CROP PRODUCTIVITY, EFFICIENCY AND COMMERCIALIZATION OF SMALLHOLDER FARMERS IN THE HIGHLANDS OF EASTERN ETHIOPIA

PhD DISSERTATION

ALELIGN ADEME MENGISTU

JANUARY 2017

HARAMAYA UNIVERSITY, HARAMAYA

Crop Productivity, Efficiency and Commercialization of Smallholder Farmers in the Highlands of Eastern Ethiopia

A Dissertation Submitted to the Postgraduate Program Directorate

(School of Agricultural Economics and Agribusiness)

HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

IN AGRICULTURAL ECONOMICS

Alelign Ademe Mengistu

JANUARY 2017

HARAMAYA UNIVERSITY, HARAMAYA

Haramaya University

Postgraduate Program Directorate

I hereby certify that I have read and evaluated this Dissertation entitled "***Crop Productivity, Efficiency and Commercialization of Smallholder Farmers in the Highlands of Eastern Ethiopia***" prepared under my guidance by Alelign Ademe. I recommend that it be submitted as fulfilling the dissertation requirement.

Belaineh Legesse (PhD)	_____	_____
Chairman, Advisory Committee	Signature	Date
Jema Haji (PhD)	_____	_____
Member, Advisory Committee	Signature	Date
Degye Goshu (PhD)	_____	_____
Member, Advisory Committee	Signature	Date

As a member of the Board of Examiners of the PhD Dissertation Open Defense Examination, I certify that I have read and evaluated the dissertation prepared by Alelign Ademe and examined the candidate. I recommend that the dissertation be accepted as fulfilling the dissertation requirement for the degree of Doctor of Philosophy in Agricultural Economics.

_____	_____	_____
Chairperson	Signature	Date
_____	_____	_____
External Examiner	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date

DEDICATION

I would like to dedicate this dissertation to my beloved son, Mikiyas Alelign!

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Dissertation is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Dissertation. Any scholarly matter that is included in the Dissertation has been given recognition through citation.

This Dissertation is submitted in partial fulfillment of the requirement for PhD degree at Haramaya University. The Dissertation is deposited in the Haramaya University Library and is made available to borrowers under the rule of the Library. I solemnly declare that this Dissertation has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotation for this Dissertation may be made without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from our reproduction of this Dissertation in whole or in part may be granted by the Head of the School of Agricultural Economics and Agribusiness when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the Dissertation.

Name: Alelign Ademe Mengistu Signature _____

Date: January 2017

School: Agricultural Economics and Agribusiness

BIOGRAPHICAL SKETCH

Alelign Ademe was born at Dega Damot district, Western Gojjam zone, Amhara Regional State, Ethiopia on January 15, 1978. He attended his elementary education at Dikulkana Elementary School and his secondary school education at Feres Bet Senior Secondary School. He then joined the then Alemaya University, now Haramaya University for his Bachelor of Education Degree in Mathematics in 2000. After graduation, in 2003, the author joined Dire Dawa Comprehensive Secondary School as Mathematics Teacher for 2 years and then joined Agarfa ATVET College as a Senior Instructor from 2005 up to 2007/8. He obtained his Master's degree in Agricultural Economics from Haramaya University in July 2010. He then joined Haramaya University in October 2010 to serve as a lecturer until he re-joined the doctoral program in the same university for his PhD degree in Agricultural Economics 2014.

ACKNOWLEDGEMENTS

First and foremost, I would like to express my special gratitude and appreciation to my advisors Dr. Belaineh Legesse, Dr. Jema Haji, and Dr. Degye Goshu, for their critical comments and support throughout the whole research process. Even when their schedules were tight, I was privileged to have lots of inspiring discussions in their respective offices and shared their fertile professional experiences which let me overcome problems I faced regarding my study.

I need to mention how much I benefited from The Global Research Capacity Building Program of Global Development Network (GDN) under the grant scheme of BERCEA Program, for financing the field research and providing different econometric software and empirical research method trainings for the improvements of this work. In this aspect, my profound sense of gratitude goes to the BERCEA Program designers and coordinators (Dr. Mengistu Ketema and Dr. Degye Goshu). I would like to extend my sincere appreciation and respect to Haramaya University, in general, and School of Agricultural Economics and Agribusiness in particular, for allowing me to pursue my PhD degree study and for the unreserved support and supply of pertinent materials during the study period.

I would also like to acknowledge the commendable efforts put by the data collection team: Mr. Teshome Lejisa, Mr. Sime Shiferaw, Mr. Beyan Ahmed, Mr. Nano Alemu, and Mr. Daniel Alemu who made the data collection effective. My sincere appreciation and thanks goes to Mr. Wondifraw Mihret (Assistant professor) who made the work more readable by editing the language of the manuscript.

My last but deep sense of appreciation goes to Mikiyas Alelign (my beloved son) for his tolerance of overcoming all the challenges during my study period and this is the fruit we enjoy together. I love you my son!

Thank you all!!

ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
AIC	Akaike's Information Criteria
BCC	Banker, Charnes and Cooper
CCR	Charnes, Cooper, and Rhodes
CCI	Crop Commercialization Index
CSA	Central Statistics Agency of Ethiopia
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Program
DFA	Deterministic Frontier Analysis
DMU	Decision Making Unit
EE	Economic Efficiency
EEA	Ethiopian Economic Association
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FTC	Farmers' Training Centre
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
Ha	Hectare
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IMR	Inverse Mill's Ratio
Kg	Kilogram
LM	Lagrange Multiplier
LP	Linear Programming
LR	Likelihood Ratio
ML	Maximum Likelihood
MoFED	Ministry of Finance and Economic Development
NPC	National Planning Commission

OLS	Ordinary Least Squares
PFP	Partial Factor Productivity
PDF	Parametric Distance Functions
SFA	Stochastic Frontier Analysis
SSA	Sub-Saharan Africa
TE	Technical efficiency
TFP	Total Factor Productivity
TLU	Tropical Livestock Unit
VRS	Variable Returns to Scale
WB	World Bank

TABLE OF CONTENTS

STATEMENT OF THE AUTHOR iv
ACKNOWLEDGEMENTS vi
ACRONYMS AND ABBREVIATIONS vii
TABLE OF CONTENTS ix
LIST OF TABLES xii
LIST OF FIGURES xiii
LIST OF TABLES IN THE APPENDIX xiv
ABSTRACT xv
1. INTRODUCTION 1
1.1. Background 1
1.2. Statement of the Problem 3
1.3. Objectives of the Study 5
1.4. Scope and Limitations of the Study 5
1.5. Significance of the Study 6
1.6. Organization of the Dissertation 7
2. LITERATURE REVIEW 8
2.1. Definitions and Concepts 8
2.1.1. Definitions and Concepts of Agricultural Commercialization 8
2.1.2. Definitions and Concepts of Agricultural Productivity and Efficiency 10
2.1.2.1. The concept of productivity 10
2.1.2.2. The concept of efficiency 11
2.2. Theoretical Perspectives 15
2.2.1. Farm Household Production Decisions and Commercialization 15
2.2.2. Theoretical Perspectives of Productivity and Efficiency 18
2.3. Methodological Frameworks 19
2.3.1. Measurement of Market Participation and Market Orientation Indices 19

TABLE OF CONTENTS (Continued)

2.3.2. Measurement of Crop Productivity 21
2.3.3. Measurement of Efficiency 23
2.4. Analytical Framework 27
2.4.1. Analytical Method to Measure Determinants of Crop Market Orientation 27
2.4.2. Analytical Method to Measure Determinants of Market Participation 28
2.4.3. Procedures to Measure the Effect of Market Orientation on Total Factor Productivity 29
2.4.4. Procedures of Cluster-Based DEA Efficiency Analyses 31
2.5. Related Empirical Literature 34
2.5.1. Empirical Studies on the Determinants of Crop Commercialization 34
2.5.2. Empirical Studies of the Effect of Commercial Orientation on Productivity 36
2.5.3. Empirical Studies on Productive Efficiency and its Determinants 37
2.6. Conceptual Framework 41
3. RESEARCH METHODOLOGY 43
3.1. Description of the Study Area 43
3.2. Sampling Design 45
3.3. Data Sources, Types and Data Collection Methods 47
3.4. Methods of Data Analyses 48
3.4.1. Descriptive Statistics 48
3.4.2. Econometric Analysis 49
3.4.2.1. Households' commercial orientation decision and intensity 49
3.4.2.2. Households' output market participation decision and level of sales 50
3.4.2.3. Households' input market participation decision 52
3.4.2.4. Effect of crop commercial orientation on total factor productivity 53
3.4.2.5. Sources of inefficiency 54
3.5. Variables Definition and Hypotheses 55
3.5.1. Definition of Variables for Crop Market Orientation 55
3.5.2. Definition of Variables for Crop Output Market Participation 62

TABLE OF CONTENTS (Continued)

3.5.3. Definition of Variables for Input Market Participation 68

3.5.4. Definition of Variables for the Effect of Commercial Orientation on Total Factor Productivity 72

3.5.5. Definition of Variables for Cluster DEA Efficiency 75

3.5.6. Definition of Variables for Inefficiency of Crop Production 77

4. RESULTS AND DISCUSSION 84

4.1. Descriptive Analysis 84

4.1.1. Characteristics of Sample Households 84

4.1.2. Socio-Economic and Institutional Characteristics 85

4.1.3. Indicators of Crop Output Commercialization 87

4.1.4. Indicators of Crop Input Commercialization 89

4.1.5. Farm Productivity and Production Efficiency Indicators 91

4.2. Econometric Analyses 96

4.2.1. Determinants of Smallholder Farmers' Crop Commercialization 96

4.2.1.1. Determinants of crop market orientation 96

4.2.1.2. Determinants of crop outputs market participation and level of sales 103

4.2.1.3. Determinants of crop input commercialization of smallholder farmers 106

4.2.2. Effects of Farmers' Commercial Orientation on Crop Productivity 109

4.2.3. Efficiency Analysis Using DEA Method 114

4.2.4. Estimation Results of Sources of Inefficiency 121

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 125

5.1. Summary 125

5.2. Conclusions and Recommendations 127

6. REFERENCES 132

7. APPENDICES 151

LIST OF TABLES

Table **Page**

1. Distribution of the sample in districts, *Kebeles* and households 47
2. Description of variables hypothesized to influence crop market orientations 62
3. Description of variables hypothesized to influence crop output market participation 67
4. Description of variables hypothesized to influence fertilizer market participation 71
5. Description of variables hypothesized to influence TFP of crops 75
6. Summary of crop input and output variables used in the DEA models 77
7. Description of variables hypothesized to influence inefficiency of crop production 83
8. Demographic characteristics of sample households 85
9. Tests of equality of means of socio-economic and institutional characteristics of sample households, by crop output market participation 87
10. Market participation and market orientation indices of crop output market participant sample households 89
11. Tests of equality of means for input market participation index and area share of crops, by crop output market participation 91
12. Descriptive statistics of output and production inputs for individual crops 93
13. Descriptive statistics of production input costs for individual crops 95
14. Double-hurdle model estimation results of factors influencing smallholder farmers' crop market orientation 102
15. Heckman selection model two-step estimates result of market participation 105
16. The marginal effect of Tobit estimation results of fertilizer purchases 109
17. 2SLS estimation results of factors influencing TFP 113
18. Summary of the cluster groups DEA efficiency score results 120
19. Inefficiencies and marginal effects (uncensored part) of change in explanatory variables 124

LIST OF FIGURES

Figure **Page**

1. Technical, allocative and economic efficiencies 13
2. Production frontier and technical efficiency 14
3. A conceptual framework of smallholders' crop commercialization and production efficiency at household level 42
4. Geographical location of the study area (East and West Hararghe Zones) 45
5. Dendrograms for hierarchical cluster analysis of efficiency scores 117

LIST OF TABLES IN THE APPENDIX

Appendix Table Page

1. Heckman estimation results of market orientation 152
2. Tobit estimation results on factors affecting fertilizer purchases 153
3. Multicollinearity test on the factors of commercial orientation and productivity 154
4. First-stage regression results expressing the effect of instruments on market orientation 155
5. Multicollinearity diagnostic tests of inefficiency factors using VIF 156
6. Maximum likelihood estimates of the Tobit model 157
7. Conversion factors to compute tropical livestock unit (TLU) 158
8. Conversion factors to compute adult equivalents 159
9. Efficiency scores summary of sample households 160
10. Market participation, market orientation and TFP indices 166

Crop Productivity, Efficiency and Commercialization of Smallholder Farmers in the Highlands of Eastern Ethiopia

ABSTRACT

The agriculture sector is the most important segment in the Ethiopian economy. This is because of its contribution to the national GDP (38.5%) where crop accounted for 27.4%, and provides employment for 72.7% of the total population. Despite efforts made to commercialize and transform Ethiopian agriculture from subsistence to production of high value crops, the sector's performance has been below expectations. In light of the problems and the research gaps identified, this study seeks to address and generate information on the important factors influencing crop productivity, efficiency and commercialization of smallholder farmers in the highlands of eastern Ethiopia. Field surveys were conducted during 2014/15 cropping season on a total of 385 sample farm households that were randomly drawn from 8 Kebeles in four Weredas selected through a multi-stage sampling technique. The data were analyzed using descriptive statistics and econometric models including double-hurdle, Heckman two-stage selection, Tobit, 2SLS, and DEA models. The double-hurdle model result pointed out that sex, experience, land allocated to khat and location dummy negatively and significantly influenced commercial orientation, whereas, cultivated land size, off/non-farm income, fertilizer, crop diversification and on-farm income positively and significantly influenced it. On the other hand, results of the second-hurdle indicated that level of crop market orientation is negatively and significantly influenced by dependency ratio, social capital, khat land, town and road distances. Heckman two-stage selection model result indicated that crop output markets participation are influenced by sex, experience, livestock holding (excluding ox), cultivated land size, khat land, off/non-farm income, fertilizer, on-farm income, market distance, crop diversification and location dummy. Moreover, farm households' intensity of crop output market participation is found to be influenced by the proportion of irrigated land, social capital and dependency ratio. Results of 2SLS regression indicated that TFP was strongly and positively influenced by the endogenous commercial orientation index. In addition, oxen holding, market distance,

extension visits, manure used, labor and location dummy significantly influenced TFP. The overall average farm households' TE, AE, and EE scores obtained from DEA model results were 66, 72 and 46%, respectively. Inefficiency factors estimated using Tobit model confirmed that TE was significantly influenced by market distance, distance to FTC, crop diversification, oxen and other livestock holdings. Moreover, sex, market distance, distance to FTC, oxen and other livestock holdings were important factors affecting EE. Further, AE of crop growing farm households were significantly influenced by sex, market distance, khat land, and oxen holdings. The overall results imply that the major improvements related to smallholder farmers' crop commercialization and production efficiency would require attention on the identified significant factors. Generally, there is no single and best (universal) strategy that can be recommended to solve farm households' problems and factors limiting their commercial orientation as well as production efficiency. Hence, the findings of this study unveil the need for implementing differential policies that separately target and address the specific determinants of farm households' crop commercialization and production efficiencies.

Key words: Crop Commercialization, Market Orientation, Market Participation, Productivity, Efficiency.

1. INTRODUCTION

1.1. Background

Agriculture continues to be a strategic sector in the development of most low-income nations. It employs about 40% of the active labor force globally. Close to two third of the natural wealth in low-income countries is engaged in crop and pasture land (Otieno *et al.*, 2009). Sub-Saharan Africa (SSA) is categorized as an agrarian economy where 32% and 65% of the region's total gross domestic product (GDP) and total labor respectively depends on agriculture (WB, 2007; Bach and Per, 2008). WB (2007) puts forth that most of SSA smallholder farmers use small-scale rain-fed agricultural system and categorized them as the poorest, least educated, poorly linked to market, most vulnerable to non-conducive policies and surrender more severely to unfavorable environmental conditions such as drought.

Agriculture is the most important sector in the Ethiopian economy sharing 38.5% of the national GDP, and crop accounted for 27.4% (NPC, 2016), and it also provides employment for 72.7% of the total population (UNDP, 2015). Moreover, Ethiopian agriculture is dominated by smallholder farming which accounts for 85% of households farming less than 2 ha and 40% less than 0.5 ha (FAO, 2014). Ethiopia Bellmon Analysis Reprt (2015) also indicated that the agricultural sector is characterized by a very large number of fragmented smallholdings averaging 0.95 ha in size, together with a much smaller number of commercial farms that make up 2.5% of the land area. This shows the dominant contribution of smallholder farmers in the overall agricultural growth and development of the country.

In Ethiopia, population growth is outpacing agricultural production (EEPRI, 2002). From the ends of 1980's to 2005, population has grown by 97% but production has increased only by 59% (EEA, 2006). There were several attempts made to address low agricultural productivity. In the 1950s the emphasis had been on improving productivity and reducing economic dependence on agriculture whereas in the 1960s,

it shifted to agro-industrial economy and increment of foreign earnings. In the 1970's the focus shifted to smallholder potential after inefficiencies were observed in mechanized farms. In the 1980's the country adopted the socialist agricultural development strategy following the rise of the *Derg* regime to power. Since the current government came to power in the 1990s, strong focus has been given to smallholder farming and poverty reduction and supporting agricultural intensification (Sharp *et al.,* 2007).

Considering the view of Leavy and Poulton (2007), commercialization of agriculture should be a core research theme in various countries. Samuel and Sharp (2007) put forth four categories that represent four potentially complementary "pathways" for agricultural commercialization policy in Ethiopia. These pathways categorize farmer under subsistent-oriented smallholder farms, market oriented smallholder farms, small investor-farmers and large-scale "agribusiness". Majority of Ethiopian farmers (about 85%) are categorized under the first two categories which assemble smallholder household farms ownership (FAO, 2014). Following this reality, the current study targets the first two categories.

Commercial transformation of subsistence agriculture and increasing productivity and efficiency levels are crucial policy choices in economic growth and poverty reduction in many developing countries (von Braun, 1995; Pingali and Rosegrant, 1995; Timmer, 1997; WB, 2008). As a result, Ethiopia has adopted commercialization of smallholder agriculture as a strategy towards attaining an economic transformation (MoFED, 2010; NPC, 2016). Empirical studies elsewhere indicated that increasing the rates of market participation or productivity could have bidirectional synergies, and increasing market participation and productivity could boost living standards of farmers (von Braun, 1995; IFAD, 2003; Barrett, 2008). Thus, understanding the effects of commercial orientation on crop productivity would provide policy makers with information to design programs or develop strategies that can contribute to increase the production potential of smallholder farmers.

1.2. Statement of the Problem

Smallholder farmers in low-income countries are characterized by low production and productivity (Azam *et al.,* 2012). As a result, production is primarily for self-consumption (Orden *et al.,* 2004) with a possibility of supplying only a small part of total output to the local markets. Due to their semi-subsistence nature, these smallholder farmers depend on the local commodity market to satisfy part of their consumption needs as, in most cases, they are not self-sufficient.

Currently, the government of Ethiopia had set plans and strategies to build on the Agricultural Development Led Industrialization (ADLI) framework through commercialization of agriculture. Despite efforts made to commercialize and transform subsistence crop production to production of high value crops, the current reality shows that commercialization of smallholder farming is much below the expectations and farmers are not yet out of the subsistence-oriented agriculture, low productivity, low income, and low degree of specialization (Workneh and Michael, 2002; Berhanu and Moti, 2010; NPC, 2016). The poor performance of Ethiopian agriculture could be due to: population explosion (Holden *et al*., 2004), poor use of modern inputs, and internal inefficiency of the farmers in using the available agricultural resources (Kindie, 2005), the dominance of traditional smallholder farming practices with poor production technology, dependency in rain-fed agriculture, and low-input-low-output mode of production (FAO, 2011).

Despite their undisputed importance, most studies focused on smallholder market participation and analyzed determinants of the proportion of output sold in crop markets (von Braun *et al.,* 1994; Moti, *et al*., 2009; Otieno *et al.,* 2009; Adane, 2009; Bedaso *et al*., 2012; Degye, 2013). Such studies only capture the revealed marketing decisions of households while totally ignoring production decisions primarily meant for sale (Moti, *et al*., 2009). Thus, analysis of the determinants of market orientation and market participation separately would be useful in guiding the type of interventions needed at production and marketing levels to facilitate commercial

transformation (Adam, 2009; Berhanu and Moti, 2012). More importantly, all studies mentioned (except Adam (2009)) failed to analyze the relationship between crop productivity and commercialization. However, the current study analyzes the determinants of market orientation and market participation separately. In addition, it evaluates the relationship between commercial orientation and productivity.

