. This is due to the homogeneity of population of study area.

Using the population data from (Yabello Pastoralist Development Office, 2017) the sample size was calculated since this data is not available on the CSA 2014 Ethiopian population projection. As in 2015/2016 Borana zone was separated into two zones and then many of district's and kebele's data were changed. By using the **Yamane (1967)** formula for sample size determination (Eq. 1) the study computed a total of representative 200 sample size.

$$n = \frac{N}{1+N(e2)} \quad (1)$$

Method of Analysis

The demographic and determinant characteristic of respondents were analysed using the combination of simple descriptive and inferential statistics. In addition, Propensity Score Matching model applied.

The propensity score matching of non-experimental methods of impact evaluation was used in ordered to assess the income impact of pastoralist women participation in the Aloe Vera soap production in the Yabello district of Borana zone, southern Ethiopia.

PSM builds a statistical comparison group that is based on a model of the probability of participating in the production, using observed characteristics. Participants are then matched on the basis of this probability, or propensity score, to nonparticipants. The average treatment effect of the production on treated is then calculated as the mean difference in outcomes across these two groups. PSM valid if two conditions are satisfied:

(a) Conditional Independence Assumption; (namely, that unobserved factors do not affect participation). It assumes that given a set of observable covariates X which are not affected by treatment, potential outcomes are independent of treatment assignment. This condition was tested using sensitive analysis.

(b) Sizable Common Support or Overlap: is about probability, propensity scores, across the participant and nonparticipant samples **(Khandker *et al.*, 2010).** Common support assumption is central for this study analysis and both on support as well as off support households are found in the result. But, for all respondent overlap range is $0 < P(D = 1|X) < 1$. This ensures that persons with the same X values (observed covariates or characteristic X) have a positive probability of being both participants and non-participants. Consider the outcome of participants after participating in the production as Y_1 and the outcome of nonparticipants or control households as Y_0. This with-and-without group comparison measures the program's effect (participating in production) as $Y_1 - Y_0$. This difference is called impact of intervention. But this measure is not always give a right estimate of program effect because of the pre intervention situations of treated and control groups, the counterfeit comparison could yield an over- or underestimation of the program's effect.

The basic evaluation problem comparing outcomes Y across participant and non-participant individuals i*;* is given by Eq. 2. Income is an outcome variable.

$$Y_i = \alpha X_i + \beta T_i + \varepsilon_i \quad (2)$$

Where:

T is a dummy equal to 1 for those who participate and 0 for those who do not participate, X_i is a set of other observed characteristics of the individual and perhaps (maybe) of her household and local environment and ε is an error term reflecting unobserved characteristics that also affect Y.

The average treatment effect (ATE) of the program might be represented by Eq. 3.

$$D = E(Y_i(1) \mid T_i = 1) - E(Y_i(0) \mid T_i = 0) \quad (3)$$

Where: D is representing an impact of program.

The problem is that the participant and non-participant groups may not be the same prior to the intervention, so the expected difference between those groups may not be due entirely to program intervention. If, in equation 2, one then adds and subtracts the expected outcome for nonparticipants had they participated in the program E(Yi(0) | Ti = 1), or another way to specify the counterfactual one gets Eq. 4 - Eq. 6.

$$D = E(Y_i(1) \mid T_i = 1) – E(Y_i(0) \mid T_i = 1) + [E(Y_i(0) \mid T_i = 1) – E(Y_i(0) \mid T_i = 0) \quad (4)$$

$$D = ATE + [E(Y_i(0) \mid T_i = 1) – E(Y_i(0) \mid T_i = 0)] \quad (5)$$

$$D = ATE + B \text{ (selection bias)} \quad (6)$$

In Equations 4-6, ATE is $[E(Y_i(1) \mid Ti = 1) – E(Y_i(0) \mid T_i= 1)]$, that is, the average gain in outcomes of participants relative to nonparticipants, as if non-participating households were also treated. The ATE corresponds to a situation in which a randomly chosen household from the population is assigned to participate in the program, so participating and non-participating households have an equal probability of receiving the treatment T. The term B, $[E(Y_i(0) \mid T_i = 1) – E(Y_i(0) \mid T_i = 0)]$, is the extent of selection bias that crops up in using D as an estimate of the ATE. Hence $E(Y_i(0) \mid T_i= 1)$, is unknown, the calculation of magnitude of selection bias is became difficult. As a consequence, it may impossible to know the exact difference in outcomes between the treated and the control groups. Therefore the basic objective of a sound impact assessment is then to find ways to get rid of selection bias (B = 0) or to find ways to account for it. The solution for this problem is conditional independence assumption or unconfoundeness assumption. It means assuming that whether or not households or individuals receive treatment (conditional on a set of covariates, X) were independent of the outcomes that they have. So B = 0 (selection bias is disappeared).

$$(Yi(1), Yi(0)) \perp Ti \mid Xi \quad (7)$$

Generally in independence assumption, the participant and non-participant groups must be the same in at least three ways. The average characteristics of the participant and non-participant groups must be identical in the absence of the program, the participant should not affect the non-participant group either directly or indirectly this is called (no spillovers) and the outcomes of units in the non-participant group should change the same way as outcomes in the participant group, if both groups were given the program (or not) **Khandker *et al.*, (2010).**

RESULTS AND DISCUSSION

Descriptive Statistic Results

The study uses a total of 200 sample respondent data for analysis which was collected from Yabello district. Comprising 57 participants and 143 non-participants women in Aloe Vera soap production, as indicated in Table 2.

Sex of the household head: According to the survey result obtained in the study area, 42 households are headed by female and the remains 158 households are male headed. Result of chi^2-test found that the difference is statistical insignificant. This means participation is not different by which sex is headship of the family (Table 3).

Trade experience of respondent women: according to survey result obtained in the study area, 23.5 percent of respondent women had an experience of trading in different small business sectors. According to their response, the livelihood of study area community is depends on livestock, crops and livestock products whereas the crops and livestock products such as milk and butter are sold by women. From the comparison views between participant and non-participant women, there is higher frequency of trader in non-participant (29) than participant women (18). This difference is statistical positive and significant at 10% level.

Table 1: Definition of hypotheses variables and expected sign/s

Variable code	Variable name	Variable type	Expected sign
COOP	Membership in other cooperative	Dummy	-
LAND	Size farm Land owned in hectares	Continuous	-
Sexhhh	Sex of household head	Dummy	-
EDURW	Educational level of women in year	Continuous	+
AGERW	Age of respondent woman in year	Continuous	+
FAMILYSIZE	Total family size of household	Continuous	+
Training	Access to training	Categorical	+
TRW	Respondent women trade experience	Dummy	+
CREDIT	Take credit	Dummy	+
EXTN	Numbers of extension contact	Continuous	+
TLU	Number of livestock has	Continuous	-
DROUGHT	Occurrence of drought	Dummy	-
AGEMARRIED	year of married for respondent women	Continuous	+
Labourforce	Number of labour force	Continuous	-
DISTANCE	Distance from nearest market in hrs.	Continuous	-
FASS:	Father Assets	Categorical	+

Table 2: Total sample of respondent

Variables	Freq.	Percent
non-participant	143	71.50
Participant	57	28.50
Total	200	100.00

Source: Own survey data, 2018

As Table (3) indicated, 47 percent of respondent women had extension contact per month and 0.5 percent of them had extension contact when asked. According to respondent reaction, agricultural development agents are advising them on agricultural production whereas the issue about resource management and how to work in cooperatives are not yet reached most of respondent by GOs. But, some NGOs are initiated to give them training on this concern. Majority of respondent had also credit services from different organization starting from their own women cooperative groups.

Moreover, the chi^2-test result from Table (3) shows extension contact and membership in other cooperative of respondent women is positive and significant at 5% and 1% level respectively. But, rest of the variables (credit, drought and Father's asset) are with chi^2-test of insignificant result even though there were some figurative differences among participant and non-participant women are seen.

Table (4) shows minimum, maximum, mean and std. deviation of age of respondent's women are 17, 80, 39 and 14.083 years respectively. This table also reflected that mean age of participant women are 44.87 years and that of non-participants are 36.65 years. Which is also statistical negative and significant at 1% level as a witness of age difference between participant and non-participant. This result also tallied with the study hypothesis which stated that age is one of factor which increases women participation.

The minimum, maximum and mean age at which respondent women got marriage is 5, 30 and 16-17 years respectively. As one can see from Table (4), there is no that much difference between this two groups on their age of getting married both are on average at their 16th years. Statistical t- test for this variable also shows no significant difference.

The educational level: Results of education show that on average respondent women are below grade one which means high illiteracy rate. Statistical t-test is also revealed insignificant result.

The minimum, maximum, mean and std. deviation of family size are 2, 12, 6-7 and 2-3 persons per household respectively. Mean family sizes of participant women (7.94) are greater than that of non-participant women (6.24). This difference is statistical negative and significant at 1% level. This result is also tallied with the study hypothesis which is stated that child is one of a driven force that pushes women towards productive works for their family wellbeing.

Table 3: Descriptive Statistics for categorical Variables

Variables	Total Freq.	%	Participant Freq.	Nonparticipant Freq.	χ^2
Sex of hhh					1.357
Female	42	21.0	15	27	
Male	158	79.0	42	116	
TRW					2.89*
Yes	47	23.5	18	29	
No	153	76.5	39	114	
Extension contact					9.81**
Weekly	45	22.5	21	24	
Once in two week	32	16.0	7	25	
Monthly	94	47.0	23	71	
Once in a year	28	14.0	6	22	
when asked	1	.5	0	1	
Taking credit					0.02
Yes	65	32.5	19	46	
No	135	67.5	38	97	
Membership in other cooperative					21.27***
YES	110	55	46	64	
NO	90	45	11	79	
Drought occurrence					0.22
Sometimes	18	9	6	12	
Frequently	182	91	51	131	
Father asset					1.40
Poor	46	23.00	10	36	
Middle	116	58	36	80	
Rich	38	19	11	27	

Source: Own survey data, 2018

Table 4: Descriptive Statistics for continuous Variables

Variables	Participant Mean (std. d)	Nonparticipant Mean (std. d.)	Total Min	Max	Mean (std. d.)	t-value
AGERW	44.87 (11.51)	36.65 (14.35)	17	80	39.00 (14.083)	-3.85***
AGEMARRIED	16.87 (2.42)	16.23 (3.04)	5	30	16.41 (2.88)	-1.43
EDURW	0.08 (0.47)	.16 (.81)	0	5	.14 (.73)	0.64
TLU	11.20 (9.85)	15.46 (16.60)	.3	121.05	14.25 (15.09)	1.8*
Family size	7.94 (2.22)	6.24 (2.51)	2	12	6.73 (2.55)	-4.48***
Labourforce	2.24 (1.02)	1.90 (.56)	0	6	2.00 (.73)	-3.03***
Monthly income	1019.3 (664.52)	938.46 (645.45)	200	5000	961.50 (650.3)	-0.79
Land	1.09 (.69)	1.115 (.71)	0	5.	1.108 (.708)	0.20
Distance	1.61 (.94)	2.16 (.80)	0	4.	2.007 (.877)	4.1***

Source: own survey data, 2018

According to the Table (4), the minimum, maximum and mean of labour force person per household is 0, 6, and 2 respectively. The mean labour force of both family of participant and non-participant women are approximately 2person which is too much less than mean family size (6-7). Statistical t-test for labour force is also revealed negative and significant result at 1% level. This result also tallied with the study hypothesis.

According to **UN (2017**) on average family size in Ethiopia is 4.6person per household. They also said that "Small average household sizes, fewer than three persons per household are concentrated in Europe and Northern America, whereas large average household sizes, five or more persons per household are observed across much of Africa and the Middle East". Thus, the family size of the respondent in both cases is that of Ethiopian national level and within the range of most African and Middle East countries.

Table (4) also shows the minimum, maximum, mean and str. deviation of average estimated household income per month are 200, 5000, 961.50 and 650.3Birr respectively. But, mean monthly income of participants and non-participants women households is 1019.3 and 938.46 Birr respectively. It show that there is some what difference on mean monthly income earning of participants and non-participant in which the participant's mean income is greater than that of non-participants' households even though this difference is statistical insignificant.

The possible reason for this difference is that; according to the respondents' responses of participant women they were benefited for being participant of this production, they are always gaining the acting of learning and exercising experience from different organization such as local, national and international NGOs and GOs. Beside this, the participant themselves formed different form of cooperatives like butter, mirt stove, milk cooperative and also joining into other formed cooperatives. This all training and learning process are gradually developed among participant as they come together as co-workers. In monetary benefit, participants also had a lot of saved deposited money on account and some capital asset inform of cooperative.

But, according to participant women responses their problem was: there is no dividend sharing to members that cause them disincentive to work. And another problem that they were raised as hindering factor for this production was problem of input supplied especially caustic soda and cooking oil. Many women said that, if they were getting these ingredients (inputs) individual, they will produce soap as individual business.

The minimum, maximum and mean total tropical livestock units are 0.3, 121.05 and 14.254 respectively. The difference in this characteristic is also similar to household monthly income. There is gap between minimum and maximum which explained in std. deviation (15.09) of mean (14.25) total tropical livestock unit. As result indicated the mean and standard deviation of participant women household livestock holding is smaller than that of non-participant women household. This result is statistical positive and significant at 10% level. This result also supports the study hypothesis.

The minimum, maximum and mean distribution of land is 0.0, 5 and 1.1087 hectares respectively. The mean land holding of participant (1.09 hectares) is below that of non-participant (1.115 hectares) but this difference is statistical insignificant. The mean land holding of total respondent is below that of national level. As national level land use survey shows the average household farm size in Ethiopia is 1.37 hectares, but its varies by place of residence and the gender of the household head (**CSA, 2013**).

The mean distance of respondent from the nearest market is 2hrs on foot. This result is also positive and significant at 1% level where on average it take less hours for participants women to go a nearest market. But standard deviation result revealed that there is somewhat higher variation within participant (.94) than non-participant (.80). This means, compared to non-participant, not all participants were nearby market. It is tallied with the study hypothesis.

Propensity Score Matching Model Results

The “sum myscore” command was used to check/ summarize the propensity score (Table 5).

As propensity score is a probability, it has to be in the interval of [0:1]. Hence, the average probability of respondent women to participate in the Aloe Vera soap production for all the individuals is 28.5%.

Check Range of Common Support

Psgraph test for the common support was used to check the extent to which distributions of propensity scores in treatment (participants) and comparison (non-participants) groups are overlapped from logistic regression of propensity score matching model.

Note: the common support option has been selected. The region of common support is [.00411911, .97775877].This assumption of common support was also checked graphical as following; if an assumption of common support holds, there must be an overlap of the propensity scores of the participants and non-participants.

That’s why the Figure (1) depicted as three colour of blue, red and green. The blue and red colours are on common support region, but green colour indicated the propensity score out of common support regions. In each class of the propensity score there is a certain number of non-treated and treated individuals as well.

Check Balancing Property

Step 1: Identification of the optimal number of blocks. The final number of blocks is 5. This number of blocks ensures that the mean propensity score is not different for treated (participants) and controls (non-participants) in each blocks. The Stata was used t-tests to determine whether each covariate is balanced within each block.

Step 2: Test of balancing property of the propensity score across groups. It should be needed to check balancing before trusting the ATT estimation. This was the test of whether mean of propensity score is equal in treatment and comparison groups within each quintile. Therefore, the Stata result of both steps revealed that the balancing property is satisfied in each blocks for each covariates.

Table (6) shows the inferior bound, the number of treated and the number of controls for each block under the assumption of common support. And in this case, total 190 respondents are on common support of which 133 are non-participant women and 57 are participant women.

Figure (2) shows the distribution of the all household with respect to their estimated propensity score. Accordingly, most of the treatment households are found partially in the middle and partially in the right side of the distribution. On the other hand, most of the control households are partially found in the center and partially in the left side of the distribution.

Of course, two conditions were identified and as well satisfied, the success of the matching for each of the independent variables was also tested from the matching algorithm of propensity score after the choice of matching algorithm estimator.

Choice of Matching Algorithm

Note: There is no universal best strategy among matching algorithm of propensity score matching but the focus should be given on the trade-off between bias and variance/efficiency.

For instance, According to **Caliendo and Kopeinig (2005)** on their review of “*practical guidance for the implementation of propensity score matching*”, one way of assessing the quality of matching is t-test of standard bias for all covariates as all covariates should be balanced. In this case of study on hand, as indicated in Tables (7 and 8), the test revealed that all covariates are balanced after matching. Again, **Caliendo and Kopeinig (2005)** offered that the joint significance test was found another method to assess matching quality. And they elaborated this joint significant as this; the best matching result was found in such away as before matching there might be significant difference in all covariates, and should be the insignificant difference result existed after matching or for matched sample case.

Table 5: Summary of pscore

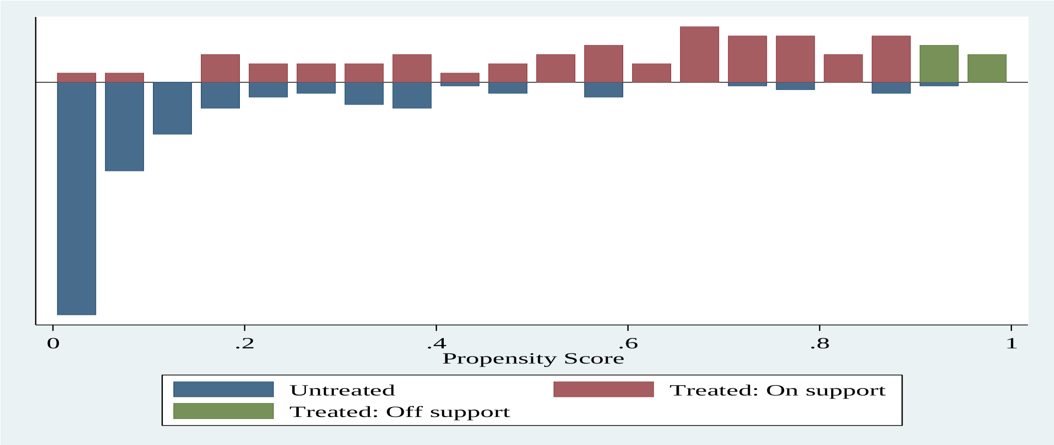
Variable	Obs	Mean	Std. Dev.	Min	Max
Total household	200	.285	.3229254	3.36e-06	.9857269
non-participant	143	.1371315	.2047364	3.36e-06	.9857269
Participant	57	.6559683	.2614782	.0041191	.9777588

Source: own survey result, 2018

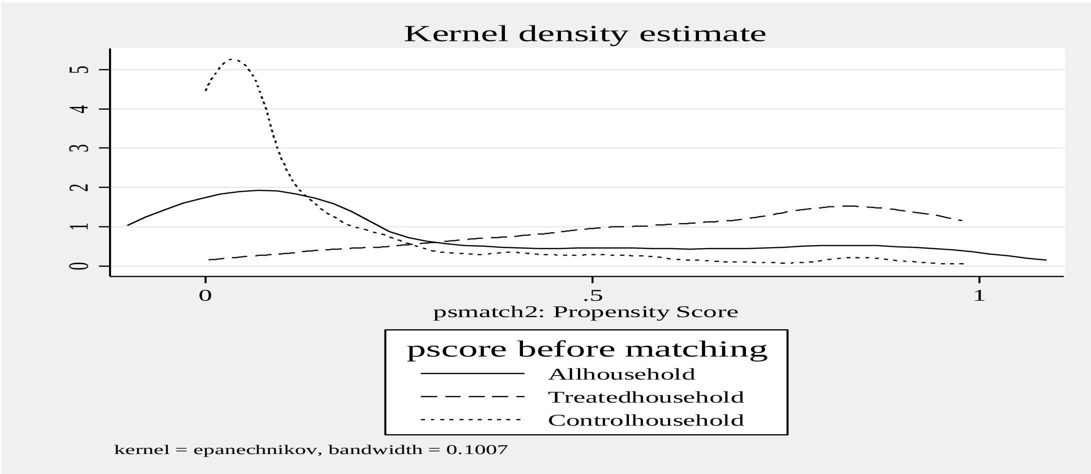
Table 6: Inferior block of propensity score

Inferior of block of pscore	PARTALS		
	non-participant	Participant	Total
.0041191	104	4	108
.2	15	6	21
.4	8	12	20
.6	2	12	14
.8	4	23	27
Total	133	57	190

Source: Model result, 2018



Source: own survey result, 2018
Figure 1: Psgraph between treated versus untreated groups



Source: own survey result, 2018
Figure 2: Pscore before matching

In line with this connotation, the joint significant test of different matching algorithms for this study was taken as this and the result was found, in Table (7), that all used algorithm satisfied to some extent the test condition even though the difference was found in the level of percentage significance. Accordingly, the result of kernel band width (0.25) has the lowest Pseudo-R^2 and all covariates are balance after matching for matched sample among all algorithm. Similarly, (**Dehejia and Wahba, 2002**) noted that, the choice of a matching estimator was based on different criteria like equal means test (balancing test of covariates), lowest pseudo-R2 and largest numbers of matched sample size.

Therefore, the matching algorithm with highest sample size matched, insignificant matched sample or equal means and with the lowest Pseudo-R^2 value for matched sample, among the other used matching algorithm for this study is kernel band width (0.25) as indicated in Table (7).

Covariate Imbalance Tests (before and after matching) and Graphing

According to the summary of (**Leuven and Sianesi, 2003**) on psmatch2 module; the main focus of this test was; for each variable t-test the equality of means before and after matching, standardized % bias before and after, and achieving % reduction in |bias| is found to be important. And as long as overall significance concerned; pseudo R^2 from logistic of treatment on covariates before matching and on matched samples, p-values of the likelihood-ratio test of joint insignificance of covariate before and after matching and summary indicators of the distribution of |bias| before and after are critically issues. Accordingly, for these point illustrations, pstest was applied and discussed for this study as follows:

The Table (8) show that a t-test on the hypothesis that the mean value of each variable is the same in the treatment group and the non-treatment group. It was done before and after matching.

Moreover, a bias before and after matching was calculated for each variable and the change /reduction/ in this bias was indicated. In this table, one can see the difference of the values of the exogenous variables between the two groups before matching.

With matching, all covariates are shown us, no significance mean difference after matching as it indicated by the p-value of test in Table (8). **Caliendo and**

Kopeinig (2005) "before matching differences are expected, but after matching the covariates should be balanced in both groups and hence no significant differences should be found".

Also standard bias reduction result in Table (8) revealed that the differences between treatment group and non-treatment group are reduced for many variables where exception was found in the variables such as training, sexhhh (sex of household head); family size and AGEMARRIED (age at first married). Even though in the case of these variables the difference between two groups were not reduced, but these variables are statistical significant effect on participation as it revealed.

Therefore, pstest indicated all variables are satisfied the insignificance test of after matching which means there is no mean difference after matching for each variables are balanced.

The Table (9) description was about the joint significance, taking together all predictors variable, that explained by Pseudo-$R2$ and p>chi2. The pseudo-R^2 indicates how well the regressors Xs explain the participation probability. As it was explained, after matching there should be no systematic divergences in the distribution of covariates between both groups. This means for the joint significance; p>chi2 value before matching might be statistical significant, and p>chi2 value after matching (for matched sample) should be statistical insignificant.

Accordingly, test in Table (9) was also illustrated that (p>chi2 is 0.000 for unmatched sample) so there is not to be rejection before matching, and (p>chi2 is 0.937 for matched) there is to be highly rejection after matching which was an expected result of this regression.
Figure (3) portrays graphically the distribution of mean score of each of explanatory variable for the participant and non-participants of unmatched and matched. And it shows the standardized % bias across covariates.

Hence, the conclusion from pstest, in all foresaid whether graphically or table from, was that the propensity-score of kernel band width (0.25) matching was the best matching algorithm for this data. This means it's the best algorithm through which possible to generate a control group which is similar enough to the treatment group to be used for the ATT estimation.

Therefore, based on this assumption of bias and variance/efficiency trade-off as well pstest, this study estimated ATT using propensity score matching of kernel band width (0.25) algorithm in order to look at the effect of women participation in Aloe soap production on the outcome variable which is household income as following.

Hence, the results of propensity score matching of kernel band width (0.25) matching indicated that the ATT difference on score monthly income of household of women between matched respondents' were, on average, 45.693 Birr which is a positive result. Even though this result is not significant, the positive sign implies that on average monthly income of participant's women households are better than that of non-participant women as similar to the result already explained in the descriptive statistic (Table 4). According to respondent responses the participant women are getting benefit from different angels. One, they can get soap in kind at home from the residual of marketed soap. This will reduce their household expenditure from home consumption. Second, participant also had a training from different NGOs in relation to their production and from that training NGOs give some cash money as an incentive. Third, coming together participant formed *ikub* group and other women association like milk cooperative, and through all this they could winning monetary benefit. But, all these, they sold their soap 4 to 6 days within a week at market even though that profit is collected inform of cooperative in bank deposit and/or inform of capital asset of cooperative.

Table 7: Comparison of different matching algorithm estimators

Matching estimator nearest neighbour	balancing test*	PS R^2	LR χ^2	Prob> χ^2	matched N
NN(1)	16	0.101	15.92	0.459	200
NN(2)	16	0.069	10.98	0.811	200
NN(3)	15	0.070	11.04	0.807	200
NN(4)	16	0.074	11.62	0.770	200
NN(5)	16	0.068	10.73	0.826	200
radius caliper					
0.1	16	0.055	8.69	0.925	200
0.01	16	0.102	8.52	0.932	173
0.25	16	0.061	9.67	0.883	200
0.5	16	0.110	15.27	0.644	193
kernel matching					
band width0.1	16	0.068	10.80	0.822	200
band width 0.01	16	0.085	7.09	0.972	173
band width 0.25	16	0.053	8.38	0.937	200
band width 0.5	15	0.083	13.08	0.667	200

Source: Model result, 2018

* Number of explanatory variables with no statistically significant mean differences between the matched samples.

Table 8: pstest table

Variables	Unmatched	Mean		%reduct		t-test		V(T)/ V(C)
	Matched	Treated	Control	%bias	bias	T	p>|t|	
Sexhhh	U	.73684	.81119	-17.7		-1.16	0.246	.
	M	.73684	.71208	5.9	66.7	0.29	0.770	.
AGERW	U	44.877	36.65	63.2		3.86	0.000	0.64
	M	44.877	42.39	19.1	69.8	1.23	0.220	1.34
TRAINING	U	3	1.8112	90.0		5.97	0.000	1.40
	M	3	2.8041	14.8	83.5	0.80	0.426	1.46
AGEMARRIED	U	16.877	16.231	23.5		1.43	0.153	0.63
	M	16.877	16.63	9.0	61.8	0.53	0.599	0.87
FAMILYSIZE	U	7.9474	6.2378	72.0		4.48	0.000	0.78
	M	7.9474	8.0991	-6.4	91.1	-0.33	0.741	0.71
TLU	U	11.204	15.47	-31.2		-1.81	0.071	0.35*
	M	11.204	11.856	-4.8	84.7	-0.36	0.721	1.06
LAND	U	1.0921	1.1154	-3.3		-0.21	0.835	0.94
	M	1.0921	.97823	16.1	-389.2	0.99	0.326	1.75*
Labourforce	U	2.2456	1.9021	41.7		3.04	0.003	3.33*
	M	2.2456	2.1187	15.4	63.1	0.85	0.397	4.69*
TRW	U	1.6842	1.7972	-25.8		-1.71	0.090	1.35
	M	1.6842	1.7318	-10.9	57.9	-0.55	0.580	1.10
EXTN	U	2.2456	2.6573	-40.5		-2.65	0.009	1.26
	M	2.2456	2.3087	-6.2	84.7	-0.32	0.752	1.04
CREDIT	U	1.6667	1.6783	-2.5		-0.16	0.875	1.03
	M	1.6667	1.6497	3.6	-45.2	0.19	0.851	0.98
DROUGHT	U	2.8947	2.9161	-7.3		-0.47	0.636	1.24
	M	2.8947	2.8285	22.5	-210.1	1.02	0.310	0.66
COOP	U	1.193	1.5524	-79.6		-4.86	0.000	0.64
	M	1.193	1.2341	-9.1	88.6	-0.53	0.596	0.87
DISTANCE	U	1.6132	2.164	-63.0		-4.17	0.000	1.38
	M	1.6132	1.6205	-0.8	98.7	-0.04	0.967	1.00
EDUCRW	U	.08772	.16084	-11.0		-0.64	0.524	0.34*
	M	.08772	.04868	5.9	46.6	0.48	0.635	1.40
FASS	U	2.0175	1.9371	12.6		0.79	0.430	0.85
	M	2.0175	2.0235	-0.9	92.6	-0.05	0.961	0.75

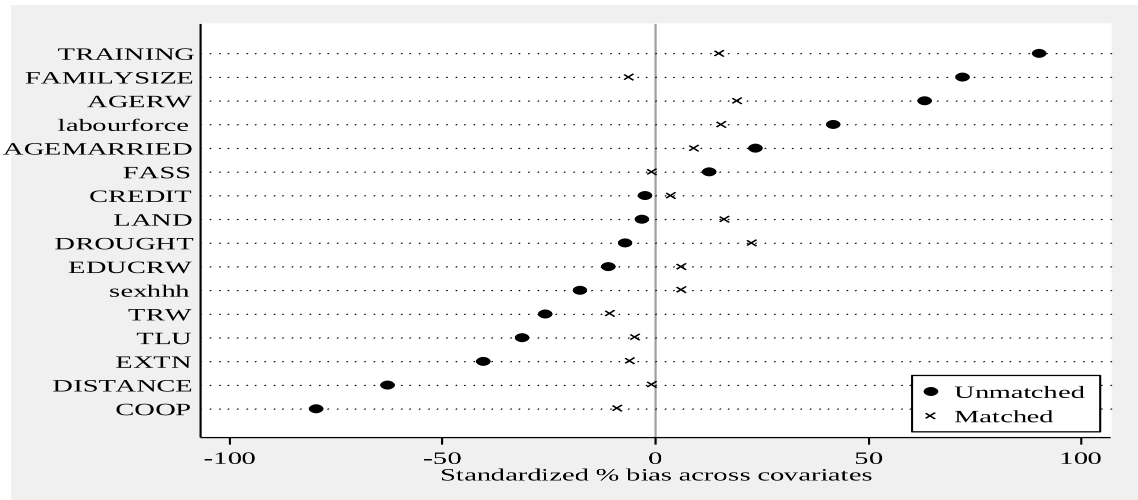
Source: Model result, 2018

* If variance ratio outside [0.59; 1.70] for U and [0.59; 1.70] for M

Table 9: Joint significance test of psmatch2

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias
Unmatched	0.448	107.10	0.000	36.6	28.5
Matched	0.053	8.38	0.937	9.5	7.7

Source: Model result, 2018



Source: own survey result, 2018

Figure 3: pstest graph

Table 10: ATT of participation of the women on income and CEI

Variable	Sample	Treated	Controls	Difference	T-stat
MONTHLYINCOM	Unmatched	1019.3	938.462	80.837	0.79
	ATT	1019.3	973.605	45.693	0.27

Note: S.E. does not take into account that the propensity score is estimated.
Source: model result, 2018

Table 11: Bootstrap standard error

	Observed Coef.	Bootstrap Std. Err.	Z	P>|z|	Normal-based [95% Conf. Interval]	
_bs_1	-10.61338	139.9015	-0.08	0.940	-284.8153	263.5886

Source: model result, 2018

Table 12: Rosenbaum bounds for outcome variable (N = 200 matched pairs)

Outcome Variable	Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
Monthly income	1	0	0	850	850	800	900
	1.1	0	0	800	900	800	900
	1.2	0	0	800	900	800	900
	1.3	0	0	800	900	800	950
	1.4	0	0	800	900	750	1000
	1.5	0	0	800	900	700	1000

* gamma - log odds of differential assignment due to unobserved factors
sig+ - upper bound significance level
sig- - lower bound significance level
t-hat+ - upper bound Hodges-Lehmann point estimate
t-hat- - lower bound Hodges-Lehmann point estimate
CI+ - upper bound confidence interval (a= .95)
CI- - lower bound confidence interval (a= .95)

Robust test

The S.E. does not take into account that the propensity score is estimated (Table 10). This is because the estimated variance of the treatment effect also include the variance due to the estimation of the propensity score, the imputation of the common support, and possibly also the order in which treated individuals are matched. **Caliendo and Kopeinig (2005)**, thus, one way to deal with this problem is to use bootstrapping. According to **Schmidheiny (2016)** the bootstrap takes the sample (the values of the independent and dependent variables) as the population and the estimates of the sample as true values

Sensitivity Analysis of Pscore Matching

As long the PSM method are concerned for the impact analysis, it might needed to analysis sensitivity of ATT estimation to any unobserved covariates that might introduce the hidden /endogeneity bias. Hence, as the Table (12) indicated the Rosenbaum bounds test was applied to evaluate the sensitivity of how the changing values of a parameter gamma, Γ, would influence the significance of the results obtained from the matching analysis. According to many literature like If Γ = 1, then, hidden bias is zero.