Regardless of the importance of economic efficiency analysis, the majority of farm efficiency studies in Ethiopia focus on TE which is just a single component of overall EE (Kindie, 2005; Endrias *et al*., 2010; Shumet, 2011). In order to improve crop production and productivity, promoting EE of crop production at household level under the existing technology is very important. According to Betty (2005), efficiency measures are important as it is a factor for productivity growth. Such studies benefit economies by determining the extent to which it is possible to raise productivity by improving the neglected source of growth (efficiency) with the existing resource base and available technology. Hence, it is of critical importance to generate latest information on smallholder farmers' production efficiency.

Generally speaking, most of the previous empirical studies that have been conducted in Ethiopia have limitations in identifying the connection between crop productivity and commercialization. Moreover, there is negligible amount of information available, and the interplay between commercial orientation, productivity and efficiency at the household level is not adequately researched and verified in the study area. In addition to the above challenges, there are research gap priorities identified by FAO (2011) to be researched in areas of smallholder farmers' commercialization, access to improved agricultural inputs, and increased involvement of the private sector in the production.

Thus, it is critically vital to generate up to date empirical evidences on factors determining crop commercialization activities, commercial behaviors related to crop productivity, the extent of economic inefficiency in production, and factors that contribute to the inefficiency of smallholder households. In light of these big issues, this study has been designed and executed to answer the following key research questions:

1. What factors determine smallholder farmers' crop commercialization?
2. Do smallholder farm households' commercial orientations affect crop productivity? How?
3. What are the levels of smallholder farmers' crop production efficiencies?
4. Which factors are responsible for the inefficiency differentials among crop producer farm households?

1.3. Objectives of the Study

Owing to the above key research questions and problems, the overarching objective of the present study is to analyze and generate information on the important factors influencing crop productivity, efficiency and commercialization of smallholder farmers in the highlands of eastern Ethiopia.

The specific objectives of the study are to:

1) Identify and measure the determinants of market orientation and market participation of crop producer smallholder farmers;
2) evaluate the effect of smallholder farmers' commercial orientation on total factor productivity (TFP);
3) estimate the level of smallholder farmers' technical, allocative and economic efficiencies in crop production; and
4) identify sources of technical, allocative and economic inefficiencies of smallholder crop producers.

1.4. Scope and Limitations of the Study

The present study has used cross-sectional data obtained from 385 households sampled from two major locations (East Hararghe and West Hararghe zones of Oromia Regional State, Ethiopia). Sampling procedures, including capturing important variables and timing of data collection were carefully employed to minimize misleading results. A household is a unit of analysis in this study since a

farm household is still the overriding decision-making unit in the study area. However, an in-depth analysis at an individual household member level and usage of collective model may be required to improve usability of the findings of this study in the future.

As far as research is concerned, there are always certain limitations. Thus, the current study has also encountered certain challenges in the course of collecting data from the study areas. In the first limitation, the study just used cross sectional data due to the problem of accessing and/or generating panel data which may reveal the change over time. Moreover, managing the dynamic household's behaviors related to the shift in their choices over time affects the study. The other possible limitation of the study is the non-representativeness of the selected sample households to other farming systems, elsewhere in Ethiopia. Hence, results of this study should be continuously interpreted and used in the other farming systems throughout the country.

1.5. Significance of the Study

This study has generated new empirical evidence on how and to what extent smallholder farmers' commercialize their outputs. Knowing the amount of output produced and supplied to the market helps to understand the level of market supply and the socio-economic factors that can influence market orientation of farming households. Household level examination of the constraints and opportunities with regard to commercial behavior of smallholders would enable us to formulate and design appropriate development (market) oriented courses of action needed to mitigate the existing problems and contribute to the improvement of smallholder farmers' who are mainly engaged crop production.

The effects of commercialization on the productivity of food crops are not uniform and cannot be generalized. The effects may differ based on the type of crop featured in commercialization strategies and other factors. As a result, it is challenging for the government to identify and facilitate strategic pathways to create positive interactions between commercialization and productivity of crops. Therefore, this study has

provided input for policy makers since it evaluates the effect of commercialization on crop productivity in the study area.

Estimating the level of production efficiency among smallholder farmers in advance is a key and crucial factor that helps much to improve efficiency in production. In addition to this, identifying the different factors contributing to the inefficiency is vital and a thorough understanding of them is essential in order to formulate a better policy for intervention with a view to bring a desired change in agricultural production. Especially in the areas where resources are scarce, making such measurements and identifying their determinants are highly important to improve production and productivity without incurring additional investment. Because the efficiency levels indicates the possibility of increasing production without increasing the consumption of inputs or decreasing the level of inputs, that is, reduce total production cost without decreasing the level of output. Moreover, identifying factors influencing production inefficiency enables policy makers on which factors to focus and improve it.

Lastly, this study with other previous studies can be used as an input for future empirical studies in the area of crop commercialization and production efficiency.

1.6. Organization of the Dissertation

The Dissertation is organized into five chapters. The first chapter basically introduces the background, the statement of the problem, objectives, limitations and significance of the study. The second chapter presents review of literature where relevant materials related with the present study are explored and annexed with what this study furnishes instead. The third chapter deals with the research methodology where all the statistical ways of undertaking the investigations of this study are outlined and justified as well. Fourth chapter is about the result and discussion of the study. The descriptive and econometric analysis results of the present study are discussed in this section. Finally, the fifth chapter narrates the summary, conclusions and recommendations of the study.

2. LITERATURE REVIEW

This chapter reviews the theoretical, conceptual, methodological, analytical frameworks and empirical studies conducted on smallholder farmers' crop commercialization, productivity and efficiency. The theoretical review provides the background that supports investigation and offers justification of the research problem and used to construct theoretical framework used in the study. The methodological framework section briefly discusses the different measurements and tools used to perform specific research activities. The analytical framework leads to a specific methods and deemed to have clarity on the analytical techniques and procedures. The empirical literature provides evidence from past studies related to the subject and the gaps to be filled by this study. The review also provides insights on key variables and analytical models used in examining and identifying the influence of smallholder households' crop commercialization, productivity and efficiency.

2.1. Definitions and Concepts

2.1.1. Definitions and Concepts of Agricultural Commercialization

Commercialization of agriculture takes many forms and is defined in different ways. Generally, smallholder commercialization in agriculture can be defined in terms of smallholder participation in commercial input and output markets, type of crops grown by smallholder farmers and goals of smallholder farmers.

Timmer (1997) and Pingali (1997) defined agricultural commercialization as the proportion of agricultural production that is marketed. Commercialization can be measured along a continuum from zero (total subsistence-oriented production) to unity (100% of production is sold). Commercialization of agriculture involves a transition from subsistence-oriented to increasingly market-oriented patterns of production and input use. Economists have long advocated cash crop production as part of a broader strategy of comparative advantage. The underlying premise is that

markets allow households to increase their incomes by producing crops which provide the highest returns to land and labor, and then use the cash to buy household consumption items, rather than being constrained to produce all the various goods that the household needs to consume.

Despite the fact that there is no-consensus reached on the definition of the term commercialization, commonly agricultural commercialization is defined as the degree of participation in the (output) market, focusing very much on cash incomes (Strasberg *et al*., 1999; von Braun, 2005). According to these authors, commercialization is supplying higher amount or percentage of surplus product to market. However, the meaning of commercialization goes beyond supplying surplus products to markets; and it has to consider both the input and output sides of production, and the decision-making behavior of farm households in production and marketing simultaneously (von Braun *et al.,* 1994; Pingali, 1997; Berhanu and Moti, 2012).

Moreover, commercialization is not restricted only to cash crops as traditional food crops are also frequently marketed to a considerable extent (Von Braun *et al.,* 1994; Berhanu *et al.,* 2006). Therefore, this study defines and uses the concept of commercialization as the smallholder farmers' behavior or inclination towards commercial activities and may be expressed broadly by higher proportion of agricultural crop input and output that is marketed for cash and resources allocated in increased amount to cash crops.

Definition of market participation: Market participation has been defined and interpreted in various ways. Goetz (1992), Key *et al.* (2000) and Holloway *et al.* (2005) view market participation as a two stage phenomenon: In the first stage households decide whether to be net buyers, net sellers, or autarchic in the market for that commodity and in the second stage, net buyers and net sellers determine the extent of market participation. Based on the work of Barrett (2008), two basic interpretations can be inferred. He asserts that households can participate in the

market either as sellers or buyers. Both the decision to enter the market as a seller or a buyer is motivated by the theory of optimization where the household seeks to maximize utility subject to the cash budget and available non-tradable resources. Therefore, market participation has a demand side; households participating as buyers, and a supply side; households participating as sellers.

Definition of market orientation: A smallholder is market oriented if its production plan follows market signals and produce commodities that are more marketable. Under a semi-commercial system, where both market and home consumption are playing a central role in production decision, all crops produced by a household may not be marketable in the same proportion. Market orientation in agriculture is basically a production decision issue. Thus, market orientation is defined as the degree of allocation of resources (land, labor and capital) to the production of agricultural produce that are meant for exchange or sale (Hinderink and Sterkenburg, 1987; Immink and Aarcon, 1993; Berhanu and Moti, 2012).

2.1.2. Definitions and Concepts of Agricultural Productivity and Efficiency

In economics, terms such as productivity and efficiency are often used interchangeably. However, although there are similarities and linkages between them, they are not equivalent.

2.1.2.1. The concept of productivity

Agricultural productivity refers to the amount of output produced to a given level of input(s) used in the agricultural sector of a given economy (Fulginiti and Perrin, 1998). As a general concept, productivity growth is the growth in volume of output relative to growth in the volume of inputs. More formally, it can be defined as "the ratio of the value of total farm outputs to the value of total inputs used in farm production" (Olayide and Heady, 1982).

Increasing productivity implies either more output is produced with the same amount of inputs or that fewer inputs are required to produce the same level of output. The highest productivity (efficient point) is achieved when maximum output is obtained for a particular input level. Hence, productivity growth encompasses changes in efficiency, and increasing efficiency has been shown to raise productivity (Rogers, 1998). Consequently, if productivity growth of an organization is higher than that of its competitors, or other firms, that firm performs better and is considered to be more productive (Pritchard, 1990).

Productivity can be divided into two sub-concepts: Partial Factor Productivity (PFP) and Total factor Productivity (TFP). Partial/single factor productivity (SFP) is defined as the ratio of a measure of output quantity to the quantity of a single input used (Diewert and Nakamura, 2005). Partial measures of productivity can be misleading as it ignores the role of other inputs in any observed output changes (Zepeda, 2001). TFP is usually defined as the ratio of aggregate output to aggregate input (i.e., as the average product of aggregate input), it is necessary to account somehow for the sum total of changes of services of land, labor, capital, and material inputs used in production (Zepeda, 2001; Wiebe *et al*., 2003; Keith, 2010).

2.1.2.2. The concept of efficiency

Efficiency is the value of output produced to the cost of inputs used in the production process. Farrell (1957) introduced a method to decompose the economic (overall) efficiency of a production unit into its technical and allocative components.

Technical efficiency (TE): Refers to the achievement of the maximum potential output from given amounts of inputs, taking into account physical production relationships. Koopmans (1951) and Farrell (1957) put forth that TE is measured within two main frameworks: input and output-oriented. In an input-oriented framework, TE gives the potential input reduction that a farm could apply without reducing its output level. In an output-oriented framework, TE gives information

about the potential output increase that a farm could implement without increasing its use of inputs. In the case of constant returns to scale, both orientations give close results.

On the contrary, in the case of variable returns to scale (increasing or decreasing) an additional component, scale efficiency, must be taken into account in the calculation of technical efficiency. Likewise, different writers (e.g. Lovell, 1993; Hensher, 2001; Hollingsworth, 2008) defined TE as producing the maximum amount of output from a given amount of input or alternatively, producing a given output with minimum input quantities.

According to Koopmans (1951), a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Thus, a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output.

Allocative Efficiency (AE): Refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices. Hence, AE shows whether the use of different proportions of production factors guarantees the attainment of maximum production with a particular market price (Koopmans, 1951; Farrell, 1957). Unlike TE concept that only considers the process of production, AE concept pertains to the idea that society is concerned with not only how an output is produced, but also with what outputs and balance of output are produced (Hensher, 2001).

Economic Efficiency (EE): It is the product of TE and AE (overall efficiency). It can be interpreted as the potential reduction in production costs (cost efficiency) or the potential increase in revenue (revenue efficiency) that a farm could apply in order to operate at the point of TE and AE. EE enables conclusions to be drawn on whether the farm operates at optimal or suboptimal size.

Based on Graphical illustration of Farrell (1957), TE can be obtained by using input and output quantity. Accordingly, observation P utilizes two inputs to produce a single output, i.e. one-output multi-input. SS' is the efficient isoquant estimated with an available technique/ methods of production. Now point Q on the isoquant represents the efficient reference of observation P. The TE of a production unit operating at P is most commonly measured by the ratio OQ to OP (Farrell, 1957).

TE value will take a value between zero and one showing the extent of technical in/efficiency of the production unit. As the value approaches to one, the firm will approach to technically efficient point. From figure 1, point Q is technically efficient since it lies on the efficient isoquant. If planned expenditure for the firm is shown by the slope of the isocost line AA', then allocative efficiency (PQ') of a Production unit operating at P is defined as the ratio OR to OQ. The distance between R and Q (i.e. RQ) shows reduction in productions costs. This cost reduction would occur when production were to occur at the allocatively and technically efficient point Q' instead of only the technically efficient point Q. The total EE is also defined as the ratio OR to OP.

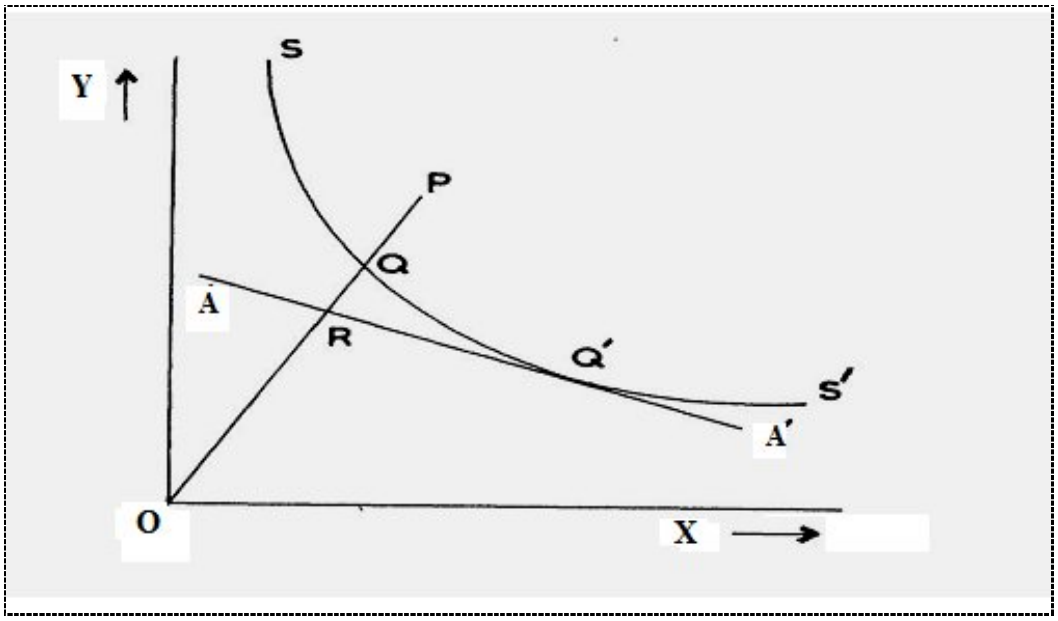

Figure 1. Technical, allocative and economic efficiencies

Source: Farrell, 1957.

The concept of productivity and efficiency can be explained more easily using input or output-oriented approaches followed by Coelli *et al*. (1998). Points A, B and C in Figure 2 define the relationship between input and output of three different firms and these points represent the productivity level of each firm respectively. Firms that produce outputs on the production frontier are operating at maximum possible productivity and are recognized as technically efficient. Firms producing below the frontier line are considered to be technically inefficient. Thus, firms which operate at points B and C on the production frontier are considered technically efficient firms. The firm operating at point A is considered inefficient because it could increase its productivity by moving from output Y_1 to maximum productivity at output Y_2. The firm at point C produces output level Y_1 by using a lower input level X_1, while firm A produces the same output level Y_1 by using more inputs. Accordingly, firm A is considered as a technically inefficient firm.

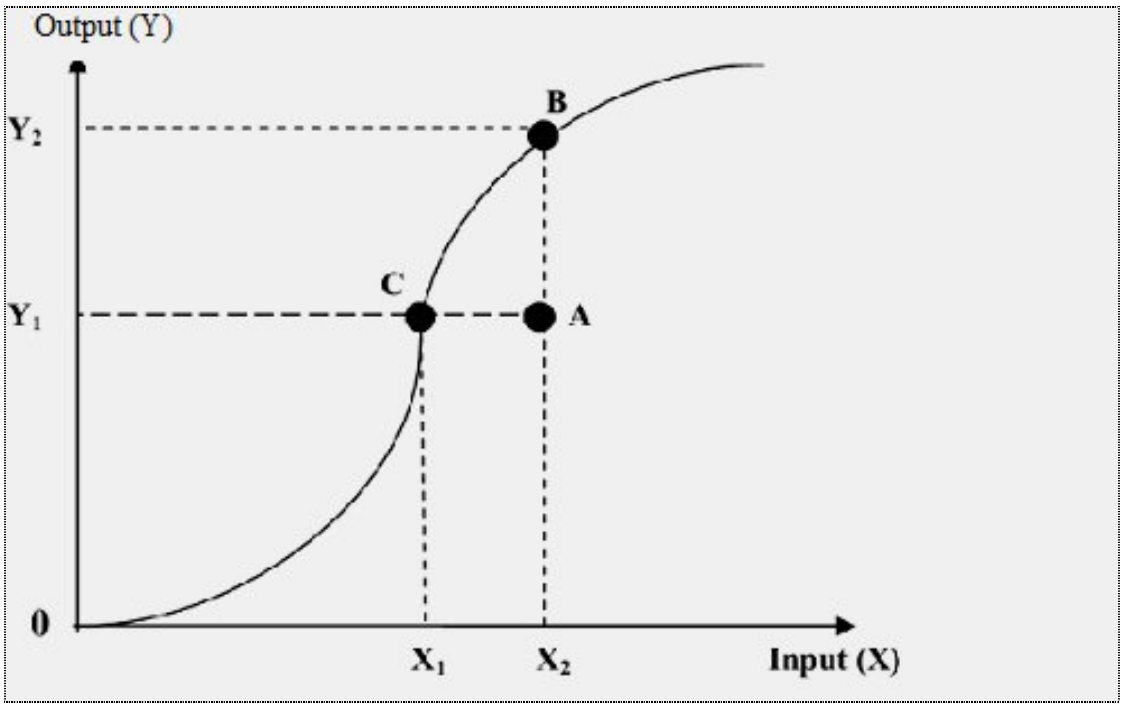

Figure 2. Production frontier and technical efficiency

Source: Coelli *et al*., 1998.

2.2. Theoretical Perspectives

2.2.1. Farm Household Production Decisions and Commercialization

Neoclassical economic theory, which represents mainstream economic thought, recognizes two key units of analysis at the microeconomic level: consumers and firms. In neoclassical theory, however, consumers and firms are treated independently; all consumption activities are modeled in terms of the household (or individual consumer), while all production activities are modeled in terms of the firm. The complete separation of consumption from production is not especially useful for modeling the household economic portfolio, particularly in developing countries where most households engage in a mix of market and nonmarket production (Chen and Dunn, 1996).

Economic history divides models of household decision-making into unitary and collective. Unitary models assume one utility function and joint decision-making based on agreement, where preferences are identical and resources are pooled whereas collective models allow different decision-makers to have different preferences and tastes. The unitary model is the most widely-employed. The collective model is limited in its use due to large data needs, fear of difficulties of getting reliable data against each member of the household and complexity in applying appropriate analytical models (Ellis, 1988; Haddad, 1994; Haddad *et al*., 1997).

The earliest model to integrate production and consumption decisions in the analysis of the peasant household was first proposed in the 1920s by A.V. Chayanov, a Russian agricultural economist (Thorner *et al.,* 1966). In the Chayanov's model, the household seeks to maximize its utility, where utility is derived from the consumption of goods produced on the farm, purchased goods, and leisure. By combining utility maximization from consumption theory with the production function from production theory, the Chayanov model provides a foundation for the integrated models of household decision making, including the farm household model.

Farm households' resource allocation decisions between subsistence and commercial production are influenced by demographic, socio-economic, institutional and natural factors. Seeking to insure household members against hunger and destitution is of great importance to any rural household in a less developed setting (Dasgupta, 1993). Within the standard expected utility approach, the introduction of risk in peasant production choices has entailed including household preferences toward risk. The risk behavior of agents is determined not only by preferences but also by the availability of institutions that facilitate risk bearing (Roumasset, 1976). Institutional arrangements provide imperfect insurance, households will self-protect by exercising caution in their production decisions (Morduch, 1995).

There are three alternative economic theories of peasant household behavior of production choices. These are: profit-maximizing peasant theories, utility maximization theories, and the risk-averse peasant theories. Each approach assumes that peasant households have an objective function to maximize, with a set of constraints. Moreover, these theories are based on a set of assumptions about the workings of the wider economy within which peasant production takes place. Not all these assumptions are shared by all theories, but all adopt the same theoretical method to explain farm household behavior (Mendola, 2007).

Profit-maximizing peasant theories: Referring explicitly to allocative efficiency, and implicitly to technical efficiency, Schultz's (1964) describes the peasant production mode as profit-maximization behavior, where efficiency is defined in a context of perfect competition (i.e., where producers all apply the same prices, workers are paid according to the value of their marginal product, inefficient firms go out of business, and entrepreneurs display non-diminishing marginal utility of money income). Several studies have adopted the AE criterion to test whether peasants were or were not efficient (i.e., whether they were profit-maximizers or not) with some contradictory results (Bliss and Stern, 1982).

Utility maximization theories: The neoclassical farm household model explains the behavior of farm households in simultaneous decision making about consumption and production. This model typically incorporates the notion of full household income and conceives of the household as a production unit that converts purchased goods and services as well as its own resources into use values or utilities when consumed (Becker, 1965). Thus, the household maximizes utility through the consumption of all available commodities (i.e., home-produced goods, market-purchased goods, and leisure), subject to full income constraints. The model shows that if all markets exist and all goods are tradable, prices are exogenous and production decisions are taken independently of consumption efficiency infers the nature of the former by investigating on the latter. In such conditions the decision making process could be regarded as recursive (or separable), because time spent on leisure and time used in production becomes independent; utilization of household labor will be directly linked to the market-determined wage rate, and income is singled out as the only link between production and consumption (Singh *et al.*, 1986).

In reality, households operating in developing countries are likely to face more than one market imperfection, which prevents first-best transactions and investments from taking place. Empirical analyses of recursivity in farm household decision making have generally produced negative results (Bardhan and Udry, 1999). Therefore, as indicated in Mendola (2007), there is no separability between consumption and production. The decision process becomes circular as consumption affects income and income affects consumption. Hence, the validity of recursive modelling of household resource allocation depends on the household being a price taker and the absence of missing or imperfect markets (for output or input, including labor and capital).

The risk-averse peasant: According to Ellis (1992), peasants produce under very high levels of uncertainty induced by natural hazards (weather, pests, diseases, natural disasters); market fluctuations; and social uncertainty (insecurity associated with control over resources, such as land tenure and state interventions, and war). These conditions pose risks to peasant production and make farmers very cautious in their

decision making (Walker and Jodha, 1986). It is not surprising, therefore, that farmers (in common with most other decision makers) are generally assumed to exhibit risk aversion in their decision making. Lipton's (1968) criticism of the profit approach sought to show how the existence of uncertainty and risk eroded the theoretical basis of the profit-maximizing model. Small farmers are risk-averse because they have to secure their household needs from their current production or face starvation.

2.2.2. Theoretical Perspectives of Productivity and Efficiency

The theory of production is based on the firm as the unit of analysis. The firm seeks to maximize its profits by selecting the optimal levels and combinations of inputs and outputs. The physical relationship between inputs (otherwise known as factors of production) and outputs is represented by a production function. In the competitive model, the firm is assumed to pay a given price to purchase inputs and to receive a given price when selling its outputs. The amounts of inputs the firm can purchase and outputs it can sell are considered unlimited. Also, it is interesting to note that the standard model does not consider the firm to be capital constrained. The optimal combination of inputs and outputs occurs where the contribution to profit of each additional unit of an input is equal to the price of the input and the contribution to profit of each additional unit of output is the same (Chen and Dunn, 1996).

There are several important concepts from neoclassical production theory that are useful in building a model of the household economic portfolio. First, production theory provides a framework for understanding how the household would (or should) allocate its resources to the various economic activities in order to maximize profits. The household's productive resources correspond to the inputs, or factors of production, in this theoretical framework. In addition, production theory provides the basis for clear conceptual definitions of technical, allocative, and economic efficiency. This provides us with a benchmark for the profit maximizing household and allows us to predict how the household might react to changes in prices or technology (Chen and Dunn, 1996).

The economic theory of production has provided the analytical framework for most empirical research on productivity measurement. The cornerstone of the theory is the production function, which postulates a well-defined relationship between output and factor inputs. Productivity can be achieved from two sources; first, through technological change of using improved practices of production such as ploughs, fertilizers, pesticides, improved seeds, etc which pushes the production frontier upward; and second, if the farmer has got further skills in using the existing techniques of production, productivity will increase (Gezahegn *et al.,* 2006).

Economic theory assumes that producers optimize both from a technical and economic perspective: (1) from a technical perspective, producers optimize by not wasting productive resources and (2) from an economic perspective producers optimize by solving allocation problem involving prices (Kokkinou, 2010). According to Singh (1986) productive efficiency constitutes three components: technical, allocative, and over all individual production (economic) efficiencies. Other economists like Färe *et al*. (1985) and Antle and Capalabo (1988), have tried to include scale efficiency in addition to technical and allocative as components of production efficiency. Scale inefficiency is the situation where the firm is unable to operate at its constant returns to scale (CRS), at a long-run competitive equilibrium. AE reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices and the production technology.

2.3. Methodological Frameworks

2.3.1. Measurement of Market Participation and Market Orientation Indices

The determinants of market orientation and market participation may not be the same because a household may produce marketable commodities but use them for home consumption if the household specific endogenous prices lie between the mark-up selling and buying prices. Where of course this situation is more common when there are high transaction costs and the price band is wider (Key *et al.,* 2000). A household

could also have high market participation because of surplus production due to various reasons, including favorable weather conditions, although it may not be market oriented, which is a good conclusion for framing.

Measuring Crop Output Market Participation Index (COMPI): The output side of commercialization can be seen at household or community level. In the case of household level, one definition of agricultural commercialization is the ratio of the value of agricultural outputs sold to the total value of agricultural outputs produced by a household (Von Braun and Kennedy, 1994; Strasberg *et al*., 1999; Berhanu and Moti, 2010). Hence, output side commercialization index for a household (COMPI) can be computed as:

$$\text{COMPI}_k = \sum_{i=1}^{N} \frac{S_{ki}}{Q_{ki}} \quad ; \quad Q_{ki} \geq S_{ki} \tag{1}$$

Where, COMPI_k is the proportion of crop k sold (S_{ki}) to the total amount produced (Q_{ki}) aggregated over the total sample households in a given location.

The index measures the extent to which household agricultural production is oriented toward the market. A value of zero would signify a totally subsistence-oriented household; the closer the index is to 100, the higher the degree of commercialization.

Measuring Market Orientation Index (MOI): The market orientation and commercial scale of farm households can usually be divided into two binary values or three ordinal scales (as non-commercial, semi-commercial, and commercial), depending on the distribution of the commercialization scale (von Braun *et al.,* 1994; Samuel and Ludi, 2007; Samuel and Sharp, 2007; Berhanu and Moti, 2010; Bedaso *et al*., 2012). Based on the proportion of total amount sold to total production, a crop specific marketability index (α_k) was computed for each crop produced at household level as follows:

$$\alpha_k = \sum_{i=1}^{N} \frac{S_{ki}}{Q_{ki}} \quad ; \quad Q_{ki} \geq S_{ki} \text{ and } 0 \leq \alpha_k \leq 1 \tag{2}$$

Where α_k is the proportion of crop k sold (S_{ki}) to the total amount produced (Q_{ki}) aggregated over the total sample households in a given location. Then, household's market orientation index in land allocation is derived from equation (2) as:

$$MOI_i = \sum_{k=1}^{k=k} \alpha k \frac{L_{ik}}{tL_i} \quad ; \quad tL_i > 0 \text{ and } 0 < MOI_i \leq 1 \tag{3}$$

Where MOI_i is market orientation index of the household i, L_{ki} is amount of land allocated to crop k, and t_{Li} is the total crop land cultivated by the household i.

A household is commercial oriented if market orientation index is a minimum of 65% whereas values in between 30% and 65% termed as semi-commercial and the rest non-commercial (Samuel and Ludi, 2007; Samuel and Sharp, 2007; Bedaso *et al*., 2012).

Crop Input Market Participation Index (CIMPI): From the input side perspective, commercialization is defined as the ratio of the value of agricultural inputs acquired from the market to the total value of agricultural production of a household. Hence, input side of commercialization index for a household (CIMPI) can be computed as (based on von Braun *et al.,* 1994; Berhanu and Moti, 2010):

$$\text{CIMPI}_i = \left[\frac{Gross\ value\ of\ inputs\ acquired\ \ from\ the\ market_{HHi}}{Gross\ value\ of\ all\ agricultural\ production_{HHi}} \right] * 100 \tag{4}$$

2.3.2. Measurement of Crop Productivity

The choice between different productivity measures depends on the purpose of productivity measurement and on the availability of data. Broadly, productivity measures can be classified as single factor productivity measures (relating a measure

of output to a single measure of input) or multifactor productivity measures (relating a measure of output to a bundle of inputs). Another distinction, of particular relevance at the industry or firm level is between productivity measures that relate some measure of gross output to one or several inputs and those which use a value-added concept to capture movements of output (OECD, 2001).

In determining productivity and efficiency of all factors, TFP can be measured in two ways, namely, the index number approach and the frontier approach (Coelli *et al*., 1998; Rogers, 1998). The index number approach obtains a single index by using all inputs and outputs. For example, a single index can show movements in prices of goods over time, when there are many goods. The TFP index is widely used to measure agricultural productivity performance because it provides a broad indication of how efficiently farmers combine all market inputs to produce total output. To measure TFP, researchers can aggregate various agricultural outputs (i.e. crop and livestock products) into an index of total output and compare this to an index of total input (i.e. land, labor, capital, and intermediate inputs). Specifically, the ratio of the two indexes gives the index of TFP, and movements in the TFP index over time reflect changes in productivity (Sheng, 2013).

Generally, three types of approaches can be used to measure TFP. Each approach has different data requirements to address different questions and they have their own strengths and weaknesses. First, growth accounting approach involves compiling detailed accounts of inputs and outputs. However, growth accounting methods are found to be unable to demonstrate much of a link between the amount of physical capital formation and output growth (Denison, 1987). Second, the econometric approach is based on econometric estimation of the production technology, either the production function (primal approach) or a cost function (dual approach) (Antle and Capalbo, 1988). Third, nonparametric methods use linear programming techniques to calculate TFP (Chavas and Cox, 1992). The major limitation of the nonparametric approach is that it does not involve statistical tests.

The econometric approach, though data hungry, has the advantage of employing statistical tools, hence permitting hypothesis testing and calculation of confidence intervals to test the reliability of the model estimated. This approach explicitly measures the marginal contribution of each category of inputs to aggregate agricultural output. If a flexible functional form is chosen it can also provide a second order approximation to a general function (Antle and Capalbo, 1988). Hence, the present study uses the advantages of econometric approach to assess the causal relationship between productivity and commercialization.

2.3.3. Measurement of Efficiency

Many different approaches have been applied by many researchers to measure efficiency changes in various types of institutions, and levels of decision-making units as well. Further, different approaches to efficiency measurements give different numeric answers. Therefore, it is essential to select appropriate measurements for efficiency to avoid measurement bias in results (Bozec *et al*., 2006).

Since the seminal work of Farrell (1957), efficiency measurements are carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. These frontier methodologies are broadly categorized under two frontier methods: the non-parametric Data Envelopment Analysis (DEA) and the parametric Stochastic Frontier Analysis (SFA). The choice of parametric and non- parametric estimation method has been an issue of debate. A large number of studies on efficiency measurements argue that a researcher can safely choose any of the methods since there are no significant differences between the estimated results (Abdourhmane *et al*., 2001; Coelli *et al.*, 2002). The strengths, weaknesses and measurements of each approach are presented below.

The parametric approach (Stochastic frontier models): As proposed by Aigner *et al*. (1977), the parametric approach consists of specifying and estimating a parametric production function frontier, and calculating technical inefficiency. The frontier

production function is an extension of the familiar regression model based on the microeconomic premise that a production function represents some sort of ideal, the maximum output attainable given a set of inputs (Greene, 1997).

The parametric approach is naturally subdivided into deterministic and stochastic models. Deterministic models envelope all the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency. On the other hand, stochastic approaches permit one to distinguish between TE and statistical noise (Luis and Juan, 2000).

The strengths of the stochastic frontier approach are that it deals with the stochastic noise and permits statistical tests of hypotheses pertaining to the structure and it allows the test of hypothesis concerning the goodness of fit of the model. Its main weakness is the assumption of an explicit functional form for the technology and the distribution of the inefficiency terms (Hjalmarsson *et al*., 1996). Moreover, Favero and Papi (1995) argue that parametric approaches use a specific functional form; need to make specific assumptions; make it impossible to implement diagnostic checking; and are difficult to implement in multiple input and multiple output settings.

The non-parametric approach (Mathematical programming models): The Farrell's approach to frontier estimation was reformulated by Charnes *et al*. (1978) as a mathematical programming model using the DEA. DEA is defined as a mathematical programming model applied to the observational data that provides a new way of obtaining empirical estimates of the production functions and/or efficient production possibility surfaces that are cornerstones of modern economics. This methodology was used initially to measuring the relative efficiency of a set of Decision-Making Units (DMUs). The aim of the CCR model was to define a frontier envelopment surface for all sample observations. This surface is determined by the efficient DMUs that lie on it, while the others can be considered as inefficient and an individual inefficiency score will be calculated for each one.

The CCR model has an input orientation and assumes constant returns to scale (CRS). Banker *et al.* (1984) proposed a model (BCC model) considering variable returns to scale (VRS). In the CRS model the measure of global TE may be obtained by comparing large scale units with small scale units and vice versa. The VRS model allows for variations in returns to scale: in this case an additional constraint is necessary that ensures the evaluation of pure TE regardless of issues of scale. The following sections provide detailed descriptions and differences between the CRS and VRS models.

The CCR model (Constant Returns to Scale): The CCR model generalizes Farrell's approach, considering multiple outputs and reformulating the calculation of individual efficiency measures, solving a linear programming problem for each production unit. In this model, CRS and input orientation are assumed: this means that all the units under analysis are performing at an optimal scale.

The BCC model (Variable Returns to Scale): CRS DEA model assumes that the DMUs are operating at an optimal scale. This model permits a measure of global TE to be obtained without variations in returns to scale. In the real world, however, this optimal behavior is often precluded by some factors such as imperfect competition, constraints, finance, etc. To take this circumstance into account, Banker *et al.* (1984) have employed an extended DEA to the case of VRS. This model distinguishes between pure TE and scale efficiency (SE), identifying if increasing, decreasing or constant returns to scale are present.

DEA is a relatively new data oriented approach for providing a relative efficiency assessment and evaluating the performance of a set of peer entities called DMUs which convert multiple inputs into multiple outputs. DEA is thus a multi-criteria decision making method for evaluating effectiveness, efficiency and productivity of a homogenous group (DMUs). DEA is convenient to determine the efficiency of DMU, which are mutually comparable- using the same inputs, producing the same outputs, but their performances are different. DMU is efficient if the observed data correspond

to testing whether DMU is on the imaginary production possibility frontier. All other DMU are simply inefficient. The best-practice units are used as a reference for evaluation of the other group units. The aim of this method is to decide if DMU is effective or not effective by the size and quantity of consumed resources and by the produced output (Cook and Zhu, 2008).

The main advantage of DEA approach is that it provides means of decomposing EE into technical and AE and also TE into pure technical and scale efficiency (Coelli *et al.,* 2005). The main attributes of DEA techniques are their flexibility and adaptability (Charnes *et al*., 1978). This adaptability has led to the development of a large number of extensions to the initial model and of applications in recent years. Moreover, Fried *et al.* (2002) suggested that DEA is an appropriate method of measuring relative efficiency of multiple decision-making units by enveloping observed input-output elements as tightly as possible. Further, it is useful to estimate relative efficiency for discussion of the relative importance of inputs and to observe the marginal contribution of each input. More importantly, the decision maker does not need prior information about weights of inputs and outputs which reflect the relative importance of the different inputs and outputs.

The main criticism of DEA is that it assumes all deviations from the frontier are due to inefficiency. Due to this, non-parametric frontier approach may overstate inefficiencies and hence outliers may have profound effect on the magnitude of inefficiency. Another limitation is that it is not possible to estimate parameters for the model and hence impossible to test hypothesis concerning the performance of the model (Coelli and Rao, 2003; Coelli *et al.,* 2005). Moreover, the first problem of DEA models assumes that all decision making units (DMUs) are homogenous and identical in their operations.

2.4. Analytical Framework

2.4.1. Analytical Method to Measure Determinants of Crop Market Orientation

In analyzing the decision for and the level of commercial orientation, past studies used different analytical models including distance function, ordinary least squares, simultaneous regression, double-hurdle, Logit, Cobb-Douglas, Probit and Tobit models, household model and their various combinations. Such studies generally used either independent or simultaneous decision making as per their area of interest. Most studies begin, however, from fundamentally different assumptions on the nature of households' market participation choices. On one hand, analyses of most studies on market participation decision revealed that choice of the different models depended on the models' capacity to best address the reality. On the other hand, the studies begin with modeling farmers participation decision taking only the after harvest situation and covering mostly the output side.

In analyzing the decision for and the level of market orientation, past studies used the double-hurdle model since it has the implicit advantage of being flexible to accommodate either sequential or simultaneous decision making of households and provides for the possibility of using same or different determinants in each one of the two commercial orientation hurdles (Goetz, 1992; Key *et al*., 2000; Holloway *et al.,* 2005; Bellmare and Barrett, 2006; Adam, 2009).

The two-tier/double-hurdle model was developed by Cragg (1971). According to Lijia *et al.* (2011), Cragg first proposed the double-hurdle model as a generalization of the Tobit model by allowing the possibility that a factor might have different effects on the probability of acquisition and the magnitude of acquisition. The application of the model to any empirical study divides the study into two stages: an initial discrete probability of participation model and condition on participation, a second decision is made on the intensity of participation (Olwande and Mathenge, 2012). The first step in a two-tier model involves a Probit estimation while the second stage can take

different functional distributions. While the simplest two step models assume lognormal distribution in the second stage, Cragg's double-hurdle assumes a truncated normal distribution.

The main advantage of the truncated normal distribution over the lognormal is that it nests the usual Tobit model thus allowing the testing of the restrictions implied by the Tobit hypothesis against the two step model (Olwande and Mathenge, 2012). This makes the double-hurdle model theoretically more applicable than other two-tier models. The difference between the Heckman model and the double-hurdle model is in the second stage where the Heckman estimates an Ordinary Least Squares (OLS) equation while the double-hurdle model estimates a censored regression usually a truncated regression.

Thus, the study used double-hurdle model to analyze crop market orientation decisions and intensity of orientation decisions due to its implicit advantage of being flexible to accommodate either sequential or simultaneous decision making of households and provides for the possibility of using same or different determinants in each of the two hurdles.

2.4.2. Analytical Method to Measure Determinants of Market Participation

In order to analyze households' market participation decision, the typical approach in the existing literature is to divide the market-participation decision into two stages. In the first stage, households are assumed to make a participation decision regarding crop sale (a binary choice). In the second stage, they decide on the extent of their participation (a decision regarding level of crops they are going to sell). Since the amount of crop sold is observed only for households that participate in the crop market, there is going to be selectivity bias. Thus, the two-stage econometric model that best addressed households' market participation decision and level of sales was the Heckman two-stage model (Heckman, 1979). This model was used because of its advantage over the Tobit model in eliminating sample selection bias (Birhanu *et al*., 2009; Ouma *et al*., 2010; Siziba *et al*., 2011).