The result in Table (12) revealed that for all chosen gamma level (1, 1.1, 1.2, 1.3, 1.4 and 1.5), the upper and lower bound significance level, upper and lower bound of Hodges-Lehmann point estimate and upper and lower bound of confidence interval for outcome variable. The result of upper and lower bound significance level is significant for outcome variable. The result of upper bound Hodges-Lehmann point and confidence interval is decreasing and the lower bound in both cases is increasing. This witnessed that, the computed ATTs are relatively insensitive to unobservable covariates that might introduce as hidden bias.

CONCLUSION AND RECOMMENDATIONS

The study concluding and recommending it's finding as follows; the first major problem in production of Aloe Vera soap was input (caustic soda and cooking oil) availability since production is impossible without these inputs. First, caustic soda is only found at national level market which is also just by order, and there is highly problem with market supply and market price of cooking oil. In order to skip this problem of inputs so far aloe soap producers have been organized under milk union and then it facilitate inputs supply and product market of those primary cooperative. District trade office also sometime with very little attention gives them a few litre of oil to those cooperative which is not that much interesting and initiating them for higher level production. Therefore, based on the income impact of this production, the NGOs, government office such as cooperative, trade office, and management at zone and district level should aware of this opportunity and facilitate the input supply (caustic soda and cooking oil) for those primary cooperative, and also for any woman demanding individual in production, and letting this production to goes beyond cooperative to individual level.

Overall according to the impact result of propensity score matching of kernel band width (0.25) result revealed, participation of women in Aloe Vera soap has a positive impacts on the household income even though the result is statistical insignificant. Therefore, non-participant women should be encouraged to have an opportunity to participate more in such productive activities. But, the insignificant result might be due to the study estimation method and data, the study also recommend other researcher to conduct further research taking this study as a base line. Remind, from theory of population growth, Esther Boserup was quoted as 'more people there are, the more hands there are to work". Therefore, so is women role for total wellbeing of community at large.

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REGULAR ARTICLE

THE IMPACT OF SUPPORT POLICIES ON TECHNICAL EFFICIENCY OF FARMS IN KOSOVO

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ABSTRACT

The effects of support policies on technical efficiency are not clear and are very complex because the results may be either positive or negative. The effects can be positive if the money received will serve as an incentive to innovate or to switch to new technologies or can have a negative effect if the money received increase the income of the farms and as a result prefer to have more leisure time. Given the theoretical uncertainty of the impact of supporting policies on efficiency, productivity and added value, the aim of this paper is to address this issue empirically. This paper contributes to the literature for the case of Kosovo by fulfilling the following objectives (i) to measure technical efficiency of farms in Kosovo and (ii) to identify the effect of subsidies by employing a stochastic output distance function and an inefficiency effect model as the one proposed by Battese and Coelli (1995). Parametric stochastic frontier approach was employed to estimate technical efficiency and to determine the effect of exogenous variables on technical efficiency through one-step approach. The share of total subsidies to total output (%) was used as proxy for policy variable and a set of farm characteristics as exogenous variables. We used FADN of Kosovo data provided by MAFRED for 2014. The results suggest that on average a farm in Kosovo produced 15.7% of the maximum output, while the rest of the potential output was lost due to technical inefficiency. Subsidies had negative effect on technical efficiency, however insignificant.

Keywords: farm performance, technical efficiency, SFA, subsidies, Kosovo
JEL: R15, Q18, Q12, R28

INTRODUCTION

In the economy of Kosovo, agriculture plays a very important role and has a positive impact on the quality of life and on the sustainable development of the rural areas considering that 60% of population live in rural areas and its contribution to GDP is 10.5%. In addition, there are 130,775 agricultural holdings which occupy 413,635 ha of land for agricultural purposes and employ 362,700 persons or approximately 20.5% of total population as of 2014 (**KAS, 2014**). Although it may be thought that this contribution of agriculture to the economy is volatile, on the other hand, it is suggested that Kosovo has the potential to compete in different subsectors of agriculture, especially in the livestock and cash crop subsectors. Due to this importance, the Kosovo Government has assured to further increase the budget for the development of the agricultural sector by increasing support for sectors with comparative advantages such as the crop and livestock sectors. The actual budgetary support for agriculture and rural areas has increased from €11 million in 2010 to €27.0 million in 2014 and to €59.1 million in 2015. Compared to 2010, in 2014 the budget support for agriculture has increased for 145 % and in 2015 for 437 % (**Kerolli-Mustafa and Gjokaj, 2016).**

On the other hand, subsidies are a major part of every nation's budget. A large part of almost every nation's income is headed for agricultural subsidies. Subsidies are intended for the protection of the domestic agriculture (**Koo and Kennedy, 2006**), are used as accelerator of the growth of agricultural sector and are important for international trade (**Swain, 2009; Vozarova and Kotulic, 2016**). In agriculture, subsides are paid to the farmers to supplement their incomes, to manage the supply of agricultural products and also to influence the cost and supply of such product in international markets (**Swain, 2009**).

For the case of Kosovo, the Ministry for Agriculture, Fishery and Rural Development (MAFRED) since 2008 has started to support farmers with subsidies and grants through direct payments and the rural development programme. The planned budget for Direct Payments increased from €14 million in 2014 to €23 million in 2015 (**MAFRD, 2015, 2016**). Even though the planed budget for direct support in 2014 was €14 million, there were spent €15.3 million. In 2015, €21.4 million were distributed to farmers in the form of direct payments which compared to the previous year marked an increase of 40% (**MAFRD, 2016)**. Also in 2016, the total support through direct payments exceeded the planned budget which was €23 million to €26.1 million (**MAFRD, 2017)**. Compared to the previous year, the support through direct payments increased by 22% (**MAFRD, 2017**). However, the empirical analysis would provide clearer information regarding the direction and the significance of the effect of subsidies on the performance of the farm.

Different papers consider different indicators for measuring the performance of the agricultural sector.

Efficiency is an important indicator for performance measurement. Efficiency can be distinguished into technical and allocation efficiency. Technical efficiency represents the capacity of an entity to produce the maximum output from a quantity of inputs subject to the available technology (**Koopmans, 1951**). Allocation efficiency refers to the ability to choose optimum input levels for given factor prices. When adding both the technical and the allocation efficiency, we generate the economic efficiency. Assuming that inputs are exogenously given, one may not address allocation inefficiency simply because the input allocation problem is assumed away. By contrast, if inputs are endogenous, then allocation decisions using some economic behaviour have to be made (**Kumbhakar, Wang, and Horncastle, 2015**). Because in this study we treat the inputs as exogenous, then the focus of this paper is on technical efficiency by assuming that there is no allocation inefficiency. (i.e., all the producers are assumed to be allocation efficient).

Factors affecting the technical efficiency of the agricultural sector are numerous, however what is of interest in this paper is to assess the impact of agricultural support policies on technical efficiency. Support policies are considered as one of the most effective mechanisms for increasing the agricultural sector (**Swain 2009**). Despite the fact that economic theory offers relatively little information on the direction of the relationship between support policies and technical efficiency, it is still possible to find a theoretical background (**Latruffe *et al*., 2008**). According to **Bojnec and Latruffe (2009**), support policies are one of the main factors that explain the farm's efficiency or even its inefficiency. These support policies can increase the level of technical efficiency if they make the farmers to innovate more or to move to new technologies (**Harris and Trainor, 2005**), or even lower it if the higher incomes from subsidies cause a lack of efforts and initiatives (**Bergström, 2000**). In general, the effects of support policy are complex and theoretically unclear. However, they need to be analysed in detail because the farms are supported by the state budget and it is very important to continually analyse the efficiency of money spent on value added (**Kroupová and Malý, 2010**).

So, the purpose of this paper is to assess the performance of the agricultural sector for the case of Kosovo by measuring technical efficiency and the incorporation of exogenous variables. More specifically, the impact of various factors on technical efficiency of the farms will be studied, paying particular attention to subsidies. The objectives of this research are: (i) to calculate farm level technical efficiency on farms in Kosovo and (ii) to identify important factors causing efficiency differences among the farms in Kosovo by focusing on subsidies.

DATA AND METHODS

Production frontier model and the inefficiency effect model

The model to be used in this paper follows the one proposed by **Battese and Coelli (1995).** This production frontier model allows for simultaneous estimation of technical efficiency and the effect of exogenous variables on technical efficiency (more specifically on technical inefficiency). This is also the reason why this is called as one-step procedure. In this paper, the SFA approach is preferred over nonparametric approach (e.g. DEA) because agriculture is characterized as a stochastic sector, meaning that the unpredictable weather and diseases may influence the production. Also the data from transition economies are generally noisy in comparison to the data from the other countries. In addition, compared to the deterministic approach where all the deviation from the frontier is attributed only to inefficiency, in the stochastic frontier the deviation from the frontier is attributed to inefficiency as well as to random factors such as measurements errors, unspecified variables and even the hazard factors.

The stochastic production frontier model relates the quantity of output *(y)* of a given farm to a vector of inputs used ($X \in R^N_+$) through the production technology (*f*) (Eq.1).

$$y_i = f(x_i) \cdot exp(v_i - u_i) \qquad (1)$$

Where v_i is the two sided noise component with $v_i \sim iid\ N\ (0, \sigma_v^2)$ which means that this component is assumed to be independent and identically distributed normal random variable with zero mean and constant variance and which captures the random effects. On the other side, u_i is the non-negative technical inefficiency component with truncated normal distribution with different mean and variance among farms $u_i \sim N^+(\mu_i, \sigma_i^2)$ and which captures technical inefficiency effects.

Technical efficiency is calculated as (**Kumbhakar and Lovell, 2000**) (Eq. 2).

$$TE_i = exp(-u_i) \qquad (2)$$

On the other hand, there is a set of various factors, also known as exogenous variables or explanatory variables that can explain the technical efficiency differences among farms (**Zhu, Demeter, and Lansink, 2008**). These variables are known as exogenous because they neither are used as inputs in the production process such as labour, capital and land nor are as output of the farm but still influence the degree of technical inefficiency and hence the performance of the farm. As a result, they are incorporated in the inefficiency term such as in the model of **Kumbhakar *et al.* (1991**) and **Battese and Coelli (1995).**

The exogenous variables are denoted as $z \in R^J$ (**Battese and Coelli, 1995**) which can be indexed by *p*, *p= 1, 2, …..J* . Technical inefficiency model (u_i) is defined by Eq. 3.

$$u_i = z_i\delta + w_i \qquad (3)$$

where z_i is the vector of firm-specific *J* variables, δ is the unknown vector of *J* parameters to be estimated, and the error term $w_i \sim N(0, \sigma_w^2)$ is truncated from below by the variable truncated point -$z_i\delta$.

The production frontier model and the inefficiency effect model can be estimated simultaneously and this one-step procedures allows that in the same time to be estimated the efficiency scores and the factors that determine technical efficiency. According to **Zhu *et al.* (2008),** the production frontier model and the inefficiency effect model can be defined as Eq. 4.

$$TE_i = exp(-u_i) = exp\{-z_i\delta - w_i\} \quad (4)$$

Many authors **(Kalirajan, 1991; Ray, 1988)** use the two-step procedure to estimate the effect of subsidies on farm performance, however, other authors **(Kumbhakar *et al.*, 1991; Battese and Coelli, 1995)** challenge this approach by arguing that subsidies and other firm-specific factors should be incorporated directly in the estimation of the production frontier because such factors may have a direct impact on productivity and efficiency.

As in many other papers, also in this paper, will be employed the **Battese and Coelli (1995)** model of the stochastic production frontier which estimates the technical efficiency and which in the same time allows for the inclusion of explanatory variables with a one-stage procedure (Eq. 5-6).

$$y_i = f(x_i; \beta) + v_i - u_i \quad (5)$$
$$u_i = z_i\delta + w_i \quad (6)$$

These models differ from the others because subsidies are allowed to affect output but not also vice-versa and can be estimated jointly.

Parametric Approach

One of the primary task, when estimating the stochastic frontier model, is to determine the functional form of the production frontier. According to **Coelli *et al.* (2005),** there exist different functional forms for the production frontier such as Cobb-Douglas, CES, Translog, generalised Leontief, normalised quadratic and its variants. It is recommended to estimate the production frontiers according to a number of alternatives and then to select a preferred model using the likelihood ratio test **(Coelli, 1996).** In addition, in the study of **Giannakas *et al.* (2003)** is suggested the choice of the functional form can affect the estimates of the production structure as well as the measurements of the technical efficiency. In this sense, the choice of an appropriate functional form affects the identification of the factors that determine individual performance. Cobb-Douglas and the Translog functional form are the two the most used forms in the empirical studies of production **(Battese and Broca, 1997).** More specifically, the production frontier of the i^{th} farm expressed according to the two functional forms (Eq. 7 - 8).

Cobb-Douglas frontier model:

$$lny_i = \beta_0 + \sum_{j=1}^{K} \beta_j \ln x_{j,i} + v_i - u_i \quad (7)$$

Translog frontier model:

$$lny_i = \beta_0 + \sum_{j=1}^{K} \beta_j \ln x_{j,i} + \frac{1}{2}\sum_{j=1}^{K}\sum_{h=1}^{K} \beta_{jh} \ln x_{j,i} \ln x_{h,i} + v_i - u_i \quad (8)$$

where the u_i also knows as technical inefficiency is expressed according to Eq. 9.

$$u_i = z_i\delta + w_i = \delta_0 + \sum_m^J \delta_m z_{mi} + w_i \quad (9)$$

the subscript *i*= 1,2,…..,n stands for farms; *j*,*k* = 1,2,….,J stands for inputs while *m* = 1,2,….,M stands for farm-specific efficiency related variables.

In this regard, it is firstly required to test which of these specifications best represent the data by considering that the SFA accommodates both production functions. For this purpose, is needed to test firstly the adequacy of the Cobb-Douglas production function relative to Translog productions function, otherwise known as a less restrictive model. The null hypothesis to test for the functional form, states that all the interaction terms and the square specifications in the translog functional form are equal to zero (Null Hypothesis: β_{ij} =0). The alternative hypothesis states that the translog terms are not equal to zero (Alternative Hypothesis: $\beta_{ij} \neq 0$)

H_0: Cobb-Douglas is the appropriate functional form.

H_1: Cobb-Douglas is not the appropriate functional form.

Considering that both of the models are nested we have to test the Cobb-Douglas (restricted model) against the Translog specification (unrestricted model) based on the value of likelihood ratio (LR) statistics. If the null hypothesis (H_0) is not rejected, it means that the Cobb-Douglas functional form is more appropriate for our productions frontier estimation and it will take the form of Eq. 10.

$$lny_i = \beta_0 + \beta_1 lnCapital_i + \beta_2 lnLabour_i + \beta_3 lnLand_i + \beta_4 lnIntermediateCon_i + v_i + u_i \quad (10)$$

Contrary, if the null hypothesis (H_0) is rejected, it means that the trans-log functional forms should be used in the form of Eq. 13.

$$lny_i = \beta_0 + \beta_1 \ln(K_i) + \beta_2 ln(L_i) + \beta_3 \ln(H_i) + \beta_4 \ln(VI_i) + \frac{1}{2}(\beta_5 lnK^2 + \beta_6 lnL^2 + \beta_7 lnH^2 + \beta_8 lnVI^2) + \beta_9 lnK_i * lnL_i + \beta_{10} lnK_i * lnH_i + \beta_{11} lnK_i * lnVI_i + \beta_{12} lnL_i * lnH_i + \beta_{13} lnL_i * lnVI_i + \beta_{14} lnH_i * lnVI_i + v_i + u_i \quad (11)$$

The LR statistics can be calculated from the likelihood values of the Cobb Douglas functional form (LLF_o) and the Translog functional form (LLF_1) using this formula: $\lambda = -2(LLF_0 - LLF_1)$. The LR value is compared with the critical values of χ^2_R. The critical value depend on the number of degrees of freedom which is equal to the number of restrictions (R). Degrees of freedom is equal to 10, number of restriction from the restricted model to the unrestricted model. The condition for the rejection of the null hypothesis is $LR > \chi^2_R$, for our case is $LR > \chi^2_{10}$, $LR >$ 17.670, at 5 % significance level.

In order to conduct this test, it is needed to firstly run into the STATA the restricted model, the Cobb-Douglas model. In this case the likelihood functional level was -355.31634. For the Translog functional form were created 10 more variables (interaction terms and square terms) and after running this specification the likelihood value was -352.78693. When computing the calculation based on the formula above, we get this result: $\lambda = -2[\text{LLF}_0 - \text{LLF}_1) = -2[-355.31634 - 352.78693) = 5.055882$. This value is lower than the critical value of χ^2_{10} which is 17.67, and as a result we do not have enough statistical evidence to reject the null hypothesis, indicating that the Cobb-Douglas functional form better fits the data.

The model to be used from further estimations is the Cobb-Douglas model in which the dependent and the independent variables are expressed in natural logarithmic (Eq. 12).

$$lnOutput_i = \beta_0 + \beta_1 \text{lnCapital}_i + \beta_2 \text{lnLabour}_i + \beta_3 \text{lnLand}_i + \beta_4 \text{lnIntermediateCon}_i + v_i + u_i \quad (1)$$

where the subscript i (i=1, 2,…,n) refers to the ith sample farm. In our case as there are 396 farms, then i ranges from 1 to 396. The dependent variable (yi) represents the total output in value during 2014 for each farmer i. Following the dependent variable in the model are also included four independent variables: Capital presents the value of total assets for the ith farm, Labour presents the average working units (AWU), Land presents the total utilized agricultural area (UAA) in ha, and lastly Variable Input is defined as the value of total intermediate consumption.

In addition, the technical inefficiency model is defined according to the following explanatory variables, specified as a linear function of a series of variables, which are included with the aim to capture some farm specific characteristics that are assumed to have an impact on technical efficiency. The model is presented as Eq. 13.

$$u_i = \delta_0 + \delta_1 z_{1i} + \delta_2 z_{2i} + \delta_3 z_{3i} + \delta_4 z_{4i} + \delta_5 z_{5i} + \delta_6 z_{6i} + \delta_7 z_{7i} + \delta_8 z_{8i} + \delta_9 z_{9i} + v_i + u_i \quad (2)$$

By using the STATA software, we estimated: the frontier production function, the inefficiency effect model, the technical efficiency scores for each farm. In order to obtain the estimates, the Maximum Likelihood approach is used in the centre of which lies the choice of the distribution assumption for the random variable u_i. The v_i random variable has the zero-mean normal distribution while for the u_i can be assigned different distribution assumptions. The literature has identified many of such distributions. Most often mentioned distributions are the:

- Half-Normal Distribution with $u_i \sim i.i.d. N^+(0, \sigma_u^2)$ and $v_i \sim i.i.d. N(0, \sigma_v^2)$,
- Truncated- Normal Distribution $u_i \sim N^+(\mu, \sigma_u^2)$ and $v_i \sim N(0, \sigma_v^2)$, and
- Exponential Distribution.

In this paper, the Half-Normal Distribution will be assumed for the u_i as the most usual distribution suggested in literature.

However, the analysis of efficiency continues, as the focus of this paper in not only to obtain some efficiency scores but also to know the effect of some firm-specific variables on the efficiency scores. This analysis may help us to know the factors which cause inefficiency. The interest increases even more, when we include also the variables of subsidization. The effect of subsidies on (in) efficiency scores is of high interest not only for researchers but also for the government. For this purpose, we will continue the analysis by allowing the variance of the inefficiency terms to be a function of some z variables which are also known as inefficiency explanatory variables **(Kumbhakar, Wang, and Horncastle, 2015)**. In order to conduct this analysis, will be employed a one-step procedure, meaning that the parameters in the ML method and the relationship between inefficiency score and the x variables are estimated in the same time. If a specific z variable has a positive significant signs, in means that a firm with higher level of that variables tends to have higher level of inefficiency, on contradictory, the variable with the negative sign means that it decreases inefficiency (it is more efficient).

Data

For the estimation of the production frontier we used Farm Accounting Data Network (FADN) Kosovo data (**FADN MAFRD, 2014)** available for 394 farms for year 2014. FADN is considered as a consistent database for the estimation of the production frontiers of farms in Kosovo.

These cross-section data of 394 farms in Kosovo were used to estimate the production frontier, to derive their technical efficiency scores and to determine the effect of exogenous variables by focusing on subsidies. The structure of the farms in the sample according to their size and typology is shown in Table 1.

From 62,616 farms that are in Kosovo with Standard Output (SO) greater than €2,000 per year, in this dataset are included 394 farms of six different typologies and of 5 different economic sizes. Majority of the farms (38%) are of the lowest economic size €2,000-4,000 while the farms with the highest economic size are only 8% of the farms. According to farm typology, most of the farms belong to mixed crops and livestock (40%) and of specialized grazing livestock (36%), followed by specialized field crops 10%, mixed cropping (9%) and others. Even though the sample represents only 0.6% of total population, these were the only data available from MAFRD and as a result will be used for analysis.

Definition of Variables

As defined in literature on farm technical efficiency, there are three main groups of variables employed as determinants of technical efficiency in transition and western economies which are organized in output, inputs and exogenous variables **(Brummer 2001, Giannakas *et al.* 2001, Mathijs and Vranken 2001, Rezitis *et al.* 2003, Latruffe *et al.* 2004).** These variables are related with the characteristics of the farm and technology employed, locational and environmental variables characterizing the conditions for farming and human capital variables.

As output variable (Y) we use Total Agricultural Output (the value in EUR of crops, livestock and livestock products and other output). The total output is used as output in many studies such as in**: Bojnec and Latruffe (2013), Latruffe and Fogarasi (2009).** As input variables (Xs) Labour (AWU), Land (UAA), Capital (value) and Intermediate Consumption (value) are considered. All the input variables (land, labour, capital and intermediate consumption) are expected to positively and significantly affect the performance of the farm proxied by technical efficiency (Table 2).

The classical inputs are taken into account when calculating technical efficiency scores, however, technical efficiency should be explained also by using other variables that may be related to the quality of the factors of production, to the environment, or to policy support which also represent the variable of interest.

There exists a large set of exogenous variables (Zs) that influence the mean and the variance of farm efficiency and that could potentially explain the differences of technical efficiency among the farms in the sample. These explanatory variables in the inefficiency model are related with the management strategies of the farm (financial management proxied by the ratio of debts to total assets) with the environment factors (such as location and specialization) structure of the farm (size, labour) as well as with socio-economic factors (public policies proxied by subsidies) (Table 3).

Table 1 Farms in the sample according to their typology and economic size

Farm Typology	Economic Size					Total	Participation
	2000-4000	4000-8000	8000-15000	15000-25000	25000-		(%)
Specialist field crops	6	12	10	8	11	47	10
Specialist permanent crops	1	4	4	1		10	2
Specialist grazing livestock	5	23	55	30	10	123	36
Mixed cropping	2	3	5	7	4	21	9
Mixed livestock holdings		2	3	1	1	7	4
Mixed crops - livestock	17	61	77	14	15	184	40
Total	31	105	155	61	42	394	100
Participation (%)	38	35	14	6	8	100	

Source: **FADN MAFRD (2014)**

Table 2: Definition of main variables

Factor	Definition	Measurement Unit	The expected sign
Total Output (Y)	Total of output of crops and crop products, livestock and livestock products and of other output (SE131)	EUR	
Capital	Capital, in terms of the value of fixed assets (SE436)	EUR	Positive
Labour	Labour in terms of the number of annual working units (AWU) on the farm (SE010)	AWU	Positive
Land	Land is presented in the number of hectares (ha) of utilised agricultural area (UAA) (SE025)	Ha	Positive
Intermediate Consumption	Total specific costs (including inputs produced on the holding) and overheads arising from production in the accounting year. = Specific costs + Overheads (SE275)	EUR	Positive

Note: definition according to **EC (2018)**

Table 3: Exogenous variables in the inefficiency effect model and definitions

Variables (vector z)	Definition
Z_1:Age	Age in years
Z2: Subsidy composition	Share of subsidies in total output (%) (the ratio of total subsidies received by the farms to their total output
Z3: Share of Crop Output to Total Output	This variable serves as a proxy for specialization and is measures as the Ratio of crop production in total production (%)
Z4: Total Land to Total Labour ratio	Ratio of total land to total labour (%)
Z5: Hired labour to total labour	Share of Hired Labour to Total Labour (%)
Z6: rented land	Ratio of rented land to total utilised land (%)
Z7: Debt ratio	Ratio of total debts to total assets (%)
Z8: DumReg	1 for farms in Rrafshi i Kosoves and 0 for otherwise (Rrafshi i Dukagjinit)
Z9: DumLegal	a legal form dummy, taking the value 1 if the farm is a company, and 0 otherwise (family)

RESULTS AND DISCUSSION

The descriptive statistics of output, inputs and other exogenous variables for 394 farms in sample are shown in Table 4. On average, a farm in Kosovo produces output with a value of 17,675 Euros by using 2.59 AWU of labour, 99.02 ha of land, 294 thousand Euros of assets and more than 6 thousand euros of variable input.

Results of estimated production function (Table 5) suggest that the classical inputs together with the variable input are all statistically significant at 1% significance level. The signs of the input coefficients are as expected for labour, land and variables input. For the labour variable input, a 1 % increase in labour input (AWU) increases the output for 0.46%, a 1% increase in total utilized area (UAA) increase the output by 0.12% and a 1% increase in intermediate consumption increases the output by 0.66%. The capital input, however, is found to have negative impact on output. Its interpretation is that for 1% increase in capital, the output is decreased by 0.46%. This negative impact can be due to outdated technology. Effect of total subsidies is negative but insignificant.

Table 4 Descriptive statistics of variables

Variable	Obs	Mean	Std. Dev	Min	Max
Y-Output (€)	394	17,675.03	23,486.49	1,100	343,150
L-Labour (AWU)	394	2.59	2.50	0.22	22.91
C-Capital (€)	394	294,389.60	555,877.60	50	7,137,800
H- Land (ha)	394	99.02	1,336.19	0.1	24,125
VI-Intermediate Consumption (€)	394	6,882.32	37,102.43	250	698,350
Z_1:Age	392	52.78	13.03	0	85
Z2:Share of Total Subsidies to Total Output	394	6.93	40.92	0	770.46
Z3:Share of Crop Output to Total Output	394	52.66	25.03	0	100
Z4:Share of Total Land to Total Labour	394	565.12	800.82	4.93	8,550
Z5:Share of Hired Labour to Total Labour	394	18.42	246.67	0	4,223
Z6:Share of Rented Land to Total UAA	394	61.78	251.80	0	3,400
Z7:Share of Total Liabilities to Total Assets	394	0.16	0.97	0	9.96
Z8:DumReg	394	0.59	0.49	0	1
Z9:DumLegal	394	0.97	0.16	0	1

Source: Own computation based on **FADN MAFRD (2014)** data

Table 5 Results of the SFA model: production function and the inefficiency effect model

Ly	MLE Coeff.	Std. Err.	z	P>|z|
Frontier				
Ln Capital ***	-0.46583	0.0013	-350.00	0.000
Ln Labour***	0.460707	0.0031	150.00	0.000
Ln Land***	0.120963	0.0018	68.00	0.000
Ln Variable Input***	0.663622	0.0014	480.00	0.000
_cons	11.42037	.	.	.
Usigmas				
Z_1:Age	-0.00343	0.0058187	-0.59	0.555
Z2: Share of Total Subsidies to Total Output	0.00332	0.0041406	0.80	0.423
Z3: Share of Crop Output to Total Output	0.004538	0.0030089	1.51	0.131
Z4: Share for Total Land to Total Labour**	-0.00021	0.0000897	-2.36	0.018
Z5: Share of Hired Labour to Total Labour**	0.000727	0.0003332	2.18	0.029
Z6: Share of Rented Land to Total UAA	0.000182	0.000288	0.63	0.526
Z7: Share of Total Liabilities to Total Assets	0.035166	0.0711658	0.49	0.621
Z8: DumReg *	0.248634	0.1492074	1.67	0.096
Z9: DumLegal	0.056056	0.4520715	0.12	0.901
_cons	1.506596	0.5817548	2.59	0.01
Vsigmas				
_cons	-39.3687	1382.505	-0.03	0.977

Note: *, **, *** significance at 10%, 5% and 1% significance level respectively.
Source: Own computation based on **FADN MAFRD (2014)** data

Table 6 Technical efficiency scores from the model with the firm specific variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Technical Efficiency Scores	394	0.156971	0.160575	0.00025	0.9999

Source: Own computation based on **FADN MAFRD (2014)** data

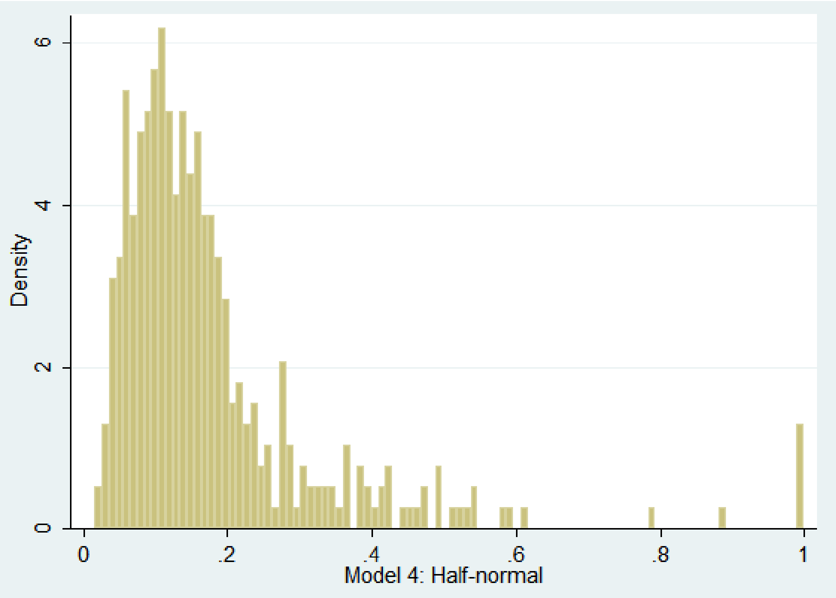

Figure 1. Histogram of efficiency score of the Half-Normal model with exogenous variables
Source: Own computation based on FADN MAFRD (2014) data

The calculated technical efficiency scores for 2014 are very low (Table 6). Technical efficiency score indicates that on average a farm produced 15.7 % of the maximum output. This low level of efficiency means that the rest of the potential output, 84.3 %, was lost due to technical inefficiency.