The Heckman model consists of two equations to be estimated in two steps. The first equation is referred to as the selection equation. It is estimated using a Probit model which predicts the probability that an individual household participates or does not participate in the market. It also estimates what is known as the Inverse Mill's Ratio (IMR). The purpose of the IMR is to account for sample selection in the study so that the estimates would be unbiased. The second equation is referred to as the outcome equation. It is estimated using the OLS. The OLS estimation is done with the inclusion of the IMR as a regressor. The first and the second models incorporate the same variables except that the second model includes some other variables suggested by Wooldridge (2006) as exclusion restriction variables.

Moreover, a major limitation with the Tobit model is that it assumes the same set of parameters and variables determine both the probability of market participation and the level of transactions. A two-step model however relaxes these assumptions by allowing different mechanisms to determine the discrete probability of participation and the level of participation. This model allow for a separation between the initial decision to participate and the decision of how much to sell.

2.4.3. Procedures to Measure the Effect of Market Orientation on Total Factor Productivity

Following different arguments, the present study utilizes the advantages of econometric approach to assess the causal relationship between productivity and commercialization. In general, studies conducted by researchers in different parts of the world have used various self-augmenting regression models to analyze causal relationships between explanatory and dependent variables concerning partial productivity and mere market participation. This study tried to fix the relationship that is assumed to exist between crop productivity and commercial orientation.

To investigate the alleged role of commercial orientation in enhancing crop productivity in general, farm outputs of the smallholder households were used. Estimation of the effects of commercial orientation as defined by market share in crop

sales follows simultaneous analysis of a recursive process that is composed of the output variable and the commercialization index in the framework of other conditioning variables. In establishing the relationships between commercial orientation and farm output this study assumes a productivity factor measured TFP and the endogenously determined crop commercialization index as central factors (Adam, 2009).

Procedures to analyze the relationship between the commercial orientation and a measure of productivity will be done in three steps. The first step involves determining the measure of productivity; the second step deals with determining the measure of commercial orientation; and the third step involves establishing the mathematical relationship in the appropriate form of the model for estimation. The method of analysis of the causal relationship between commercial orientation and TFP were done in three steps:

(1)Measurement of crop productivity: In this study, index of TFP involving elements of outputs and inputs were defined over gross value of crop output, labor and traction power (human and animal), rental value of cultivated land and value of purchased inputs (fertilizer, chemicals and seeds). The TFP elements were then estimated with TFPIP version 1.0 software that was developed by Coelli and Battese (1998) to produce a widely used Tornqvist TFP index.

The general equation in its logarithmic form is:

$$lnTFP = ln\frac{O}{I} \quad = lnO\text{-}lnI \tag{5}$$

Where, TFP = total factor productivity, O = output index, I = input index.

$$lnTFP_{io} = \underbrace{\left[\frac{1}{2}\sum_{i=1}^{n}(\omega_i + \omega_{i0})\,(\ln y_{io} - \ln y_i)\right]}_{\text{Output}} - \underbrace{\left[\frac{1}{2}\sum_{j=1}^{m}(v_j + v_{j0})\,(\ln x_{jo} - \ln x_j)\right]}_{\text{Input}} \tag{6}$$

Where, ω - value share of outputs; ν- value share of input; y- output(s) in physical quantities; x- input(s) in physical quantities; i - i^{th} output (n selected crops); j - j^{th} input (human labor, animal traction, land, seed, fertilizer, chemicals); o- observations (sample farm households).

(2)Measurement of crop commercial orientation: Commercial orientation of smallholder farmers is defined in terms of a scale neutral measure adapted from von Braun *et al.* (1994) and Strasberg *et al.* (1999) as indicated in section 2.3.1.

(3)Establishing the relationship between commercial orientation and TFP: As a strategy, it is worthy to start with commercial orientation index is supposed to be endogenous with TFP. Hence, the mathematical relationship between commercial orientation and TFP is established using two-stage least squares (2SLS) procedure in equations (7) and (8),

$$Y_i = \alpha_0 + \alpha_1 \hat{C}_i + \alpha_2 X_{1t} + \varepsilon_{1t} \quad (7)$$

$$C_i = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + u_{1t} \quad (8)$$

Where, Y_i - productivity (measured as TFP); α_0, α_1, α_1, β_0, $\beta_1$and β_2- unknown parameters; X_{1t} - exogenous variables hypothesized to affect TFP and market orientation; $\hat{C}_i$- the predicted value of market orientation index; C_1 - market orientation index itself; X_{2t} - a vector instruments for market orientation; ε_{1t} and μ_{1t} - error terms such that $E(\varepsilon_{1t})=0$ and $cov(\varepsilon_{1t}, \mu_{1t})=0$

2.4.4. Procedures of Cluster-Based DEA Efficiency Analyses

According to the economic notion of Pareto optimality, the DEA method states that a DMU is considered inefficient if some other DMUs or some combinations of other DMUs produce at least the same amount of output with less of the same resources input and not more of any other resources. Conversely, a DMU is considered Pareto efficient if the above is not possible. Suppose there are *n* DMUs to be evaluated where

every DMU_j (j=1,...,*n*) produces the same *s* outputs in various amounts, y_{rj} (i=1,...,s), using the same *m* inputs, x_{jj} (i=1,...,m), also in various amounts.

The mathematical formulation of the relative efficiency of the DMUp can be obtained by using the following CCR model proposed by Charnes *et al.* (1987):

$$\begin{aligned} \text{Maximize} \quad & \theta_p = \frac{\sum_{r=1}^{s} u_r y_{rp}}{\sum_{i=1}^{m} v_i x_{ip}} \\ \textit{Subject to} \quad & \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, \quad \forall \text{j}, \\ & u_r, v_i \ge 0, \qquad \forall r, i \end{aligned} \tag{9}$$

Where u_r and v_i are the weights assigned to the r^{th} output and i^{th} input, respectively. The interpretation of the DEA model (9) is a ratio of a weighted sum of outputs to a weighted sum of inputs where the weights for both inputs and outputs are to be selected in a manner that calculates the efficiency of the evaluated unit. Model (9) can be solved using a linear form as shown below by performing the Charnes–Cooper (1962) transformation:

$$\begin{aligned} \text{Maximize } \theta_p = \quad & \sum_{r=1}^{s} u_r y_{rp} \\ \textit{Subject to} \quad & \sum_{i=1}^{m} v_i x_{ip} = 1 \\ & \sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 1, \quad \forall \text{j}, \\ & u_r, v_i \ge 0, \qquad \forall r, i \end{aligned} \tag{10}$$

The DMUs with $\theta_p^* = 1$, are called (technically) efficient units, and those units with $\theta_p^* \neq 1$ are called (technically) inefficient units. It is generally helpful for decision

makers only to focus on the efficient DMUs. However, decision makers always face the problem of how to carry out additional comparisons among the efficient DMUs. The following duality form of model (10) also provides information about the contraction of resources or expansion of outputs for the DMUs to move from inefficiency to efficiency.

$$
\begin{aligned}
&\text{Minimize} \quad \theta_p \\
&\textit{Subject to} \quad \sum_{i=1}^{m} \lambda_j x_{ij} \le \theta_{ip}, \quad \forall i \\
&\qquad \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rp}, \quad \forall \mathrm{r}, \\
&\qquad \lambda_j \ge 0, \quad \forall j
\end{aligned}
\tag{11}
$$

Model (11) is referred to as the envelopment or primal problem, and (10) the multiplier or dual problem.

One important problem of DEA model is that it assumes all DMUs are homogenous and identical in their operations. If the heterogeneous DMUs are assessed by DEA without any modifications, the DEA yields a biased performance scores and inaccurate analyses. Therefore, this study applied a new algorithm called clustering-based technique provided to perform the DEA computation in non-homogenous DMUs. Clustering is the process of organizing a data set into useful set of mutually exclusive clusters such that the similarity of the objects within a cluster is maximized while the similarity of the objects between different clusters is minimized (Okazaki, 2006; Rai *et al*., 2006; Samoilenko and Osei-Bryson, 2008).

The clustering techniques may be broadly classified in two main categories: hierarchical and non-hierarchical clustering techniques (Mooi, 2011). The hierarchical cluster analysis is one of the most obvious methods. It uses the dissimilarities such as distances between objects when forming the clusters. These techniques are broadly classified in two groups, namely; agglomerative technique and divisive technique. Agglomerative technique of hierarchical procedures starts with n clusters of single

data point. They keep merging observations with the clusters till only one cluster containing all n data points remain. Divisive technique of hierarchical procedures start with a single cluster of n data points and keep dividing until there remain n clusters, each having a single data point (Kaufman and Rousseeuw, 1990).

Non-hierarchical clustering techniques start with a user-defined value of k, which is the number of clusters to be formed. In general, these techniques work by selecting k-initial partitions and then altering the memberships of the objects in those partitions to obtain better partitions. The algorithms differ in the way they approach the problem of finding better partitions (Anderberg, 1973). Thus, the study used agglomerative hierarchical clustering technique because of its computational ease and it is a very commonly used method of choice in software implementations. The divisive method on the other hand suffers from the drawback that the best partition has to be found during the first stage, which is a computationally expensive task.

2.5. Related Empirical Literature

2.5.1. Empirical Studies on the Determinants of Crop Commercialization

A number of area-and commodity-specific studies of crop commercialization are conducted in Ethiopian and other countries. A study by Goetz (1992) on the Senegalese agricultural households' decision to participate in the grains market (whether as buyers or sellers, without distinction) was investigated using a Probit model which was followed by a second-stage endogenous switching regression model to understand the extent of market participation.

Workneh and Michael (2002) in their study on intensification and crop commercialization in Northeastern Ethiopia applied Logit model to assess the participation decision of farmers in food crop marketing and commercialization. They used Cobb-Douglas production function to assess determinants of crop intensification. They found that farm size, age and use of technology (fertilizer) significantly influence food crop marketing and commercialization under study.

Holloway *et al.* (2005) used a Bayesian double-hurdle model to study participation of Ethiopian dairy farmers in the milk market when non-negligible fixed costs lead to non-zero censoring, distinguishing between the discrete participation decision and the continuous marketed volume decision. Bellemare and Barrett (2006) applied a mix of Probit and Ordered Tobit models to assess discrete market participation choice and net sales and net purchase decisions of pastoralists in Ethiopia and Kenya, and consequently they established market participation decision making process of the pastoralists in livestock marketing to be made sequentially and not simultaneously and the investigators favored the use of double-hurdle model to define the process involved in making marketing decisions.

A study by Mahelet (2007), based on the data collected from North Omo Zone, Southern Nations Nationalities and People's region (SNNP), indicated that land size and number of labor employed are crucial factors determining agricultural sales in the zone. In addition, the study found that other factors such as education, technology (such as irrigation) and shifting of production to high value crops could help a lot in improving the income and reducing poverty of smallholder farmers.

Pender and Dawit (2007) applied a theoretical farm household model of food crop production (*teff* and maize) and marketing decisions using data on cereal production and marketing in Ethiopia. They found that most producers of these crops were either autarkic or net buyers; net buyers and autarkic households were poorer in many respects than net sellers. They suggested that interventions to increase cereal productivity will enhance distribution for most producers. Moreover, increasing production of *teff* and maize was the most important factor contributing to increased sales and increased smallholder access to roads, land, livestock, farm equipment, and traders was key to enabling increased smallholder production and commercialization.

Adam (2009) also applied double-hurdle model and compared its result to the alternative Tobit model in the area of crop output and input commercialization to examine the smallholder farmers' commercial orientation decision and decision

processes. His study also augments the land area allocation behavior of farm households to commercial crops using multiple linear regression analysis. Based on his result, decision making behavior of farm households are influenced by farm internal factors and farm external factors. The farm external factors generally cover the general environment: climate and access to finance, marketing, information, institutions, infrastructure, technology and extension. The farm internal factors include resource availability and use, demography /household characteristics/, capital or income, and knowledge variables.

Bedaso *et al.* (2012) estimated a multinomial Logit representation of commercialization status of smallholder farmers in Ethiopia and the results showed that asset ownership, access to extension service and market information, quantity of inputs used, labor cost, total production and improved storage methods tend to increase the probability to be commercial farmer while labor size, seed rate, distance from market, and traditional storage methods tend to decrease the probability of commercialization. Price fluctuation, market distance and lack of transport facilities were the major factors that hinder marketing of their produces.

A study by Degye (2013) applied Tobit model for household participation in crop output market as seller. The univariate probit estimation of households' crop market orientation status verified that the marginal effects and the predicted probabilities of market orientation for households in Central highlands were very poor. The probability of the sample households to be partially market-oriented was 13.2%; but households in Hararghe highlands were relatively more market-oriented with a predicted probability of 39.9%, compared to the probability of households in Central highlands (4%).

2.5.2. Empirical Studies of the Effect of Commercial Orientation on Productivity

Strasberg (1997) conducted an investigation on the dynamics between cash cropping and food cropping in Mozambique and suggested that cotton producers grew greater

quantities of maize than households with no cotton production. Smallholder cash-cropping participation had a positive effect on smallholder food production. Further, households who grew cotton under a high-input package (using fertilizer, herbicides and insecticides) but who grew low-input maize had significantly greater maize yields per hectare than their neighbors in low-input cotton schemes or those that did not grow cotton.

A study conducted by Govereh and Jayne (2003) in Gokwe North district of Zimbabwe highlighted the complementary relationship between cotton commercialization and food crop productivity at the household level where commercialization was defined as per cash crop production. Based on their findings, each additional percentage increase in the cash crop commercialization index was associated with a $11.23 per hectare increase in the value of grain crop production per hectare.

A study by Adam *et al*. (2010) on the effects of crop commercial orientation on productivity of smallholder farmers in drought-prone areas of the Central Rift Valley of Ethiopia indicated that there is a tradeoff between farm households' commercial orientation index and total factor productivity index resulted in non-recursive relationship. Based on their result, the contribution of commercial orientation to productivity may not be meaningful without the complementary effect of the resource endowment of farm households. The complementary determinant factors include sex of the household head, livestock holding, access to credit, availability of active labor, off-farm employment and location.

2.5.3. Empirical Studies on Productive Efficiency and its Determinants

Betty (2005) used a one-stage estimation procedure with the Stochastic Frontier Approach and primary cross-sectional rural household data for the 2003/04 main harvest-cropping season in Kenya to analyze TE in Kenyan's maize production. She found that there is distinct intra and interregional variability in TE in the maize

producing regions. In addition, TE varies by cropping system; the mono-cropped maize fields have a higher TE than the intercropped maize fields. Years of school in formal education, age, health, gender of the household, use or none use of tractors and off-farm income have significant impact on technical efficiency.

Arega *et al.* (2006) in their study on measures of the efficiency of intercropping systems of annual and perennial crops production in southern Ethiopia using the SFP, parametric distance functions (PDF), and DEA, compared the empirical performances of the three methods. The results from the multi-output PDF and DEA approaches have revealed significantly higher efficiency of the systems than the single output SFP approach. They found that both DEA and PDF are appropriate in multi-output agriculture involving intercropping of annual and perennial crops. Single-output measures of productivity and efficiency may thus underestimate resource use efficiency of intercropping systems.

A study conducted by Jema and Andersson (2006) on the determinants of efficiency of vegetable production in smallholder farms indicated that the EE of the farm household was positively and significantly affected by total household asset and improved technology adoption. The rest of the variables, including labor force available, size of farm, size of livestock, access to extension and credit service and education had the expected positive signs but insignificant effect on EE at less than 1% probability level. The statistically significant negative effect on the estimated coefficients on all efficiency scores for the household consumption expenditure may reveal a situation where household that spent excessively on consumption goods were unable to support their agricultural activities.

A study done by Jema (2008) on EE and Marketing performance of Vegetable Production used both parametric and non parametric approaches. The results revealed that there was similarity in the estimates of efficiency in both approaches. He used the two stage approach in determining factors affecting efficiency. Results based on the comparison of the two production systems showed that lower EE scores for the market

driven production is attributable to limited access to capital markets, high consumer spending, and large household size. The mean TE, AE and EE, estimated by the non parametric DEA, were 91%, 60% and 56% respectively indicating that farmers have attained a relatively high level of TE but lower AE and EEs. These results indicate the existence of a considerable potential to increase agricultural output without using additional inputs, given the existing technology. The result also indicates that if these farmers operate at full efficiency levels, they could, on average, reduce their costs of production by 44% and still produce the same level of output.

Krasachat (2009) investigated factors affecting technical inefficiency of white shrimp farms in Thailand. The DEA approach to estimate TE scores and a Tobit regression model to determine factors that affect farm efficiency were employed. The author found that the producers who experienced in tiger prawn production are likely to achieve higher levels of overall technical and scale efficiencies. Moreover, the difference in producers' participation in farm management training, producers' education level have a positive and significant impacts on the overall technical, pure technical and scale efficiencies.

Kaleab (2010) analyzed TE of smallholder farmers and commercial farms in Bale Zone of Oromiya. He estimated Cobb-Douglas stochastic production function for both smallholder and commercial farms. The result of inefficiency model showed that education, gender, extension, cooperative membership, weeding and organic fertilizer use had positively determined TE of wheat production in the study area. On the contrary, land fragmentation, distance of the plot from homestead and illness of the household members had a significant negative effect on TE. In addition, for commercial farms experience of the manager, distance of the farm from the main road, current value of farm machineries and provision of mechanization service by the farms had positive and significant impact on TE.

A study by Hassen *et al.* (2012a) on the EE of mixed crop-livestock production system in the north eastern highlands of Ethiopia using the parametric methods of efficiency measurement indicated that most farmers in the study area were not

efficient suggesting that efficiency improvement is one of the possible avenues for increasing agricultural production with available resource and technology. I addition, the EE of mixed crop-livestock production system was determined by farm size, livestock ownership, labor availability, off/non-farm income participation, total household asset, total household consumption expenditure and improved technology adoption.

Musa (2013) analyzed the EE of maize producers in Arsi Negelle district of Oromia National State of Ethiopia. The study employed the Cobb-Douglas stochastic frontier production and its dual cost functions were estimated from which TE, AE and EE extracted. The results from the production function showed that DAP fertilizer, area, labor, oxen power and seed were positively and statistically significant. He was applied Tobit regression techniques to examine the relationships between TE, AE, and EE and various variables that are expected to have effect on farm efficiency. Results showed that soil fertility, frequency of extension contact, credit and distance to market were found to be statistically significant to affect the level of TE. Moreover, education, credit and frequency of extension contact were important factors that affect EE of farmers in the study area.

Seyoum *et al.* (1998) find the mean TE of maize producers in Eastern Ethiopia for farmers within and outside the Sasakawa-Global 2000 project to be 88 and 74%, respectively. Arega and Rashid (2005) found mean TE, AE and EE of 68, 83 and 56%, respectively for traditional maize producers and 78, 77 and 61%, respectively for hybrid maize producing farmers in Eastern Ethiopia. Endrias *et al.* (2010) found low average TE of 40% among maize producing farmers in Southern Ethiopia using DEA and normalized Translog production function. Sisay *et al*. (2015) found the average TE, AE and EE levels estimated at 62.3, 57.1 and 39%, respectively among maize producing smallholder farmers in Southwestern Ethiopia.

2.6. Conceptual Framework

Literatures reveal that the processes of commercialization can be primarily driven by population growth and demographic change; urbanization; development of infrastructure and market institutions; development of the non-farm sector and broader economy; rising labor opportunity costs; and macroeconomic, trade, and sectoral policies affecting these forces (von Braun *et al.,* 1994; Pingali and Rosegrant, 1995). At household level, commercialization is also affected by many factors, including agro-climatic conditions and risks; access to markets and infrastructure; community and household resource and asset endowments; development of local commodity, input, and factor markets; laws and institutions; and cultural and social factors affecting consumption preferences, production, and market opportunities and constraints (Pender *et al.,* 2006).

The basis of the conceptual framework, therefore, is organized based on the assumption that smallholder agricultural commercialization is a processes; primarily pushed by key interrelated components called driving forces; influenced by internal and external factors (enablers and constraints); measured by input and output market orientations; and market orientation and crop productivity are influenced by farm internal and external factors. In addition, the framework is built on the hypothesis that there will be a causal relationship between commercial orientation and productivity/efficiency (Figure 3).

The farm external factors include population growth and demographic change, technological change and introduction of new commodities, development of infrastructure, market institutions and regulations, and institutions such as property rights and land tenure, cultural and social factors, agro-climatic conditions, development of the non-farm sector and the broader economy, rising labor opportunity costs, macroeconomic, trade and sectoral policies affecting prices and other driving forces (von Braun *et al*., 1994; Pingali and Rosegrant, 1995; Pender *et al*., 2006). On the other hand, factors like smallholder resource endowments including

land and other natural capital, labor, physical capital, human capital and so on are household specific and considered to be internal determinants (Moti *et al*., 2009).