The histogram of the efficiency score demonstrates clearly the level of efficiency of the Kosovo farms. Majority of the farm efficiency score range between 0 and 0.2 (Figure 1).

The results of the analysis of technical efficiency for farms in Kosovo in 2014 suggest, that the technical efficiency scores were very low. For the estimation of technical efficiency, it has been assumed that producers produce one single output from multiple inputs. They produce one output either because they actually do produce a single output or because they are able to aggregate their multiple outputs into a single output index. We considered that the farmer produced one output through the use of three classical inputs (capital, labour and land) and one variable input (intermediate consumption). All the inputs were expected to have positive and significant effect on output. The results suggest that for the case of Kosovo all the input variables were significant at 1% significance level and have the expected positive sign except the variable of capital which has the negative sign. The negative sign of capital was found also by **Latruffe *at al.* (2004)** on the case of the Polish farms, which was explained by less productive old machinery in the countries with economy in transition. Since also Kosovo is a transition country and still in the developing stages, this negative sign of capital is due to the old technologies used by the farmers. Another reason for the negative sign found in our study for capital, may be overestimation of the capital by the farmers. Instead of declaring the real value of capital, the farmers in Kosovo overestimated this value.

Regarding the inefficiency model, the share of total land to total labour positively affect the efficiency scores. The variable which presents the share of hired labour to total labour affects negatively the technical efficiency score. Both the mentioned variables are significant at 5% significance level. Also the variable of region is significant, indicating that farm in the region of Kosovo are less efficient than farms in the region of Dukagjini.

Public support, given in the form of direct payments or as rural development measure, during the last decades has gained lot of attention because of the effect that they have on the performance of the farm. Limitations of our study steam from availability of cross-session data for one year 2014, while the SFA techniques requires more observations, preferable panel data. In addition, the sample of 394 farms represents only 0.6% of total farm population in Kosovo, therefore the analysis of the results should be treated with caution due to insufficient representation of farms according to economic size.

CONCLUSIONS

The farm average technical efficiency in transition economies is 86% whereas in Kosovo is only 15.7%, indicating that an average farmer in Kosovo produces 68.3 less percentage points of the potential output than an average farms in transition countries. Regarding the inefficiency model, is can be suggested that total subsidies to total output as a proxy for supporting policies has negative effect but is not significant. The findings of this paper suggest that efficiency scores for the case of Kosovo are very low and as such the Kosovar government should assist farmers to promote the production process by providing technical assistance and research and development activities, rather than providing subsidies without any kind of criteria and target.

Even though the empirical result on the performance of the farms in Kosovo is not promising, it is the first study to measure farm efficiency by implementing SFA methodology on cross-sectional data. As a result, the investigation of efficiency on Kosovo farms in this study is primarily of substantial policy relevance because contributes to better policy making. On the other hand, it is believed that in the near future when the FADN datasets will be available also for the other years and with more variables, it will be possible to create panel data sets and as such to have more realistic results regarding the technical efficiency scores.

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REGULAR ARTICLE

DETERMINANTS OF RURAL HOUSEHOLD SAVINGS BEHAVIOUR: THE CASE OF TOMATO FARMERS IN GHANA

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ABSTRACT

Much as savings plays an important role in economic development process, it has been neglected very much in favour of credit in rural communities particularly in developing countries. Against this backdrop the study sought to determine tomato farmers' capacity to save and also to examine the determinants of savings among this group of farmers in three regions of Ghana namely Ashanti, Brong Ahafo and Upper East regions. Data was collected with the aid of structured questionnaire. Descriptive statistics and Ordinary Least Squares (OLS), were used to analyse the data. Empirical results based on four models of the savings functions advocated by Keynes, Klein and Landau showed the marginal propensity to save (MPS) of the respondents to be 0.88 (88%), indicating a relatively high levels of savings among the respondents. This runs counter to Keynes' assertion that the equalization of income distribution increases aggregate consumption, and hence, reduces savings. The study also established the hypothesis of non-linearity between savings and income among the respondents. This implies that due to lack of permanent income sources among rural dwellers, they tend to consume less of their income in order to save more for the "rainy day". The results of the study have demonstrated that rural households particularly tomato farmers have the capacity to save which is indicated by their relatively high marginal propensity to save of 88%. This finding makes a convincing case for financial intermediaries to extend the needed financial services to rural households.

Keywords: Savings, Marginal propensity, Tomato farmers, Income, Ghana
JEL: Q12, C21, D14

INTRODUCTION

Savings behaviour has variously been explained as an understanding of how people save in a country in order to realize supply of funds for investment (**Salam and Kulsum, 2002**). It is fundamentally underscored by the combination of perceptions of future needs, a saving plan and a saving action (**Thung *et al*., 2012**). The importance of savings behaviour becomes more apparent especially in developing countries where economic fluctuations coupled with climatic risks result in significant income variations. This situation may be exacerbated by restricted social coverage as well as poorly developed credit and insurance markets. Under such circumstances, households' savings becomes crucial to provide the needed insurance against economic and social shocks (**Abdelkhalek *et al*., 2010**). Therefore, a better understanding of the dynamics of the savings behaviour at the household level will help in the formulation of appropriate policies for savings mobilisation, thereby improving upon local capital formation capacity to enhance national development.

Ghana has been observed to be the second largest importer of tomato paste after Germany. The nation imports several tonnes of tomato and tomato products into the country, consuming an average of 25,000 tonnes of tomato paste in a year at a total cost of about $25 million dollars (**Yeboah, 2011**). In Ghana, the focus of the efforts by various stakeholders in the tomato industry geared towards finding "lasting" solutions to the myriads of problems associated with tomato production has mostly been considered from agronomic perspective (**Aidoo-Mensah, 2018)**. However, the challenges of the tomato industry persist in spite of the many solutions proposed by agronomists and allied scientists. Thus, the need to look beyond the agronomic issues to determine the inability of farmers of such an important crop to sustain their production activities.

Hence, the paper which brings to the fore the fact that these farmers' quest for survival now and into the future in today's ever-changing and challenging environment of economic development hinges not only on agronomic issues but also on their ability to sustain their production activities through their savings. In Ghana, this is one of most commonly produced and consumed vegetable (**Sinnadurai, 1973; Chagomoka *et al*., 2015**) and the activities of the farmers of this all important crop may be scattered throughout the nation but more concentrated in the study areas.

MOTIVES FOR SAVINGS

Much as the socio-economic benefits accruing from savings are varied, so also are the motives or reasons underlying individuals' savings decisions (**Aidoo-Mensah, 2017**). This is not unexpected as research in psychology has identified a hierarchy of saving motives ranging from the more concrete or immediate goals (like consumption), through intermediate goals (like security needs, retirement, debt avoidance and precaution) to the more abstract goals of self-esteem and self-gratification (**Canova, Rattazi and Webley, 2005**). Among the early economists to identify savings motives, was **Keynes (1936)** whose eight savings motives listed below have withstood the test of time:

1. Precaution: Setting aside for unexpected circumstances.
2. Foresight: Meeting anticipated future needs.
3. Calculation: Earning interest.
4. Improvement: Increasing a standard of living over time.
5. Independence: Needing to feel self-sufficient and in control.
6. Enterprise: Investing money into business.
7. Pride: Leaving money to heirs.
8. Avarice or miserliness: Being greedy or tight-fisted.

To these motives suggested by **Keynes (1936), Browning and Lusardi (1996)** added a ninth one, that is, to accumulate deposits (savings) to buy houses, cars and other durables, termed as the down payment motive. **Katona (1975)** offered six more general motives for saving as follows: (1) for emergencies, (2) to have funds on reserve for necessities, (3) for retirement or old age, (4) for children's needs, (5) to buy a house or durable goods and (6) for holidays.

In the opinion of **Fisher and Anong (2012)** these motives may not necessarily be mutually exclusive but rather complementary. According to Browning and **Lusardi (1996**), there is considerable heterogeneity among the motives for saving. In other words, it is unlikely that a single motive will suffice for all members of a population at any given time or even for the same person over a long stretch of time (**Aidoo-Mensah, 2017**).

Factors Influencing Savings Behaviour

Although available evidence according to **Alamgir (1976)**, does not permit any generalization about savings habits in terms of specifying a precise functional form and the variables to be included, it is however, maintained that savings habits are significantly influenced by certain socio-economic and demographic characteristics, cultural and physical variables as well as institutional factors. It is therefore imperative to understand and evaluate the relevant significance of these factors (determinants) especially with reference to their applications in studies relating to farm households in developing countries.

Household Demographic and Socio-economic Characteristics

It has long been established that size of household, age structure and other demographic as well as socio-economic characteristics affect household savings habits (**Snyder, 1974**), hence their importance for empirical studies on analytical grounds (**Leff, 1969**). The Life Cycle Hypothesis first proposed by Modigliani and **Brumberg (1954)** and later by Ando and **Modigliani (1963)** incorporates various demographic and socio-economic characteristics as way of explaining consumption and savings behaviour of individuals or households. Empirically, this hypothesis is tested by introducing such demographic characteristics as age of the household head, the dependency ratio and income into the analytic framework used for explaining savings habits of rural households. Among household demographic and socio-economic characteristics underlying rural savings habits include the following:

Gender of Household Head

Empirical evidence points to the fact that the economic well-being and savings behaviours of men and women differ significantly (**Fisher, 2010**). Women particularly those in most developing countries have been found to possess lower levels of wealth and have significantly lower earnings than men (**IMF, 2015**). In rural areas of South Saharan Africa for instance, women's ability to obtain assets is governed by family and community norms, which traditionally have favoured men to the detriment of women (**Kameri-Mbote, 2005**). In addition, the legal systems at the macro level in different countries determine how much control women can have over assets (**Chowa, 2006**).

Even though much information has been obtained on the differences in earnings, risk aversion, investment behaviours, and level of wealth among the sexes, little is known about how the factors related to general saving behaviours may differ between men and women (**Fisher, 2010**). However, it has been found that women live as many as five more years than men in retirement as a result of having longer life expectancies (**Gottschalck, 2008**). Moreover, it has been reported that women invest their financial resources more conservatively and are, in general, more risk averse than men (**Bajtelsmitans VanDerhei, 1997; Yuh and Hanna, 1997**). Various studies have also shown that women have lower rates of involvement in retirement plans as compared with men (**Sung, 1997**) and are more likely to be found in poverty during retirement (**Pearce, 1989**).

In spite of these shortcomings relating to the female gender as far as financial issues are concerned and despite the importance of saving in regards to the financial security of households, relatively few studies have examined whether there are gender differences in saving (spending less than income) at the household level (**Fisher, 2010**). However, **Chowa (1996)** has reported that women save better than men when they have the opportunity to save.

Age Structure of Household

The life cycle hypothesis defines the age between the consumption plans of an individual and his/her present earnings and expectations concerning future income, as he or she passes from childhood, through the work participating years, into retirement and the eventual demise of the individual (**Spio and Groenewald, 1996**). This implies that household savings are highest during the working years of the head and when income declines during retirement years (**Saint-Pierre, 1996**), the household draws from their previous savings to maintain the standard of living (**Wilson, 2000**). Thus, savings is needed by the household to reallocate resources over time thereby smoothing consumption over their life span especially during the retirement age of the household head. Many empirical studies have noted some degree of correlation between the age structure of the household and the savings-income relationships of households.

The first independent test of the hypothesis was done by **Fisher (1956)**, who conducted a cross section analysis of savings of some 2000 households. Data were sub-classified by age of head of household and by socio-economic group as a proxy for income stability. Current income and liquid asset holdings were used as independent variables. There was evidence of peaking of marginal propensities to save in higher age working groups and a rundown of assets in retirement years. Negative savings were also exhibited in the youngest age groups (**Spio and Groenewald, 1996**). The most searching analysis of the hypothesis was carried by **Kelley and Williamson (1968)**. They found that income per family member declines up to the age group 40-49 and stabilises or rises only slightly thereafter.

Household Size

Household size has relevant implications for household purchasing and spending behaviour (**Jerome and Perreault, 1991**), vis-à-vis, savings-income relationships. All things being equal, it is assumed that households with large family sizes spend more on goods and services than households with small family sizes. Larger family size is therefore found to be associated with greater budget shares devoted to housing and education and all things being equal, this has the tendency to deprive such households enough resources to save and this in most cases results in cyclical poverty (**Arthur, 2005**). This is more pronounced in rural areas where food and other basic needs consumption, absorb up to 80-90per cent of the household budget. However, in a life cycle context, children may add to the household's productive resources by providing more labour and probably more assets (**Chernichovsky, 1978)** but in general, household size is supposed to reflect the expenditure pull on household income and the usual expectation is that it will negatively correlate with savings (**Alamgir, 1976**).

Marital Status of Household Head

Studies indicate that being married has a large effect on reducing the risk of poverty and is associated with a higher probability of attaining affluence over the life course when compared with non-marriage. Compared to married couples, unmarried people have also been found to save much lower portions of their income and accumulate fewer assets (**Grinstein-Weiss, Zhan and Sherraden, 2004**).

From an economic point of view, marriage has several characteristics that may enhance wealth accumulation (**Waite, 1995**). **Grinstein-Weiss *et al*., (2004)** outlined six economic perspectives underlying wealth accumulation vis-à-vis, savings in households where the head is married: First, the total product of a married couple is larger than the sum of the outputs of each produced separately. Second, the institution of marriage entails long-term commitment in which a division of labour enables each spouse to specialize in specific skills and duties. This specialization increases the productivity and the efficiency of the household. Third, economies of scale in consumption suggest that a married couple may achieve the same utility with less combined expenditure than the sum of their individual consumption if living apart. Fourth, the requirements and expectations of married (versus single) life may encourage people to buy a house, save for children's education, and acquire cars and other assets. Fifth, there is persistent evidence that married men earn more than unmarried men. Sixth, the institution of marriage expands one's social network and social support, which may result in additional opportunities and benefits that lead to savings. Finally, married individuals may have access to many benefits such as health and life insurance provided by the spouse's employment which in a way will reduce the pressure on the household income, thereby enhancing the ability to save.

Dependency Ratio

Age-dependency ratios are a measure of the age structure of the population. They relate the number of individuals that are likely to be "dependent" on the support of others for their daily living – youths and the elderly (that is, the percentage of the population aged 15 years and below together with the percentage of the population aged 65 years and above) to the number of those individuals who are capable of providing such support (**OECD, 2007**). In defining the dependency ratio, it has been implicitly assumed that the population aged 15 years and below plus 65 years and above adds to household consumption and contributes nothing towards production.

The life cycle model predicts that a relatively large burden of children (and/or the elderly) would cause aggregate savings rates to be relatively small, and that are relatively large size of the older working proportion of the household would reflect a higher aggregate savings rate. The model can therefore be expanded to include the hypothesis of household dependents creating a burden on household savings-income relationships, that is, households provide for the consumption of dependents particularly the younger ones by sacrificing savings in the early stages of household formation and then save at a high rate during the empty-nest stage in order to prepare for retirement (**Wilson, 2000**). For instance, in an empirical study of 47 countries, **Leff (1969)** indicated that the dependency rate of the young (those aged 15 and below) and of the old (those aged 65 and above) negatively affected savings rates in those countries. It therefore stands to reason that dependents contribute to consumption but not to production, therefore, imposing a constraint on society's potential for savings.

According to **Gedela (2012)**, the dependency burden on savings is more pronounced in developing countries where 70 percent of the population lives in the rural areas. In these areas, children are considered an asset because of their contribution to household activities and farm operations (**Amaza *et al*., 2009**). Thus, the impact of the dependency ratio on household savings can be more meaningfully examined if, instead of putting a restriction on the age of the household member, their earning status is explicitly taken into account.

Educational level of Household head

The variable educational status of the household is usually defined as the number of years of formal education attained by the household head. It is usually assumed that a high educational status equips one with better financial management, thereby, impacting positively on savings habits. For instance, **Solmon (1975)** compared the savings rates of different educational groups and found that both the marginal and average propensities to save tend to rise with the number of years of education. Using longitudinal data from the 1983 and 1986 Surveys of Consumer

Finances from the United States, **Avery and Kennickell (1991)** reported that as respondent education level increased, wealth increased over the three-year-period.
In contrast to the positive relationship between education and savings, **Rha, Montalto, and Hanna (2006)** found that households having household heads with an advanced degree were significantly less likely to save than other wise similar households where the head had a high school diploma. However, the overall conclusion is that increased level of education of the household head explains a substantial part of the growth of the economic output and increased incomes of households in both developed and developing countries (**Johnson, 1990**).

Income

Generally, rural household income has been defined as the sum of the net flow of receipts or earnings from all members of the household from different economic activities during a reference period usually one accounting year (**Alamgir, 197**6). Such economic activities may include agricultural wages (from crops and livestock; and other related enterprises, non-agricultural wages, remittances, and receipts from property-rentals both in cash and in kind.

Income has been considered the most important factor in the determination of savings not only at the rural household level but at the national level as well. Various empirical studies based on different methodologies conducted in different parts of the world, all found a positive relationship between income and savings (**Kodom, 2013**). In general, both Keynesian and non-Keynesian savings functions postulate a positive relationship between savings and income. The positive relationship postulated by both models has been confirmed in various empirical studies. For instance, **Kudaisi (2013)** in her study of West African countries during 1980-2006 confirmed that increase in income has a positive effect on household savings. Similarly, **Guma and Bonga-Bonga (2016)** in their empirical work among corporate and household savings in South Africa as well as **Fisher and Anong (2012)** in their study of 3,822 non-retired households in the United States all confirmed that increase income has a positive effect on household savings.

Institutional Arrangements Influencing Savings Behaviour

One of the shortcomings of the economic theories of savings, according to **Beverly (1997)** is that they are prejudiced towards individuals and households with higher income. The institutional model of savings underscores the fact that suitable institutional arrangements other than income and preferences may play an important role in promoting savings particularly among rural households (**Beverly and Sherraden, 1999**). This reinforces the larger message that institutional (either formal or informal) mechanisms play a vital role in any household's decision to save, thus, low saving rates partly stem from a lack of appropriate institutional saving devices, not lack of desire to save on the part of rural households (**Armendariz and Morduch, 2005**).

A fundamental difference between the institutional model of savings and the traditional neoclassical economic theory is in the way savings are generated. Whereas the traditional economic theory sees savings as a result of individual choices, the institutional model suggests that savings occur in households largely through appropriate institutional arrangements. Thus, effective asset accumulation can be structured and often subsidised through favourable institutional arrangements. Among most households, unstructured savings, which are left over from income minus consumption, are likely to be smaller than asset accumulation generated by institutional arrangements (**Grinstein-Weiss *et al*., 2004**).

According to **Hussein and Thirlwall (1999)**, there is no single measure that can capture the institutional determinants of the savings-income relationships of rural households. However, **Beverly and Sherraden (1999)** proposed four institutional determinants of savings: institutionalized saving mechanisms (*access*), targeted *financial education*, attractive saving *incentives* (e.g., matched savings), and *facilitation* (e.g., payroll deduction). It is therefore posited that a number of institutional arrangements suitable to the rural household setting can elicit from them favourable savings response. These may include the following:

Locational convenience – Proximity of the service provider to the clients, that is, the distance covered by the rural household in order to access the nearest savings facility (**Akaah *et al*., 1987; Wright, 1999; Bendig *et al*., 2009**).

Cost of transaction, that is, how much it will cost the clients to access the services of the service provider in terms of transportation cost, service charges, and inconveniences if the premises or the office of the service provider is not within a walking distance (**Akaah *et al*., 1987; Wright, 1999; Carpenter and Jensen, 2002; Bendig *et al*., 2009; Kar and Dash, 2009**).

Varied range of financial products or services available to the rural household.

Speed with which services are provided, that is, how fast or how quick the service provider fulfils the financial requirements of the clients, that is, quick and access to savings without a lot of bureaucracy (**Robinson, 2001; Mbuthia, 2011**).

Simplicity and straightforwardness of transactions – this refers to the ease with which the clients can access financial services from the service provider in terms of language used in filling transactions and the level or extent of the use of technical financial terms or jargons as well as services without a lot of bureaucracy (**Wright, 1999; Robinson, 2001; Hirschland, 2006; Mbuthia, 2011**).

Customer-friendly attitude towards clients – this is necessary because of the westernised perception of formal institutions by rural folks and therefore the tendency that rural clients would be looked down upon by the staff of the financial institutions (**Wright, 1999; Robinson, 2001**).

Safety or security of savings – how secure the savings of the clients are (**Klaehn, Branch and Evans, 2002**).
Ability to deposit/save small amounts (**Aryeetey and Gockel, 1991**).

Flexibility and reliability of service provided.

Convenience of service hours of opening and closing (**Beck *et al*., 2006**).

Savings density – a measure of the number of financial institutions available to the rural households.
Ease and convenience with which one gets access to his/her savings (**Rutherford, 1996; Robinson, 2001; Beck *et al*., 2006**)

DATA AND METHODS

Types and Sources of Data for the Study

Empirical research into the dynamics of household savings is generally undertaken using either of two methods: the use of aggregate data and the use of primary data (**Niculescu-Aron, 2012**). This study made use of the second method, that is, the employment of primary data. The employment of primary data for the study is underlined by the fact that exploration of such data can be relied upon to give accurate facts and valuable understandings of household savings. Additionally, the analysis of primary data on savings can be a good source to obtain a wealth of information for policy considerations. Structured questionnaire was administered to obtain information on respondents' income from tomato production, amount received in the form of remittances from relatives and their tomato farm sizes. Moreover, relevant socio-economic and demographic factors such as educational background, gender, household size, distance to the nearest financial service provider and engagement in non-farm activities were obtained.

Sampling Technique

Number of respondents for the study was obtained by utilizing **Bartlett *et al*., (2001)** (Eq. 1).

$$n = \frac{Z^2(p)(q)}{(E)^2} \quad (1)$$

Where
n Sample size
p Proportion of people who access financial services/those who have bank account
q Proportion of people who do not have to access financial services/those who do not have bank account
Z Number of standard deviation for a chosen confidence interval level
E Allowable margin of error

In line with the GLSS (5) report which estimated that about 42% of inhabitants of rural areas have access to financial services (savings account) (GSS, 2008), and assuming a 95% confidence level and 5% margin of error, the number of respondents was obtained by:

$$n = \frac{1.96^2 \text{ x } 0.42 \text{ x } 0.58}{0.05^2} = 374$$

Nevertheless, as a means of capturing the economic multiplicity of the selected regions on an enlarged scale, thereby, ensuring realistic distribution of the respondents within the selected districts, as well as improving the reliability and validity of the results, the sample size was augmented by 60%. Accordingly, the total sample size was approximated to 599 as indicated on Table 1. This was uniformly spread across the selected districts based on the number of households engaged in agricultural production obtained from the 2010 Population and Housing Census. The response rate was 94%, that is, 562 out of the 599 were fit for the analyses.

The sample for the study was carefully chosen using three (3) approaches. The first of these approaches was the purposive selection of the regions, that is, Ashanti, Brong Ahafo and Upper East regions. The second approach was based on purposive selection of two districts from each of the afore-mentioned regions. The third approach involved random selection of respondents for the study and this was done with assistance from Agricultural Extension Agents (AEAs) responsible for the operational areas in each of the selected districts. The choice of the three regions and their respective districts was informed by the level of tomato production as a result of analysis of official statistics from Ministry of Food and Agriculture (MoFA).

Table 1: Selected districts and sample size

Region	Districts	Number of households[1]	Number of households engaged in agricultural production[2]	Proportion of households engaged in agricultural production (%)[3]	Sample size selected from each district[4]
Ashanti	Offinso North	11,164	8,794	77	61
	Sekyere Central	14,632	11,764	80	82
Brong Ahafo	Wenchi	19,138	12,485	65	87
	Techiman North	47,627	23,916	50	166
Upper East	Bongo (Vea)	15,188	12,711	84	88
	Kasena-Nankana East (Tono)	19,790	16,562	84	115
TOTAL		127,539	86,232		599

Source: [1,2]Regional Analytical Report of the 2010 Population and Housing Census, Ghana Statistical Service Statistics; [3,4]Author's calculation

Analytical Framework

According to Keynesian economists, savings represents that part of a person's disposal income earned in a given period, which has not been consumed. That is, savings is algebraically given as the amount left over when a person's expenditure is subtracted from his/her disposable income. The functional relationship between income (Y) and consumption (C) as postulated by Keynes can be expressed as Eq. 2.

$$C = \alpha + \beta Y \quad (2)$$

Where:
α is autonomous consumption and β is the marginal propensity to consume out of income, Y.

Given the definition of savings, S as a residual of household consumption (expenditure) from income, it may be symbolically expressed as Eq. 3.

$$S = Y - C \quad (3)$$

Combining Equations (2) and (3), Keynesian Savings Functions can be derived as Eq. 4.

$$S = -\alpha + (1 - \beta)Y \quad (4)$$

The negative intercept denotes dis-saving and the coefficient $(1 - \beta)$ of income is termed as the marginal propensity to save (MPS). However, the Keynesian savings function in its most commonly used form is linear with a constant MPS, which can be expressed as Eq. 5.

$$S = \beta_0 + \beta_1 Y \quad (5)$$

Where:
$\beta_1$is the constant MPS. It is assumed that $\beta_0 < 0$ and $0 < \beta_1 < 1$ such that as the level of income (*Y*) rises, average propensity to save ($^S/_Y$) will also increase. However, if the intercept, β_0 is positive or β_1 is negative, then average propensity to save (APS) will decrease with increasing income (**Mikesell and Zinser, 1973**).

The most widely used functional form in analysing household savings behaviour is based on Keynes' Absolute Income Hypothesis whose empirical application is expressed in the linear form as Eq. 6.

$$S = \beta_0 + \beta_1 Y + \beta_2 Z \quad (6)$$

Where:
S and Y are savings and income respectively and Z is an aggregate of socio-economic variables that underline savings. However, many empirical applications of the savings function have proved that though savings increases with increases in income, the relationship is not necessarily linear (**Bofinger and Scheuermeyer, 2014**). Equation (6) may therefore be deemed as unsuitable to analyse the respondents' savings behaviour. One possible way of introducing nonlinearity in the savings function is the quadratic Keynesian function given as Eq. 7.

$$S = \beta_0 + \beta_1 Y + \beta_2 Y^2 + \beta_3 Z \quad (7)$$

However, the possibility of encountering problems with heteroscedasticity of the estimates of the coefficients of β_1,β_2 and β_3 make Equation (7) equally unsuitable. One way according to **Burney and Khan (1992)**, to avoid the problem of heteroscedasticity is to express savings as a percentage of income as given by Eq. 8.

$$\frac{S}{Y} = \beta_0 + \beta_1 Y + \beta_2(^1/_Y) + \beta_3 Z \quad (8)$$

Klein (1954) introduced nonlinearity in the savings function by suggesting the functional form of Eq. 9.

$$^S/_Y = \beta_0 + \beta_1 logY + \beta_3 Z \quad (9)$$

A positive and statistically significant coefficient of β_1 in Equation (8) and β_1 in Equation (9) would support the traditional Keynesian wisdom that equalization of income distribution increases aggregate consumption (**Burney and Khan, 1992**). In order to test the hypothesis of linear versus nonlinear relationship between savings and income, **Landau (1971)** suggested the functional form of Eq. 10.

$$^S/_Y = \beta_0 + \beta_1 Y + \beta_2 (logY)^2 + \beta_3 \quad (10)$$

A positive and statistically significant coefficient of β_2 would support the hypothesis of nonlinearity (**Burney and Khan, 1992**).

Four models of the savings function (Model 1-4) were estimated using ordinary least squares (OLS) method:

$$S = \beta_0 + \beta_1 Y + \beta_2 Z \quad \text{(MODEL 1)}$$
$$\frac{S}{Y} = \beta_0 + \beta_1(^1/_Y) + \beta_2 Z \quad \text{(MODEL 2)}$$
$$^S/_Y = \beta_0 + \beta_1 logY + \beta_2 Z \quad \text{(MODEL 3)}$$
$$^S/_Y = \beta_0 + \beta_1 (logY)^2 + \beta_2 Z \quad \text{(MODEL 4)}$$

Where:
S and Y are savings and income respectively and Z is an aggregate of demographic and socio-economic variables that underline savings. Model 1 is the linear functional form based on Keynes' Absolute Income Hypothesis. Model 2 is a modified version of the non-linear Keynesian functional form suggested by **Burney and Khan (1992)**. Models 3 and 4 also non-linear functional forms propounded by **Klein (1954)** and **Landau (1971)** respectively with some modifications on the one suggested by Landau.

RESULTS AND DISCUSSION

Production of tomato in the three regions is in the domain of males (98.1%) (Table 2). This to some extent has been attributed to the labour requirement of tomato cultivation which tends to be very high as well as the intensive use of agro-chemicals with its concomitant health hazards (**Mensah, Konadu and Agyare, 2013**), making this sector of agricultural production less attractive to females.

Table 2: Demographic characteristics of respondents

Variable	Ashanti Region (N=134)		Brong Ahafo Region (N=237)		Upper East Region (N=191)		All households (N=562)	
	N	%	N	%	N	%	N	%
Gender of Respondents								
Male	98	73.1	204	86.1	148	77.5	450	80.1
Female	36	26.9	33	13.9	43	22.5	112	19.9
Age Category								
< 30	13	10	63	27	28	15	104	19
30-65	114	85	161	68	162	85	437	78
> 65	7	5	13	5	1	1	21	4
Highest level of formal education								
None	30	22.4	39	16.5	73	38.2	142	25.3
Primary	26	19.4	27	11.4	74	38.7	127	22.6
MSLC	41	30.6	75	31.6	1	0.5	117	20.8
Secondary	34	25.4	34	39.2	42	22.0	169	30.1
Certificate	2	1.5	1	0.4	0	0.0	3	0.5
Diploma	0	0.0	2	0.8	0	0.0	2	0.4
Graduate	1	0.7	0	0.0	1	0.5	2	0.4
Marital Status								
Single	18	13.4	49	20.7	24	12.6	91	16.7
Married	116	86.6	188	79.3	167	87.4	471	83.3
Number of years of experience in tomato farming								
<= 5	33	24.6	56	23.7	36	18.9	125	22.2
6-25	80	59.7	156	67.8	149	78.0	385	68.5
26-45	21	15.7	24	10.1	6	3.1	51	9.1
> 45	0	0.0	1	0.4	0	0.0	1	0.2
Household Size								
<= 3	24	17.9	74	31.2	16	8.4	114	20.3
4-6	76	56.7	87	36.7	127	66.5	290	51.6
7-9	26	19.4	60	25.3	42	22.0	128	22.8
> 9	8	6.0	16	6.8	6	3.1	30	5.3
Age of dependents								
< 15	276	50.4	383	32.1	368	38.1	1027	38.0
15-65	268	48.9	763	64.0	5722	59.3	1603	59.2
> 65	4	0.7	46	3.9	5	2.6	75	2.8
Total	548		1192		965		2705	
Dependency Ratio		104.5		56.3		68.6		68.9

Source: Field Survey, 2015

Besides this, it is claimed that since women have limited experience in the market economy, they tend to be cautious in their choice of business undertakings in order to avoid possible failures (**Sharma and Zeller, 2000**). These possible business failures which have become a constant and prominent feature of the tomato industry in Ghana (**Donkoh *et al*., 2013**), are likely to be higher for females than for males, given pervasive gender inequalities. The male dominance could also be explained by the fact that in most African societies with Ghana being no exception, males are the decision makers and usually traditional owners of land and have easier access to land for farming (**Kameri-Mbote, 2005**). In relating this to the capacity to save among the respondents, it can be conjectured that all things being equal, in Ghana as far as tomato production is concerned, males hold sway in terms of income from this sector of agricultural production. Hence, males are more likely to have higher savings capacity in the tomato sector than their female counterparts (**Aidoo-Mensah, 2017**).

The age distribution of the respondents indicates a mean age of 39.90 years with the modal age group being 30-65 years. There is therefore compelling evidence that there is potential for savings mobilisation from the tomato sector in Ghana since majority of these respondents are in their middle ages where according to the life cycle hypothesis savings are positive (**Modigliani and Brumberg, 1954; Ando and Modigliani, 1963**).

Education has been described as the process of acquiring knowledge, values, skills and attitudes in order to enable an individual develop his/her capacities for general well-being (**Aidoo-Mensah, 2017**). It has been observed to affect the level of discretion an individual employee while making purchases. Thus, the more educated a person is, the higher the level of discretion, it is assumed that individual will employ in making purchases (**Pratap, 2017**). This implies that an educated customer would weigh his options carefully before going for a purchase. Education is therefore, regarded as important determinant of savings habits as it equips one with the required knowledge in the discretional use of one's income (**Donkoh, Tachega and Amowine, 2013**), thereby positively influencing one's ability to accumulate assets – savings (**Avery and Kennickell, 1991; Browning and Lusardi, 1996**).

Table 2 indicates that the Upper East Region has the highest level of respondents with no formal level of education (38.2%) as compared to 22.4% in the Ashanti Region and 16.5% in the Brong Ahafo Region. The gap in the educational attainment between the Upper East Region and the country as a whole is still very wide. The relatively low level of education in the region has been attributed not only to general poverty and cultural practices but also to the very late introduction of education into the region (GSS, 2013) and this is more likely to have a negative effect on their income levels, vis-à-vis, and their savings levels (**Aidoo-Mensah, 2017**).

Research indicates that marriage has a large effect on reducing the risk of poverty and is associated with a higher probability of attaining affluence over the life course when compared with non-marriage (**Aidoo-Mensah, 2017**). Compared to married couples, unmarried people have also been found to save much lower portions of their income and accumulate fewer assets (**Grinstein-Weiss, Zhan and Sherraden, 2004**). Therefore, from an economic perspective, marriage has several characteristics that may enhance wealth accumulation (**Waite, 1995**) and also brings in its trail an array of benefits (**Waite and Gallagher, 2000**) of which savings is key.

Table 2 indicates that 83.3% of all the respondents were married. Marital status across the three regions of the study indicates that over 70% of the respondents are married in each region. It is most likely that majority of the farmers are married in order to get extra hands to assist them in their farm operations (**Aidoo-Mensah, 2017**).

Much as it is true that marriage may play an important role in wealth accumulation, the reality of this assertion depends very much on the contribution each member of the marital union makes to the household wealth (**Aidoo-Mensah, 2017**). This is because the total product of a married couple, provided both are engaged in income generation activities, is larger than the sum of the output of each produced separately (**Grinstein-Weiss, Zhan and Sherraden, 2004**). Of the 471 married respondents, about 88% indicated that their spouses were engaged in some form of income generating activities as seen on Table 3. It can therefore be inferred that all things being equal, this 88% (412) whose spouses were engaged in some form of income generating activities are more likely to have higher income levels, hence, higher savings capacity than their counterparts (13%) (**Aidoo-Mensah, 2017**).

Table 3: Distribution of Income Generating Status of Spouses of Respondents

Income Generating Status of Spouse	N	%
Spouse is not engaged in income generation	59	12.5
Spouse is engaged in income generation activities	412	87.5
Total	471	100.0

Source: Field Survey, 2015

The idea of the importance of years of experience in farming is consistent with the widely held notion that considerable years of experience in farming helps the farmer to adapt to the risks of farming (**Boggess *et al.*, 1985**). This implies that an increase in the number of years in farming will increase farm productivity because farmers will gain more skills in the performance of farm operations (**Maliwichi, Pfumayaramba and Katlego, 2014**). Moreover, this may lead to reduction in the use of financial reserves as the increased skills of the farmers allow them to adapt to the risky and uncertain environment in which the farming activities operate (**Boggess *et al.*, 1985**).

Table 2 indicates that 68.5% of all the respondents have 6-25 years of experience in tomato farming. This implies that majority of the tomato farmers have considerable length of experience in tomato farming and therefore would be conversant with constraints to tomato production, thereby increasing their chances of circumventing these constraints in order to increase their tomato production (**Al-Shadiadeh *et al.*, 2012**). This could increase their level of income which is likely to reflect on the volume of their financial savings (**Aidoo-Mensah, 2017**).

Household size is seen as an important economic indicator which highlights the notion of dependency ratio. The dependency ratio tends to serve as a relationship between the population aged 0-14 years and 65 years and above to the working-age population (15-64 years old). This ratio gives an indication of the pressure a household or an individual may experience as a result of supporting economically dependent ones. This is for the reason that a high dependency ratio underscores the economic liability imposed on working members of a household due to the economic support such members offer to children and older household members who are often economically dependent.

The overall dependency ratio of the respondents as indicated on Table 2 is 68.9%. This is however lower than the national age dependency ratio of 73.43% which was last measured in 2014.

According to **Amaza *et al.*, (2009)**, a large household size offers farmers ample availability of labour pool for farm operations. Nevertheless, a large family size has the unpleasant possibility of bringing in its trail greater risk of poverty, chronic food insecurity and child malnutrition (**Maxwell, 1996**). This is particularly true when most of the household members are economically dependent on the working members of the household.

Table 2 indicates that 51.6% of all the respondents have household size of 4-6 persons. Surprisingly, all the regions have their highest household size within this household size bracket. The Upper East Region has the highest proportion of 66.5% within this household size bracket, followed by the Ashanti Region (56.7%) and the Brong Ahafo Region (36.7%).

The agricultural sector in most developing countries has been observed to be dominated by smallholder farmers whose agricultural activities though done on small scale are responsible for the production of most of the crop and livestock products (**Salami, Kamara and Brixiova, 2010**). In Ghana, the pattern of tomato production does not differ from other agricultural ventures in which farmers make use of small holdings. The underlying reasons for small farm holdings in tomato production in particular have been attributed to the fact that land preparation and other cultural practices are mainly carried out manually (**Aidoo-Mensah, 2018**). From Table 4, it can be seen that the average farm size for the pooled sample is 1.30 hectares (ha) which is below the national average area of production of 2.0 ha per farmer per year for tomato cultivation (**Adu-Dapaah and Oppong-Konadu, 2002**).

Table 4: Means and standard deviations of respondents' farm sizes (Hectares) by locations

Region	Minimum	Maximum	Mean	Std deviation
Ashanti Region (N=134)	0. 50	5.00	1.77	0.98
Brong Ahafo Region (N=237)	0.40	7.00	1.28	0.67
Upper East Region (N=191)	0.30	6.00	0.99	0.60
All households (N=562)	0.30	7.00	1.30	0.87

Source: Field Survey, 2015

Empirical Characteristics of Respondents' Savings Behaviour

Diagnostic Statistics

Table 5 indicates that the F-statistics for all the 4 models were significant at the 1% level implying that the predictors as a group were important determinants of the pooled savings of the respondents. On the basis of the R^2 statistics, the two Keynesian models give a better fit. However, all the four models explain a relatively larger proportion of variations in savings for the respondents.

Table 5: Diagnostic Statistics

MODEL	R^2	F-statistic	p-value
Model 1	0.857	F(12, 546)=273.616	p< .001
Model 2	0.925	F(12, 546)=546.349	p< .001
Model 3	0.853	F(12, 546)=263.116	p< .001
Model 4	0.833	F(12, 546)=227.722	p< .001

Source: Field Survey, 2015

Income

From Table 6, Model 1 (Absolute Income Hypothesis) which is the linear savings function propounded by Keynes indicates that the Marginal Propensity to Save (MPS), that is, the coefficient of the income is 0.884. The positive sign of income is consistent with a priori expectation and it is also significantly different from zero at the 1% level of probability. The MPS of 0.884 implies that for every GH¢1 increase in income, the respondents are likely to save about GH¢0.88 of this GH¢1, giving an MPS of 88%. **Burney and Khan (1992)**, similarly, found a considerably high MPS among rural households in Pakistan, but (**Guma and Bonga-Bonga, 2016**) found that a 100% change in GDP growth resulted in a relatively low MPS of 3% among households in South Africa.

The absolute income hypothesis is a short run theory and makes the assumption that marginal propensity to consume (MPC) is between zero and one. MPC declines with increase in income, implying that marginal propensity to save increases as income increases (**Mbuthia, 2011**). The implication of this assertion that MPS increases with increase in income becomes more apparent in developing countries where income plays an important role in determining household savings as the ability to save depends largely on having more than enough income to take care of basic household needs (**Carpenter and Jensen, 2002**). In most instances among rural households, as the income increases, the increment is partly consumed and partly saved for purposes of financial security in periods of poor harvest, unemployment, illness, death of bread-winner or for investment so as to enhance future income (**Mbuthia, 2011**). Moreover, since rural activities are predominantly agrarian in nature with high level of uncertainty, it tends to exert a powerful influence on their savings behaviour such that these households become more risk-averse and tend to save more for the rainy day (**Burney and Khan, 1992**).

It is therefore not surprising that the MPS of the respondents is relatively high because of the need to take their destiny particularly in the areas of saving for their social security and the provision of finance for their production activities, into their own hands. These respondents who are mainly tomato farmers and who find themselves in the informal sector of the economy in most cases depend on the informal financial sector for their financial needs especially credit to beef up their production activities. However, because of the small size of the resources the informal financial sector controls, it is hardly able to satisfy the credit needs of its beneficiaries. On the other hand, the formal financial sector which is relatively well resourced and in a better position to meet the credit needs of such credit seekers like the respondents scarcely seem to come to their aid, because of difficulties in loan administration, high transaction costs and risk of default (**Osei, 2011**). Moreover, farmers by nature of the financial weaknesses are unable to access credit facilities from the formal financial institutions due to their lack of requisite collateral security to buttress their credit application (**Adu-Dapaah and Oppong-Konadu, 2002**). Under such circumstances, actors in the informal sector like the respondents (tomato farmers) have to build their own capital from their savings for the acquisition and employment of complementary production inputs and for the adoption of improved technologies for their production activities.

Farm Size

Model 1 also indicates a significant but negative relationship between farm size and savings. This result is contrary to the findings of **Osondu *et al*., (2015)**, whose work among farm households in Anambra State, Nigeria, found a positive and significant relationship between amounts saved using informal means by female headed farms households and farm size.

Though the negative sign is contrary to *a priori* expectation, it sounds plausible as large scale farms as part of their expansion strategies have been found to invest in such high-end inputs as certified seeds, fertilizers and adoption of better agronomic practices (**Mburu *et al*., 2014**). It is therefore envisaged that the investment of funds as part of expansion strategies by large farms may invariably reduce the amount that can be saved particularly in the short run (**Osondu *et al*., 2015**).

However, when the relationship between savings and farm size is considered from the productivity point of view, the inverse relationship given by Model 1 may be justified. In agricultural production inverse relationship is a stylized fact which corroborates negative connections between farm size and its corresponding productivity. It means that with the increase in farm size output per unit (that is, per acre or hectare) of land decreases (**Mahmood *et al*., 2014**). If this happens to be the case, then income per unit of land would decrease as productivity decreases, hence, savings would all things being equal fall as well.

Proximity to the financial service provider

As seen on Table 6, all the models indicate a significant but negative relationship between savings and proximity to the financial service provider. The result is contrary to the findings of **Kiiza and Pederson (2002)** who found a positive and significant relationship between the level of net savings deposits and proximity of financial institution to households in a study on savings mobilisation in Uganda.

The negative sign is contrary to *a priori* expectation in that proximity to the financial service provider has been posited as one of the factors that would influence households' use of the service of financial intermediaries for savings as shorter geographical distance to the financial institution or the premises of the financial intermediary is deemed vital in cutting down transaction costs for savers (**Akaah *et al*., 1987; Wright, 1999; Bendig *et al*., 2009**). In spite of this assertion the negative sign is still important particularly in rural areas of developing countries where social ties and the web of extended family obligations demand that prosperous family members share their wealth with their kinsmen (**Akaah *et al*., 1987**). As a consequence, in order to avoid undue interference from family members, most wealthy savers would want to transact their financial dealings with financial institutions at relatively long geographical distances from their communities where their relatives may not see them.

Secondary Earners and the amount they contribute to household income

Model 2 indicates a significant (at the 10%) but negative relationship between savings and the number of secondary earners and the amount contributed by these secondary earners.

Table 6: Ordinary Least Squares Estimates of the Savings Functions for the Respondents' Savings Behaviour

Variables	Model 1 R^2 = 0.857 F = 0.00 Coefficient	 P-value	Model 2 R^2 = 0.925 F = 0.00 Coefficient	 P-value	Model 3 R^2 = 0.853 F = 0.00 Coefficient	 P-value	Model 4 R^2 = 0.833 F = 0.00 Coefficient	 P-value
(Constant)	-2962.	0.000	97.6	0.000	-1164.5	0.000	-604.9	0.000
Gender	32.286	0.584	-.015	.993	2.349	0.340	2.822	0.281
Marital status	72.628	0.305	2.736	.193	1.728	0.558	1.522	0.627
Engagement in non-farm activities	-111.795	0.104	-0.137	0.937	14.046	0.000***	14.007	0.000***
Years of education	4.795	0.267	0.122	.341	.059	.743	0.077	0.689
Years of tomato farming experience	3.134	.344	.037	.708	-.072	.601	-0.062	0.671
Income	.884	.000***						
Inverse of income			-348722.6	.000***				
Log of income					318.622	.000***		
Log income squared							45.3	.000***
Farm Size	-51.99	.06*	-1.216	.137	-1.55	.180	-1.309	0.286
Household Size	-1.276	.911	.002	.995	.262	.580	0.252	0.616
Secondary Earners	-37.425	.136	-1.301	.081*	-.843	.421	-0.65	0.559
Contribution by secondary earners	-.092	.164	-.004	.070*	-.001	.616	-0.001	0.685
Proximity	-17.506	.000***	-.355	.000***	-.555	.000***	-0.565	.000***
Age	-3.421	.240	-.077	.371	-.071	.559	-0.085	0.508

Source: Field Survey, 2015 ***significant at 1%, **significant at 5%, *significant at 10%

This finding is contrary to results of many empirical studies in developing countries which have indicated a positive and significant relationship between household savings and remittances such as the work by **Brown and Foster (1994)** in Tonga and Samoa which found that remittances make a significant contribution to savings of households on the island. Moreover, according to the permanent income hypothesis (**Friedman, 1957**) which draws a distinction between components of income – permanent and transitory incomes, households mainly spend out of permanent income whilst transitory income of which remittances form a part, is channelled into savings.

Secondary earners are family members who contribute to household income in the form of remittances. In essence, this finding is a reflection of an important aspect of social networks particularly among rural households which the study has termed as social diversification whereby households/individuals may prefer to depend not only on their own income but on remittances from family members who might have migrated from the household. This implies that economic development among the communities of the respondents is shaped by the networks of financial interactions and dependence that exist among them (**Udry and Conley, 2004**). In other words, strong family and social ties seem to make it less necessary for one to depend only on his/her personal savings for economic survival but also on remittances which in most cases appear to influence the timing of household savings within the life-cycle of an individual or household especially when dis-saving sets in (**Spio and Groenewald, 1996; Bendig *et al*., 2009**). It can therefore be inferred that among the respondents, one does not only depend on his/her savings for economic survival but also on the financial assistance received from working family members who are termed as secondary earners.

Engagement in non-farm activities

Models 3 and 4 indicate a positive and significant relationship between savings and engagement in non-farm activities and this is consistent with *a priori* expectation. This is in line with the findings of many empirical studies in which it has been observed that in many places in Africa, engagement in non-farm activities tends to be a form of income diversification. This invariably serves as a major source of savings for farm households for food purchase in difficult times (**Reardon, 1997; Gordon and Craig, 2001**).

For instance, Model 3 indicates that engagement of non-farm activities would increase savings by about GH¢14.05. This suggests that non-farm activities have become an essential component of livelihood strategies among rural households in many development countries (**Babatunde and Qaim, 2009**) and most importantly it has been found to be positively correlated with income therefore offers a pathway out of poverty if it can be seized by the rural poor (**Barrett *et al*., 2001**).

The main driving forces for the observed trend of diversification into non-farm activities by rural households have been the declining farm incomes and the desire to insure against agricultural production and market risks (**Babatunde and Qaim, 2009**). In Ghana, the import of diversification into non-farm income generating activities among tomato farmers has become more apparent due to the decline in the ability of the industry to sustain farmers' livelihood. This is mainly as a result of the fact that the production of the crop is confined to only few months of the year and also largely under rain-fed conditions resulting in glut at the time of harvest, hence, low producer prices even sometimes total cost of production exceeding income realized (**Adu-Dapaah and Oppong-Konadu, 2002**).

Equalization of income distribution

Models 2 and 3 according to **Burney and Khan (1992)** have important implications for income distribution policies. In particular, a positive and statistically significant coefficient β_1, that is, the coefficient of the log income ($logY$) of Model 3 would support the traditional Keynesian hypothesis that the equalization of income distribution increases aggregate consumption, and hence, reduces savings. The sign of the coefficient of the inverse of income, that is, β_1 of Model 2 can be either positive or negative depending on the shape of the savings function. In general, however, it is found to be negative (**Burney and Khan, 1992**) which is correctly specified by the results of the study.

Equalization of income distribution which is achieved through income re-distribution is an economic practice which basically aims at addressing the widening economic disparity between the rich and the poor (**Todaro, 1997**) by levelling the distribution of income or wealth among a population through direct or indirect transfer of income usually from the rich to the poor. Income re-distribution effort is generally justified on the grounds that it is an important means of lessening income inequality in a society particularly the gap between the rich and the poor and also to eliminate or reduce poverty in the society (**Chetty *et al*., 2012**)

Contrary to Keynes' assertion that the equalization of income distribution tends to increase aggregate consumption particularly among those at the lower end of the economic ladder, and hence, reduces savings, the MPS of the respondents as given by Model 1 is relatively high (about 88%). This contradiction is best explained by the permanent income hypothesis which was formulated by **Friedman (1957)** as his challenge to the traditional Keynesian consumption theory. The central theme of Friedman's hypothesis is that consumption is based on what people consider as their "normal" income, which leads to an attempt to maintain a fairly constant standard of living even when incomes vary from period to period. Therefore, increases (and decreases) in income have little effect on consumption as people deem the increase in income as temporary, hence, the urge to save more in anticipation that future incomes may decrease significantly. The expectations of future income according to Friedman depend largely on what has happened in the past.

If this is the case, then it makes economic sense for the respondents to consume less of their present income in order to make room to save more since the performance of the tomato industry in Ghana for the past few years has not been encouraging. This is consistent with the assertion of **Robinson and Kolavalli (2010)** that the tomato sector in Ghana has failed to reach its potential, in terms of attaining yields comparable to other countries, in terms of the industry's ability to sustain processing plants, and in terms of improving the livelihoods of those households involved in its production. Furthermore, because of the seasonal nature of the tomato industry, the respondents receive a large part of their incomes only once or twice a year, whereas their expenditure is continuous. Such a cash-flow pattern usually results in periods of deficits and surpluses, thus, in order to survive the periods of deficits, they have to save more of their income (**Desai, 1983**).

Moreover, looking at the incidence of the relatively high MPS (about 88%) among the respondents, it can be inferred that saving/consumption decisions among the respondents, rest not only on the levels and variance of their income which is linked to changes in their production. However, their saving/consumption decisions also take into consideration the absence of suitable credit and insurance markets to take their peculiar situation into consideration (**Aryeetey and Udry, 2000**). Not only that but also these are people who do not receive public pension payments as they work outside the formal sector (**Bendig *et al*., 2009**). Hence, the need to take their future into their own hands by saving high proportions of their incomes in expectation that future incomes will decrease significantly especially in their old age as predicted by the both the permanent income hypothesis and the life cycle hypothesis. Both theories assume that households have a perfect vision of their future income flows, their consumption levels as well as their lifespan and therefore behave rationally with self-control in order to save towards their retirement (**Mbuthia, 2011**).

Beside all these, according to **Cooke *et al*., 2016**, a recent IMF paper on income inequality and fiscal policy, categorized Ghana as having one of the fastest increasing inequality levels in Africa. This is in spite of such programmes as the Livelihood Empowerment Against Poverty (LEAP) cash transfer aimed at reducing the level of inequality in Ghana. This to a large extent implies that the respondents cannot rely on government's social intervention efforts to limit growth in income inequality, support the provision of public services as well as foster economic growth in their communities and must therefore rely on their own initiative by cutting down consumption in order to save to take care of their future. The decision of cutting down consumption in order to save in the face of income inequality gives credence to the assertion by **Loayza *et al*., (2000)** that income inequality is an important determinant of saving and that it played a prominent role in post-Keynesian models of savings and growth (**Kaldor, 1957; Pasinetti, 1962**).

Non-linearity of savings and income

According to **Burney and Khan (1992)**, a positive and statistically significant coefficient, β_1 of the log squared income of Model 4 would support the hypothesis of non-linear relationship between savings and income and this is correctly specified by the results of the study. This suggests that among the respondents, the hypothesis of non-linear relationship between savings and income holds. In other words, a change in income (a decrease or an increase) may not always bring about an equal or proportional change in savings.

In the view of **Burney and Khan (1992)**, this hypothesis of non-linearity between savings and income may be explained in part by the level of uncertainty surrounding income particularly at the rural household level. This is because rural income generating activities are basically agrarian in nature and the income derived from agriculture and its related activities are inherently uncertain. The uncertainty surrounding the rural income poses not only a real threat to their consumption levels but is also more likely to exert a powerful influence on their savings behaviour. Thus, rural dwellers who in most cases have been observed to be risk-averse due to high level of poverty among them, have been observed to consume less of an increase in income in order to save more for the "rainy day" (**Burney and Khan, 1992; Alvarez-Cuadrado and Vilalta, 2012**).

CONCLUSIONS AND RECOMMENDATIONS

The study was motivated by the fact that it is important to understand that rural households more especially farmers can play an essential role in providing voluntary savings for capital formation, vis-á-vis, and economic development which in some cases can significantly reduce the volume of external credit lent to them at usurious interest rates. Thus, the need for accurate analysis of the savings behaviour of these farmers in order to gain thorough knowledge of the determinants of their savings behaviour as a means of enacting appropriate policies to tap into savings pool at the rural level for national development. In essence, the need to achieve substantial and sustainable rural development by means of household savings requires creating a synergy between rural households and researchers on one hand and researchers and policy makers on the other hand.

The following specific findings among others were made: The study indicated a significant but negative relationship between farm size and savings. Though the negative sign is contrary to *a priori* expectation, it sounds plausible since expanding farm size requires more investment of funds which is more likely to reduce the amount saved particularly in the short run.

The study showed a significant but negative relationship between savings and proximity to the financial service provider. Though the negative sign is contrary to *a priori* expectation, it gives an indication that in order to avoid undue interference from family members, mostly wealthy savers would want to transact their financial dealings with financial institutions at relatively long geographical distances from their communities where their relatives may not see them.

Negative but significant relationship was established between savings and the number of secondary earners and the amount contributed by these secondary earners. In essence, this finding is a reflection of an important aspect of social networks particularly among rural households which the study has termed as social diversification whereby households/individuals may prefer to depend not only on their own income but income from other income earners within their households. In other words, strong family and social ties seem to make it less necessary for one to depend only on his/her personal savings for economic survival. Thus, it can be inferred that among the respondents, one does not only depend on his/her savings for economic survival but also on the financial assistance received from working family members who are termed as secondary earners.

Engagement in non-farm activities positively and significantly influenced savings. This suggests that non-farm activities have become an essential component of livelihood strategies among rural households in most developed countries.

Contrary to Keynes' assertion that the equalization of income distribution increases aggregate consumption, and hence, reduces savings, the study found the opposite to be the case, that is, the MPS of the respondents was relatively high (about 88%).

The study also established the hypothesis of non-linearity between savings and income among the respondents. This implies that due to uncertainty surrounding rural incomes, rural dwellers may tend to consume less of an increase in income in order to save more for the "rainy day".

It has long been recognised that household size has serious implications for a nation's labour supply, savings rates and capital formation, all of which can shape and influence the nation's economic growth. Though, relatively smaller as well as larger household sizes have their consequential socio-economic implications for a nations' well-being, it is however, obvious that the negative repercussions of relatively larger household sizes override their supposed benefits. The negative effects of the household size on household income, vis-à-vis, and savings may become more pronounced when there is an increase in the number of household members below age 16 who are not income earners and therefore have to depend on others. In the same way, the low income and savings associated with relatively larger household size may be compounded by an increase in the number of household members above 65 years, that is, those on retirement. All things being equal, a household with few dependents can devote a smaller share of its income on supporting these dependents and can therefore save more. It is therefore recommended that as part of agricultural extension activities, education on population issues and its implications for development is passed on to farmers. Moreover, it is recommended that the government through the Ministry of Health will intensify the support given to family planning programmes to ensure that population growth rates and household sizes are reduced to promote higher levels of household savings. In addition, knowledge on national population policy could be included in the curriculum of schools for an early appreciation and understanding of population issues and its effect by the younger ones.

Economic growth and development have been observed to be strongly correlated with poverty alleviation. Meanwhile, it is agreed that one of the key ingredients to economic growth and development lies in access to financial services particularly among rural households. The study indicated a relatively high marginal propensity to save of about 88% among the respondents which is an indication of their capacity and potential to save. This finding makes a convincing case for financial intermediaries to extend the needed financial services to rural households. Such an approach of extending the needed financial services to the rural households may result in two-pronged opportunities; one, to the rural households who may be set on the pathway to economic growth and development and two, to the financial intermediaries in their quest for savings mobilisation and its subsequent investment into crucial sectors of the economy.

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REGULAR ARTICLE

FOOD PRODUCTION AND CONSUMPTION IN THE HIGHLANDS OF ETHIOPIA: THE MISSING LINK IN FOOD SYSTEMS

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ABSTRACT

This paper attempted the nexus of food production and consumption, and determinants of food consumption in *Gudo Beret* watershed, central highlands of Ethiopia. The study used cross-sectional data collected from 211 randomly selected households through interview. Descriptive statistics and linear regression were the key analytical techniques. Results revealed that households produced a gross yield of 1.5 ton and a net food supply of 1.1 ton per household which was equivalent to 274 kg of grain per adult per annum. The average food demand per capita was 323.8 kg per adult. It implies food production was inadequate for food consumption. Sex of household head being male, livestock holding, inorganic fertilizer, total land size, and market distance affected household food consumption positively whereas household size had negative impacts on household food energy. One of the current themes of the food systems is balancing food production and consumption. The government of Ethiopia should deliberate population policy with the intention that the rising population need to have adequate subsistence. In addition, women empowerment can enable them access to and control over food resources.

Keywords: Crop production, food energy, grains, Ethiopia, households
JEL: R52, R58, H41

INTRODUCTION

Food system is a wide range of activities that makes certain food production reaches consumers **(Burrows and Kuyper, 2018)**. The main function of food system is food production (**FAO, 2017**). At household level, the key characteristic of food system is seed exchange despite local seeds are attributable to low yields, lack of quality, mixed varieties and loss of desirable traits (**Asante *et al.*,2017**). Access to improved crop varieties is critical to food and nutrition security (**Toledo and Burlingame, 2017**). Farm households grow more than one variety of a given crop at a time for which no single variety would satisfy their livelihood demands. Varietal selection and farm management are the most crucial actions in agricultural production and genetic conservation. Agricultural production is the main pathway that impacts human nutrition. Globally, there has been a contemporary interest in food and nutrition security to decelerate malnutrition. Much of this interest is focused on sustainable agriculture to produce adequate food for the growing population. Agriculture contributes for 34% of gross domestic product, 80% of export earnings, and 80% of employment opportunities in the Ethiopian economy (**WB, 2013; NPC, 2016; Admasu, 2017**). Farmers in the highlands of the country depend largely on mixed farming to improve dietary diversity, increase household income, reduce vulnerability to shocks, create job opportunity, minimizes risks and insurance against crop failures **(Liniger et al., 2016; Alexandratos and Bruinsma, 2012; Belay *et al.*, 2012; Darnhofer *et al.*, 2012; Herrero *et al.*, 2012; Moraine *et al.*, 2014**). Mixed farming provides a wide range of responses to uncertain conditions and increase household resilience **(Liniger *et al.*, 2016; Kuria *et al.*, 2014)**. In Ethiopia, nearly 14 million households cultivate about 15 million ha of land **(CSA, 2015**). The average productivity of major crops is 21.5 qt per ha **(FDRE, 2016**). Crops are the major sources of food while animal products are often low (**Belay *et al.*, 2012, CSA, 2012**). Livestock generate more than 85% of cash income, 16% of export earnings **(Yayneshet, 2016)**, and 25% of growth domestic product **(FDRE, 2016**). Households with large herd sizes have better chance to ensure household food security **(Messay, 2010; Mesfin, 2014**).

In Ethiopia, farm households have long experiences on varietal selection, adaptation and adoption of various crop varieties in the history of crop evolution. For instance, barley is one of the first domesticated cereals since 3000 B.C **(FAO, 2008**). Farmers are rational decision makers in the processes of production based on their existing knowledge **(Olango *et al.*, 2014)** that aligned with the broader social and ecological landscapes where diverse landraces are maintained in the seed systems **(Samberg *et al.*, 2013).** A particular crop serves for different purposes as barley grain is used for soup, stew, bread, biscuit, *injera*, and feed for honeybee colonies **(Alemayehu, 2011**). The supply of malt demand for breweries is 32.8% from domestic sources of barley while the remaining proportion has been imported from abroad. It implies the subsistence farming system could not supply an adequate level of malt for beer industries.