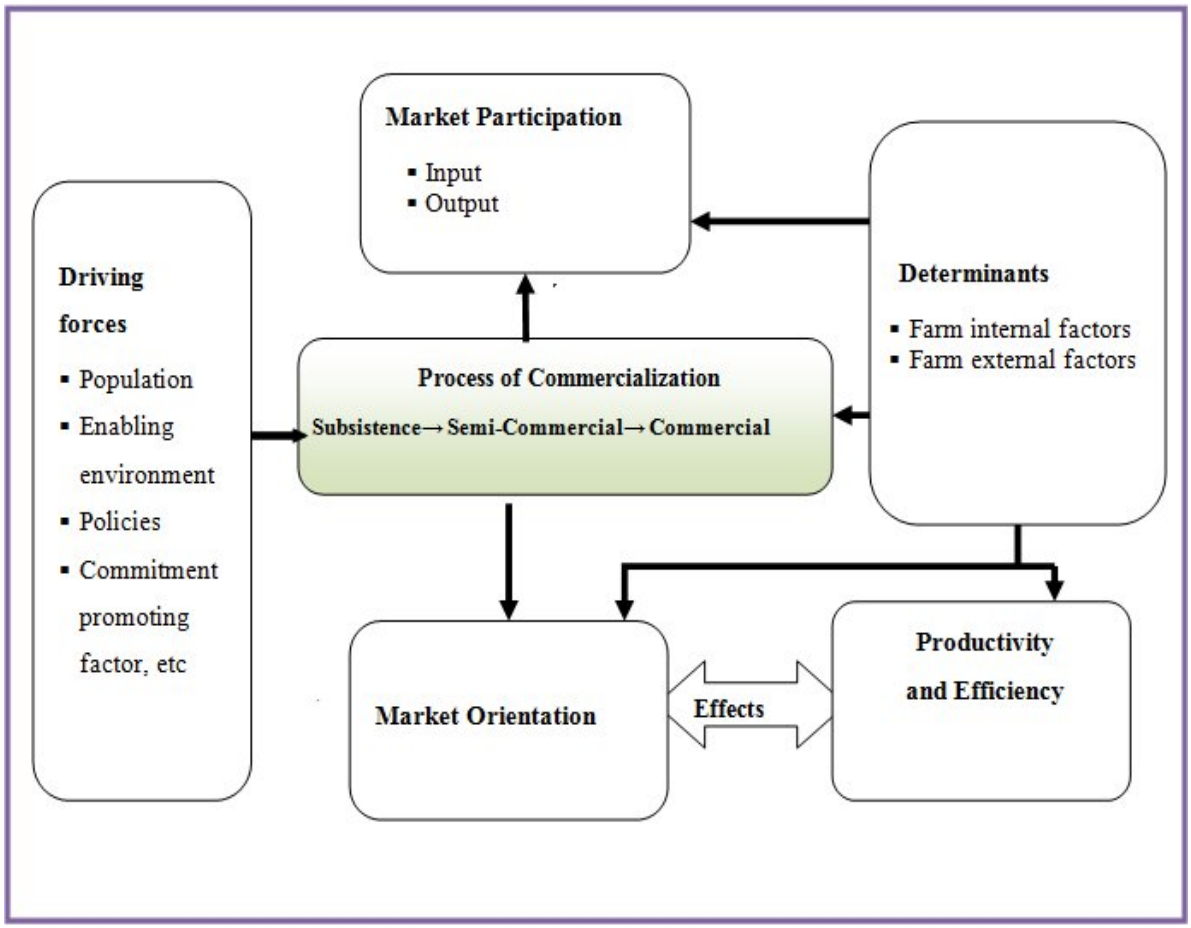

Figure 3. A conceptual framework of smallholders' crop commercialization and production efficiency at household level

Source: Adapted from Zhou *et al.* (2013) and illustrated based on the literature review.

3. RESEARCH METHODOLOGY

This chapter provides details of the methodology used to address the objectives of the study. It includes description of the study area, sampling design, data type and collection method, methods of data analyses, and important variables selected for the study. The choice of analytical models and variables are made in view of the empirical and analytical reviews discussed under chapter two.

3.1. Description of the Study Area

The study area, East Hararghe and West Hararghe, are found in Oromia National Regional State of Ethiopia. Oromia is the largest region in terms of population and area coverage. According to the 2012 intercensal population survey projection, it has a total population of more than 31.9 million (CSA, 2012). The Hararghe highlands are situated in the Eastern part of Ethiopia, circumscribed by East and West Hararghe zones and covers about 10% of the total population of highland farming systems in Ethiopia.

Farming system in the East and West Hararghe zones of Ethiopia constitute complex production units involving a diversity of interdependent mixed cropping and livestock activities. The known cash crops predominantly produced are *khat* (*Catha edulis),* coffee, and other crops such as potatoes, onions/shallots and other vegetables. The main staples are sorghum, maize as well as sweet potato (Ralph, 2004). The major annual crops grown in the two zones are sorghum, maize, groundnuts, potato, wheat, haricot beans, barley, and so on (CSA, 2008). Cereal production in both zones is mostly for home consumption; only about 5.2% of the produce in East Hararghe, and 4.6% of the produce in West Hararghe were sold in 2008 (CSA, 2009). Livestock keeping is also an integral activity of farmers in the study areas. As indicated by William (2003), relatively large herds of cattle, sheep and goats are reared, at least 3.6 livestock units per household are kept, and the arable land and stubble grazing provide most of the animal feed.

The agro-climatic range includes lowlands (locally called *kola* or *gammoji*) with rainfall distribution of less than 700 mm and constituting about 30 to 40%; midlands (*weyna-dega* or *badda-daree*) with rainfall distribution ranging from 700 mm to 1200 mm and constitutes 35 to 45%; and highland (*dega* or *baddaa*) with rainfall distribution of more than 1200 mm and constitutes 15 to 20% of the whole areas in these zones. There are two rainy seasons in these zones, the short (*belg* or *badheessa*) rainy season extending from March to May and the main (*meher* or *ganna*) rainy season extending from June to September. *Belg* rains are mainly used for land preparation and planting of long cycle crops such as maize and sorghum and seed bed preparation for *meher* crops. The *meher* rains are used for planting cereal crops like barley, *teff*, wheat, and vegetable crops like onion, shallot and potatoes in the mid and highlands, and peanut in the lowlands. *Meher* rains are also responsible for the growth and development of perennial crops such as coffee and *khat* (CSA, 2009). Figure 4 below shows the map of the study areas.

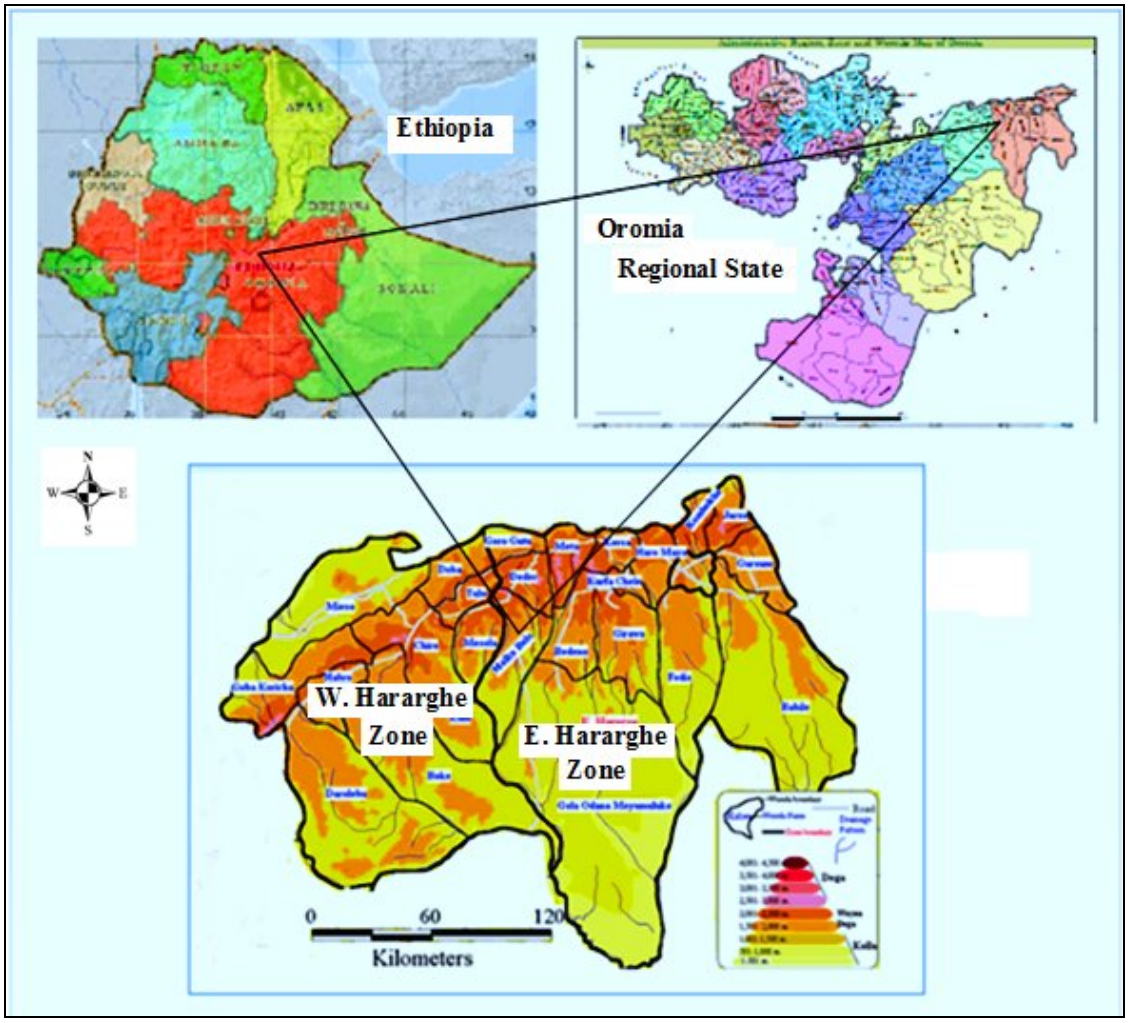

Figure 4. Geographical location of the study area (East and West Hararghe Zones)

3.2. Sampling Design

The primary survey was carried out in two phases. First, a reconnaissance survey was conducted to broadly understand the farming systems and the dominant types of crops grown in the study area. During this exploratory survey, informal discussions were held with different stakeholders including farmers, rural development agents, farmers' association leaders, and agricultural personnel. The purpose of this phase is to facilitate characterization of the existing farming systems and livelihood strategies of the farm households in the context of their specific biophysical, socio-economic, and cultural settings and to refine the study objectives, sampling methods and the survey

instrument. Once having the basic information using community survey, household survey was carried out using structured survey instrument.

This study focused on smallholder farmers' households as a decision-making unit and considered farm household heads as key respondents and decision points of the household's farm and non-farm activities. The fresh lists of farm households in each *Kebele* available at *Wereda* offices constitute a sampling frame, which were used for random selection of the target-sampling units. A two-stage sampling procedure was employed to draw the target sample households of the study. In the first stage, two zones were purposively selected from eastern Ethiopia and highland districts from these zones were considered in order to obtain representative sample household heads from highlands. Then, a random sampling procedure was employed to draw the target sample districts. Accordingly, two districts from East Hararghe Zone and two districts from West Hararghe Zone were randomly selected. In the second stage, total of eight *kebeles* (two *kebeles* per district) were randomly selected from the four districts.

The total sample size was determined using a formula which provides the maximum size to ensure the desired precision using the formula given by Kothari (2004) as follows:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} = \frac{(1.96)^2(0.5)(0.5)(126382)}{(0.05)^2(126382) + (1.96)^2(0.5)(0.5)}$$

$$= 382.9958 \approx 383$$

Where, n is desired sample size; Z is the standard cumulative distribution that corresponds to the level of confidence with the value of 1.96; e is desired level of precision; p is the estimated proportion of an attribute present in the population with the value of 0.5 as suggested by Israel (1992) to get the desired minimum sample size of households at 95% confidence level and ±5% precision; q=1-p; and N is the size of the total population from which the sample is drawn. Accordingly, a sample of 385 farm household heads were selected from eight *kebeles* using random sampling with probability proportional to size as shown in Table 1.

Table 1. Distribution of the sample in districts, *Kebeles* and households

Sample Districts			Sample Kebeles		
Districts	Total hhs	Sample hhs	*Kebeles*	Total hhs	Sample hhs
Grawa	38545	117	Raasaa Jannata	803	43
			Leenca	1402	74
Haramaya	34732	106	Daamota	1483	62
			Finqilee	1041	44
Tulo	28832	88	Ifaa Handodee	635	43
			Kufa Kaas	676	45
Habiro	24273	74	Haro-Chercher	876	34
			Bareda	1027	40
Total	**126382**	**385**	**Total**	**7943**	**385**

Note: "hhs" means household heads

Source: Own computation results (data obtained from East Hararghe and West Hararghe Zones Bureau of Agriculture and Rural Development, 2015).

3.3. Data Sources, Types and Data Collection Methods

The study was conducted based on data obtained from primary and secondary sources. Face-to-face personal *interviews* using semi-structured questionnaire was employed to collect primary data. The types of data collected are based on the need of each and every research objectives. Both open and close-ended types of questions were included in the questionnaire to collect information pertinent to the purpose of the study.

The questionnaire were pre-tested before conducting the field survey for appropriateness (clarity, adequacy and sequence of questions), and revised according to the feedbacks from pre-testing. In addition to formal questionnaire survey, focus group discussions at village level and field observation on some randomly selected household plots were conducted. Moreover, key informant interviews were also

employed for the purpose of characterizing the farming system and identifying realistic typologies. The main purpose of the focus group discussion is to validate information obtained from the survey and to generate in-depth information on some of the survey findings and perceptions of the farmers that may not be adequately captured by the questionnaire survey. To generate information at the field level, 10 enumerators who are familiar to the study area and believed to have sufficient exposure to rural life was selected and trained on data collection tools and interview handling. Field supervisors are responsible to carry out field level verification and initial approval of the works of the respective enumerators.

Secondary data regarding the priority, distribution, prices and yields of most important annual crops that are major sources of livelihood to the smallholder farmers, population, type of credit and technology available were collected through use of simple checklists. The major sources of secondary data include Central Statistical Agency (CSA), East and West Hararghe Zones Agriculture and Rural Development offices.

3.4. Methods of Data Analyses

The method of analysis for this study includes simple descriptive statistics and econometric analysis. Thus, the major analytical steps followed with respect to addressing the individual research objectives are provided as follows.

3.4.1. Descriptive Statistics

Descriptive analysis was used to analyze demographic and socio-economic characteristics and the commercial orientation typology of farm households. Further, descriptive statistics such as means, proportions and standard deviation were used to describe economic and physical characteristics associated with respondents categorized based on their commercial orientation behaviors. Independent sample t-test, chi-square tests and ANOVA were used to make comparisons between the

categories with respect to key variables specified. These analyses were also used as inputs for the econometric analysis in the subsequent sections.

3.4.2. Econometric Analysis

3.4.2.1. Households' commercial orientation decision and intensity

Double-hurdle model was applied for the analysis of farm household commercial orientations. The first hurdle involves factors determining crop market orientation decisions and assessed against a discrete choice dependent variable by market orientation decisions equation. The second hurdle concerns the relationships between market orientations indices for the level of indices with their determinants using the equation defined for level of market orientations. Thus, the double-hurdle model specification for both cases follow the same syntax as presented below:

$$\text{a) } y_{i1}^{*} = \dot{w}_i \alpha + \nu_i \qquad \text{(Market orientation decision)}$$

$$y_i = \begin{cases} 1, & \text{if } y_{i1}^{*} > 0 \\ 0, & \text{otherwise} \end{cases} \tag{12}$$

$$\text{b) } y_{i2}^{*} = \dot{x}_i \beta + u_i \qquad \text{(Level of market orientation equation)}$$

$$\begin{cases} y_i = y_{i2}^{*} = \dot{x}_i \beta + u_i, & \text{if } y_{i1}^{*} > 0 \text{ and } y_{i2}^{*} > 0 \\ y_i = 0, & \text{otherwise} \end{cases} \tag{13}$$

Where, y_{i1}^{*} is the latent variable describing the household's market orientation decisions; y_{i2}^{*} is the latent variable describing the level of market orientation defined by crop market orientation indices; y_i is observed level of market orientation; $\dot{w}_i$ is a vector of variables explaining household internal and external factors influencing initial market orientation decisions; $\dot{x}_i$ is a vector of variables influencing how much the household involved; and ν_i and u_i are error terms and are assumed to have independence between them.

The two equations could be estimated separately by truncated regression. Truncated regression fits a regression model of dependent variables on explanatory variables

from a sample drawn from a restricted part of the population. Under the normality assumption for the whole population, the error terms in the truncated regression model have a truncated normal distribution, which is a normal distribution that has been scaled upward so that the distribution integrates to one over the restricted range.
Let the truncated regression model be specified as follows:

$$y = \mathrm{x}\beta + \varepsilon \tag{14}$$

Here y represents continuous outcomes either observed or not observed. Our model assumes that the errors are normally and independently distributed.

The log-likelihood function for the double-hurdle model that nests a univariate Probit model and a truncated regression model is given following Cragg (1971) by:

$$l\mathrm{ogL} = \sum_{0} \ln\left[1 - \Phi(\dot{\omega}_{\mathrm{i}}\,\alpha)\left(\frac{\dot{\mathrm{X}}_{\mathrm{i}}\,\beta}{\sigma}\right)\right] + \sum_{+} \ln\left[\Phi(\dot{\omega}_{\mathrm{i}}\,\alpha)\frac{1}{\sigma}\phi\left(\frac{y_i - \dot{X}_i\,\beta}{\sigma}\right)\right] \tag{15}$$

Where, "0" indicates summation over the zero observations in the sample; "+" indicates summation over positive observations; Φ (.) and ϕ (.) refer to the standard normal probability and density functions respectively; $\omega^{\bullet}_{\mathrm{i}}$ and $\mathrm{X}_{\mathrm{i}}^{\bullet}$ represent independent variables for the Probit model and the Truncated model respectively; and α, σ, and β are parameters to be estimated for each model.

3.4.2.2. Households' output market participation decision and level of sales

The dominant crops the farm households grew in the study area are maize, sorghum, potato and haricot beans. Hence, households' market participation was expressed through sale of these four crops at different levels. In order to analyze households' market participation decision, the typical approach in the existing literature is to divide the market-participation decision into two stages. In the first stage, households that produce crops decide whether they are net buyers, net sellers, or autarkic in the

crop output market. In the second stage, net buyers and net sellers determine the extent of crop market participation. Thus, the study used Heckman two-stage model since the model best addressed households' market participation decision and level of sales.

Thus, the participation equation can then be written as:

$$Pr(Z_i = 1 \mid w_i, \alpha) = \Phi(h(w_i, \alpha)) + \varepsilon_i \quad (16)$$

Where Z_i is an indicator variable equal to unity for households that participate in crop sells; Φ is the standard normal cumulative distribution function; w is a vector of factors affecting market participation; α is a vector of coefficients to be estimated; and ε_i is the error term assumed to be distributed normally with a mean of zero and variance of σ^2. The variable Z_i takes the value of 1 if the marginal utility that the household i gets from participating in crop market is greater than zero, and zero otherwise.

So we have:

$$Z_i^* = \alpha w_i + \nu_i \quad (17)$$

Where Z_i^* is the latent level of utility that the household gets from crop market participation, $\nu_i \sim N(0,1)$ and,

$$Z_i = \begin{cases} 1 \text{ if } Z_i = 1 \text{ if } Z_i^* > 0, \\ 0 \text{ if } Z_i = 0 \text{ if } Z_i^* \leq 0, \end{cases} \quad (18)$$

In the second stage, the inverse mills ratio (IMR) is added as a regressor in the sales function or level of participation in order to correct for potential selection bias. If only households who participate in the market are included in the second stage, the IMR is computed as follows:

$$\hat{\lambda} = \frac{\phi(h(w_i, \hat{\alpha})}{\Phi(w_i, \hat{\alpha})} \tag{19}$$

Where, ϕ (.) is the normal probability density function. The second-stage (level of sales) equation is then given by:

$$E(Y_i \mid Z = 1) = \mathrm{f}(\mathrm{x}_\mathrm{i}, \beta) + \gamma \frac{\phi(h(w_i, \hat{\alpha})}{\Phi(w_i, \hat{\alpha})} \tag{20}$$

Where E is the expectation operator, Y is the (continuous) extent of market participation, or sales, x is a vector of independent variables affecting sales, and β is the vector of the corresponding coefficients to be estimated.