Crop yields are a function of climate variables, seed varieties, availability of water, soil nutrients, and knowledge of farmers (**God fray, 2010**). Favorable weather conditions of a year results in good harvest whereas severe droughts causes for crop failures that adversely affect agricultural production and consumption patterns. Despite apparent yield increment has been reported in Ethiopia (**Alemayehu, 2011**), the amount of growth is not overwhelming **(Dercon and Hill, 2009; Mekuria *et al.*, 2017**). In the country, large number of people (29.6%) is living below the poverty line **(WFP, 2014)** and significant number of people (35%) is undernourished **(FAO, 2018**). On the one hand, pasturelands and the natural vegetation are converted to croplands and commercial investments in some parts of Ethiopia **(Wily, 2011**). On the other hand, lands allocated for cereals, coffee, fruit, root and vegetable crops are converted to *Khat* and eucalyptus plantation in many parts of the nation (**Yeshaneh *et al.*, 2013; Cochrane and O'Regan,2015; Daniel *et al.*, 2016; Tadesse and Tafere, 2017)**. Moreover, there is no policy decree on social protection towards consumption insurance except productive safety net programs in some draught prone areas of the country (**FAO, 2018**).

Ethiopia is vulnerable to the twin threats of natural resource degradation and poverty owing to high population growth, soil loss, and negative impacts of climate changes **(Liniger *et al.*, 2016, WFP, 2014, Badege, 2009; Yitebitu *et al.*, 2010; IFAD, 2013).** Climate shock is one of the leading causes of food crisis situations that 8.5 million people were affected recently by climate shocks and conflict **(FAO, 2018**). Rapidly growing population is one of the key drivers for competitive demands between crop production and livestock husbandry **(IFAD, 2010; Rota and Sperandini, 2010**). One-third of rural households in Ethiopia could not produce adequate food to meet their subsistence needs as they cultivate less than half hectares of land per capita **(Herrero *et al.*, 2012**).The existing agricultural land is unable to feed the growing population and thus many Ethiopians remain trapped in vicious circle of poverty, disease and hunger **(Sahlu, 2004**).Rising in food prices, unemployment, lack of pasture for livestock, and intensive removal of natural vegetation aggravates food shortages. Food and nutrition insecurity, low crop and livestock productivity, excessive land fragmentation, and severe land degradation are among persistent challenges in the highlands **(NPC, 2016, Yeshaneh *et al.*, 2013, IFAD, 2013, Demese *et al.*, 2010; Haregeweyn *et al.*, 2015; Hurni *et al.*, 2016; Guush *et al.*, 2017; Mekonnen *et al.*, 2017**). In the country, 14%, 9%, and 25% of children are stunted, wasted and underweight, respectively **(Birhanu, 2015**). The negative impact of climate change exacerbate land degradation by increasing water stress, soil erosion, soil acidity, landslides, feed shortage, and increase the incidence of animal diseases (**Liniger *et al.*, 2016; Tongul and Hobson, 2013; Bewket, 2015).**

Intensified farming and continuous cultivation with limited soil amendments and conservation practices resulted in soil erosion and nutrient depletion **(IFAD, 2010).** Low adoption of agricultural technologies and feed scarcity are still adversely affecting the livelihoods of farmers and landscape situations of the study area **(Kuria *et al*, 2014, Mekonnen *et al.*, 2017, Tigist, 2016; Tamene, 2017).** Although research institutions have been developed new crop varieties, improved seeds do not reach farmers at all, or if they do, they get to them late. Lack of improved seed varieties affects both producers and consumers. The supply of raw materials alone could not able to keep with the increasing demands of domestic industries **(Asante *et al.*, 2017)**. Despite several researches have been conducted on food security and production efficiencies, studies on food systems in terms of production and consumption linkages is minimal. The assumption is that farm households may not consume what they produce due to several reasons. Therefore, the objectives of this paper are to examine the linkage of food production and consumption and to analyse determinants of food consumption in the study area. The next sections of the paper include materials and methods, results and discussion, and conclusion and policy implications.

DATA AND METHODS

Description of the study area

The study area is located in the highlands of Ethiopia. The site is found in *Gudo Beret Kebele, Bsona Werana* district, and North Shewa zone of Amhara region. (*Kebele* is the lowest geographical administrative unit). The total population size of the study was estimated to be 2070 inhabitants and the population density was about 85 persons per square kilometer. The total number of households in the study catchment was 447. Subsistence rain-fed cultivation, livestock husbandry, and woodlots were the dominant farm activities. The natural vegetation cover has declined over time due to anthropogenic factors. Currently, there is no natural forest except some shrubs and bushes at the upper escarpment of the watershed. Eucalyptus trees are grown around homesteads, hillsides, and gully buffers. A small town (*Gudo Beret*), the local market, *Kebele* agriculture office, human and animal health clinics, rural villages, churches, elementary schools, electricity power line, private mobile telephone, and asphalt road are the main infrastructures and institutions found in the study watershed. The study site is characterized by degraded lands above the tolerable soil erosion limits (**Tamene, 2017).**

Sampling procedures

The study watershed was purposively selected because of high crop-livestock production potential. The area was delineated starting from the bottom confluence point between the two streams (*Feleku* and *Weynabchu*) and reached the upper escarpment of the watershed. The top part of the dividing line of the study watershed is the boundary between the Blue Nile and Awash basins. A total sample size was determined according to **Israel (1992**) (Eq. 1).

$$n = \frac{N}{1+N(e)^2} = 211 \quad (1)$$

Where: n is the total sample size, N is the size household in the study watershed, and e is a confidence level taking 0.5 as an average level of precision in social science.

Among the total households, 29% were female-headed. The total sample size was selected using systematic random sampling. Four data collectors were employed and household survey was conducted in face-to-face interview through house-to-house visits from end of May to the first week of July 2016. Training was conducted for enumerators on methods of data collection. The interview schedule was prepared by administering different socio-economic, institutional and climatic variables. The questions in the interview schedule were pretested before administering data collection.

Methods of data collection

The collected data were cross-sectional obtained from primary and secondary sources but were not limited to demographic attributes (sex, age, level of education, household size, and social status), economic factors (total land size, household income, crop varieties, livestock breeds, crop yields, consumptions), and bio-physical variables (settlement patterns, distance between households' residence and the local market and asphalt road). In-depth interviews were employed for purposively selected key informants to identify crop-livestock portfolios. Key informants include local level officials, elders, and agricultural experts. Household interviews were conducted using a semi-structured interview schedule. The primary data were collected from selected respondents during household survey. Questions in the interview schedule were pre-tested prior to conducting the formal survey and essential amendments were made on the interview schedule. Training on methods of data collection was employed for enumerators how to collect primary data. All information contained in the interviews was confidential. Personal observation was employed to triangulate landscape situations, settlement patterns, accessibility of infrastructures and institutions as well.

Methods of data analysis

Data processing such as coding, editing, cleaning, verification, and entry were employed prior to data analysis. Depending on the nature of data, descriptive statistics (frequency, percentage, and mean) and inferential tests were employed. Descriptive statistics were mainly employed to compute the food produced and consumed in the study area. Household food balance model was employed to compute the food expenditure and net food supply for household consumption. Consequently, the net available food was converted to food calorie per capita at household level. First, each food item was computed in terms of quintal or ton and then converted to kg (1 ton = 10 qt = 1000 kg). Secondly, food items measured in kg was converted to food calories after multiplying by each conversion factor that was given for each food items. The conversion factors from kg to calories are shown in the Table 1.

Table 1: Conversion factors for per capita calorie consumptions

Available food items	Conversion factors	Available food items	Conversion factors
Food barley	3320	Green vegetables	220
Malt Barley	3680	Apple fruit	480
Wheat	3340	Sheep meat	1230
Faba bean	3420	Chicken eggs	1390
Field pea	3460	Cow milk	610
Lentil	3460	Butter	7170
Linseed	4980	Honey	2980
Potato	670		

Source: **EHNRI (1998)**

Linear regression was employed to examine determinants of food consumption. According to **FAO *et al*. (2018),** food availability is the dietary energy supply expressed in terms of kcal/ person/day. An average food calorie per AE per day was taken as a continuous dependent variable while thirteen independent variables were considered for analysis (Table 2). The linear regression, ordinary least square (OLS) was adapted in Gujarati **(Gujarati, 2003**) (Eq. 2).

$$Y_i = X'\beta_i + U_i \quad (2)$$

Where; Y_i is a continuous dependent variable; β_i are parameters; X_i are independent variables; U_i is error terms.

RESULTS AND DISCUSSION

Household characteristics

The proportion of female-headed households was 29%. The size of illiterate household heads was 20.9%. About 42.7% of household heads had basic educational levels. Grade 1-4 and 5-8 were 15.2% and 16.1%, respectively while grade 9 and above were 5.2%. The minimum age of household heads was 23 while the maximum age was 82 years old. In the study area, the mean age of household heads was 43.8 years old. The minimum and maximum household sizes were 1 and 10 while the average size of household members and labour force were 4.5 and 2.9, respectively. The average land size was 1.3 ha per household whereas the average livestock holding was 4.0 TLUs per household.

Agricultural production in the study area

In the study watershed, crop production, animal husbandry, and eucalyptus plantation were the major livelihood strategies for rural households. There is inter-household heterogeneity for choice of crops and livestock activities. Limited number of households (5.6%) could not access land use rights and they were dependent on their livestock holdings and non-farm/off-farm activities, while 8% of households did not own livestock. Cattle, equines, sheep, goats, and chicken are the major livestock types in the study area (Table 3).

Table 2: Hypothesis of independent variables in relation to household food consumption

Acronyms	Explanations	Units and measurements	Hypothesis
AGE	Age of household head	A continuous variable measured in years	-
HHSIZE	Household size	A continuous variable measured in number of household members	-
SEX	Sex of household head	It is a dummy variable, 1=male and 0 otherwise	+ (male)
EDUC	Educational level of household head	It is a continuous variable measured in years of schooling	+
INCOME	Household income	It is a continuous variable in ETB	+
LAND	Total land size	It is a continuous variable measured in ha	+
MANURE	Compost used	It is a continuous variable measure in kg	+
LIVES	Livestock holding size	It is a continuous variable measured in TLU	+
FERT	Fertilizer applied	It is a continuous variable measured in kg	+
DMKT	Market distance	A distance between the local market and household's residence measured in walking minutes	-
DROAD	Road distance	A distance between the main asphalt road and household's residence measured in walking minutes	-
EXTEN	Extension contact	Extension contact is the frequency of contact of DAs with household head in per month	+
CREDIT	Access to credit service	It is a dummy variable, 1 =access to credit, 0 otherwise	+

Table 3: Livestock production by sampled households (2016)

Types of livestock	Number	TLU	Proportion (%)
Cow	151	121	3
Ox	288	317	15
Heifer	53	26	38
Bull	50	30	38
Calf	109	22	59
Horse	35	28	5
Mule	4	3	50
Donkey	246	123	25
Sheep	1532	153	22
Goat	115	12	10
Chicken	744	7	52
Total	3327	841	28

Livestock contribute for food, wool, draught power, transportation, manure, hide and skin, fuel, and socio-cultural services such as wedding, dewy, festivities, holidays, and rituals. However, the productivity of livestock per animal such as milk, meat, and egg were relatively low. Sheep and goat accounted for 20% while donkeys represented 15% of the total livestock population in terms of TLU. The highest proportion of cattle was for oxen (38%) followed by cows (14%). The remaining stock (bull, heifer, calf, horse, mule) accounted only 13%. The majority of livestock populations (61%) were cattle followed by sheep and goat (20%), equine (18%) and chicken (1%), respectively. About, 60.2% of households owned cows. The sizes of local and crossbred cows were 1.21 and 1.15 per household respectively, 1.19 on average. Households produced on average 15 kg of eggs, 2280 kg of meat, and 105 kg of milk per year, respectively.

Most recently, animals were prioritized based on land preparations for cultivation purposes and immediate benefits compared to purposes of rearing for permanent household assets. In this regard, households rear livestock for farming operations and selling purposes than keeping them for long-term asset accumulation. According to key informants, the reasons for increment of livestock population were rising demand for household food consumption, market price incentives and increasing number of households. The size of dairy cows was 23.4% of the total cattle population, which is higher than the national average-14.6% (**Aleme and Lemma, 2015**). Three-quarters (75%) of the cattle population were indigenous breeds while 25% were improved breeds. In terms of livestock number, oxen were the highest cattle population while sheep were the highest in livestock population. Sheep and chicken were the largest livestock population in number followed by oxen, donkeys and cows. In the study area, sheep production was the most common practice due to the fact that agro-climates in highlands is suitable for sheep production so that households rear them mainly for selling to earn household incomes.

Almost every household produced annual crops. Among the five major cereals (*tef*, wheat, maize, sorghum, and barley), barley and wheat were the predominant (50%) crops grown in the study area. Faba bean, field pea and lentil were the three major pulse crops grown in the study watershed. Households also produced vegetables, Irish potato, oats and linseed on small plots of land. The majority (96%) of households produce food barley followed by faba bean, field pea and wheat. Food barley, faba bean, and wheat were the three most important crops produced in the study area (Table 4). Households produced 1.7 ton of crops per capita annually. The average crop productivity was 1.34 ton per ha while the total cropland size of households was 1.2 ha.

Table 4: Crops produced by sample households (2015/16)

Crops	Farmers (%)	Land size (ha)	Total production	
			Ton	%
Barley	105	100	174	50
Wheat	55	30	46	13
Faba bean	85	54	68	19
Field pea	66	43	31	9
Lentil	7	11	2	1
Linseed	10	3	1	0
Irish potato	19	7	25	7
Vegetables	15	12	1	0
Total		260	349	

Household food consumption

According to the balance sheet model, the net food supply is the difference between food resources obtained from various sources and food expenditure. Households produced various crops and livestock for different purposes. The yield they produced went to various economic, social and cultural obligations. Locally grown crops and livestock resources were the major sources of food products. Market and social transfers were supplementary food sources. Food items in dietary diversity could be more than 46 types **(Gujarati, 2003)**. In the study watershed, households produced fifteen types of food crops. In this paper, food consumption refers to net food supply in terms of calories. According to **Kearney (2010)** food consumption is synonymous with food availability. The annual consumptions of animal products were estimated to be 8, 22, and 75 kg of egg, meat, and milk per household, respectively. The most important meat sources were sheep, goat, chicken, ox, and cow. Several studies overlooked food items obtained from animal products. In this study, the contribution of animal products for food consumptions was only 10%. Almost 90% of the food sources were crops (Table 5). Household consumed 71.5% of staple foods and 32.9% of leafy vegetables and potato. Lentil, barley and wheat were the major source of food for home consumption. Households consumed fewer amounts of linseed, pea and staple crops. The majority of butter (87.5%), honey (75.4%), and eggs (50.8%) went to market for cash income which were not used for food consumption

The food balance sheet model indicated different food sources, food expenditures and net food supply. Food demand was calculated in accordance with major demographic variables such as sex and age of each household member. Conversion factors for children vary between 0.29 and 0.79 adult equivalent depending on their ages, for women ranges between 0.75 and 0.86 while for men it ranges between 0.98 and 1.18 **(Claro, *et al.*, 2010)**. Despite the minimum and maximum amount of food demand is 357 and 536 kg per adult per year is required at global level (**WHO, 2004**), the average grain food consumption demand per capita is 323.8 kg in Ethiopia (**Guush *et al.*, 2017).** In this study, for 844 adults, the annual food supply was estimated 274 kg of grain per adult, which was equivalent to a gross yield of 1.5 ton and a net food supply of 1.1 ton per household. Based on the actual grain yield supply estimation, sample households need an extra 42 ton of grain or 6.7% additional cropland to raise the grain supply to achieve 0.3 ton per capita. Some households purchased food crops both for home consumption and seed resources. The sources for the majority of food consumption were from their own production. Households spent about 70% of the food for own consumption and the remaining 30% went to different expenditures such as selling, social transfer, post-harvest loss, and seed reserves.

Table 5: Food balance sheet model for sample households (2015/16)

Food items	Sources of food (Qt)					Food expenditure (Qt)					Net food (Qt)
	Produced	Purchased	Aid	Gift	Total	Loss	Seed	Sales	Transfer	Total	
Staple crops											
Barley	1748.5	31.1	1.5	0.0	1781.1	103.6	263.7	84.3	6.0	459.6	1321.6
Wheat	462.3	26.1	0.1	0.0	488.4	48.8	63.2	11.5	0.0	123.6	364.8
Faba bean	681.9	23.9	0.0	0.0	705.8	70.6	142.8	74.7	0.0	288.1	417.6
Pea	313.5	11.5	0.0	0.0	325.0	32.5	61.8	43.9	1.5	139.7	185.3
Lentil	15.8	6.4	0.0	0.0	22.2	0.9	2.0	2.4	0.0	5.2	16.9
Linseed	12.9	0.0	0.0	0.0	12.9	1.3	0.9	4.0	0.0	6.1	6.8
Total	3234.8	98.9	1.6	0.0	3335.4	257.7	534.4	222.7	7.5	1022.2	2313.1
Vegetables											
Potato	290.3	7.9	0.0	0.0	298.2	15.0	18.0	187.0	0.0	220.0	78.2
Leafy vegetables	6.0	14.0	0.0	0.0	20.0	0.0	0.0	1.0	0.0	1.0	19.0
Fruits (apple)	0.8	0.0	0.0	0.0	0.8	0.0	0.0	0.2	0.2	0.4	0.5
Total	297.1	21.9	0.0	0.0	319.0	15.0	18.0	188.2	0.2	221.4	97.7
Animal product											
Meat	48.11	0.04	0.0	0.0	48.1	1.9	0.0	0.0	0.0	1.9	46.2
Egg	31.3	1.2	0.0	0.0	32.4	0.0	16.5	0.0	0.0	16.5	15.9
Milk	222.5	3.5	0.0	0.0	226.0	0.0	0.0	4.1	0.0	4.1	221.9
Butter	3.8	0.0	0.0	0.0	3.8	0.0	0.0	3.3	0.0	3.3	0.5
Honey	183	0.0	0.0	0.0	183.0	0.0	0.0	138	0.0	138.0	45.0
Total	488.7	4.7	0.0	0.0	493.3	1.9	16.5	145.4	0.0	0.0	267.4

Determinants of food consumption

Different factors such as demographic attributes, topographic terrains, disposable income, and others affect food consumption **(Aleme and Lemma, 2015**). Linear (OLS) regression was used to identify determinants of household food consumption. The dependent variable is household food energy, which took the value of food in terms of kcal. There was no multicollinearity problem among hypothesized independent variables. Contingency coefficient for discrete variables and variance inflation factor for continuous variables were multicollinearity tests and their values were less than 0.75 and 10.0, respectively. Consequently, all independent variables were entered to the model for analysis. The results of linear regression showed that sex, household size, fertilizer, market distance, and land size were influenced household food consumption significantly (Table 6).

Sex of household head (SEX): The coefficient of sex for household head is positive and significant at 5%. It implies that male-headed households have higher level of calories than female-headed households. Male-headed households increase the food dietary energy by 545 kcal keeping all other variables constant. One probable reason for positive effect of sex on household food consumption is that male-headed households could access to and control over income and other economic resources. In contrast, female-headed households are less likely to practice diversified farm activities. That means male-headed households have less chance of being food anxious than female-headed households. The result is similar with several empirical findings. The sex of a household head being male is significant and has positive relationships with household food energy **(Messay, 2010; Mesfin, 2014; Arega, 2012; Aziz *et al.*, 2016**). It means that female-headed households are more at risk of food than their counterparts.

Table 6: Result of linear regression for household food energy

Variables	Coef.	Std. Error	t-value	Sig.
AGE	-0.70	9.14	-0.08	0.939
SEX	545.18**	235.77	2.31	0.022
HHSIZE	-715.77***	67.96	-10.53	0.000
EDUC	-107.90	95.24	-1.13	0.259
INCOME	0.01	0.02	0.31	0.760
MANURE	1.95	1.79	1.09	0.278
LIVES	117.46**	57.12	2.06	0.041
FERT	6.92***	1.79	3.88	0.000
EXTEN	-64.43	101.35	-0.64	0.526
LAND	498.38**	207.86	2.40	0.017
DMKT	24.24***	7.51	3.23	0.001
DROAD	-10.62	9.48	-1.12	0.264
CREDIT	67.95	227.55	0.30	0.766
Cons	3956.44***	606.10	6.53	0.000

Notes: ***, **, * significant at 1%, 5% and 10%; F=16.65***, R^2=0.524***, St. Error=1425.1

Household size (HHSIZE): Household size has negative relationships with household food consumption and significant at 1%. As household size increases by one member, household food calorie decreases almost by 715.7 kcal. Larger household sizes affect household food availability or food energy adversely. The result of this study agrees with several research findings (**Messay, 2010; Mesfin, 2014; Arega, 2012; Aziz *et al.*, 2016**). Increasing household size deteriorates household food resources (**Bashir *et al.*, 2012**). Low food per capita combined with high population growth are serious challenges of household food security, particularly where import capacity is limited (**Alexandratos and Bruinsma, 2012**). The increment of household size puts pressure on food resources and the share of food among household members will be less.

Livestock holding size (LIVES): The relationship between livestock holding and household food availability is positive and significant at 5%. As livestock size increases by one TLU, household food calories also increases by 117, holding other variables constant. The positive correlation of livestock size with household food energy is in line with some other research findings (**Messay, 2010; Mesfin, 2014; Arega, 2012; Asmelash, 2014; FAO, 2013**).

Inorganic fertilizer (FERT): The relationship between inorganic fertilizer and household food consumption is found to be positive and significant at 1%. The positive relationship indicates that the use of fertilizer increases crop production and productivity per unit area. Household food energy increased almost by seven kcal as a household increases the application of fertilizer by one kg. That means up to the optimum level of fertilizer supply, food increases almost seven kcal per one kg of fertilizer. Households apply different rate of fertilizer depending on the fertility status of the soil and crop varieties. If a household apply 150 kg of fertilizer per ha to produce cereal crops on a given land, the food energy can increase about 1000 calories. The positive relationship of this result agrees with the findings of other studies (**Messay, 2010; Asmelash, 2014; Temesgen *et al.*, 2016**).

Total land size (LAND): The correlation between land size and household food energy is positive and significant at 5%. Land is the source of wealth and has the capacity to reduce risk and bear incomes. Land has an ability to increase capital, production yields, investment and ensure food energy. Keeping other factors constant, household food energy increases by 498 kcal as the total land holding size increases by one ha. The result is in conformity with other findings (**Mesfin, 2014; Asmelash, 2014**). Nonetheless, the result for positive relationship between land and household food energy is not constantly the same.

Market distance (DMKT): The relationship between market distance and household food energy is not as per the prior expectation. The effect of market distance on dietary energy is positive at 1% significant level. As market distance increases by one minute of walking distance, household food energy increases by 24 kcal. About 60% of households travel less than the mean distance (27.5 minutes) of the local market. About 93% of households travel at a distance not more than an hour of walking distance. Despite the relationship between market distance and household food energy is positive, the extent of correlation was weak, i.e., R-value 0.312 or R^2=0.097.

The local market and the small town of *Gudo Beret* are found in the same place. According to personal observation and key informant interview, the bases of livelihoods for households who reside near to the town or the local market are mainly non-farm/off-farm activities. The information obtained from key informants is consistent with statistical findings. Informants were requested to disclose why market distance was correlated positively with dietary energy. Households who reside near to the market place could have a possibility of selling crop and livestock products often times compared to those who are living far at a distant. Households who reside near to the town or to the local market may misspend their money for alcohol drinking. With the aim of receiving money, those households are expected to sell farm products for their habits. Proximity to the market facilitates selling of farm products (**Rahman and Chima, 2016**). Contrary to near residents, households situated relatively far from the local market may hoard crop products for their subsistence food requirements.

Households who reside farther from market centers can diversify crops and livestock for their household consumption. High transport costs in accessing to local market may discourage supply of agricultural products. Although the accessibility of market is essential for marketing, access to information and other advantages, households who reside far away from the local market have better food energy than that of households who reside near to the local market. In the study of **Sichoongwe *et al* (2014)**, crop diversifiers are located farther distance from the local market.

CONCLUSIONS AND RECOMMENDATIONS

Food production and consumption are the two most important functions of food systems. Food and nutrition insecurity is one of the key and persistence challenges in Ethiopia. The study area was degraded higher than the tolerable soil erosion limits that resulted in low capacity of production and productivity. Households produced crops and livestock for home consumption, market demands and other socio-economic obligations. The yield produced in the study area was not adequate to feed the current population. Crops in general and grains in particular have played significant roles for food consumption compared to animal products. From this empirical findings point of view, the local market is one of the significant variables that affected household food energy positively. With regard to food supply, households who reside far from the local market or the local town had better opportunity to access food for home consumption compared to households that reside near to the local market. Despite market proximity facilitates better access to various agricultural and industrial products; households were not wise and could not manage their crop and livestock products. They have inadequate knowledge on food budgeting so that the nearby households to the local market sold and waste more food resources compared to households who reside at remote areas. One of the current themes of the food systems is balancing food production and consumption. The government of Ethiopia should deliberate population policy with the intention that the rising population need to have adequate subsistence. In addition, women empowerment can enable them access to and control over food resources.

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REGULAR ARTICLE

EFFECTS OF IRRIGATION TECHNOLOGY ADOPTION ON FARMS PERFORMANCE IN ALGERIA: A STOCHASTIC FRONTIER PRODUCTION FUNCTION APPROACH

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ABSTRACT

The aim of this study is to evaluate the performance of water-saving technologies (WST) through an investigation of its effect at the farm level. Indeed, the study attempts to estimate the economic value of WST use in Algerian farming, through the comparison of some farm performance indicators between WST adopters, drip irrigation system as a WST, and farmers practicing gravity irrigation as a traditional system. A cross-section data from a survey is conducted in an irrigated perimeter situated in the north-eastern Algeria (Jijel region) encompassing 106 small horticultural farms (including 60 pepper producers and 46 tomato producers). First, the study compares some performance indicators between the two groups of farms. Second, a stochastic production frontier model is used to estimate the productivity gain generated by the WST adoption. Main results show that water consumption, gross margin, and water productivity are statistically significant between the two groups of farms. The average water productivity differential between WST users and non-users is 29% and 25% for tomato and pepper, respectively. The regression model has shown that increasing the WST use by 1% help to increase water productivity of the region by 0.20% for pepper production and 0.11% for tomato production. The findings of this study confirm the hypothesis that WST economize on water quantity, positively affects crop yield and can enhance water productivity.

Keywords: water-saving technologies, stochastic production function, irrigation, water productivity, Algeria
JEL: Q25, Q15

INTRODUCTION

Investment in Water Saving Technologies (WST) was always considered as a solution to manage water demand. Indeed, the adoption of this technique allows the use of less water in the agricultural production process. For this reason, WST have been widely promoted in Algeria. However, little published research exists to support popular claims about their effectiveness in Algeria.

Algeria has a Mediterranean climate characterized by a long period of drought observed during the summer and a large seasonal and regional variability of precipitations. The important irregularity of rainfall accentuates the problem of water availability. Indeed, with nearly 292 m^3/Capita/year in 2014, it is characterized by a very hard water stress, Algeria is thus more vulnerable than its neighbours Tunisia (420 m^3/cap/year) and Morocco (879 m^3/cap/year) (**FAO, 2017**). The situation becomes even more complicated and the pressure on the resource will certainly increase in the next years because of the population growth, urban expansion, the improvement of living conditions, and the effects of climate change.

In Algeria, there is limited scope for further increase in the use of land in order to increase the production. According to **Bellal (2011)**, the water resource shortage represents the main impediment for the intensification of Algerian agriculture. In fact, fresh water mobilization has reached its limit (**Benblidia & Thivet, 2010**). Otherwise, many researches are showing that water is underpriced in the irrigated schemes of Algeria (**Benmihoub & Bedrani, 2011; Azzi *et al.*, 2018; Oulmane *et al.*, 2019**). This leads to inefficient allocation of irrigation water by farmers and large loss of water. Therefore, future increases in irrigated production have to be originated from enhancing the productivity of farms.

Crop productivity has often been increased by adding inputs, including water, fertilizers and pesticides. However, these activities usually increase rather than reduce water use. It is therefore more rational to consider increasing crop productivity per unit water, which is generally termed water productivity. Thus, the key research question to ask here is the following: are WST allow to achieve the goal of increasing water productivity and reducing water consumption? Therefore, this work aims to estimate the economic value of WST use in the Algerian farming, through the comparison of some farm performance indicators between WST adopters, especially drip irrigation, and farmers practicing gravity irrigation. We also estimate a production function for the two groups of farmers in order to reveal the impact of WST adoption on water productivity in the study area. Although there has been little research done in the Algerian context.

Previous studies have been limited on the study of determinants of irrigation technology choice at the farm level (**Salhi & Bédrani, 2010; Belaidi, 2013; Benmehaia & Brabez, 2017**).

LITERATURE REVIEW ON WATER PRODUCTIVITY

Comparison of the Water Productivity (WP) for different crops or different production process could be an interesting indicator to face the challenge of increasing food production with less water (**Troy, 2012**). Increasing WP is particularly appropriate where water is scarce compared with other resources involved in production. Reasons to improve agricultural water productivity include: i) to meet rising demands for food from a growing, wealthier, and increasingly urbanized population in light of water scarcity, ii) to respond to pressures to reallocate water from agriculture to cities and ensure that water is available for environmental uses, and (iii) to contribute to poverty reduction and economic growth (**Molden *et al*., 2009**).

It is well accepted that there is substantial scope to reduce irrigation water deliveries through a range of technical and management practices: drip and sprinkler irrigation, reduced allocations of water to farmers or pricing to influence demand. Many of these practices increase yields, and are important for water quality management and the overall control of water (**Evans & Sadler, 2008; Molden *et al*., 2009**).

There is an emerging literature investigating the effects of irrigation efficiency improvements. Both theoretical modelling (**Huffaker, 2008**), and programming models or simulations (**Peterson & Ding 2005; Ward & Pulido-Velazquez, 2008**) show that more efficient irrigation may or may not reduce water use, depending on a variety of economic and hydrologic factors. In addition, not all water-saving technologies can achieve their expected levels of water saving after adoption. The effectiveness of water-saving technology also depends on factors such as farmers' skills in implementing technology and the production environment (e.g., soil characteristics).

Nowadays, the challenge for the agricultural sector is considerable, it needs to adapt in order to address the decline in the available volume of water for irrigation, while producing more. Partially, and in response to this challenge the Algerian government is encouraging the use of WST by farmers. These technologies are generally promoted as reducing the loss of water and enhancing water productivity (**Sanz, 1999, Evans & Sadler, 2008**). Indeed, modernization of irrigation systems is considered as one of the technological options for increasing the efficiency of water use at the level of irrigated farms (**Dinar & Jammalamadaka, 2013**). In addition, **Letey *et al*. (1990)** report significant increases in crop yield and significant decreases in irrigation water use have been observed when pressurized irrigation systems (watering or drip irrigation) replace gravity irrigation methods. According to **Playan & Mateos (2006)**, these technologies not only save 48% to 67% of water but also reduce energy costs by 44% to 67% and from 29% to 60% of wages (**Narayanamoorthy, 2009**).

Another study, conducted by **Dechmi *et al*. (2003)** in Northeastern Spain, shows that the efficiency of water use at the farm level is improved and reaches 90% in the case of sprinkler irrigation systems. The analysis of irrigation along the King Abdullah Canal in Jordan, by **Battikhi & Abu-Hammad (1994)**, shows similar results, with greater irrigation efficiency from pressurized systems. These authors showed an improvement in efficiency by 30% compared to surface irrigation systems (not pressurized). However, these remain elusive in some cases. Improperly managed WST can be as wasteful and unproductive as poorly managed traditional systems (**Perry *et al*., 2009, Benounich *et al*., 2014**). When incorrectly applied, irrigation technology can cause losses arising on investments made by farmers, thus decreasing the economic water productivity and the overall sustainability (**Battilani, 2012**). Then, to gain the extra benefits of such technology, the most important is adequate system design, alongside proper installation, operation and maintenance, regardless of the irrigation method used (**Hanson *et al*., 1995**).

Furthermore, **Salvador *et al*., 2011** compared various irrigation methods in Spain via the annual relative irrigation supply index (ARIS), i.e. a ratio of water applied versus water required. They found a greater efficiency of solid-set and drip irrigation systems than surface irrigation. Nevertheless, average annual figures conceal great variations in water applied to a given crop and irrigation efficiency at farm level, partly for lack of adequate knowledge. A remedy would be actions to improve farmers' water management via a combination of irrigation advisory services and policy measures'. Another study conducted in North China by **Huang *et al*. (2017)** describes the extent of water-saving technology usage and evaluates their impacts on water use, water productivity. Their results also show that using water saving technologies can reduce crop water use and improve the water productivity.

DATA AND METHODS

Data and study area

A cross-section data from 60 pepper producers and 46 tomato producers in the 2013-2014 period was collected from surveys conducted in an irrigated perimeter situated in the Northeastern Algeria. The total agricultural area is around 4 885 ha. The irrigated area is about 2 011 ha, representing 36% of the agricultural area. The area is characterized by small farms with the average size 2.6 ha, where 60% are equal to or less than 2 hectares. There is a low heterogeneity in the farm size (standard deviation of 2.24). In contrast, farms with an area at least equal to 5 ha represent 14% of the total number of farms but represent 38% of the area.

Thanks to the availability of water in the study area, several rotations can be grown during the year. The greenhouse crops are the most frequent in the region, they are practiced in more than 85% of the surveyed farms, with pepper and tomato as main crops under greenhouses. The open field is also present in 48% of the surveyed farms with cabbage as main winter crops, and watermelon and tomato as summer crops. The most widely used irrigation technique is drip irrigation system. It covers about 69% of the irrigated area. Irrigation by gravity system is a system used mostly for crops in greenhouses and cover 31% of the irrigated area. Each farmer can therefore use a combination of the two irrigation techniques based on the crops type.

Water productivity measurement

Water productivity concept aims to measure how a system converts water (associated with other resources) on products and services (**Cai *et al*., 2011**). It is defined as the ratio of agricultural output to the amount of water consumed (**Molden *et al*., 2009**). Thus, the Water Productivity (*WP*) is computed as in Eq. 1.

$$WP = outcome\ from\ the\ use\ of\ water\ /\ water\ supply \quad (1)$$

The outcome can be measured in terms of physical mass (expressed in kg) or in monetary value (local currency). The amount of water used is expressed in different ways according to the objectives, but also according to the availability of data: precipitation, withdrawal for irrigation, water supply to the plot or evapotranspiration (**Troy, 2012**). In our case, water productivity will be computed by considering the amount of water brought by the farmers, i.e., irrigation system.

Estimation Methods

In order to examine the effects of WST use for the main economic performances in the farm, we proceed an explanatory factorial analysis. A common method used in this case is a one-way analysis of variance. The performance index is considered as a quantitative dependent variable and the adoption as an explanatory factor, i.e. $x_i = f\,(irrigation\ systems)$. Results are evaluated by habitual tests. The differences express the effects of the WST in pepper and tomato production for the study region.

In order to reveal the impact of WST adoption, we use the production function approach. The stochastic production frontier model was first, and nearly simultaneously, elaborated by **Meeusen & Van den Broeck (1977)** and **Aigner *et al*. (1977)**, there has been considerable research to extend the model and explore exogenous influences on producer performance. Early empirical contributions (**Schmidt & Lovell, 1979, 1980, Kumbhakar *et al*., 1991**) investigating the role of exogenous variables in explaining inefficiency effects. In this study, the evaluation of the economic cost of the WST use has been evaluated according to the theory of production. This technique seeks to approximate the water productivity gain generated by the use of the WST.

As for **Fouzai *et al*. (2013)**, we assume that, for two groups of identical farms in terms of edaphic, climatic and socio-economic characteristics, but different in terms of irrigation techniques, the difference in productivity is calculated by the difference in the productivity according to water factor in each group of farmers. This approach then requires the estimation of a production function (**Heady & Shaw, 1954; Wampach, 1967; Cline, 1970; Hayami & Ruttan, 1971; Lilyan & Richard, 1998, Karagiannis *et al*., 2003**) for the two irrigation techniques to measure the difference of the water productivity.

The production functions of the two groups of farms expressed in terms of a multiplicative error term (Eq. 2).

$$P = X^{\alpha_i} e^{u-v} \quad (2)$$

where *P* represents farm yield, *X* for a set of explanatory variables, α_i for parameters to be estimated, *u* represents error term due to individual differences, and *v* as stochastic disturbance having the habitual assumptions (i.i.d., with zero mean and constant variance). Similarly, water production function will be represented by Eq. 3.

$$W = X^{\beta_i} e^{u-v} \quad (3)$$

where *W* represents water productivity, β_i for unknown parameters.

Explanatory variables used in this study are: the value of total fertilizer used, the value of labour (permanent and seasonal), the quantity of water consumed, and the variable costs. To reflect the effect of WST use on water productivity, a binary dummy variable was introduced as a regressor in the final equations. This dummy variable noted *wst adoption*, takes the value of 1 if the farmer uses WST, and 0 if he doesn't. The insertion of this dummy variable allows estimating the two models in the form of a single regression.

To be estimated, both models are used in terms of log-linear forms. The algebraic model is a stochastic linear Cobb-Douglas production function model. The log-linear form is commonly used in demand and production models (**Griliches, 1964; Hayami & Ruttan 1971**). The log-linear form was considered as functional form for both equations. It allows for estimating coefficients that can be directly interpreted as elasticity.

RESULTS AND DISCUSSION

The descriptive approach of the question raised in this study could be illustrated by showing concretely the difference in irrigation water use. This could be done simply by plotting the water productivity variable factorized by crops and by WST adoption (Figure 1).

Figure 1 displays water productivity in both crops (pepper and tomato). The difference is evidently clear to the extent that tomato production presents higher water consumption by its nature, regarding the used farming practices (including irrigation systems). Furthermore, the difference is primarily due to the fact that tomato crop has significantly higher yields than pepper. On the other hand, Figure 1 also displays water productivity for irrigation systems (drip irrigation system as a WST taking the value of 1, and gravity irrigation system as a traditional system taking a value of 0). The difference is remarkable. This means that, whatever the farming system considered, the WST presents higher levels of water productivity. From this fact, WST gains its superiority over traditional irrigation systems.

We examine first the effects of WST adoption in our case. The statistical comparison of economic performance between both groups of farming activities is presented in Table 1. We used one-way analysis of variance to highlight effects that make a statistically significant difference.

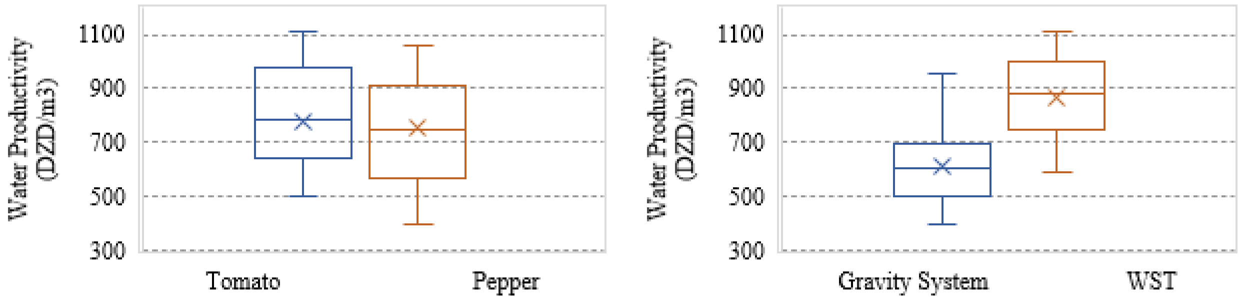

Figure 1. Water productivity in term of crop type (Left) and irrigation system (Right)

Table 1. Comparison of Performance Indices between WST Adopters and Gravity Irrigation Users

	Tomato			Pepper			Average	
	WST users	Non users	t	WST users	Non users	t	WST users	Non users
Water consumption (m^3/ha)	3360	3840	.003**	3136	3520	0.000**	3248	3680
Fertilizer (DZD/ha)	262608	228311	.030*	240544	212461	0.001**	251576	220386
Labour (DZD/ha)	711664	756032	.033*	703728	742304	0.679	731696	749168
Variable costs (DZD/ha)	1633616	1526400	.474	1509120	1460592	0.122	1571368	1493496
Yield (Kg/ha)	94208	83600	.014*	66560	59600	0.044*		
Gross margin (DZD/ha)	1004208	814400	.032*	887040	685008	0.004**	945624	749704
WP (DZD/m^3)	785	610	.000**	764	610	0.001**	775	610

Note: 100DZD ≈ 0.84 $US. * significant at 5%, ** significant at 1%.

Results from descriptive analysis show that using WST can lead to reduction in crop water and labour for both pepper and tomato producers. From the Table 1, the difference in terms of water used between WST users and non-users is statistically significant at 1%. However, we note that the use of fertilizers is higher among WST users. This can be explained by the fact that farmers using drip irrigation system make fertigation. Therefore, they use water-soluble fertilizers which are more expensive. The average variable costs, represented by the cost of: water, fertilizers, labour, seeds and other intermediate consumption (mulching, greenhouse covers, and irrigation system), per hectare of WST users are 1 633 and 1 509 thousand DZD/ha, which are higher than the non-users variable costs, 1 526 and 1 460 thousand DZD/ha for tomato and pepper producers, respectively. However, the differences in terms of variable costs between both farms groups are not statistically significant.

The average yield of WST users and non-users are 94.2 and 83.6 T/ha for tomato, and 66.6 and 59.6 T/ha for pepper, respectively. The yield is around 8.4 and 7 T/ha for tomato and pepper, respectively. The difference is statistically significant at 1 and 5%. The gross margins obtained by WST users and non-users are, respectively, 1 004 thousand and 814 thousand DZD/ha for tomato, and 887 thousand and 685 thousand DZD/ha for pepper. These results show that the average gross margin differential between WST users and non-users is, respectively, about 23% for tomato (190 thousand DZD/ha) and 29% for pepper (202 thousand DZD/ha). The difference is statistically significant at 5%.

From Table 1, results also show that using WST improves productivity and allocation of irrigation water resources for both crops. In fact, differences between WST users and non-users regarding water productivity and water value are highly significant at 1% for both crops.

We turn now to the examination of the determinants of water productivity gain for both farming systems. Results of the estimation reveal some significant variables affecting the water productivity in study area. The results of the estimation by the method of ordinary least squares (OLS) for production function and water productivity are presented in Table 2.

The overall significance for the estimation performance is quite satisfying. The adjusted R^2 and Fisher test are acceptable for all models, except for the tomato production function (fourth column), showing that the water productivity variations could relatively is explained by the regressed variables considered in our analysis.

We note that the specification adopted in this study is logarithmic. Given the statistic linear form of the model's equation, the elasticity of each explanatory variable calculated based on this model is equal to the slope of the corresponding function. Thus, obtained parameters are directly interpreted as elasticity.

According to Table 2, the coefficient estimates associated to *water* variable is negatively significant at 1% for both crops. The sign of this variable is explained by the fact that *water* and *WP* are negatively correlated. This coefficient is interpreted as the elasticity of water compared to the variable water productivity. When *water* increases by 1% *WP* decreases by 0.9%. We notice that the *fertilizer* coefficient estimates for pepper is 0.16 with a statistical significance, whereas insignificant in tomato crop. This finding explains the fact that *fertilizer* and *WP* vary in the same direction.

Table 2. Econometric Models of Production Functions and Water Productivity for Surveyed Farms

Explanatory Variables	Pepper Farm Production		Water Productivity		Tomato Farm Production	Water Productivity	
const.	5.80		8.57	**	6.61	9.38	**
	(1.37)		(2.03)		(1.47)	(2.08)	
wst adoption	0.20		0.20		0.11	0.11	
	(3.30)	***	(3.30)	***	(1.39)	(1.39)	
water	0.02		-0.97	***	0.09	-0.90	
	(0.20)		(-6.79)		(0.59)	(-5.96)	***
fertilizer	0.16	**	0.16	**	0.01	0.01	
	(2.66)		(2.66)		(0.17)	(0.17)	
labour	0.32	***	0.32	***	0.08	0.08	
	(3.10)		(3.10)		(1.17)	(1.17)	
variable costs	0.04		0.04		0.21	0.21	
	(0.14)		(0.14)		(0.68)	(0.68)	
csu	0.002	*	0.002	*	0.007	0.007	
	(1.89)		(1.89)		(0.31)	(0.31)	
Observations	60		60		46	46	
Adjusted R^2	0.384		0.739		0.034	0.677	
Log-likelihood	30.175		30.175		31.791	31.791	
F(6, N)	7.144	***	28.940	***	1.270	16.749	***

Note: *** significant at 1% level, ** significant at 5% and * significant at 10%. *csu* for cross-sectional units. The values of the *t*-ratio is in parentheses.

Therefore, when *fertilizer* increases by 1%, *WP* increases by 0.16% in paper cropping, while without influence in tomato production.

The coefficient of the variable *labor* is 0.32 and is positively significant at the 1% in pepper production while it is not significant in tomato. This is explained by the fact that *WP* is positively affected by *labor*, i.e., when *labor* increases by 1%, *WP* increases by 0.32% without influence in tomato production. The elasticity of water productivity in relation with *variable costs* have lower values with no statistical significant in all models. This coefficient is positive according to the theory of economic but not significant for any interpretation. The parameter associated with the dummy variable *wst adoption*, which represents the used irrigation technique, is positive and highly significant for peppers' production function and its water productivity. Whereas, the tomato crop, both for production and water productivity functions, doesn't show any statistical significance. The sign of this variable confirms the hypothesis that a differential in water productivity exists and it is related to the use of the WST. This finding shows that the increase in the use of the WST by 1% generates a gain in water productivity by 0.2% in pepper production. Finally, the *water* variable shows a negative sign, and the *labor* with a positive sign. These corroborate our later findings on the differentials in farm performance regarding irrigation technology used. Consequently, WST enhance water productivity and economize water allocation, while it requires more labour. These findings confirm the hypothesis that WST economize on water quantity, it is labour-intensive technique, and it presents higher yields for both crops.

CONCLUSIONS

The Algerian's irrigation is characterized by a water use inefficiency essentially caused by the use of traditional irrigation techniques. This situation results in lower levels of yields and productivity. The main objective of this study is to describe the extent of water-saving technology adoption and evaluates their effects on water use and its productivity in small horticultural irrigated schemes (pepper and tomato crops) in the Northeastern Algeria. In this study, we compared the two groups using different irrigation techniques, the first using drip irrigation system as a WST, and the latter by the gravity irrigation system as a traditional system.

Contribution of each input to water productivity was also examined in this study. Findings indicate the relative importance of inputs contributing to water productivity. Therefore, we estimate the water production functions for the two groups of farmers by OLS for production functions.

The results show that water productivity has often been increased by adding inputs, including labour and fertilizers and it is negatively correlated to water quantity. This reflects the fact that farmers manage factors of production (labour, fertilizers and other inputs) to get better economic gains. These findings confirm the hypothesis that WST economize on water quantity, it is labour-intensive technique, and it presents higher yields for both crops. Our results show that using WST can enhance crop water allocation and positively affects crop yield and water productivity.

The results found are valuable for policy makers since they are enlightening the gain on water productivity in horticultural farms in Algeria. Then, the government should continue its efforts to promote and extend water-saving technologies. Increasing the adoption of such packages by farmers would be encouraged by credit access and enhancement of the extension and training services. As a continuity in this direction, research can be made in order to analyse changes in farmers' practices as a result of WST introduction. One such change is the use of different and improved varieties or crops that can be grown using these techniques. A concrete example for research in this direction is to analysis the expansion of the strawberry crops during the last decade in the irrigated perimeter studied.

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REGULAR ARTICLE

DETERMINANTS OF TECHNICAL EFFICIENCY OF COTTON FARMERS IN TOGO

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ABSTRACT

Cotton is a cash crop that occupies an important place in Togolese economy. However, a downward trend in productivity has been observed over the last twenty years, but the reasons are not well known. The purpose of this article is to determine the level of technical efficiency of cotton producers and analyse its determinants. The stochastic frontier analysis was adopted and data collected from 150 cotton producers in five regions in Togo was used. The results show that the average technical efficiency of cotton producers is 48.33%. It is therefore possible to increase the level of cotton production to 51.67% using the available resources. The factors that affect the technical inefficiency of farmers include the use of herbicides, the education level and the nature of the soil. In order to increase the productivity of cotton, policy should target on the capacity building of the producers by an effective support of the extension agents in order to ensure the follow-up of the technical itineraries.

Keywords: Agriculture, Technical efficiency, Cotton, Togo
JEL: Q1, D13; D61, E23

INTRODUCTION

At the industry level, the resources managements are a key element for its development. Agriculture, as an industry, also needs an efficient use of resources in order to sustainably increase income and reduce poverty while improving agricultural productivity. For instance, **Christiaensen (2017)** finds that increasing productivity requires rational or efficient use of resources as supports the neoclassical production theory. The rational behaviour is therefore a key factor of productivity and producers' income while contributing to the development dynamics. Indeed, the agricultural sector continues to be the key driver of economic and social development for most developing countries (**Dorosh and Thurlow, 2018; Christiaensen *et al*., 2011**). According to **Diao *et al.* (2010**), agriculture employs more than 60% of the workforce and contributes more than 35% of the gross domestic product (GDP) of most African countries and more than 40% for the least developed countries. In most developing countries, agricultural products fulfil food security and play an important role in income generation and meet farmers' subsistence needs (**Sun and Li, 2018; Christiaensen *et al*., 2011; Valdés and Foster, 2010**). Moreover, agricultural products, mainly cash crops, account for a significant share of exports (**Narayan and Bhattacharya, 2019**).

Cotton is recognized as one of the most widely grown cash crops in the world (**Fatima et al., 2016; Sarker and Alam, 2016; Mensah, 2015; Lyford, 2009; Baffes, 2005**). Cotton is mainly grown on rain-fed land by smallholder farmers. It plays an important role in the livelihoods of rural households as it generates income for smallholder farmers, improves rural welfare and contributes to economic growth (**Sodjinou *et al*., 2015; Sneyd, 2015; Badiane *et al*., 2002**). In Sub-Saharan Africa, cotton remains a strategic crop and constitutes the *white gold* and accounts for 13% of world exports between 2002 and 2003 (**IFM, 2014; Goreux 2003**). Between 1998 and 1999, the share of cotton in exports accounted for between 30% and 44% of exports in five West African countries: Benin, Burkina Faso, Chad, Mali and Togo (**Baffes, 2005**). In 2000, cotton accounted for about 5% of GDP for Mali and Chad and on average 4.9% of GDP for Togo and its share in total agricultural exports was about 70.5% for Togo (**Fortucci, 2003**). According to **Mensah (2015)**, between 1991 and 2009, the share of cotton exports in total cash crop exports (cotton, cocoa and green coffee) in Togo was about 88% or 16% of total exports (all commodities included). These data show that cotton export alone represents about 5% of GDP.

However, there is a persistent decline in cotton productivity in Togo according to data from **NSCT (2017)**. Indeed, from 1998 to 2017, it appears that cotton production in Togo has a downward trend (Fig. 1). Several factors may explain this decline, in particular technical factors as well as farmers' socio-economic characteristics. This requires an analysis of the allocation of productive resources in the sector. For example, **Ali and Byerlee (1991)** have shown that the adoption of new technologies is subject to significant technical inefficiency leading to a decrease of productivity. Alternatively, **Olmstead and Rhode (2008)** have shown that the development and adoption of new cotton varieties were the main sources of increase of efficiency of cotton production in the case study of South America. The lack of sufficient information on the new technologies available to farmers can explain these differences in the adoption of new technologies affecting productivity (**Piesse and Thirtle, 2000**).

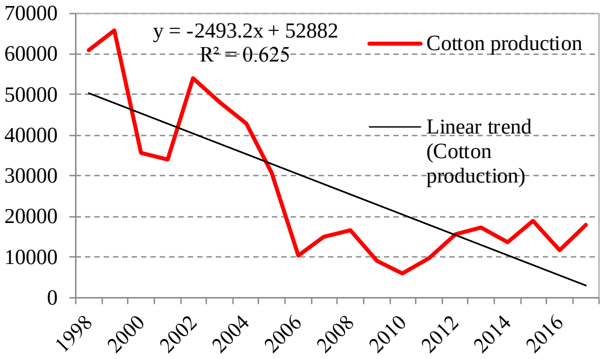

Figure 1: Trend of cotton production in Togo (1998-2017)
Source: Authors design based on data from **NSCT (2017)**

On the other hand, the allocation of resources such as fertilizer, land, labor (**Sarker and Alam, 2016, Bojnec and Latruffe, 2013; Binici *et al.*, 2006a; Rizov *et al.*, 2001**) and socio-economic and institutional factors such the access to extension services, the education level, and the amount of credit can be determinants of the level of production (**Sarker and Alam, 2016; Karimov, 2014; Sauer and Balint, 2008; Sauer, 2006).** Better management of resources and well organization and management of the farm would increase productivity (**Theodoridis *et al.*, 2014; Karimov, 2012; Binici *et al.*, 2006b; Coelli *et al.*, 2002**).

However, there is little knowledge of how resources are used in the cotton production process in Togo except some work by **Koffi-Tessio (2000)** who finds that the price is not a determinant of cotton supply; and **Mensah (2015)** who only addresses the issues of impact of cotton price variability on cotton farmers' welfare. It is therefore important to understand the sources of low level cotton production in the sector in order to propose actions or policies likely to boost cotton production in Togo and increase farmers' income and reduce vulnerabilities. The current challenge needs to improve the performance of cotton producers in order to increase producers' incomes.

The main objective of this study is to evaluate the performance of cotton producers in terms of resources allocation in cotton farming. Specifically, the study aims to determine the level of technical efficiency of cotton producers in Togo and analyses the main determinants of the technical efficiency of cotton producers in the study area.

DATA AND METHODS

Theoretical and conceptual frameworks

The problem of technical efficiency has long been a concern for many researchers in various fields such as health (**Kuntz *et al.*, 2007**), finance (**Weill, 2002**) and agriculture (**Fontan, 2008; Coelli *et al.*, 2002**). Efficiency refers to the ability to achieve a goal. In production theory, the term efficiency refers to the ability of producers to achieve a good performance in a given type of task. In our context, the technical efficiency of cotton production can be defined as the ability to obtain the highest level of production given the available resources. The question of the technical efficiency of cotton production can be attributed to several causes including the lack of access to extension services, the lack of incentives for producers, the non-respect of the technical itinerary, the choice of sowing period, and the under-use or over use of inputs such as seeds, fertilizer, pesticides and herbicides (**Rasse *et al.*, 2018, Chogou *et al.*, 2017; Rapidel *et al.*, 2009**). It is therefore necessary to understand the drivers of inefficiency and enable the decision-makers to take actions in order to improve the overall efficiency of the sector.

Although the issue of efficiency is of interest to the wide range of researchers, several debates arise when it comes to the choice of the estimation technique. Two techniques are often discussed (**Lovell and Schmidt, 1988**). On the one hand, the data envelopment technique or deterministic approach (**Farrell, 1957; Charnes *et al.*, 1978; Shafiq and Rehman, 2000**) and the stochastic frontier approach on the other hand (**Coelli *et al.*, 1998; Coelli *et al.*, 2002; Weill, 2003**). Like deterministic approach, the stochastic frontier approach leads to the computation of a specific technical efficiency score for each production unit (**Farrell, 1957; Shafiq and Rehman, 2000; Coelli *et al.*, 2002**). This involves estimating the stochastic frontier or specifying a regression model relating each of the score of a firm's efficiency in a given period and producer's socio-economic characteristics. However, this procedure has been disputed in the literature (**Coelli, 2002; Battese and Coelli, 1995, Sexton *et al.*, 1986; Farrell, 1957**). Indeed, the estimation of the parameters in the second step contradicts a hypothesis made in the first stage (**Sexton *et al.*, 1986**). To overcome this gap, various studies have led to models that make it possible to simultaneously estimate the stochastic production frontier and the factors that explain the differences in technical efficiency between firms (**Coelli, 2002**). This approach will be used in this context.

The sampling technique and method of data collection

The sampling was done in such a way to take into account the producers of the 5 administrative regions in Togo. One hundred and sixty cotton producers were randomly chosen in cotton based famers' groups (thirty two farmers in each region). The list of producers was provided by the Cotton Company of Togo (NSCT) thanks to the regional Directorates through the Technico-Commercial Agent (ATC) which is a grouping of several cotton farmers based organization under the control of a technical agent of each region. The structured questionnaire previously pre-tested was used to collect data. The questionnaire includes open, semi-closed and closed questions that are designed to measure variables that fall within the definition of the production function. Finally, 150 well-filled questionnaires were considered for the analysis. The other 10 questionnaires were rejected because all the questions were not answered. The econometric analysis was done using the FRONTIER software (Version 4.1c).

The econometric approach

This study uses the stochastic frontier approach proposed by **Aigner *et al.* (1977), Meeusen and Van Den Broek (1977)**, and improved by **Jondrow *et al.* (1982).** The advantage is that, this approach allows the estimation of technical efficiency score specific to each production unit while taking into account the variables that cannot be controlled by farmers (socioeconomic characteristics). Following the method of **Battese and Coelli (1995)**, the individual production function can be written in the form of Eq.1.

$$Y_i = f(X_i\beta)\exp(V_i - U_i) \quad (1)$$

Where: $\boldsymbol{Y_i}$ represents the quantity of cotton produced in tons. $\boldsymbol{X_i}$ is the row matrix of exogenous or input variables used in cotton production while $\boldsymbol{\beta}$ is the column vector of the parameters to be estimated. $\boldsymbol{V_i}$ is the random error term assumed to be identically and independently distributed. $\boldsymbol{U_i}$ is a linear function of the explanatory variables related to the technical inefficiency of the production units (Eq. 2-Eq.3).

$$TE_i = \frac{\text{Production of the farm i}}{\text{Maximum of the farm i}} = \frac{f(X_i\beta)\exp(V_i - U_i)}{f(X_i\beta)\exp(V_i)} \quad (2)$$

$$TE_i = exp(-U_i) \quad (3)$$

Where: TE_i is the technical efficiency of the farm i. it is assumed to be a linear function of the exogenous variables that can explain the existence of inefficiency of farmers in cotton production.

In order to simplify the analysis and interpretation of the relationship between the dependent variable and the explanatory variables, Cobb-Douglas functional form is adopted (**Jondrow *et al.*, 1982**). The Cobb-Douglas technology can be written as Eq. 4 - Eq. 5.

$$Y_i = AX_1^{\beta_1}X_2^{\beta_2}X_3^{\beta_3}X_4^{\beta_4}X_5^{\beta_5}e_t \quad (4)$$

$$lnY_i = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 - U_i + V_i \quad (5)$$

Where: X_1 is the cultivated land for cotton crop in hectare, X_2 is the amount of insecticide and herbicide used, X_3 stands for total amount of labour used per farm and measured in man-day, X_4 is the amount of fertilizer used, X_5 is the number of kilogram of seeds used per hectare. $\beta_0 = lnA$ captures the effect of technological change cotton production.

However, the determinants of the technical inefficiency of cotton producers which is a linear function of the exogenous variables (socioeconomic variables) can be written as Eq. 6.

$$Z_i = \alpha_0 + \alpha_1\gamma_1 + \alpha_2\gamma_2 + \alpha_3\gamma_3 + \alpha_4\gamma_4 + \alpha_5\gamma_5 + \alpha_6\gamma_6 + \alpha_7\gamma_7 + \alpha_8\gamma_8 + \alpha_9\gamma_9 + \alpha_{10}\gamma_{10} + \alpha_{11}\gamma_{11} + \alpha_{12}\gamma_{12} + \mu_i \quad (6)$$

Where: Z_i defines the average efficiency of each producer (i=1,2,3, …, n); γ_1 represents the socio-economic variables that can explain the technical inefficiency of the producers and α_i are the parameters to be estimated (i = 1,2, .., 12).

Choice of variables

The selected variables gathering the production and farmers' socioeconomic characteristics and their expected signs used in this study are described in Table 1.

Table 1: Variables, the measurements and expected signs

Variables	Unit	Expected sign
Production variables		
Quantity of cotton produced (Yi)	Number of tons	
Cultivated area (X_1)	Number of hectares	+
Quantity of applied pesticide (X_2)	Number of liters	+/-
Labor (X_3)	Total man-days	+
Quantity of fertilizer (X_4)	Number of Kg used	+
Quantity of seed used (X_5)	Number of Kg used per hectare	+/-
Socioeconomic variables		
Age (γ_1)	Number of years	+/-
Sex (γ_2)	1=Man, 0=Woman	+/-
Experience (γ_3)	Number of years	-
Quantity of pesticides (γ_4)	Number of liters	+/-
Primary school (γ_5)	1=Primary, 0=Otherwise	-
Secondary school (γ_6)	1=Secondary, 0=Otherwise	-
Member of cotton farmers based organization (γ_7)	1=Yes, 0=No	-
Assisted by extension agent (γ_8)	1=Yes, 0=No	-
Sandy land (γ_9)	1=Yes, 0=No	+/-
Clayed land (γ_{10})	1=Yes, 0=No	+/-
Household size (γ_{11})	Number of persons in the household	+/-
Other activity than agriculture (γ_{12})	1=Yes, 0=No	+/-

In this paper, the output is the total amount of cotton produced and measured in tons. The cultivated area, measured in terms of hectare, can positively affect the level of cotton produced. The same hypothesis is set for labour and the amount of fertilizer used. The assistance of extension agent can help to increase productivity by assuring the respect of technical itinerary. The education level and the structure of the land could also be determinants (**Yang *et al.*, 2016**).

RESULTS AND DISCUSSION

The deterministic factors are described in Table 2. The average cultivated land for the surveyed farm households was about 2.59 hectares with a minimum of 0.5 hectares and the maximum reaching 9 hectares. The average variability of cultivated land between producers was about 2.59 hectares. The chemical fertilizer is mostly used in cotton farming and determinant of cotton yields (**Honfoga, 2018; Zulfiqar and Thapa, 2016; Soomro *et al*., 2000**). The average fertilizer used per producer was about 507 kilograms with a maximum reaching 1750 kilograms. However, the average applied fertilizer per hectare was about 200 kilograms. The lowest dose was 67 kilograms per hectare and the highest reaching 600 kilograms per hectare which is three times of the average dose of the surveyed households.

The average yield of cotton producers in the sample was approximately 1153 kilograms per hectare. This yield is higher than the average observed during the last twenty years is 933 kilograms per hectare (**NSCT, 2017**) with a large standard deviation (535.31 kilograms per hectare). The quantity of seed used per producer was on average 117 kilograms per hectare with a minimum of 25 kilograms and a maximum reaching 400 kilograms. The average seed dose used on the plots was 43 kilograms per hectare. The seeds used per hectare were relatively higher than the recommended quantity of seed to be used in Togo (25 kilograms per hectare) according to **NSCT (2017).**

Socio-demographic variables of cotton farmers in Togo

The socio-demographic characteristics of the respondents are presented in Table 3. The cotton farmers in the sample are relatively young (on average, 43 years old). However, most of them are well experienced in cotton production (12 years on average). The results show that 43.83% of cotton farmers in the sample have a formal education and agriculture still remains the main activity of most producers (61.64%).