So Y_i can be expressed as follows:

$$Y_\mathrm{i} = \beta' \mathrm{x}_\mathrm{i} + \gamma \hat{\lambda}_i + \upsilon_\mathrm{i} \tag{21}$$

Where, $\mathrm{u}_\mathrm{i} \sim \mathrm{N}(0, \sigma_\mu)$, Y_i* is only observed crop sellers (Z_i=1), in which case Y_i=Y_i*

3.4.2.3. Households' input market participation decision

Farm households who use agro-chemicals and improved seeds for the selected crops (maize, sorghum, potato and haricot bean) production are observably low in the study area. Thus, chemical fertilizer was used as input side commercialization since it has been a good indicator of whether or not a given farm household is interested to grow crops for commercial purposes (Adam, 2009). Furthermore, chemical fertilizer is selected since the behavior of farm households thriving to pull together their effort and valuable inputs in the production of a given commodity symbolize households motive to increase return from the farming business. Tobit regression model was used to quantify the magnitude and direction of the effects of the factors influencing farm households' participation in fertilizer purchases since some values of the dependent variable was observed to be zero for some individuals in the sample.

Thus, the standard Tobit model (Tobin, 1958) is defined as:

$$y_i^* = x_i\beta + \varepsilon_i$$
$$y_i = \begin{cases} x_i\beta + \varepsilon_i \ , & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \le 0, \end{cases} \qquad (22)$$

Where y_i^* is the latent dependent variable (fertilizer participation index), y_i is the observed dependent variable, x_i is the vector of the explanatory variables, β is the vector of coefficients (estimated parameter), and the ε_i's are assumed to be independently and normally distributed with zero mean and constant variance ($\varepsilon_i \sim N(0, \sigma)$) and therefore $y_i \sim N(xi\ \beta, \sigma)$.

Maximum-likelihood estimation of the Tobit model is straightforward. Let *f* (.) and *F* (.) denote the density function and the cumulative density function for *y**. Then the model implies that the probabilities of observing a non-zero *y* and a zero *y* are f(y) and p(y*<0) =F (0), respectively.

The log-likelihood function for the model is, therefore,

$$lnL = \ln\left(\prod_{y_i>0} f(y_i)\prod_{y_i=0} F(0)\right)$$
$$= \sum_{y_i>0} \ln f(y_i) + \sum_{y_i=0} \ln F(0) \qquad (23)$$

Because *y** is normally distributed (as the ε'*s* are normally distributed), *f* (.) and *F*(.) can be re-expressed in terms of the density function ϕ(.) and the cumulative density function of the standard normal distribution Φ(.), respectively. Then the log-likelihood function can be written in the familiar form as follows:

$$l\text{nL} = \sum_{y_i>0}\left[-\ln\sigma + \ln\phi\left(\frac{y_i - x_i\beta}{\sigma}\right)\right] + \sum_{y_i=0}\ln\left[1 - \Phi\left(\left(\frac{x_i\beta}{\sigma}\right)\right)\right] \qquad (24)$$

3.4.2.4. Effect of crop commercial orientation on Total Factor Productivity

Once the mathematical relationship between commercial orientation and TFP is established (as indicated in section 2.4.3), a 2SLS has been employed. The general functional relationship is as follows:

TFP = f (CI, X); where, CI-commercial orientation index (an endogenous variable) and X-exogenous variables influencing productivity. Thus,

$$TFP = \beta_0 + \beta_1 C + \beta_2 X + \nu \quad (25)$$

Where, β-coefficients to be estimated; C- the observed index of commercial orientation, X- is a set of exogenous explanatory variables, ν- is structural disturbance term, $\nu \sim N(0, \sigma^2)$.

The reduced form of the endogenous dependent variable is given by:

$$\hat{C} = \pi Z + u \quad (26)$$

Where, $\pi Z = \alpha_0 + \alpha_1 X$, $C = \hat{C}$ if $\hat{C} > 0$, otherwise 0, and $\hat{C}$ is the latent index of commercial orientation, π and α- are coefficients to be estimated); μ is reduced form error term, $\mu \sim N(0, \sigma^2)$.

3.4.2.5. Sources of inefficiency

To deal with the factors of inefficiencies of farm households in crops production, different socio-economic and institutional variables will be regressed on inefficiency estimates using a two limit Tobit regression model. The Tobit model was deployed because the efficiency scores are double truncated at 0 and 1 as the scores lie within the range of 0 to 1.

The functional form of the Tobit model is:

$$Y_i^* = \beta_0 + \sum \beta_m X_{jm} + \mu_j \quad (27)$$

Where y_i^* = latent variable representing the efficiency scores of farm j, β = a vector of unknown parameters, X_{jm} = a vector of explanatory variables m (m = 1, 2, ..., k) for farm j and μ_j= an error term that is independently and normally distributed with mean zero and variance σ^2.

Denoting y_i as the observed variables,

$$y_i = \begin{cases} 1 & \text{if } y_i^* \geq 1 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \quad (28)$$

In this Equation, the distribution of the dependent variable is not normally distributed rather its value varies between 0 and 1. If the data to be analyzed contain values of the dependent variable that is truncated or censored, the OLS is no longer applicable to the concept of estimated regression coefficients. If OLS is directly used it will lead to biased and inconsistent parameter estimation. However, Tobit model that follows the concept of maximum likelihood becomes a better choice to estimate regression coefficients (Maddala, 1999).

3.5. Variables Definition and Hypotheses

A number of dependent and independent variables were chosen to be included in each model explained previously. Descriptions of these variables, their measurements, and associated hypotheses to be tested under each analytical framework are explained here under.

3.5.1. Definition of Variables for Crop Market Orientation

The study identifies the factors influencing households' commercial orientation decision and intensity of commercial orientation in crop production. The dependent variables for the double-hurdle model are: a) the discrete binary choices of market orientation decision and b) the intensity of market orientation indices. The dependent variable for the first hurdle (Probit model) pertains the market orientation indices of less than 30% assumed to be zero value and market orientation indices greater than or equal to 30% obtained value of 1. Whereas for the second hurdle (truncated regression), the dependent variable is represented by the value of commercial orientation index calculated for individual observations.

The selection of the explanatory variables is guided by theoretical and empirical literatures and researchers view. These variables include sex of the household head, educational status, social capital, farming experience, dependency ratio, total land cultivated, land allocated to *khat*, off/non-farm income, livestock holding, on-farm income, fertilizer used, proportion of irrigated land, crop diversification index, credit use, extension visits, distance from market, distance to main road, distance to nearest town, distance to FTC, and location dummy. The list of explanatory variables used in each model and their expected signs are summarized in Table 2.

The hypothesis to be tested is that households' commercial orientation decision and intensity of commercial orientation in crop production are influenced by the combined effect of farm internal and external factors such as demographic, socioeconomic, farmer and farm specific attributes, institutional services and market access factors. The expected effects of each of these variables are discussed as follows:

Sex of household head: This is a dummy variable that takes value of 1 if a household head is female and 0 if male. Since women play a key role in agricultural production, it is important to consider the role they played in the process of crop commercialization. Female headed households are usually less likely commercialize in crop production since they are usually endowed with less resource and less exposed to new information due to their social position. It was therefore, sex of household head hypothesized to influence crop commercial orientation decision and intensity of commercial orientation negatively.

Social capital: Social capital indicates involvement of farm households in leadership activities of social organizations (such as religious activities, *edir*, and so on). This is a dummy variable that takes a value of 1 if involved in social activities and 0 if not. Portes (1998) put forth that social capital stands for the ability of actors to secure benefits by virtue of membership in social networks or other social structures, is becoming a critical factor (input) in understanding differences in economic outcome. Social capital was expected to influence market orientation decision and intensities positively.

Education status of the household head: Education is described as an essential element in any development process and is measured as the highest education level in the household. It is expected that the more years an individual is exposed to education, the more open he/she would be to new ideas. Educated households have better skills, and better access to information and ability to process information, and thus education level of farm households hypothesized to influence the decision and level of market orientation positively (Berhanu and Moti, 2010; 2012).

Experience in crop farming: Experience of the household head in crop production is a continuous variable and is one of the factors that affect crop market orientation. Experienced farmers are expected to have greater access to productive resources (such as land and labor) and be able to apply improved agricultural technologies, recommended agronomic practices and expected to be faster in adopting improved crop variety than inexperienced farmers. Thus, farming experience hypothesized to influence the decision and level of market orientation positively.

Dependency ratio: Dependency ratio is a continuous variable measured as the ratio of dependents, household members younger than 15 or older than 64, to the working age household members, those ages between 15 and 64 (WB, 2013). A household with relatively more dependent members is consuming more of its produce than it avail to sale. In other words, market orientation decision of food crops is unlikely. It was therefore anticipated that dependency ratio negatively influenced market orientation (decision and level) based on the findings of Adam (2009).

Total cultivated land: This variable is taken as a continuous variable measured as the total cropped area in hectares under the household management (be it own land, rented-in land or shared land). Cultivated land size would affect market orientation decision. This means that as the cultivated land size increases, the probability of commercialization increases. It was anticipated that land holding size positively influenced crop market orientation as it has been examined by several findings (Adam, 2009; Birhanu and Moti, 2010; and Bedaso *et al*., 2012).

Land allocated to *khat*: *Khat* is generally the dominant cash crop in the study area. Thus, land allocation to *khat* is assumed to be an important factor influencing smallholder farmers' decision and level of crop market orientation. If households allocated more land to *khat*, the larger portion of their earnings would be from the sale of *khat* and their tendency to produce and sell major cereal crop would be low. Hence, land allocation to *khat* hypothesized to influence market orientation negatively.

Off/non-farm income: It is annual income in Birr from off/non-farm activities through external labor supply, rentals of ox power, pack animals and land, handicrafts, petty trade, and so on (Hussein, 2007; Hassen *et al.*, 2012b). Based on the findings of Workneh and Michael (2002) and Adam (2009), (1) farm households with more farm resources are less attracted to non-farm activities; and (2) diversifying their income through employment outside their farm have a reduced inclination towards making marketing orientation decision mainly due to depressed productivity or depressed income sources. Moreover, farm households who obtained better income from off/non-farm activities are expected to decide to produce food crops for home consumption than for sale. As a result, off/non-farm income was expected to influence market orientation decision and level of market orientation negatively.

Livestock holding: Livestock ownership can serve as input for crop production like ox for drought animal, equine transportation and their by-product as fertilizer which can contribute for high surplus produced for market hence leads to higher commercialization. Likewise, negative relationship between livestock holding and market orientation is expected on the other side since livestock competes for land that reduces amount of crop produced perhaps leads to low probability of commercial orientation in crops (Berhanu *et al*., 2009; Habtamu, 2013). Therefore, the sign of livestock holding was undetermined.

Extension visits: Extension service is the major instrument through which new ideas and techniques are transmitted to farmers. It is a continuous variable measured in the number of days the household is visited by extension agents. Agricultural extension

services enhance farmer skills and knowledge, link farmers with modern technology and markets, and ease liquidity and input supply constraints (Lerman, 2004; Berhanu *et al*., 2006; Berhanu and Moti, 2010). So farmer' who have more contact with extension worker can improve their decision to adopt agricultural crop commercialization. A positive relationship was, therefore, expected between number of extension contacts and market orientation (decision and intensity).

On-farm income: This variable is continuous (expressed in ETB) and obtained from on-farm activities. It is assumed to be a proxy to total household income and households with larger income are able to cultivate larger parcels of land than those with lower income. Consequently, increasing income of the farm households will lead to an increase in the production of cash crop. Thus, this variable anticipated to have positive effect on the decision of households' market orientation behavior.

Fertilizer used: It is a continuous variable denoting the amount of fertilizer applied to crops in kilograms. Chemical fertilizer was used as a good indicator of whether or not a given farm household is interested to grow crops for commercial purposes. Furthermore, chemical fertilizer is selected since the behavior of farm households thriving to pull together their effort and valuable inputs in the production of a given commodity symbolize households motive to increase return from the farming business. Based on the findings of Adam (2009), chemical fertilizer is hypothesized to influence households' level of market orientation positively.

Proportion of irrigated land: Proportion of irrigated land is calculated (which is the ratio of irrigated land to total cultivated land) for each sample household and expressed in percentage. Irrigation use is believed to enhance crop productivity and in turn increases the level of sale. The findings of Moti (2007) and Sindi (2008) indicated that proportion of irrigated land could have an impact on farm households' market orientation status and this variable was hypothesized to influence it positively.

Crop diversification index: Simpson's crop diversification index is calculated for each sample household and this variable is an indicator of risk management strategies of the farmers. Based on the findings of Adam (2009), this variable was hypothesized to influence decision and level of market orientation positively.

Credit use: Credits are expected to enhance farmers' financial capacity to purchase productivity enhancing inputs (like planting materials, fertilizer and crop protection), pay wages, invest in machinery, or to smooth consumption as well as markets, ease liquidity and input supply constraints, and thus, leading to increase agricultural productivity, induce market orientation and thus greater commercialization (Lerman, 2004; Martey *et al*., 2012). Thus, positive effect was expected from credit use.

Distance from market: It is a continuous variable measured in km and included to capture the role of travel costs in influencing probability and intensity of market orientation. It is used as a proxy for market access and is expected to influence market orientation negatively as distant markets mean higher cost of transport and lesser likelihood of purchasing improved input that may lead to higher production for which market is not accessible. The findings of Betre (2006) and Birhanu and Moti (2010) attested that market distance negatively influenced crop commercial orientation decision.

Distance to main road: It is used as proxy for accessibility of transportation to markets. Farmers far away from main road become costly and difficult in transportation. It was, therefore, expected that households nearer to main road would have better chance to be commercialize than those far away from main road. Thus, it was hypothesized that long distance from main has positive inefficiencies in crop production. Based on Birhanu and Moti (2010), distance to the main road negatively influenced farmers' market orientation behavior.

Distance to nearest town: Distance to the nearest town is measured in km. Farmers far away from town are less accessible for farm inputs, market information and transportation become costly and difficult. It was, therefore, expected that households

nearer to town would have better chance to be market oriented than those far away from town. On the other hand, farmers near to towns may engage in different off/non-farm businesses. If a farmer spends more time on these activities relative to farm activities, this might negatively affect agricultural activities and hence crop market orientation. Thus, the sign of distance to the nearest town is indeterminate.

Distance to FTC: Distance to FTC is used as proxy for the accessibility of training services to farmer in crop production. Proximity to training center has advantage of obtaining awareness of farmers and exposes to new ideas and information about productivity of input and output management. Thus, this variable was hypothesized to influence crop market orientation negatively.

Location dummy: Location dummy is is characterized by 1 if the household belongs to west Hararghe highlands and 0 if the household is in East Hararghe highlands. The purpose of classifying sample households in this location dummy is due to the difference in the geographical location as well as the extent and type of crop production.

Table 2. Description of variables hypothesized to influence crop market orientations

Description of variables	Measurement	Expected sign
Sex of household head	Dummy(1female, 0 male)	+/-
Social capital	Dummy(0 not involved, 1 involved)	+/-
Education status	Dummy (1 if literate, 0 otherwise)	+
Farming experience	Continuous (years)	+
Dependency ratio	Continuous (%)	-
Total cultivated land	Continuous (ha)	+
Land allocated to *khat*	Continuous (ha)	-
Off/ non-farm income	Continuous (ETB)	+
Livestock holding	Continuous (TLU)	+/-
On-farm income	Continuous (ETB)	+
Chemical fertilizer used	Continuous (quintal)	+
Proportion of irrigated land	Continuous (%)	+
Crop diversification index	Continuous (%)	+
Credit use	Continuous (ETB)	+
Extension visits	Count	+
Distance from market	Continuous(km)	-
Distance to main road	Continuous(km)	-
Distance to nearest town	Continuous(km)	+/-
Distance to FTC	Continuous(km)	-
Location dummy	Dummy(1W.Hararghe,0 E.Hararghe)	+/-

Note: W. Hararghe=West Hararghe, E.Hararghe=East Hararghe

Source: Own formulation from theoretical and empirical literatures and authors view

3.5.2. Definition of Variables for Crop Output Market Participation

The study identifies the factors influencing households' crop output market participation decision and level of sales in crop production. The dependent variables are; a) the discrete binary choices of whether or not to participate in crop output markets and b) the intensity of market participation indices in crop sales. The

selection of the explanatory variables is guided by theoretical and empirical literatures and researchers view. Thus, explanatory variables include sex of the household head, education status, social capital, farming experience, dependency ratio, total land cultivated, land allocated to *khat*, off/non-farm income, livestock holding, on-farm income, fertilizer used, proportion of irrigated land, crop diversification index, credit use, number of extension visits, location dummy, and distances from- market, road, town and FTC. The lists of explanatory variables used in each model and their expected signs are summarized in Table 3.

The hypothesis to be tested is households' crop output market participation decision and level of sales are influenced by the combined effect of farm internal and external factors such as demographic, socioeconomic, farmer and farm specific attributes, institutional services and market access factors. The expected effects of each of these variables are discussed here under:

Sex of household head: This is a dummy variable that assumes a value of 1 if the head of the household is female and 0 for male. It is included to capture differences in market participation between males and females. Since women play a key role in agricultural systems, it is important to consider the role they played in the process of crop output market participation. Most of the time, female headed households are exposed to resource constraints like labor, capital, and land for crops production. Hence, male headed households were hypothesized to have higher probability and degree of participation in output markets than female headed (Nadezda *et al*., 2012; Leykun and Jama, 2014).

Farming experience: Experience of the household head in crop production is a continuous variable expressed in years and is one of the factors that affect crop market participation. The older the households head the better he/she has social network as well as the more experience on farming and weather forecasting (Berhanu and Moti, 2012; Habtamu, 2013). As a result, older farmers have advantage of selecting right crop and timing of production to become productive. This improves household's productivity and, therefore, increases probability of surplus production for sale which

in turn is related to market participation and intensity of participation positively. On the other side experienced households may have large family size and demand for home consumption and that leads to low surplus to supply for market. It was therefore, farming experience hypothesized to influence crop output market participation either positively or negatively.

Education status of the household head: Literate households have better skills, and better access to information and ability to process information, and thus may be positively associated with marketing decision and level of market participation (Samuel and Sharp, 2008; Berhanu and Moti, 2010). Education also reduces transaction costs and market entry barriers as it enables farmers to obtain and process market information, and gives them better negotiation skills. Consequently, it was anticipated that education status positively affects market participation decision and level of participation.

Cultivated land size: It refers to total land size cultivated in the production year (2014/15) by households including rented-in and shared or other means arrangements by household. Lerman (2005) showed that an increase of farm size leads to higher household income and greater readiness to engage in sale of the farm products, while commercialization of farm activity in turn generates higher household incomes. Landholdings have an indirect positive effect on market participation, through its positive effect on farm output (Kan *et al.,* 2006). Thus, cultivated land size was expected to influence market participation and degree of participation positively.

Proportion of irrigated land: Proportion of irrigated land is calculated for each sample household and expressed in percentage. Most farm households applying irrigation are market oriented and produce high value cash crops to the market (Omiti *et al*., 2009). It would be reasonable to expect that such households would have higher level of crop sales. Consequently, it was hypothesized that proportion of irrigated land could have a positive effect on farm households' market participation decision and level of participation.

Credit use: It is a continuous variable measured in ETB. If a household has utilized much credit, it may enable to invest largely for the good management of crops which they produced (Martey *et al.,* 2012). Access to credit, leads to increased agricultural productivity and greater commercialization through enhancing the financial and decision making capacities of the farmer forwards improved production (Mahlet, 2007; Berhanu *et al*., 2009). Therefore, it was hypothesized that credit use would have positive effect on the level of market participation decision and level of participation.

Extension visits: It is a continuous variable measured in the number of days the household is visited by extension agents during the production year 2014/15. Agricultural extension services enhance farmer skills and knowledge, link farmers with modern technology and markets, and ease liquidity and input supply constraints (Lerman, 2004; Berhanu *et al*., 2006). It was therefore, considered as a positive factor in the decision of crop market participation and level of market participation.

Distance from nearest market: It is a continuous variable measured in km and included to capture the role of travel costs in influencing probability and intensity of market participation. Marketing costs expressed in distance from the market have an effect ranging from limiting the level commercialization to completely hindering smallholder market participation as it has been examined by several authors (Key *et al.,* 2000; Eleni, 2001; Barrett, 2007; Pender and Alemu, 2007; Alene *et al.,* 2008). As a result, it was hypothesized that distance from market place negatively influence market participation and level of participation.