All producers belong to a cotton based farmers organization while 50.68% belong to other farmers' organizations (Table 3). Moreover, most of farmers in the sample (86.30%) have at least been assisted by an extension services. This participation rate is expected to reduce the inefficiency of most farmers in the sample.

Estimation of marginal risks of cotton production

The analysis of the coefficients of the production variables shows that cotton production is determinant of the cultivated area, the amount of pesticide used, the labour and the amount of fertilizer applied (Table 4). The cultivated area and the amount of insecticide used are significant at 1% level. This means that a 1% increase in the cultivated land will lead to an increase in cotton production by 44.30%. The land allocation within other crops (subsistence crops against cash crops) at the household level can be a key determinant regarding the revenue generated from each crops.

The coefficient of the amount of insecticide sprayed is significant at 1% level and positively correlated to the cotton production. This implies that a 1% increase in applied insecticide would increase production by 713.04% (Table 4). This result is consistent with those from (Gouda *et al*., 2018) who find that increasing the pesticide use would increase cotton production in the case study of Benin with similar socioeconomic characteristics. However, the health and environmental issues can be raised (**Taiwo, 2019; Donga and Eklo, 2018; Brouwer *et al*., 2017**). Getting these producers to better understand the benefits of this operation would substantially increase production.

Estimation of the determinants technical efficiency

There can be factors that farmers cannot control. These factors include farmers' socio-demographic characteristics. These factors can significantly influence the technical efficiency of cotton production (Table 5).

Table 2: Descriptive statistics of production variables

Variables	Production	Seed	Cultivated area	Fertilizer	Insecticides	Herbicides	Labour
Unit	Number of kg	Number of kg	Number of hectares	Number of kg	Number of liters	Number of liters	Number of man-days
Average per producer							
Mean	3372	117	2.59	507	8.39	4.48	34
Standard deviation (SD)	2770.3	77.34	2.59	288.70	5.15	4.4	34
Minimum	284	25	0.5	100	1.2	0.00	19
Maximum	46902	400	9	1750	33	21	60
Average per hectare							
Mean	1153.81	43	-	200	3.39	1.41	19
SD	535.31	14.04	-	45.16	1.29	1.3	10.12
Minimum	94.66	8.33	-	67	1	0.00	4
Maximum	9380	100	-	600	8.7	5.33	66

Source: Authors, using field survey data, 2018

Table 3: Socio-demographic characteristics of the surveyed cotton farmers in Togo

Variables	Unit	Minimum	Maximum	Mean	SD
Quantitative variables					
Age	Number of years	22	68	43	8.28
Household size	Household members	3	13	6	1.51
Experience	Number of years	1	32	12	6.38
Qualitative variables					
Variables		Unit			Frequency (%)
Sex		(1=Man; 0=Woman)			92.50
Formal education		(1=Yes; 0=No)			43.83
Principal activity		(1=Agriculture; 0=Other)			61.64
Member of cotton based farmers organization		(1=Yes, 0=No)			100.00
Member of other cotton based farmers organization		(1=Yes; 0=No)			50.68
Assisted by extension agent		(1=Yes; 0=No)			86.30

Source: Authors, using field survey data, 2018

Table 4: Determinants of cotton production in Togo

Variables	Coeff	Std Error	T-Ratio
Constant	-288.76***	1.46	-197.75
ln(Cultivated area)	44.30***	1.07	41.16
ln(Quantity of pesticides used)	713.04***	3.19	222.89
ln(Labor)	-24.78	22.70	-1.09
ln(Quantity of fertilizer used)	0.58	1.97	0.29
ln(Quantity of seed used)	-3.37	7.40	-0.45

Source: Field survey data, 2018. Note: ***P <0.01

Table 5: Estimation of determinants of technical efficiency

Variables	Coeff	Std err	T-Ratio
Constant	-4.02***	1.60	-2.50
Age	-29.32	21.13	-1.38
Experience	127.38***	34.36	3.70
Quantity of pesticides	151.89***	41.93	3.62
Sex	-4.30***	1.67	-2.57
Primary	3.53***	1.47	2.39
Secondary	10.53***	3.27	3.21
Member of cotton based farmers organization	-1.19	1.16	-1.02
Number of extension agent visits	16.04***	4.71	3.40
Sandy land	-20.98***	6.08	-3.45
Clayey land	4.99***	1.76	2.83
Households size	96.14***	27.16	3.53
Other activity than agriculture	10.58***	3.25	3.25
Sigma-square	17692229***	1	17692226
Gamma	1.77E-05	9.13E-05	0.19
Log likelihood	-1418.99		
Test de LR	8.16		

Source: Authors, using field survey data, 2018. Note: ***P <0.01

Having at least a primary or secondary education affects significantly and positively cotton production level. This implies that higher education level helps farmers in understanding and adopting new technologies that require a steady of some itinerary techniques. Therefore, high education increases the technical efficiency of farmers in production process. This result is similar to those of **Abdulai *et al*. (2018)** in the case study of Northern Ghana. The education level, coupled with the regular visit of extension agents in cotton production, increases significantly the technical efficiency of cotton farmers. The results show that, an increase of 1% of the number of visits by extension agent increases cotton production efficiency by 16.04%. The assistance of an extension agent is a factor that decreases the inefficiency of producers significantly. With advice from extension agents, production techniques are improved and producers are more efficient. The quantity of herbicide used has a positive sign and is significant at 1% threshold. This means that increasing the pesticide use by 1% will increase the technical efficiency of cotton farmers by 151%. However, the type of soil is determinant. For instance, the results show that growing cotton on sandy land decreases the technical efficiency of cotton farmers compared to the clayey land that has a positive effect.

The efficiency score

The efficiency score is shown in Figure 2. The results show that most of the farmers in the study areas are technically inefficient. The lowest score of technical efficiency of cotton producers was on average about 5.37% while the most rational producer has an efficiency score about 82.08% (Fig. 2). To make all producers efficient, the cost of cotton production can be reduced by 94.63% without additional resources. The results therefore show that there is a lot of space in this case to boost cotton production. The average technical efficiency score of the sample is 48.33%. This result shows that it is possible to increase the average production by 51.67% without additional resources.

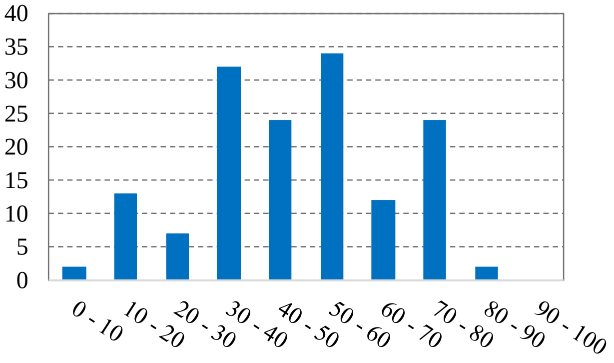

Figure 2: Distribution of technical efficiency scores of cotton farmers in Togo (%)
Source: Authors design, using field survey data, 2018

To be technically efficient, producers should reduce their cost of production by about 51.67%. These results show that there is a great possibility to boost the cotton production. This can be achieved by adopting the best farming practices of production and the follow-up of the technical itineraries would be the first target while supports from the extension services are needed.

CONCLUSIONS

Considered as the development engine for most developing countries, the agricultural sector plays an important role in poverty reduction given its contribution to the Togolese economy. The cash crops, especially cotton production, are an important source of currency inflows to the country. Unfortunately, the downward trend in cotton production over the last twenty years is observed, but reasons behind this sagging level of productivity are not well understood. The general objective of this paper is to analyse the performance of producers in cotton production in Togo. More specifically, this study determines the level of technical efficiency of cotton producers and to analyse the determinants of this efficiency. For this purpose, the data was collected from 150 randomly selected farmers in the 5 regions of Togo using a structured questionnaire administered. The stochastic frontier approach is used to achieve the assigned objectives.

The results reveal that the average technical efficiency of the producers in the sample was 48.33%. One can conclude that, it is possible for producers to reduce production costs by 51.67% with available resources. The determinants of technical efficiency that have a significant impact on production include production experience, the amount of herbicide used, , education level, and the assistance of extension services. Considering the gender aspect, the results show that women are technically more efficient than men. The nature of the soil, the size of the household and respondent's main activity were also determinants.

In order to increase the productivity of cotton, the capacity building of the producers by an effective support of the extension agents is recommended to ensure the follow-up of the technical itineraries. The gender aspect should also be taken into account in policy dealing with cotton production in the study areas. Moreover, encouraging farmers' education would be an asset in reducing inefficiency in the use of available resources and significantly increasing production. An in-depth study on the nature of soils would be an asset for better adaptation of crops and orientation of producers in their land allocation to different crops.

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REGULAR ARTICLE

DETERMINANTS OF SMALLHOLDER FRUIT COMMERCIALIZATION: EVIDENCE FROM SOUTHWEST ETHIOPIA

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ABSTRACT

The aim of the study was to identify determinants of smallholder fruit commercialization in southwest Ethiopia. To get the sampled respondents multi-stage sampling techniques were used and in view of that, three districts were selected purposively from Jimma zone by selecting eight kebeles randomly. At the end, total of 240 sample households were randomly selected from these kebeles. To answer the research questions and objective of the study both qualitative and quantitative data were collected from primary and secondary sources. The primary data were collected from fruit producers as sampled households, agricultural experts, local leaders and other subject matter specialists on various aspects of commercializing fruits. Primary data were collected from the respondents using a pre-testing questionnaires, structured interview schedule and closed and open-ended questionnaires by well-trained enumerators closely supervised by the researchers. Secondary data were previous research findings and reports collected from kebeles, districts, agricultural offices, ministry of trade, trade and revenue offices. Moreover, qualitative data were collected through discussions with different agents by using focus group discussion and key informant interviews. The collected data were analysed using descriptive statistics (frequency, percentage, average mean, standard deviation, chi square and t-test) and econometric model (Probit model) to analyse determinant factors affecting smallholder's participation decision in marketing of fruits. From the result, age of household heads, household family size, access to transport services, off-farm activities, access to extension services, distance to market, improved fruit seeds and perishability of fruit were significantly affecting smallholder farmer's participation decision in commercialization of fruits. Therefore, to overcome the investigated problems strong commitment and reformation should be done by stakeholders including farmers, extension agents, researchers, policy makers.

Keywords: Fruit producers, Commercialization, Probit Model, Ethiopia
JEL: D13, Q02, Q12, Q13

INTRODUCTION

Agriculture is the mainstay of the Ethiopia and more than 85% of the rural populations are engaged in agriculture. The livelihood of the smallholder farmers is also determined by this sector. This sector also plays a substantial role in the life and livelihood of most Ethiopians. It accounts for over 40% of GDP, over 80% of employment and 90% of foreign exchange earnings (**Diao, 2010; Demese *et al.*, 2010**). This indicates that agriculture is the basis for every economic activity of the country. Agriculture determines the economic, social, and political system of the society in developing countries like Ethiopia (**Leykun and Haji, 2014**). Ethiopian smallholder farmers are dependent on the cultivation of cereals (**Salami *et al.*, 2010; CSA, 2011**). However, agricultural production system of the rural people is featured by poor access to land, poor access to inputs, poor irrigation system, inadequate market orientation, inadequate infrastructures, poor technology, inadequate extension advisory services and low output (**Tilaye, 2010**). Besides, majority of smallholder farmers in Ethiopia are subsistence based farming system and the linkage between production and consumption decision is very low (**Muller, 2014; Tabe-Ojong *et al.*, 2018**). Their participation in subsistence farming does not ensure their food security and household welfare.

Ethiopian government has formulated a series of policies, strategies and programs to promote agricultural development to achieve food security and build resilience. The government has also developed the second Growth and Transformation Plan for the period 2016-2020 to become a middle income country by 2025 by improving the agricultural productivity and its commercialization. Among the strategies market-oriented agricultural production policies is the central one (**Shifera and Teklewold, 2007; Mekonnen, 2015**) and the government tries to promote production and marketing of high value agricultural products to increase the competitiveness of farmers in national and international markets (**Tufa *et al.*, 2013**). However, smallholder farmers are unable to benefit from such policy interventions due to unimproved varieties, high transaction costs, lack of infrastructures and inadequate extension services (**Gebremedhin and Hoekstra, 2007**). Thus, commercializing subsistence farming is very decisive and important pathway to ensure household food security and nation economic growth of the country (**Abafita *et al.*, 2016; Mitiku, 2014**).

Commercialization also enhances the links between the input and output sides of agricultural markets and farmers' participation (**Jaleta *et al*., 2009**). Some evidence shows that the average crop output and input market participation are 25% and 20%, respectively in 2009 and this indicates that market participation in rural areas is not above average (**Leykun and Haji, 2014**). Even if, the efforts made by the government to transform smallholder farmers from subsistence to commercial farming system, the performance has been considered expectations (**NPC, 2016**). This poor performance is because of lack of modern inputs and inefficient use of resources (**Kindie, 2005**) and following traditional way of farming system, poor production technology, rain-fed dependent agriculture, and low output mode of production (**FAO, 2011**). Some literatures indicate that commercial orientation of smallholder farmers for crop production in Ethiopia is very low (**Bekele, 2010; Adane, 2009; Bedaso *et al*., 2012**).

Vegetable production is another subsistence farming practiced by smallholder farmers in Ethiopia and its cultivation is considered as the supplementary to the production of main crops. Now days, these crops are the main sources of income for smallholder farmers and their demand is also growing in both national and international markets (**Bezabih and Hadera, 2007; Yilma, 2009**) and as the result, the participation of horticulture producers is increasing. Though farmers have an interest in participating in production and marketing of horticultural products, their participation is very limited because of different factors especially for those farmers who are living in rural areas. Among these factors poor transport, inadequate infrastructure, high transaction costs, lack of market information, and lack of feasible partners (**Abafita, *et al*., 2016**). **Mitiku (2014)** argued that market participation of smallholder farmers is very limited and agricultural markets are also fragmented which increases the transaction costs and reduces farmer's interest to produce products for the market. To tackle these problems increasing the participation of smallholder farmers in marketing of horticultural crops is very crucial (**Olwande *et al*., 2015**). Commercialization of smallholder farmers is the way to bring their commodities to the market and becoming beneficiary as inclusive development (**Arias *et al*., 2013**). Market oriented patterns of crop production can be effective and productive through intensification and commercialization of agriculture (**Gebreslassie *et al*., 2015).**

In Ethiopia, many research investigations have been carrying out on the production of vegetables and their determinant factors that influence their production activities but the research done on the market participation of smallholder vegetable producers is very limited. Moreover, other literatures are mainly focusing on smallholder commercialization of other horticultural crops and livestock products. In Ethiopia, vegetable production is not available in all parts of the country but southern parts particular to Jimma zone have a good potential in vegetable production which are mainly utilizing them for stable food subsistence, with less market oriented activities. Despite the production potential and importance of horticultural crops, there has been limited study with regard to commercialization of horticultural crops mainly focusing on vegetable crops. However, vegetables are commodities which have higher value at market turning by more on consumption purpose than commercializing, and this is due to lack of information and other related factors. Vegetable commercialization by smallholder farmers are determined by household characteristics, household resource endowments, institutional factors, infrastructural factors and market related factors (**Goitom, 2009; Bekele *et al*., 2010**). Although Ethiopian farmers are producing more of surplus vegetables, they are not much linked with markets and thus why their opportunity to diversify their livelihoods from vegetable production is very much limited. Thus, getting access to markets for vegetable marketing is a great important to diversify the livelihoods of smallholder farmers and reduces the rural poverty (**World Bank, 2008**). As long as my knowledge concerns and reports from government offices, there is little empirical evidence on smallholder vegetable commercialization and its associated factors in Ethiopia. Other studies carried out in Ethiopia focused on the commercialization of horticultural crops without particular investigation of vegetables. Moreover, those studies who worked out have been focusing on the proportion of output sold in market. In this study, we address such gabs in the literature.

Therefore, this research aims at linking smallholder fruit producers with markets to enhance the demand of the products and increase means of generating their income. Therefore, this study was conducted with the objective of examining smallholder fruit commercialization and their associated factors in the study context. This may be valuable input for smallholder farmers, policy makers and other stakeholders in revealing the gab in the performance of the current fruit production system to realize the nation development policy.

DATA AND METHODS

Sampling methods and procedures

The study was conducted in southwest part of Ethiopia by selecting sampled respondents as sample size based on determining factors and levels of accuracy required. In this regard, this survey was conducted in three districts in southwest part of Ethiopia and these districts were selected purposively on the basis of better production potential of fruits. From these selected districts again eight kebeles were also selected purposefully where the production potential of fruits is very high. Finally, 240 sampled households were selected using simple random sampling method assisted by probability proportion to size. Then, a total of respondents were used for personal interview by using well trained and qualified enumerators (Table 1).

Data types, sources and methods of collection

To answer the research questions and objective of the study both qualitative and quantitative data were collected from primary and secondary sources. The primary data were collected from fruit producers as sampled households, agricultural experts, local leaders and other subject matter specialists on various aspects of commercializing fruits. Primary data were collected from the respondents using a pre-testing questionnaires, structured interview schedule and closed and open-ended questionnaires by well-trained enumerators closely supervised by the researchers. Moreover, restructuring had been done using sufficient number of non-sampled respondents through pilot study in order to suitably modify the questionnaire and facilitate smooth administration. Secondary data were previous research findings and reports collected from kebeles, districts, agricultural offices, ministry of trade, trade and revenue offices. Moreover, qualitative data were collected through discussions with different agents by using focus group discussion and key informant interviews, and this served as a supplementary to quantitative data. Focus group discussions were done on specific topics with small groups of [people that consist of 10-15 farmers who are fruit-producers. Checklist was also employed to spark out the discussion to obtain the primary data from group discussion members, key informant interviews and other officials during field survey.

Methods

The unit of analysis in this study was fruit producers. To analyse the collected data both descriptive statistics and econometric models were used. The descriptive methods like mean, percentage, t-test and chi square test were used. Probit model were also used based on the nature of dependent variable. Collinearity can increase estimates of parameter variance; yield models in which no variable is statistically significant even though R^2y or $Pseudo - R^2y$ is large; produce parameter estimates of the "incorrect sign" and of non-reasonable magnitude; create situations in which small changes in the data produce wide swings in parameter estimates; and, in truly extreme cases, prevent the numerical solution of a model (**O'Brien, 2007**).

R^2 is used to represent the proportion of variance in the i^{th} independent variable that is associated with the other independent variables in the model. It is an excellent measure of the Collinearity of the i^{th} independent variable with the other independent variables in the model. Tolerance is the percentage of variance in a dependent variable that is not accounted for by other independent variable(s). This represents the proportion of variance in the i^{th} independent variable that is not related to the other independent variables in the model. Its value for the i^{th} independent variable is one minus the proportion of variance it shares with the other independent variable in the analysis $(1 - R_i^2)$. The Variance Inflation Factor (VIF) is the reciprocal of tolerance (Eq. 1).

$$\mathrm{VIF_i} = \frac{1}{(1-\mathrm{R_i^2})} \qquad (1)$$

Where: R^2-is multiple correlation coefficients between X_i and other explanatory variables. Note: VIF is the measure of multicollinearity between continuous independent variables. As a rule of thumb, if the VIF of a variable exceeds 10, which will happen if R_i^2 exceeds 0.90, that variable is said be highly collinear (**Kleinbaum *et al.*, 1988).**

Between dummy independent variables the presence of multicollinearity problem is detected from determination of contingency coefficient. Contingency coefficients can be used to estimate the extent of the relationship between two variables, or to show the strength of a relationship. The Collinearity between dummy variables was tested using contingency coefficient. This is another chi-square based on measure of association that can be used to show if there is a correlation (Eq. 2).

$$\mathrm{CC} = \sqrt[2]{\frac{\chi^2}{\chi^2+\mathrm{n}}} \qquad (2)$$

Where: χ^2 chi-square statistic, n sample size

It is a symmetric measure which indicates the strength and significance of the relation between the row and column variables of a cross tabulation. When there is no relationship between the two dummy variables, each of these measures has a value of 0. As common characteristics (relationship) between the variables increases, each of these measures also increases, although by different amounts. When CC exceeds 0.75 it is an indication of serious multicollinearity relationship between variables (**Gujarati, 1995**). To analyse determinants of smallholder farmers' participation in marketing of fruits Probit model was used. Participation in marketing decision of the respondents was taken as the dependent variable with value of 1 if the farmer participated and 0 otherwise. In this model the probability that Y=1 (the probability that the household participates in fruit marketing) was estimated using the cumulative standard normal distribution function. Assume that Y can be represented by market participation and the regression equation is representing market participation (dependent variable, Y) and the independent variables are given by Eq. 3.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k + U_{1xki} = x\beta + u \qquad (3)$$

Where: Y represents market participation, X represents the factors that determine market participation ßo and ß1-k are estimable parameters, U is the error term. The researchers opted to use the Probit regression model to identify the determinant factors that affect the decision of smallholders to participate in the market output. The reason why the Probit model used is the dependent variable is a dichotomous. Accordingly, the dependent variable assumes only two values; 1 if the household participates in output market and 0 if he/she doesn't. Thus, the Probit model is given by the Eq. 4. Y= 1 if a household participates in the market, and Y= 0 otherwise.

$$P\left(Y = \frac{1}{X}\right) = F(X\beta) = \frac{1}{\sqrt{2\pi}\int_{-\infty}^{x\beta} e^{-\left(\frac{x\beta}{2}\right)^2} dx} \qquad (4)$$

Where:

$X = (x_1 i, x_2 i, \dots x_k i)$

$\beta' = (\beta_0, \beta_1 - \beta_k)$

In the course of identifying factors influencing the participation decision in marketing of fruits the main task is to analyse which factors influence the participation of fruit products. Therefore, potential explanatory variables, which are hypothesized to influence the market participation and fruit products (Table 2). Market participation is the dummy variable that represents the market participation of the household that is regressed in the Probit model. The dependent variable was smallholder fruit commercialization (market participation). It was determined by different factors such as socio-economic, demographic and institutional factors. So, for the households who participate in market it takes the value of 1 where as it takes the value of 0 for otherwise. The explanatory variables were hypothesized to influence the market participation decision of fruit producers. These variables and their influence are described in Table 2.

RESULTS AND DISCUSSION

Descriptive statistics

Age of household heads is a continuous variable measured in terms of years. The results (Table 3) indicate that the mean age of fruit producers participating in the market was 39.53 years where as 57.86 years was for non-market participants. The mean age of non-market participants was greater than that of market participants. This implies that young households were more participating in selling of fruits than old people households. The result of the t-test indicates that the mean age difference between the market participants and non-market participants was statistically significant at 1% probability level.

Family Size is a continuous variable referring the number of total family members in the household. The mean family size of market participants (3.78 members) was less than non-market participants (7.15 members) (Table 3). This implies that the number of consumers were larger in non-participants than market participants hence the size of the family does not go along with the consumption level of the households. Thus why, a few of households were limiting themselves in commercializing of fruits due to lack of sufficient fruits for selling purpose, rather for consumption. The result of the t-test shows that the mean household family size difference between the market participants and non-market participants was statistically significant at 1% probability level.

Distance to market place is a continuous variable measured in terms of kilometres. It was found that the mean distance of the non-market participants (8.15km) was greater than market participants (4.26km). This indicates that majority of non-market participants were far from the market place as compared to market participants provided that their participation in marketing of fruits is becoming tapered. The result of the t-test shows that the mean difference between distance of household residence to the nearest market for the market participants and non-market participants was statistically significant at 1% probability level.

Table 1: The name of districts, kebeles and the final sampled respondents

Name of Districts	Name of kebeles	Total pop. in each selected kebeles	Proportion of sampled households (%)	Total sampled households
Dedo	Waro kolobo	4322	12.08	29
	Ganjo Abbe	4026	11.25	27
	Ofole korti	4531	12.92	31
Kersa	Marawwa	3502	10.00	24
	Siba	4846	13.75	33
	Girma	4123	11.67	28
Seka	Shane kochi	5268	15.00	36
Chokorssa	Buyo kachama	4737	13.33	32
Total		35355	100.00	240

Source: Authors computation (2018)

Table 2: Description of explanatory variables for Probit estimation

Variable	Type of variable	Measurement	Expected Effect
Age of households	Continuous	Number of years	+
Family size of household	Continuous	Number of children per household head	-
Education of household heads	Categorical	Education status of the household head	+
Household labour size	Continuous	Number of labour force participating in marketing	+
Access to market information	Dummy	1=Yes, 0 otherwise	+
Access to transport services	Dummy	1=Yes, 0 otherwise	+
Off-farm income	Dummy	1=Yes, 0 otherwise	+
Access to extension service	Dummy	1=Yes, 0 otherwise	+
Distance to market place	Continuous	Kilometer	-
Using improved seeds	Dummy	1=Yes, 0 otherwise	+
Perishability of fruit products	Dummy	1=Yes, 0 otherwise	_

Source: Authors computation (2018)

Labour market refers to the availability of labour in terms of both supply and demand for producing as well as marketing of fruits. During discussion with the respondents marketing of fruits was very difficult task for one person rather in cooperation. Table 3 reveals that 40.48% of market participants had no enough labour while 59.52% of them had enough labour for both production and marketing of fruits. In the case of non-market participants 55.26% of them had no enough labour but 44.74% of them had no labour problem. On another hand, market participants had more enough labour force than non-market participants for fruit marketing. The result of chi square test showed that the difference between market participants and non-market participants was statistically significant at 5% probability level based on the labour market.

Access to market information indicates that farmers need to be able to get their products to market and receive equitable price treatment. Farmers need information pertaining output prices so as to make the right decision, ahead of the production season, regarding which type of crops to produce and sell and which crops to purchase from the market. 49.21% of market participants and 35.09% of non-market participants had access to market information but 50.79%of market participants and 64.91% of non-market participants had no access to market information (Table 4). Similarly, majority of the respondents from both market participants and non-participants were unable to getting market information timely and hence they were exposed to selling their fruits with low price at farm gate. During the survey time the respondents reported that they were facing inadequate access to get the system of gathering, analysing and interpreting information about a market, a product or service to be offered for sale in that market. Result of chi square test the difference between market participants and non-market participants was statistically significant at 5% probability level based on access to market information.

Access to transport refers to out taking fruit products from one place to the market place for the purpose of selling by means transportation in the study area. Table 4 presents those farmers who had the problem of getting means of transportation or not. 53.97% of market participants and 52.63% of non-market participants had no access to transport but 46.03% of market participants and 47.37% of non-market participants were getting access to transport service (Table 4). This indicates that majority of the smallholder farmers were located in remote areas with poor transport services so that failure of smallholder farmers' participating in the marketing of fruits happened. However, the chi-square test reflects that there is no statistically significant difference between market participants and non-market participants based on access to transport.

Participation in off-farm activities like sales of butter, cheese, coffee, crops, chat and other livestock products are the major off-farm activities and cash income sources. 48.41% of market participants and 18.42% of non-market participants were taking part in off-farm activities but 51.59% market participants and 81.58% of non-market participants didn't participate in it (Table 4). This shows that fruit market participants were more participating in off-farm activities than non-market participants. The result of chi square shows that the difference between market participants and non-market participants was statistically significant at 1% probability level based on participation of off-farm activities.

Access to extension services are essential factors that enable farmers to improve their practices and help them respond to emerging challenges. Knowledge, ideas, attitudes and skills gained through extension programmes can help farmers increase their productivity, reduce losses, and gain better access to markets. Table (4) reflects majority of the non-market participants were getting less access to extension services than market participants especially on market price, costs, benefits, transactions, and time of selling. Moreover, from the total of sampled respondents 47.92% had got access to extension services while 52.08% didn't get it. This shows that there was the problem of inadequate extension services delivered to smallholder fruit producers in the study area. The result of chi square test showed that the difference between market participants and non-market participants was statistically significant at 5% probability level based on access to extension service.

Improved seed variety is another factor that determines both the production of fruits and the chance of participating in the output markets. Table 4 presents that 48.41% of market participants and 41.23% of non-market participants used improved fruit seeds but 51.59% of market participants and 58.77% of non-market participants didn't get it. Smallholder fruit producers who were getting access to improved fruit seeds were market participants as compared to non-market participants. Even though seeds were available on the market their quality was very low so that fruit producers wouldn't have increased the level of their production and brought for marketing. However, the chi square result shows that the difference between market participants and non-market participants was not statistically significant.

Perishability of fruits is used in marketing to describe the way in which service capacity cannot be stored for fruit sale in the future. Fruits are usually soft, fleshy, edible plant products because of their high moisture content they are relatively perishable. The results in Table 4 shows that among the market participants of fruit producers 59.52% of them wouldn't have access to storage facilities but 40.48% of them had. In the case of non-market participants 57.89% of them had storage facilities but 42.11% didn't have this service. However, the chi square test result shows that the difference between market participants and non-market participants was not statistically significant.

Educational level is a categorical variable that is measured in terms of educational level or schooling. The results (Table 5) indicate that 57.14% of market participants were illiterate, 21.43% attained primary education, 11.90% attained secondary education and 9.52% attained tertiary education where as 63.16%, 12.28% and 2.63%2.63% of them were attained illiterate, primary education, secondary education and tertiary education for non-market participants, respectively. This indicates that majority of sampled respondents were fallen under the illiterate and primary education in both market participants and non-market participants. However, the result of the chi-square test shows that education level was not statistically significant.

Determinants of smallholder's participation decision in commercialization of fruits

This sub-section presents the results of Probit regression model. If households sold fruits any value above zero, they were considered as participants and if not they are non-participants. The decision of smallholder farmers to participate in the marketing of fruits is determined by the maximum likelihood estimation. To obtain the marginal effects the post estimation of the selection equation results was done to analyse the data. The marginal effects were used for interpretation and it has also a direct interpretation (Table 6).

Age of household heads was statistically significant and negatively influenced farmers' likelihood to participate in fruit marketing at 1% probability level. The marginal effect shows that all other factors constant, the probability of households to participate in fruit marketing decreases by 1.8% as the age of household head increases by one year. This implies that younger people are more attached with technology and update their business mind with marketing issues so that youths were more participating in fruit marketing than elders in the study area. The older people are fewer participants in pineapple market than the younger people **(Geoffrey *et al.*, 2014)**. **Barret (2007)** also indicated that young people are more active in marketing of commodities than the older once because young people are more amenable to accept new ideas than the older, and the older people are also more risk averter than the younger once.

Table 3: Summary statistics for continuous variables

Variables	Market Participants (N=126)				Non-market Participants (N=114)				t	μ
	Min	Max	Mean	Std dev.	Min	Max	Mean	Std dev.		
Age	20	88	39.53	12.74	17	92	57.86	19.97	8.56	0.0000***
Family size	1	11	3.78	1.85	1	14	7.15	2.33	12.46	0.0000***
Distance	1	15	4.26	2.76	1	20	8.15	3.65	9.36	0.0000***

Source: Authors computation (2018); *** indicates significant at the probability level of 1%.

Table 4: Summary statistics for dummy variables

Variables	Market-participant		Non-market participant		Total		χ^2	μ
	N	%	N	%	N	%		
Labour market								
No	51	40.48	63	55.26	114	47.50	5.2477	0.022**
Yes	75	59.52	51	44.74	126	52.50		
Market information								
No	64	50.79	74	64.91	138	57.50	4.8819	0.027**
Yes	62	49.21	40	35.09	102	42.50		
Access to transport								
No	68	53.97	60	52.63	128	53.33	0.0430	0.836
Yes	58	46.03	54	47.37	112	46.67		
Off-farm activities								
No	65	51.59	93	81.58	158	65.83	23.9341	0.000***
Yes	61	48.41	21	18.42	82	34.17		
Extension contact								
No	54	42.86	71	62.28	125	52.08	9.0477	0.003***
Yes	72	57.14	43	37.72	115	47.92		
Improved seeds								
No	65	51.59	67	58.77	132	55.00	1.2482	0.264
Yes	61	48.41	47	41.23	108	45.00		
Perishability								
No	75	59.52	66	57.89	141	58.75	0.0655	0.798
Yes	51	40.48	48	42.11	99	41.25		

Source: Authors computation (2018); Notes: ***, **, represents statistically significant at the probability level of 1% and 5% respectively

Table 5: Summary statistics for categorical variables

Variable	Response	Market-participant		Non-market participant		Total			
		N	%	N	%	N	%	χ^2	μ
Educational level	Illiterate	72	57.14	72	63.16	144	60.00	4.9237	0.177
	Primary	27	21.43	14	12.28	52	21.67		
	Secondary	15	11.90	3	2.63	29	12.08		
	Tertiary	12	9.52	3	2.63	15	6.25		

Source: Authors computation (2018);

Table 6: Results of Marginal Effects of Probit Regression

Explanatory variables	Maximum Likelihood (Coeff)	Marginal Effects (dy/dx)	P>Z
Age of household heads	-.047	-.018	0.000***
Family size of the household	-.436	-.168	0.000***
Education of household heads	.170	.065	0.309
Household labour size	-.069	-.026	0.831
Access to market information	.166	.064	0.620
Access to transport services	1.384	.532	0.000***
Off-farm income	.960	.369	0.016**
Frequency of extension contact	.590	.226	0.066*
Distance to market place	-.260	-.100	0.000***
Using improved seeds	-.639	-.245	0.068*
Perishability of vegetables	-.859	-.330	0.017**

Source: Authors computation (2018); Notes: ***, ** and * implies statistically significance at 1, 5, and 10% probability level respectively, N =240, LR chi2 (12) = 242.56, Prob > chi^2=0.0000, Log likelihood=-44.775389. Pseudo R^2=0.7304

Household family size was negatively influenced household's market participation in fruit commercialization and its influence was statistically significant at 1% probability level. The marginal effect shows that keeping all other factors constant, the probability of household's market participation decreases by 16.8% as the size of the family size increases by one person. stated that as the number of household member increases more, the probability of household's market participation decreases more hence they consume fruit more **(Tufa *et al*., 2014)**. In other way round, the level of household market participation in selling of fruits decreases when the number of months to be feed increases, and disproportionate volume of production provided. Larger households are more expected to have lower market participation, controlling labour supply **(Berhanu *et al*., 2013)**.

Regarding access to transport service this variable was positively influenced farmers' likelihood to participate in fruit marketing and significantly at 1% probability level. All other factors keeping constant, improving access to transport services including its cost increases the probability of smallholder participation in fruit marketing by 53.2%. This implies that farmers prefer selling of fruits at urban market to local market and farm gate to get the right price so that the farmer is likely to choose the one which gives higher benefits. So, place of marketing determines farmers' choice to sell their fruit products at high price or low price. This further explains that most of the time rural farmers are facing the problem of lack of transportations so that their probability to sell fruit at urban market or at the right price would decrease. This brings them the opportunity to sell fruits at farm gate and their preference to select market is also limited. This result agrees with the argument of (**Matsane and Oyekale, 2014**).

Off-farm income was positively and significantly influenced market participation of smallholder fruit producers in the study area. Keeping all other factors constant, an increase in off-farm income increases the probability of participating in fruit market by 36.9%. This implies that those farmers who wouldn't have land for fruit production they ought to go for marketing of fruit by circulating from one market to another market to get extra income. On the other hand, most of the households who are lacking assets they probably have better options in off-farm jobs and/or they are better to migrate to the towns/cities as retailers/whole sellers of fruits to increase their income.

Frequency of extension contact was statistically significant and positively influenced the participation of the households in marketing of fruits at 1% probability level. This further indicates that, keeping all other factors constant, the probability of household's participation in marketing of fruits increase by 22.6%, when the rate of households' contact with extension agents increases by providing training and advisory services. This implies that the knowledge, skill, ideas and shaping attitudes gained through extension agents can improve household's productivity, access to market and also reduces losses. **Meron (2015)** noted that as the arte of extension agents visiting rural households increases more, the rate of household's in market participation also increases especially it can have a positive impact on improving vegetable and post-harvest management practices by improving the household's intellectual capacities. As frequency of extension visit should increase and not decrease the level of market participation (**Gani and Adeoti, 2011**).

Distance of market place was found to be statically significant and negatively influenced on marketing of fruits at 1% probability level. As the marginal effects shows the probability of household participation in marketing of fruits decreases by 10.0%, the distance of farmers from market increases by 1km, keeping all other factors constant. This indicates that as farmers are more near to the market place their participation in fruit marketing becomes increasing hence fruits are easily putrefied from too far. The degree of commercializing fruits increases as the distance of market from farmer's residence is too small (**Tufa *et al.*, 2014)**. **Ogunleye and Oladeji (2007)** pointed out that the extent of farmer's market participations is hampered by a greater distance to the market.

Using improved fruit seeds was found to be statistically significant and negatively influenced the commercialization of fruits at 10% probability level. The marginal effects estimates indicate that keeping all other factors constant, an increase in using improved selected seeds decreases the probability of farmers' participation in marketing of fruits by 24.5%. During survey time the respondents said that though seed was also available on the market, its quality was very low and its price was also very high. These two problems affected both the production of fruits and the chance of farmers' participation in the output markets.

Perishability of fruit products was found to be negatively related with farmer's participation in marketing of fruits and significantly influenced on marketing of fruits at 5% probability level. The marginal affects show that keeping all other factors constant, an increase in perishability of fruit products decreases the probability of farmers' participation in fruit marketing by 33%. This further entails that most of the time rural farmers don't have access to storage facilities to preserve fruit products until they get buyers so that they can't wait for marketing rather consumption. This decreases the participation of farmers in fruit marketing because of high fruit perishability. **Rais and Sheoran (2015)** stated that perishability of fruits is responsible for high market costs, market gluts, price fluctuations and other similar problems; and lack of cold storage and cold chain facilities are becoming bottle necks in tapping the marketing potential of fruits.

CONCLUSIONS AND RECOMMENDATIONS

The main objective of the research is to analyse determinants of commercializing fruits by smallholders in the southern part of Ethiopia. Accordingly, out of the twelve independent variables hypothesized to have influence on smallholder commercialization of fruits; eight variables (namely age of household heads, family size, extension contact, distance from settlement to market place**,** improved seeds, and perishability were negatively affected commercialization of fruits and also statistically significant; but place of selling and off/non-farm activities were affected commercialization of fruits positively and also statically significant. Based on the findings of the study, the following key recommendations might be forwarded to the concerned organizations to improve smallholder commercialization of fruits in Ethiopian context:

- Expanding village markets in the rural areas is very essential in consultation with government agencies to reduce transportation costs and also older farmers can easily use the markets without going long distance. Creating good environment for older farmers as they can sell their fruits at farm gate and village markets through brokers with fair price.
- For those producers who had the problem of lack of information, equipping them with training on how to sell, where to sell and when to sell their products might be provided. The problem of market price information was happened at farm-gate which was found to be inadequate because the farmers are forced to be price takers which result in lower prices. Therefore, the government and other policy makers should increase the marketing information and abilities of smallholder fruit farmers especially on disseminating price information through radio, TV, extension service, religious organizations, informal cooperative organizations (such as idir and equip) so that the farmers are encouraged to take their fruit products to competitive places where the prices are higher. Providing awareness for fruit producers on how much participation in off-farm activities links them with market issues.
- Training farmers how to use appropriate family planning to balance fruit production for both consumption and marketing. Encouraging extension agents to have frequent contacts with fruit producers to add their knowledge and skill with improved production, handling, storing and marketing for future consumer preferences. The government should provide enough improved fruit varieties timely by sustaining its quality and creating controlling system during delivering to farmers. Maintenance of transport, storage and other handling facilities are generally poor in the study area. Providing adequate storage facilities and involving proper regulation of temperature, humidity, air circulation, proper stacking pattern, regular inspection, and prompt produce disposal as soon as maximum storage life has been attained.
- Finally, there is need for further research to critically analyse other factors affecting the commercialization of smallholder fruit producers.

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REGULAR ARTICLE

FARMERS' RISK ATTITUDES, LOCATIONS AND DECISIONS TO ADOPT IMPROVED RICE VARIETIES IN OGUN STATE NIGERIA

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ABSTRACT

Farmers' willingness to taking risky decisions has important economic implications. However, while such attitudes have been previously examined, the relationship between farmers' risk attitudes and locations has not attracted research attention. This study examined the relationship between rice farmers' risk attitudes and locations, as well as the correlation between farmers' risk attitudes and past investment decisions (adoption of improved rice technology). The study utilized survey and experimental data collected across the four agricultural zones in Ogun State Nigeria. The data were descriptively analysed using frequency tables, histogram, principal component and correlation analyses. The results showed that most sampled farmers avoid taking risky prospects, with those located in the rural agricultural zones tend to avoid risk taking than their counterparts in other locations. More importantly, rice farmers' risk attitudes negatively correlated with adoption decisions. This correlation evidently confirmed spatial relationship in risk attitudes and farmers' pattern of adoption. Similar patterns of adoption and risk attitudes suggest spatial heterogeneity which have consequences on farmers' investment decisions, income and wealth accumulation.

Keywords: agricultural zones, investment decisions, rice farmers, risk attitudes
JEL: O1, O3, R1, R2

INTRODUCTION

Ability to take risky investment decisions may reflect in the income of farmers. This has multiplier effects on the economic development of a nation. Indeed, risk-taking individuals may have higher propensity to invest in economic activities that are associated with higher degree of risk and uncertainty but give higher economic returns. Specifically, decisions to adopt improved agricultural technology have been identified as important factor to improving farmers' income and livelihoods. In other words, investment decisions are often influenced by the attitudes of farmers toward risk taking.

The above assertion has been widely corroborated by many studies which conclude risk aversion negatively affect investment decisions especially adoption of improved agricultural technology (**Marra *et al.*, 2003; Liu, 2013; Barham *et al.*, 2014; Barham *et al.*, 2015).** No doubt, everyday life experience including decisions on the choices of food, children education, investment in productive economic activities, etc. are associated with risk and uncertainty. Since such decisions may have positive or negative economic consequences, it suggests the need to pay special research attention to the risk attitudes of farmers.

Much has been reported about the risk attitudes of farmers in the developing countries (**Harrison *et al.*, 2010; Brick *et al.* 2012**). However, the relationship between farmers' locations, risk attitudes and investment decisions has not received the desire attention in the literature. This study fills these gaps by examining the effects of farmers' locations in risky decision making and analyse the relationship between farmers' risk preferences and adoption of improved rice varieties as past investment experience. As earlier noted, rice farmers may show similar patterns of risk behaviour due to geographical proximity as well as the ecological conditions in the environment where they operate. Such behaviour may also be attributed to social interaction and interpersonal communication which are common phenomenon in rural areas. Therefore, this study extends knowledge on the potential correlation between experimental risk decisions and real life investment decisions.

Locations are important spatial variable that may be correlated with decision making with respect to experimental risk and real life economic investment. For instance, farmers may be spatially correlated on farm decisions with one another attributable to the presence or absence of social interaction, informal communication, as well as the existing climatic conditions in the area where they live. Like many individuals, rice farmers do rely on the information provided by their neighbours to make decisions that affect their daily activities including engagement or investment in new economic opportunities. However, while locations may be physically measured, risk attitudes are latent or intrinsic in nature. Therefore, the objective of this paper is to examine how rice farmers' risk attitudes correlate in space and with past investment decisions.

DATA AND METHODS

This section covers a brief description of the study area followed by the explanation on the nature of the risk experiment, the data collection method and the analytical methods applied.

The Study Locations

This study uses the experimental and survey data from Ogun State, Nigeria. The field work was carried out between March and May, 2016 across the four agricultural zones of Ogun State Agricultural Development Programme (OGADEP hereafter). These agricultural zones reflect the socio-economic and climatic conditions of farmers. For example, the northern part of Abeokuta zone is derived savannah vegetation while the southern part is rain forest. The Ilaro zone is derived savannah vegetation in the north and rain forest belt and mangrove swamp in the south. The Ilaro zone has the attributes of rural compared to Abeokuta zone. Ikenne is the closest zone to Abeokuta zone which it bounds in the west. The vegetation of this zone is mainly rain forest belt. The Ikene zone is also more rural relative to Abeokuta zone. Like Abeokuta zone, Ijebu-Ode zone combines both rural and urban features. The northern part is mainly rain forest belt while the southern part is mangrove swamp comprising vegetation. Given the above slight variation in the features of the Study Area, it is expected that rice farmers may behave differently across the four agricultural locations.

The Experiment

Advancement in the literature reveals risk attitudes' elicitation methods depend on nature and context. The readers are referred to **Charness et al. (2013)** for a comprehensive review on the risk preferences elicitation methods including the advantages and disadvantages. **Harrison and Rutstrom (2008)** equally summarized the different ways of eliciting individual risk attitudes.

The laboratory-based methods have been used mostly among the educated subjects who are computer literate and have good knowledge of information and communication technology (ICT). This study adapted the panel lotteries used by **García Gallego, *et al*, 2012** which was built on S**abater-Grande and Georgantzis (2002)** (SGG hereafter) but modified the nomenclatures to small gain one (SG1), small gain two (SG2), large gain one (LG1) and large gain two (LG2) because all the four treatments are in the gain domains. The original SGG lotteries were presented in the Spanish currency, peseta while all the follow-up studies presented their experiments in Euro (**Attanasi, *et al*., 2018)**. In this study, the experiment is conducted in Nigerian currency using 1 Euro to 225 Nigerian Naira as exchange rate. The reader is referred to a recent study which compares risk attitudes across elicitation methods: SGG, HL and self-reported. **Attanasi *et al*. (2018)** provides a distinction between SGG, HL (MPL) and self-reported risk elicitation methods. Supported with empirical evidences, they reported that subjects showing risk averse attitudes under the HL are equally averse to risk under SGG. However, subjects classified as risk neutral and risk loving under HL were risk averse under SGG.A significant positive correlation is also reported between the risk ordering under HL and SGG and between SGG and self-reported risk method.

The panel lotteries are summarized in Table 1. The probabilities vary across the rows in each panel. Rice farmers who avoid taking risky decisions are more likely to choose from the first few rows (top five options) while risk neutral and risk loving subjects may prefer payoffs that are closer to the bottom (last five rows). The term risk avoidance is used in place of risk aversion in this study because the parameter of the utility function is not estimated.

It follows that avoidance of zero earning and higher rewards indicates risk aversion. Only one of the panels in each treatment determines the earnings. However, this task was not incentivized due to high rewards involved and to prevent non-rice farmers from participating in the experiment.

As at the time of the experiment, the average rewards associated with the SG1 and SG2 are below the average minimum farm labour wage rate of 1,500 Naira. On the other hand, the rewards associated with the LG1 and LG2 are above the wage rate at that time. Both rewards (small and large) are presented to farmers to reflect their farm income and the reality of the economic situation in the study area. At times, farmers run at loss on their farm business. On another time they make profit at margin or at equilibrium. In addition, this variation in average rewards assists in the examination of the real risk attitudes of farmers as well as sensitivity to change in rewards (farm profit).

Data Collection Methods

Rice farmers were individually interviewed across 46 different locations (towns and villages). A total number of 329 rice farmers were drawn from the predominant rice growing areas in the four OGADEP zones with 328 fully completed questionnaires used for final analysis. The questionnaire composed of two main sections: risk experiment and the socio-economic characteristics of the respondents. The data collected on the adoption of high yielding rice varieties as past investment decisions as well as the experimental data are used in this study. The risk attitudes of rice farmers were elicited using the choice experiments described above.

The data collection was assisted by trained post-graduate students as enumerators. Before the field work, enumerators were illustrated with the record sheets which serve as guide in addition to the information on the use of the smart phone software (technology) called open data kit (ODK collect). The data were electronically recorded. Notwithstanding, the geographical point systems (GPS) of many locations were manually recorded due to poor or absence of mobile networks. Farmers were contacted at different locations including homes and farms. The risk experiment was conducted first, followed by questions on the socio-economic factors.

Experimental Instruction

After welcoming rice farmers with brief explanation on the importance of the survey, experiments and the potential impact of the study, instructions were read out to individual farmers as follows. The experiment has four panels with ten options each, the winning prize or payoff in each panel is the amount of Naira shown under the heading "amount". The ten blue balls imply hundred per cent chances (sure) of winning while one blue ball represents ten per cent chance of winning a payoff. Conversely, the red balls imply loss. Subjects earn nothing if they do not win the lottery. Your earning would be determined by tossing a four-sided die. In other words, only one panel would be used for payment with any of the number 1, 2, 3 or 4 occurring from a toss of four-sided die determines the payment panel. For instance, if you choose option seven and one appears during die toss, you will win N563 if any of the balls 1, 2, 3 or 4 is drawn from the bag and nothing otherwise. Lastly, the record sheet was shown to farmers to make their choices. The explanation given for other treatments is similar to that of small gain one. Each subject is shown with a bag containing ten mixed blue and red balls which represent the winning and losing probability in the risk experiment. The experiment is not incentivized.

The data collected were analysed using frequency tables, histogram, principal component analysis and correlation analyses.

RESULTS AND DISCUSSION

This section presents the results of the findings starting from the socio-demographic characteristics of rice farmers. This is followed by farmers' risk attitudes. The correlation between risk attitudes and past investment decisions is presented last. The centroid as the starting point, an average distance of 5.91 km is covered in Ilaro agricultural zone and approximately 19 per cent of the sample came from this zone (Table 2). With reference to the centroid, the average distances covered in Abeokuta, Ikenne and Ijebu-ode zones are 20.46 km, 40.72 km and 126.30 km respectively. The proportion of these three zones to the total sample includes 28 per cent, 26 per cent and 27 per cent, respectively.

Rice Farmers' Risk Attitudes across Stakes

Average values are computed for each treatment due to high correlation between the risk attitudes obtained across panels. The distribution of rice farmers' risk attitudes with respect to average treatment (SG1, SG2, LG1 and LG2) are depicted in Figure 1. Note that the closer the probability to 1, the higher the tendency to avoid risk taking. The mean probability values are 0.79, 0.64, 0.73 and 0.59 respectively for SG1, SG2, LG1 and LG2 (median: 0.85, 0.65, 0.75 and 0.60, respectively) indicating rice farmers generally avoid risk taking when confronted with outcomes or lotteries with sure amount relative to when faced with the more risky lotteries. A sizeable proportion of farmers are highly willing to take risk when confronted with SG1 compared to SG2. More so, rice farmers are motivated to taking risky decisions when faced with large stake. The reason may be attributed to the fact that most subjects tend to favour less risky outcomes which are the main attribute of the SG1 and LG1 lotteries but motivated to taking risky decisions under SG2 and LG2 lotteries which have no sure outcomes. On the other hands, it reflects the sensitivity of subjects to risky outcomes as well as the size of stakes.

Table 1: Risk Panel Lotteries' Payoffs

Panel Lotteries for Four Treatments (currency in Nigerian naira)										
P	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
$X(SG1)$										
Panel 1	225	251	282	322	376	451	563	751	1,126	2,251
Panel 2	225	251	282	322	376	451	564	753	1,129	2,259
Panel 3	225	251	283	324	379	455	570	762	1,145	2,295
Panel 4	225	252	284	326	382	460	578	774	1,165	2,340
$X(SG2)$										
Panel 1	0	26	57	97	151	226	338	526	901	2,026
Panel 2	0	26	57	97	151	226	339	528	904	2,034
Panel 3	0	26	58	99	154	230	345	537	920	2,070
Panel 4	0	27	59	101	157	235	353	549	940	2,115
$X(LG1)$										
Panel 1	22,500	25,002	28,128	32,148	37,507	45,010	56,265	75,024	112,540	225,090
Panel 2	22,500	25,012	28,150	32,186	37,567	45,100	56,400	75,234	112,900	225,900
Panel 3	22,500	25,056	28,250	32,358	37,834	45,500	57,000	76,167	114,500	229,500
Panel 4	22,500	25,112	28,375	32,572	38,167	46,000	57,750	77,334	116,500	234,000
$X(LG2)$										
Panel 1	0	2,502	5,628	9,648	15,007	22,510	33,765	52,524	90,040	202,590
Panel 2	0	2,512	5,650	9,686	15,067	22,600	33,900	52,734	90,400	203,400
Panel 3	0	2,556	5,750	9,858	15,334	23,000	34,500	53,667	92,000	207,000
Panel 4	0	2,612	5,875	10,072	15,667	23,500	35,250	54,834	94,000	211,500

Source: Authors' Compilation (**Ambali, 2018**)

Table 2: Rice Farmers by Distance and Agricultural Zones

ADP Zones	Distance Mean	SD	Min	Max	Percentage of Total Sample
Ilaro	5.91	4.88	0	22.05	19
Abeokuta	20.46	7.25	9.71	58.32	28
Ikenne	40.72	9.76	33.44	65.26	26
Ijebu-Ode	126.30	17.46	105.47	143.83	27

Note: Distance is in km, SD = standard deviation, Min = minimum, Max = maximum
Source: Own data analysis, 2017

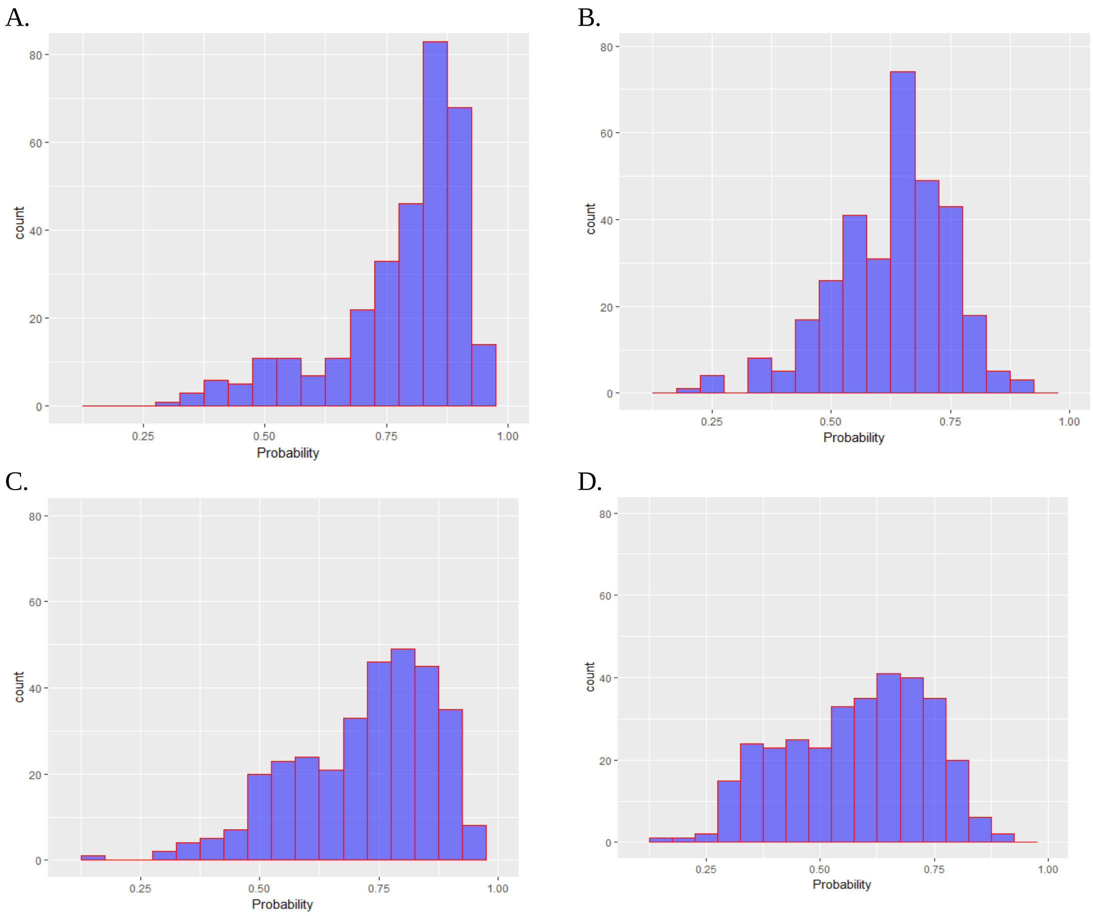

Figure 1: Distribution of Rice Farmers Showing Attitudes toward Risk Taking
Note: A, B, C and D represent SG1, SG2, LG1 and LG2, respectively. *The higher the probability, the less the willingness to risk taking. Willingness to risk taking is lower for SG1 than SG2. Willingness to risk taking is also lower for LG1 compared to LG2.
Source: Own data analysis **(Ambali, 2018**)

A slightly different pattern of risk attitudes is observed among the subjects in the developing country when compared to that reported by **García Gallego *et al.* (2012)** among subjects in a developed country. This variation may be attributed to three reasons. First, this study elicited the risk attitudes of farmers while the above study focuses on students. Thus, there is a difference in the educational level of the subjects which may have direct effect on individual behaviour. Second, the variation may be linked to the differences in age; on average, the students are younger than farmers. Lastly, the settings are different; this present study is conducted among farmers in developing countries.

Comparing across stakes, risk avoidance is higher in LG1 compared to SG1. Willingness to risk taking also increases for small relative to large stakes. These patterns of behaviour suggest that rice farmers risk attitudes move along the lottery stake and domains. Indeed, the fear of losing money may be a motivating factor for farmers to wanting to take risky decisions when faced with SG2 and LG2 lotteries which are more risky but less willing to take risk when faced with gain lotteries with sure outcome (less risky). Practically, rice farmers may be unwilling to adopt improved farm practices which offer higher but uncertain yield. Farmers are however likely to change their perceptions and preferences if they observe their neighbours get more yield and income from growing improved rice varieties.

Rice Farmers' Locations and Risk Attitudes

The summary of the results of the component analysis relating to all the sixteen panels revealed that five components with Eigen values greater than one explain 57.9 per cent of the total variation in risk attitudes of the rice farmers (Table 3). The components are named after the treatments and panels they are more loaded. Component one refers to risk attitude towards SG1 because it explains greater proportions of panel 2 and panel 3 of this treatment, respectively. Component two explains larger percentage of the panel 3 and panel 4 of LG1, respectively. It therefore reflects risk attitude towards LG1. Component three explains higher percentage of the variation in panel 3 and panel 4 of LG2, respectively implying component three is loaded around attitude towards LG2. Furthermore, component four explains most of the variations in the SG2, panel 1 and panel 2 respectively. Thus component four can be referred to as risk attitude towards SG2. Lastly, component five explains higher proportion of the variation in SG2 of panel 3 and panel 4, respectively. Therefore, component five is called attraction to risk returns.

The principal components were summarized in line with agricultural zones to examine the relationship between farmers' locations and risk attitudes. Farmers in Ikenne and Ilaro zones are less willing to take risk with respect to SG1 and LG2 while those in Abeokuta and Ijebu-Ode zones show more willingness to risk taking. The additional advantage of the panel lotteries is the identification of the fifth component which captures attraction to risk, with some rice farmers attracted to risk taking in the SG2. Obviously, farmers in Ikenne zone are more attracted to the risk premium. In summary, rice farmers living in rural communities or agricultural zones are more averse to risk taking relative to those living in urban areas or agricultural zones.

Adoption Decisions and Risk Attitudes

In this study, farmers' risk attitudes are disaggregated across adoption groups to examine the correlation between farmers' past experience (adoption decisions) and risk attitudes (Table 4). The summary of the component analysis shows that non-adopters are less willing to take risky decisions relative to adopters with respect to SG1, SG2 (component two), LG1 and LG2. Note that the figures are compared across the column, thus higher component figures imply less willingness to risk taking or higher tendency to avoiding risk taking. This finding agrees with many empirical studies which conclude risk aversion behaviour has negative effects on investment decisions such as adoption of improved agricultural technology **(Marra, *et al.*, 2003; Barham, *et al.*, 2015)**. It specifically aligns with **Liu (2013)**, which examines ex-post adoption in China and conclude that risk averse farmers adopt Biotechnology (BT) cotton late.

CONCLUSIONS

This study examined the relationship between farmers' locations and risk attitudes, as well as the correlation between risk attitudes and farmers' past adoption decisions. The findings revealed that farmers behaved heterogeneously across locations while most sampled rice farmers avoid risk taking. Locations are important economic variables that determine the level of income and overall economic development. Most economic resources and developmental facilities, including infrastructural facilities, water, lands, schools, etc., are not usually equally or evenly distributed across locations. It follows that risk attitudes may be correlated with the availability or otherwise of these resources. In addition, locations will not only determine investment choices but also the level of income of individuals as well as the economic advancement of a nation. In most cases, farmers' locations are related with their decisions on crop production, harvesting methods, processing techniques, and distribution channels. Furthermore, rice farmers located in the more rural areas out of the four agricultural zones showed less willingness to risk taking. More revealing is the fact that rice farmers' risk attitudes are strongly related with their past investment decisions (adoption of improved rice varieties).

Table 3: Agricultural Zones and Rice Farmers' Risk Attitudes

Zones	SG1	LG1	LG2	SG2	Attraction to risk premium (SG2)
Abeokuta	-0.3786	-0.1041	-0.3813	0.07606	-0.2731
Ilaro	0.0033	0.5490	0.2796	0.3864	0.0055
Ikenne	0.2983	0.08805	0.3545	0.05066	0.1718
Ijebu-Ode	0.08995	-0.3736	-0.1607	-0.4045	0.1055

Note: Non-parametric Kruskal Wallis tests: The null hypotheses of same distribution across the four agricultural zones are rejected at 0.001. The figures are the summary of principal component analysis
Source: Own data analysis **(Ambali, 2018**)

Table 4: Correlation between Risk Attitudes and Adoption Decisions

	SG1	SG2_Comp1	SG2_Comp2	LG1	LG2
Non-adopters	0.0781	-0.0070	0.0489	0.0199	0.0313
Adopters	-0.7758	0.0698	-0.4859	-0.1984	-0.3106

Source: Own data analysis, 2018

Two main policy implications emanate from this study. First, rural areas should be adequately advanced with infrastructural facilities that would improve farmers' socio-economic conditions. At the micro-economic level, decisions are made especially with respect to production and distribution. Thus, infrastructural facilities will not only aid investment decisions, but also increase farmers' income and livelihood. Second, risk attitudes of individual farmers should be given specific attention in policy making because of the direct effects they have on the ability to make investment decisions. In short, risk aversion behaviour affects farmers' income and subsequently economic development. Further research should seek to investigate and identify factors that may explain the relationship between risk attitudes, locations and investment decisions of farmers in the developing countries.

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