Distance from major town: Distance to the nearest town is measured in km. Farmers near to town are more accessible for farm inputs, market information and transportation and hence more likely better market participation decision than those far away from town. On the other hand, farmers near to towns may engage in different off/non-farm businesses and spends more time on these activities rather than crop production. Thus, the sign of distance to the nearest town was undetermined.

Distance from main road: Distance to the main road is used as proxy for accessibility of transportation to markets. Access to roads reduced marketing costs, thus encourage market decision and market participation (Barrett 2007; Rios *et al*., 2008; Omiti *et al*., 2009). Hence, households far away from roads are expected to be less in market participation decision.

Total livestock holding: This refers to the total number of animals possessed by the household measured in tropical livestock unit (TLU). Livestock ownership can serve as input for crop production like ox for drought animal and manure which can contribute for high surplus produced for market (Berhanu *et al*., 2009; Habtamu, 2013; Degye, 2013). Ownership of more livestock detracts from crop output market participation, since these livestock offer alternative sources of cash income (Berhanu and Moti, 2010). Therefore, the effect of livestock holding was undetermined.

Off/non- farm income: Off/non-farm activities refer to both self employment in non and off-farm sectors such as petty trade, craft work, stone mining, blacksmith, and employment in cash/food for work, daily labor, guard, etc. Participation in off/non-farm activities was expected to have negative relationship with crop output market participation. This is because of the assumption that households that generate income from off/non-farm activities fill financial need from that income and use output produced for home consumption and hence low market participation (Barrett, 2008).

Fertilizer use It is a continuous variable denoting the amount of fertilizer applied to crops in km. Chemical fertilizer is believed to productivity enhancing input and used as a good indicator of whether or not a given farm household is interested to grow crops for sale (Chirwa and Matita, 2012). Thus, fertilizer use was hypothesized to influence households' market participation decision and level of participation positively.

On-farm income: This variable is continuous and is income in ETB from on-farm activities. It is assumed to be a proxy to total household income and households with larger incomes are able to use productivity enhancing production inputs and cultivate

larger parcels of land than those with lower incomes. Consequently, increasing income of the farm households will lead to an increase in the production of crop for sale. Thus, this variable was anticipated to have positive effect on the decision of households' crop output market participation and level of participation.

Variable definitions for social capital, dependency ratio**,** land allocated to *khat*, crop diversification index, distances from FTC and location dummy are in similar fashion with the discussions under section 3.5.1.

Table 3. Description of variables hypothesized to influence crop output market participation

Description of variables	Measurement	Expected sign
Sex of household head	Dummy(1female, 0 male)	+/-
Educational status	Dummy (1 if literate, 0 otherwise)	+
Farming experience	Continuous (years)	+/-
Social capital	Dummy(0 not involved, 1 involved)	+/-
Dependency ratio	Continuous (%)	_
Total land cultivated	Continuous (ha)	+
Land allocated to *khat*	Continuous (ha)	-
Off/ non-farm income	Continuous (ETB)	+
Livestock holding	Continuous (TLU)	+/-
On-farm income	Continuous (ETB)	+
Chemical fertilizer used	Continuous (quintal)	+
Proportion of irrigated land	Continuous (%)	+
Crop diversification index	Continuous (%)	+
Credit use	Continuous (ETB)	+
Extension visits	Count	+
Distance from market	Continuous(km)	_
Distance to main road	Continuous(km)	_
Distance to FTC	Continuous(km)	_
Location dummy	Dummy(1-W. Hararghe, 0-E. Hararghe)	+/-

Note: W. Hararghe=West Hararghe, E.Hararghe=East Hararghe

Source: Own formulation from theoretical and empirical literatures and authors view

3.5.3. Definition of Variables for Input Market Participation

This study identifies the factors influencing households' participation in fertilizer purchases. The dependent variable is fertilizer market participation indices. The selection of explanatory variables is guided by previous theoretical, empirical literatures and researchers view. Thus, the common explanatory variables include sex of household head, dependency ratio, farming experience, cultivated land size, land size for *khat*, total livestock holdings, education status, off/non-farm income, credit use, distance to nearest market, distance to nearest town, distance to nearest road, extension contacts and amount of manure used. The lists of explanatory variables used in each model and their expected signs are summarized in Table 4.

The hypothesis to be tested is that households' fertilizer market participation indices are influenced by a combined effect of farm internal and external factors such as demographic, socioeconomic, farmer and farm specific attributes, institutional services and market access factors. The expected effects of each of these variables are discussed here under:

Sex of household head: This is a dummy variable that takes a value of 1 if the household head is female and 0 if male. Male farm households are relatively better position to get timely information about markets, prices and credit services that advance their decision to acquire fertilizer may be due to the influence of the head and cultural factors that existed over the past where females are compelled more for household activities (Adam, 2009). Thus, this variable was hypothesized to influence households' fertilizer market participation index negatively.

Education status of the household head: Literate households have better skills, and better access to information and ability to process market information, and gives them better negotiation skills (Samuel and Sharp, 2008; Berhanu and Moti, 2010). Hence, it was expected that education status of the household head positively influenced households' fertilizer market participation index.

Farming experience: Experience of the household head in crop production is a continuous variable expressed in years and is one of the factors that affect crop input market participation. The older the households head the better he/she has social network as well as the more experience on farming (Berhanu and Moti, 2012). On the other hand, experienced households may have large family size and high demand for home consumption that leads to low surplus to supply for market. This also negatively affects purchase of inputs (Adam, 2009). Therefore, farming experience was hypothesized to affect crop input market participation either positively or negatively.

Dependency ratio: A household with relatively more dependent members negatively influences households' fertilizer purchases since they may lack financial capacity to make business oriented decisions. Thus, it was anticipated that dependency ratio negatively influenced households' fertilizer market participation index.

Livestock holdings: This refers to the total number of animals possessed by the household and measured in TLU. Income generated from livestock could benefit input oriented commercialization (Workneh and Michael, 2002). Hence, livestock holding was hypothesized to affect crop input market participation index positively.

Cultivated land size: It refers to households' total cultivated land size in the production year (2014/15) including rented-in and shared or other means arrangements. Land holding has an indirect positive effect on market participation, through its positive effect on farm output (Kan *et al.,* 2006). On contrary, based on the findings of Adam (2009), households' capacity to purchase fertilizer decreased as the non-cash crops land size increases. Accordingly, the expected sign of cultivated land size was undetermined.

Land allocated to *khat*: Land allocation to *khat* is assumed to be an important factor influencing smallholder farmers' fertilizer market participation. If a household allocated more land to *khat*, he/she might earn more cash income from the sales of *khat* and their tendency to purchase chemical fertilizer would increase. Hence, this variable was hypothesized to influence fertilizer market participation index positively.

Off/non- farm income: Off/non-farm activities refer to both self employment in non and off-farm sectors such as petty trade, craft work, stone mining, blacksmith, and employment in cash/food for work, daily labor, guard, etc. Participation in off/non-farm activities was expected to have positive relationship with fertilizer market participation index. This is because of the assumption that households that generate income from off/non-farm activities can alleviate capital constraints to purchase fertilizer and other inputs.

Credit use: Access to credit is found to be significant and positively affecting the probability of using fertilizer. The implication is that credit is very helpful in relieving capital constraints faced by farmers for using fertilizer and other purchased inputs (Workneh and Michael, 2002; Adam, 2009; Mengistu and Siegfried, 2011). Thus, credit use was hypothesized to influence fertilizer market participation positively.

Distance from market: It is a continuous variable measured in km and used as a proxy for market access. Distance to nearest market detracts from crop input market participation due to its effect on increasing marketing costs of both inputs and outputs (Adam, 2009; Berhanu and Moti, 2010). As a result, market distance was expected to influence households' fertilizer market participation index negatively.

Extension visits: Frequent extension visits in giving technical advice on crop productivity enhancing inputs encourage farmers to think of acquiring the particular inputs (Adam, 2009). Makhura (2001) and Musemwa *et al.* (2008) also emphasized the importance of this interaction with extension officers in terms of improving farmers' access to information and technical farming skills. Thus, extension visits was hypothesized to influence households' fertilizer market participation index positively.

Distance from main road: It is used as proxy for accessibility of transportation to markets. Farmers far away from main road become costly and difficult in transportation. That means households nearer to main road would have better chance of getting fertilizer with minimum cost than those far away from main road. Thus, it was expected to influence households' fertilizer market participation negatively.

Distance from nearest town: Distance to the nearest town is measured in km. Farmers far away from town are less accessible for farm inputs, market information and transportation become costly and difficult. It was, therefore, expected that households nearer to town would have better chance to get fertilizer more easily than those far away from town.

Amount of manure used: Manure usually comes from animal excreta and the possession of livestock by a household usually implies its availability. Use of manure offset the use of chemical fertilizers. That means, when use of chemical fertilizer increases that of natural fertilizer decreases and vice-versa (Mengistu and Siegfried, 2011). As a result, amount of manure used was hypothesized to affect households' participation in fertilizer purchase negatively.

Table 4. Description of variables hypothesized to influence fertilizer market participation

Description of variables	Measurement	Expected sign
Sex of household head	Dummy(1female, 0 male)	+/-
Educational status	Dummy (1 if literate, 0 otherwise)	+
Farming experience	Continuous (years)	+/-
Dependency ratio	Continuous (%)	_
Total cultivated land	Continuous (ha)	+/-
Land allocated to *khat*	Continuous (ha)	+
Off/ non-farm income	Continuous (ETB)	+
Livestock holding	Continuous (TLU)	+
Credit use	Continuous (ETB)	+
Extension visits	Count	+
Distance from market	Continuous(km)	_
Distance to main road	Continuous(km)	_
Distance to nearest town	Continuous(km)	_
Amount of manure used	Continuous (quintal)	_

Source: Own formulation from theoretical and empirical literatures and authors view

3.5.4. Definition of Variables for the Effect of Commercial Orientation on Total Factor Productivity

In the analysis of the effect of commercial orientation on TFP, the dependent variable is TFP of crops. Variable selections that are anticipated to have an influence on the TFP were based on theoretical and empirical literatures and researchers view. These factors include commercial orientation (endogenous variable), instruments (distance to nearest road, annual crop income, land allocated to *khat*), sex of household head, education status, farming experience, active members to land ratio, off/non-farm income, livestock holding (excluding ox), oxen holding, fertilizer used, credit used, extension visits, distance to nearest market, manure used, labor used, annual livestock income and location dummy. Variables description and expected sign of the hypothesized determinants on the aforementioned dependent variable (TFP) are presented in Table 5.

Sex of the household head: This is a dummy variable that takes a value of 1 if the household head is female and 0 if male. The natural phenomenon includes the longstanding influence of cultural relationships between male and females in agricultural production where males have better experience of making production and marketing decisions independently. Male and female have separate spheres of decision-making with females engaged more in well-being provisioning. Smith and Chavas (1999) and Adam *et al*. (2010) attested that female-headed households are less likely productive than male-headed households. Thus, sex of the household head was expected to have negative effect on crop TFP.

Education status of the household head: Education is described as an essential element in any development process. It is argued that educated people can understand agricultural instructions very easily and be able to apply technical skills imparted to them than uneducated ones. Adam (2009) and Adam *et al*. (2010) attested that educated farmers were better in crop productivity. Hence, education status of the household head was expected to have positive effect on crop TFP of crop production.

Farming experience: Experience of the household head in crop production is a continuous variable expressed in years. The older the households head the better he/she has social network as well as the more experience on farming and weather forecasting. It is hypothesized that farming experience would have positive effect on TFP of crop production.

Active members to land ratio: It is a continuous variable measured as the ratio of number of working age household members (between 15 and 64) to the size of cultivated land (ha). This variable was hypothesized to influence TFP negatively.

Off/non-farm income: Households with higher off-farm income may reduce the time allocated to farm management and resulting in lower productivity (Ana *et al*., 2009). The findings of Adam *et al*. (2010) also assured that farmers' participation in off-farm employment exhibited lack of capacity to undertake own farm activities hence farm households enjoying off/non-farm employment face lower productivity. Hence, off/non-farm income was hypothesized to influence TFP negatively.

Oxen ownership: Oxen availability, being the main sources of draught power, plays a crucial role in crop production (Melaku, 2011). Consequently, oxen holding were expected to have positive effect on crop TFP.

Livestock holding (excluding ox): Livestock holding is measured as a continuous variable in terms of TLU. The farmer who possesses more number of livestock will have better capacity to purchase productivity enhancing inputs as income obtained from livestock serves for investment on crop production that would improves productivity (Adam *et al.,* 2010). It was, therefore, hypothesized that livestock holding has positive effect on TFP of crops.

Extension visits: Extension service has to support and facilitate people engaged in agricultural production to obtain information, skills, and technologies to solve problems and to improve the livelihoods and well-beings of farmers. According to the finding of Adam *et al.* (2010), frequent extension farm households who got large

number of extension contacts were associated with improvements in crop productivity. Consequently, extension visits was hypothesized to have positive effect on TFP of crops.

Market distance: Those farm households that are located relatively far away from market places suffered from low productivity due probably to the relative inaccessibility of input and output markets and lack of the required capacity (Adam, 2009). Thus, market distance as a proxy for transaction costs was expected to have negative effect on crop productivity.

Labor used: It refers to family, hired and shared labors that are used by the sample households for different agronomic practices of crop production and converted to man-equivalent using conversion factors for different labor classes participated in the production process. A study made by Adam (2009) signified that labor man-days available for agricultural production is negatively associated with productivity probably due to the underemployment problem caused by capacity limitation in terms of access to physical and financial capital.

Manure used: Manure usually comes from animal excreta and a widely practiced means of soil nutrient replenishment and hence considered as one variable affecting crop productivity. This variable was expected to affect TFP of crops positively.

Annual livestock income: This is income obtained from sale of livestock during the year 2014/15. Household income, including income from sale of livestock, has a positive effect on crop productivity since they gain the ability to buy improved seeds, fertilizer and other productivity enhancing inputs. Annual livestock income was therefore, expected to affect TFP of crops positively.

Credit use: Use of cash credit is one of the important factors that affect crop productivity. Credits are expected to enhance farmers' capacity to purchase of productivity enhancing inputs (like planting materials, fertilizer and crop protection, wages, and so on). As a result, it was expected to enhance crop TFP.

Fertilizer used: It refers to the amount of chemical fertilizers used by the sample farmers for their crop production in the year 2014/15 and measured in kg. Crop productivity of a household increases by using more fertilizer (Adam *et al.,* 2010). Hence, using chemical fertilizer was hypothesized to affect TFP of crops positively.

Table 5. Description of variables hypothesized to influence TFP of crops

Variable Description	Measurement	Expected sign
Commercial orientation index	Continuous (%)	+/-
Sex of household head	Dummy (1- female, 0- male)	+/-
Educational status	Dummy (1-literate, 0- otherwise)	+
Farming experience	Continuous (years)	+/-
Active members to land ratio	Continuous (%)	+/-
Off/non-farm income	Continuous (ETB)	+
Livestock holding (excluding ox)	Continuous (TLU)	+
Oxen ownership	Continuous (TLU)	+
Fertilizer used	Continuous (kg/ha)	+
Credit used	Continuous (ETB)	+
Extension visits	Continuous (count)	_
Distance to nearest market	Continuous (km)	+
Amount of manure used	Continuous (kg)	+
Amount of labor used	Continuous (Man- days)	+
Annual livestock income	Continuous (ETB)	+/-
Location dummy	Dummy(0-E.Hararghe,1-W.Hararghe)	+/-

Source: Own formulation from theoretical and empirical literatures and authors view

3.5.5. Definition of Variables for Cluster DEA Efficiency

As indicated in the analytical framework (section 2.4.4.), the estimation of relative efficiency and performance based clustering method called “clustering-based

technique of DEA computations in non-homogenous DMUs" was applied to estimate the relative TE, AE and EE of smallholder farmers.

a) Output variables: Output refers to the physical amount of produce obtained from the four crops (sorghum, maize, potato and haricot beans) that the sample households produced during the production season of 2014/15.

b) Production inputs and costs: The amount of land available, labor (both family, hired and shared), seed, fertilizer, pesticide and herbicide have a positive impact on the output in the production (Otitoju and Arene, 2010; Shehu *et al*., 2010). Justifications of input variables and input costs are presented as follows:

Land: It refers to total land cultivated for the four crops during the production season.

Labor: It refers to family and hired labors that are used by sample households for different crop production. It is converted to man-equivalent using conversion factors for different labor classes participated in the production process.

Seeds: It refers to the amount of seed (sorghum, maize, potato and haricot beans**)** used by the sample households and measured in kg.

Fertilizer (Urea/DAP): It refers to the amount of fertilizers used by the sample farmers for their crop production in the year 2014/15 measured in kg.

Oxen: Represents the amount of oxen used for crop production measured in oxen-day.

Price of seed: The amount paid by farmers to purchase seeds. In the case of own seed it was recorded based on the price required for the same quality and quantity in the local market during the same production season.

Price of labor: For hired labor the wage paid to the workers were recorded and for household labor it was estimated as the wage paid in the locality for the same quality labor.

Price of fertilizers (Urea/DAP): Price of fertilizers was recorded as the market price paid to purchase fertilizers during the 2014/15 production year.

Price of land: Rental price was taken as price of land since land does not have market price. For owned land rent paid to same quality paid in the locality was taken and for rented-in land the amount paid was taken as its price.

Price for oxen power: This is estimated as the amount of cash paid for the renters per oxen day.

Table 6. Summary of crop input and output variables used in the DEA models

Variables	Description	Unit of Measurement
Y_1	Total maize output	Kilograms
Y_2	Total sorghum output	Kilograms
Y_3	Total potato output	Kilograms
Y_4	Total haricot beans output	Kilograms
X_1	Total land cultivated	Hectare
X_2	Total labor (household and hired)	Man days
X_3	Quantity of oxen-power used	Oxen-day
X_4	Quantity of Agro-chemicals	Litre
X_5	Quantity of Urea and DAP	Kilograms
X_6	Quantity of sorghum seed	Kilograms
X_7	Quantity of maize seed	Kilograms
X_8	Quantity of potato seed	Kilograms
X_9	Quantity of haricot beans seed	Kilograms
P_1	Price of land used	Birr per hectare
P_2	Price of total labor used	Birr per man-equivalent
P_3	Price of oxen-power used	Birr per oxen-day
P_4	Price of Agro-chemicals	Birr per litre
P_5	Price of UREA and DAP used	Birr per kg
P_6	Price of sorghum seed used	Birr per kg
P_7	Price of maize seed used	Birr per kg
P_8	Price of potato seed used	Birr per kg
P_9	Price of haricot been seed used	Birr per kg

Source: Own construction based on empirical studies reviewed in the literature

3.5.6. Definition of Variables for Inefficiency of Crop Production

The study identifies the sources of technical, allocative and economic inefficiencies of smallholder crop producers. Thus, the dependent variables are obtained by deducting the DEA results of technical, allocative and economic efficiencies from 1.00. The hypothesis to be tested is the levels of technical, allocative and economic inefficiencies of smallholder crop producers are influenced by the combined effect of demographic, socioeconomic, farm attributes, institutional services and market access factors.

The selection of explanatory variables is guided by theoretical and empirical literatures and researchers view. These factors include sex of the household head, farming experience, household size, education level, credit use, extension visits, distance to nearest market, distance to nearest road, distance to town, off/non-farm income, crop diversification, land allocated to *khat,* oxen and other livestock holding. The list of explanatory variables used in two-limit Tobit model and their expected signs are summarized in Table 7. The expected effect of each of the variable hypothesized to explain technical, allocative and economic inefficiencies are discussed below:

Sex of the household head: This refers to sex of the household head. It assumes a value of 1 for female headed household head and 0 otherwise. Male-headed households are more access to resources and information related to better production technologies than female-headed households due to their social position. It was therefore, sex of the household head was hypothesized to influence technical, allocative and economic inefficiencies of crop production positively.

Household size: This variable was measured as a continuous variable by taking the total number of family members in the household. It was then aggregated by employing adult equivalent conversion factors after categorizing the members based on their sex and age. This variable was hypothesized to affect efficiency level of farmers positively. This is because, as labor is the main input in crop production, a

farmer that has large family size could carry out important crop husbandry practices timely. Family size was related to EE positively (Mbanasor *et al.,* 2008; Aye and Mungatana, 2011; Shumet, 2011; Sisay *et al*. 2015). On the other hand, others argued that increase in family size would increase expenditure for home consumption that can affect the efficiency of farmers negatively by creating financial constraints. Mekdes (2011) indicated that technical inefficiency was positively related to family size. Hence, the effect of family size on production efficiency was not determined a priori.

Education level of the household head: Education enables farmers to have access to new information, ideas, knowledge and skill to use resources in more efficient ways. It was hypothesized that the education level of the household head (years of schooling) has a positive effect on efficiencies of maize production. Studies by Arega and Reshid (2005), Aye and Mungatana (2011), Shumet (2011), Musa (2013) and Sisay *et al*. 2015 prove the hypothesis and concluded that educational level has a positive effect on efficiencies of maize production.

Livestock holding (excluding ox): Livestock holding is measured as a continuous variable in terms of TLU. The farmer who possesses more number of livestock will have better capacity to purchase agricultural inputs as income obtained from livestock serves for investment on crop production that would improve productivity. It was, therefore, hypothesized that livestock holding is negatively related to TE, AE and AE of maize production. This hypothesis is also attested empirically by Abdulahi and Eberlin (2001), Ahmed *et al*. (2002), Alemu *et al*. (2004), Beyene (2004), Tesfay *et al. (*2005), Solomon (2012) and Sisay *et al*. (2015).

Experience of crop farming: Experience of the household head in crop production is measured as a continuous variable and is expected to enhance efficiencies of crop production. That is, experienced farmers are expected to have greater access to productive resources (such as land and labor) and be able to use improved agricultural technologies than inexperienced farmers. It was, therefore, hypothesized that experience of crop production is negatively related to inefficiencies of crop

production. Ismat *et al.* (2009) found that farming experience is negatively related to technical and allocative inefficiencies.

Credit use: This is a dummy variable which represents whether the farmer has obtained credit or not during the production year (2014/15). It affects the ability of a farmer to obtain the necessary inputs at the right time and in suitable quantities. Farmers who have got credit will get capacity to purchase inputs which are necessary to improve productivity at the required time**.** Nyagaka *et al*. (2009) and Musa (2013) indicated that access to credit affects economic inefficiency negatively. Thus, credit use was expected to have negative effect on inefficiencies of crop production.

Extension contact: Frequency of extension contact during the cropping period improves farmers' skill and knowledge on the uses of recommended agronomic practices in crop farming. The higher the linkage between farmers and development agents, the more the information flows and the technological (knowledge) transfer from the latter to the former. Those farmers who have frequent contacts with development agents are likely to produce better than others. Extension contact was found to affect EE positively in the works of Hussein (2007), Nyagaka *et al.* (2009) and Sisay *et al*. (2015). Thus, it was hypothesized that there exists negative relationship between extension contacts and technical, allocative and economic inefficiencies of crop production.

Off/non-farm activities: This variable was measured as a dummy variable that took value of 1 if a farmer was engaged in off /non-farm activities and 0 otherwise. If farmer spends more time on off/non-farm activities relative to farm activities, this might negatively affect agricultural activities and hence efficiency. The same result was found in the work of Haileselassie (2005). It can also affect efficiency positively by alleviating financial constraints in terms of timely purchase of necessary farm inputs. Off/non-farm activities were found to relate positively to TE in Kindie (2005). Hence, the sign of off/non-farm activities was undetermined.

Distance to FTC: Distance to farmers' training center is used as proxy for assessing the accessibility of training services to farmer in crop production. Proximity to training center has advantage of obtaining awareness of farmers and exposes to new ideas and information about productivity of inputs, opportunities, input and output management and prudent handling of cash. Farmers who received training were hypothesized to be more efficient than those who did not received training. Ismat *et al.* (2009) found that training is negatively related to technical and economic inefficiencies.

Distance to main road: Distance to the main road is used as proxy for accessibility of transportation to markets. Farmers far away from main road become costly and difficult in transportation. It was, therefore, expected that households nearer to main road would have better chance to be efficient than those far away from main road. Thus, it was hypothesized that long distance from main has positive inefficiencies in crop production.

Distance to the nearest market center: Distance to the nearest market center is used as proxy for assessing the accessibility of the market to farmers. Farmers far away from market are less accessible for farm inputs and market information and transportation become costly and difficult. It was, therefore, expected that households nearer to market center would have better chance to be efficient than those far away from market centers. Alemu *et al. (*2004), Essa *et al.* (2011) and Musa (2013) have showed that farmers that are far from market are less efficient in resource allocation. Thus, it was hypothesized that long distance from market place has positively affect crop production inefficiencies.

Number of oxen holding: Possessing large number of oxen is crucial to increase TE, AE and EE in crop production since oxen provides a draught power, manure fertilizer and is a source of income. A study made by Endrias *et al.* (2010) indicated oxen holding positively influenced TE of maize production. Thus, this variable was hypothesized to affect crop production inefficiencies negatively.

Distance to nearest town: Distance to the nearest town is used as proxy for the accessibility of accurate and up-to-date price information. Farmers far away from town are less accessible for farm inputs, market information and transportation become costly and difficult. It was, therefore, expected that households nearer to town would have better chance to be efficient in crop production than those far away from town. On the other hand, farmers near to towns may engage in different off/non-farm businesses. If farmer spends more time on these activities relative to farm activities, this might negatively affect agricultural activities and hence efficiency. Thus, the sign of distance to the nearest town is indeterminate.

Diversification of crops: Diversification of crops indicated the number of crops grown in the study area. Based on the findings of Shumet (2011), this variable was hypothesized to influence crop production inefficiencies negatively.

Land allocated to *khat*: The Eastern part of Ethiopia is generally known for its cash crop production, predominantly *khat* (Ralph, 2004). Thus, land allocation to *khat* is assumed to be a prominent factor influencing efficiency of other crop production. If households allocated more land to *khat*, the larger portion of their earnings would be from the sale of *khat* crop and spends more time on cultivating it relative to other crops. Thus, this variable was hypothesized to affect crop production inefficiencies positively.

Table 7. Description of variables hypothesized to influence inefficiency of crop production

Description of Variables	**Units of Measurement**	**Expected Sign**
Sex of the household head	Dummy (Female=1, Male =0)	+/-
Farming experience	Years	-
Household size	Adult equivalent	+
Education level	Years of schooling	-
Credit use	Dummy Yes=1, otherwise=0	-
Number of extension visits	Days per production year	-
Distance to nearest market	Kilometers	+
Distance to main road	Kilometers	+
Distance to nearest town	Kilometers	+/-
Off/non-farm activities	Dummy Yes=1,otherwise =0	+/-
Diversification of crops	Count	-
Land allocated to *khat*	Hectare	+
Livestock holding (excluding ox)	TLU	-
Number of oxen holding	Count	-

Source: Empirical studies reviewed in the literature and own observation

4. RESULTS AND DISCUSSION

This chapter presents the results and discusses the core findings of the study. Thus, it is organized in two sections. The first section provides descriptive analyses on the demographic, socio-economic and institutional characteristics of sample farm households. The descriptive analysis further extended to discuss the farm households' crop commercialization, productivity and efficiency characteristics. The second section presents econometric analyses of crop commercial orientation, market orientation, productivity and efficiency, and it further discusses the findings of the study in comparison with earlier related research results.

4.1. Descriptive Analysis

4.1.1. Characteristics of Sample Households

Attributes of the farm households (such as sex, age, farming experience, and education status) play crucial role in either promoting or impeding crop productivity, efficiency and commercialization. As indicated in Table 8, the majority of the sample households were male-headed (with nearly 89%) and the mean age of respondents was 40 years with a minimum of 20 years and a maximum of 80 years. Females became household heads if they were either divorced or widowed or male are incapable of being the household head due to health problem. Sample farmers on average have about 20 years of experience in farming. Education level of household heads varies among the *Weredas*. However, about 34 percent of the total household heads were illiterate. Households in the study area had large average household size of six members with high mean total dependency ratio of 1.28. Household size can be considered as a proxy for labor availability.

Table 8. Demographic characteristics of sample households

Characteristics	Mean	Std.Dev.	Minimum	Maximum
Age of household head	39.64	10.23	20.00	80.00
Household size	6.40	2.00	2.00	11.00
Total dependency ratio	1.28	0.76	0.00	4.00
Sex of household head	Proportion			
Male	0.89			
Female	0.11			
Educational level				
Illiterate	0.34			
Basic education	0.29			
Elementary	0.32			
High school	0.05			

Source: Author's computation from sample survey data (2015).

4.1.2. Socio-Economic and Institutional Characteristics

Socio-economic and institutional characteristics of farm households refer to physical endowments, income and infrastructure in line with crop commercialization, efficiency and productivity. Particularly, ownership of physical resources and access to institutions are important factors that determine the operation and decision making activities of smallholder farmers. The most important resources of farmers include land holding, labor, livestock ownership, and other materials as indicated in Table 9.

Considering the socio-economic profile, sample households who participated in crop output markets were relatively and significantly better in their land holding, annual income from food crop sales and income from sale of livestock. On the other hand, farm households who were not participated in crop output markets observed to grow diversified crops as compared to their counterparts probably due to fear of drought risks resulted from their limited income.

Sample farm households under study generated their income from *Khat*, livestock sales, crop sales and off/ non-farm activities. The mean income that the sample household under study obtained from maize, potato, sorghum and haricot bean crops was Birr 16,373. The mean income of sample households earned from sale of *Khat* was Birr 4842 and Birr 3352 from sale of livestock per annum. Moreover, farm households usually augment their income through involvement in off/non-farm (such as labor wages, trading, carpentry, etc.) and other income generating activities. Those households who participated in off/non-farm activities on average earned an average of 2219 Birr per annum.

Asset holdings like land, oxen, farm implements, and human capital are essential factors for marketable surplus production at a smallholder level. A typical sample smallholder farmer owned 0.82 ha land on average and this is lower than the national land holding size average of about 1.17 ha per household (CSA, 2014) indicating the scarcity of land in the study area. On the other hand, the average cultivated land was found to be 0.75 ha. Moreover, households in the study area owned 3.63 TLU on average and a household did not own a pair of oxen required for plowing since the average oxen holding is below 2.

Access to institutional services and markets are important factors that affect crop commercialization of farmers through their impact on ease of access to inputs and output markets in addition to technology transfer and capacity building for farmers. Marketing of maize, sorghum and haricot bean crops and production inputs were almost undertaken in the district town markets which were on average 5.78 km away from their residents. However, it was observed that district town markets were not much important for potato producers since they sold it at the farm gates. Road access of farm households who participated in crop output markets was better as compared to non-participants and the average road distance from their residents was 2.68 km.

Table 9. Tests of equality of means of socio-economic and institutional characteristics of sample households, by crop output market participation

Descriptions	COM participant (n=298)	Not participated (n=87)	Total (n=385)	t-value
Total own land (ha)	0.87 (0.02)	0.64(0.02)	0.82(0.02)	-6.98***
Total land cultivated (ha)	0.79(0.015)	0.61(0.02)	0.75 (0.01)	-6.31***
Crop diversification index	0.81(0.01)	0.89(0.01)	0.83(0.01)	5.28***
Value of crops produced (Birr)	18244(580)	9964(489)	16373(495)	-7.48***
Amount of yield	28690(764)	20841(667)	26917(632)	-5.38***
Income from livestock (Birr)	3756(420)	1954(477)	3352(345)	-2.19**
Off /non-farm income (Birr)	2526(443)	1166(397)	2219(356)	-1.60
Income from *khat* (Birr)	5087(370)	4005(532)	4842(311)	-1.46
Livestock (excluding ox) (TLU)	2.90(0.11)	2.52(0.22)	2.81 (0.10)	-1.57
Number of oxen owned	0.85(0.05)	0.72(0.08)	0.82(0.04)	-1.23
Distance to market (km)	5.58(0.20)	5.83(0.35)	5.78 (0.17)	0.63
Distance to road (km)	2.52(0.09)	3.23(0.24)	2.68 (0 .09)	3.47***
Distance to DA offices (km)	2.64(0.13)	2.79(0.08)	2.70(0.08)	1.84*

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; COM=Crop Output Market; Figures presented are Mean (Standard Error).
Source: Author's computation from sample survey data (2015).

4.1.3. Indicators of Crop Output Commercialization

The levels of commercialization and production characteristics of smallholder farm households are generally determined by the combined effects of share of output sold from the value of total crop production, the share in value of each input purchased and the share of land allocation to individual crops. The net market position for the different categories of crops and for all crops were calculated by aggregating the values of sales and purchase of the different crops using the prices at which the farmer sold and/or purchased.

Crop output commercialization: Crop output market participation indices were calculated using the share of output sold from the value of total crop production and considered as an important indicator of commercial behavior of sample households. The descriptive results of commercialization level considering sale of outputs derived from the ratio of the value of sales to the value of crops produced expressed in percent is summarized in Table 10. Accordingly, the proportion of households' market participation was expressed through sale of maize, potato, haricot bean and sorghum at different levels, ranging from to 0 to 1.

As indicated in Table 10, the mean of market participation indices for the typical household head is computed to be 0.297 which indicates that on average a typical household sells 29.7% of his/her total crop production. This shows the level of crop market participation in the study areas was very low. On the other hand, the average market orientation index of the four crops was found to be 19% which indicates that on average a typical household is either less commercial or semi-commercial.

Generally, farm households market participation records for most of the crop output market participant farm households fall in semi-commercial and non-commercial orientation. Potato and haricot bean were the most important market oriented commodities produced by the majority of households with the aim of selling more to the market in the study areas. Even though maize and sorghum were the major cereals produced, households often used these crops for own consumption and hence small amount was marketed.

Table 10. Market participation and market orientation indices of crop output market participant sample households

Indices (in percentage)	Mean	Standard Deviation
Market orientation index of aggregated crops	19.7	10.1
Market participation index of aggregated crops	29.7	14.7
Maize market participation index	14.3	10.3
Potato market participation index	69.8	14.3
Sorghum market participation index	10.5	91.4
Haricot-bean market participation index	61.1	19.1
Maize market orientation index	5.8	4.3
Potato market orientation index	18.8	8.5
Sorghum market orientation index	2.3	1.8
Haricot-bean market orientation index	14.3	11.2

Note: Aggregated crops represent the four crops (maize, sorghum, potato and haricot bean).
Source: Author's computation from sample survey data (2015).

4.1.4. Indicators of Crop Input Commercialization

Crop inputs commercialization: Smallholders' commercialization can also be analyzed from input side. Adapting the approximate definition of commercialization given by von Braun *et al.* (1994), crop input commercialization indices were obtained for inputs in relation to the proportion of input purchases in total crop production that is weighted by the prevailing market prices of the inputs and outputs considered in the calculation. The most commonly and intensively used agricultural inputs used include chemical fertilizers, improved seeds, and agrochemicals among others.

Survey results show that, seeds (local and improved), chemical fertilizers (Urea and DAP), and agrochemicals were the major agricultural productivity enhancing inputs purchased by farm households under study. Even though there is no a statistically significant difference in the use of chemical fertilizers among market participant and non-participant farm households, fertilizer use is expected to boost production and the

possibility of households to engage in output markets. However, market participant farm households were found to be better in purchase of improved seeds and agrochemicals including irrigation costs (Table 11).

Assessment of the raw data that was obtained through field survey indicated that 95% of sample farm households (n=367) participated in purchasing of chemical fertilizers in growing at least one of the major crops. Regarding the sources which farmers used to get seeds, it was revealed that they got from their own carry-over stock and purchased seeds from crop market and seed providers. About 74% of sample households purchased improved and local variety maize seeds from crop markets and improved seed providers. Similarly, 29% of potato and 13% of sorghum grower households purchased improved and local seeds. Almost all haricot bean growers understudy principally relied on local seeds from own stock.

Area share of individual crops: Area share of individual crops were calculated as a percentage of total cultivated land. Results are summarized and presented in Table 11. Market participant households in both potato and haricot bean markets have more share of land allocated than non-market participants. The result is as expected, because those who have large size of land may produce more and sale more of the produces. On the contrary, market participant sample farm households exhibit less area share of land for maize and sorghum crops. It may be due to the fact that maize and sorghum are produced for the purpose of consumption than for sale. More importantly, non-market participants were found to allocate more land to *khat* crop as compared to non-market participants. The possible explanation is that such households may possibly substitute their financial constraints in selling *khat* and decline to sell food crops for the purpose of cash income.

Table 11. Tests of equality of means for input market participation index and area share of crops, by crop output market participation

Indicators	COM participant (n=298)	Not participated (n=87)	Total (n=385)	t-value
Commercialization index of fertilizer (%)	4.24 (0.09)	4.17(0.21)	4.22(0.08)	-0. 34
Commercialization index of agro-chemicals (%)	1.62(0.19)	0.06(0.03)	1.27(0.15)	-4.34***
Commercialization index of local and improved seeds (%)	5.16(0.16)	4.36(0.25)	4.98(0.13)	-2.47**
Area share of maize (%)	38.24(0.56)	40.62(0.90)	38.77(0.48)	2.06**
Area share of potato (%)	27.51(0.68)	22.12(1.42)	26.63(0.62)	-3.26***
Area share of sorghum (%)	25.79(0.545)	34.31(1.09)	28.07(0.54)	7.63***
Area share of haricot beans (%)	18.58(1.24)	6.60(1.45)	17.81(1.19)	-2.5**
Area share of *khat* crops (%)	18.15(0.30)	22.24(0.72)	19.07(0.30)	5.99***

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; Figures presented are Mean (Standard Error).

Source: Author's computation from sample survey data (2015).

4.1.5. Farm Productivity and Production Efficiency Indicators

There are many factors that determine productivity and efficiency of smallholder farmers. Hence, to understand these factors it is important to know the descriptive statistics of the yield obtained from individual crops and inputs used during the production year 2014/15. Generally, the intensity of productivity and efficiency depends greatly on the allocation of production inputs such as land, quantity and quality of seed, quantity of chemical fertilizer, amount of labor (in man days) and amount of oxen-power (oxen-day).

Quantity of outputs and inputs: The mean values of the patterns of outputs and inputs used for producing the four major crops under study are summarized in Table 12. Results indicated that the mean yield amounts obtained by sample households were 42.45, 58.92, 33.71 and 22.85 qt/ha of maize, potato, sorghum and haricot bean, respectively during 2014/15 production year.

Chemical fertilizers are known for their responsiveness in increasing productivity to a greater extent. Thus, the majority of sample farm households applied chemical fertilizer in growing maize (96%), potato (94.5%) and sorghum (95.9%). On the other hand, only 53% of the farm households applied chemical fertilizers for haricot bean crop due to the fact that haricot bean is leguminous crop and the use of chemical fertilizer, particularly Urea, may not be important.

Smallholder farmers in the study area are familiar with use of daily laborers and share-cropping arrangements to accomplish major farming activities (such as ploughing, weeding and harvesting). The main source of labor is household labor, hired labor and non-cash exchange of labor among household especially at peak season (*Guza*/*Jigge*/*Debo*). The price of labor was 20 to 30 Birr per day. Amount of labor (in man- days) a farm household on average used 23, 15, 16 and 10 man days of labor input for maize, potato, sorghum and haricot bean production, respectively.

Table 12. Descriptive statistics of output and production inputs for individual crops

Variables	Mean	Standard Deviation
Maize Production (n=374)		
Output of maize (qt/ha)	42.45	18.79
Quantity of seed (qt/ha)	1.55	0.44
Chemical fertilizer applied (qt/ha) (n=359)	1.97	0.99
Land size (ha)	0.32	0.11
Amount of labor (Man -days)	23.07	13.57
Amount of oxen-power (Oxen-days) (n=356)	3.62	1.68
Potato production (n=272)		
Output of potato (qt/ha)	58.92	35.10
Quantity of seed (qt/ha)	5.42	2.50
Chemical fertilizer applied (qt/ha) (n=257)	2.25	1.25
Land size (ha)	0.21	0.10
Amount of labor (Man days)	15.43	11.56
Amount of oxen-power (Oxen-day) (n= 243)	2.58	1.80
Sorghum Production (n=269)		
Output of sorghum (qt/ha)	33.71	11.75
Quantity of seed (qt/ha)	2.08	0.64
Chemical fertilizer applied (qt/ha) (n=258)	1.80	0.93
Land size (ha)	0.22	0.08
Amount of labor (Man days)	16.31	9.90
Amount of oxen-power (Oxen-day) (n= 255)	2.61	1.43
Haricot Bean Production (n=125)		
Output of haricot bean (qt/ha)	22.85	10.50
Quantity of seed (qt/ha)	1.11	0.34
Chemical fertilizer applied (qt/ha) (n=66)	1.01	0.33
Land size (ha)	0.16	0.08
Amount of labor (Man days)	9.97	7.08
Amount of oxen-power (Oxen-day) (n= 62)	1.03	1.15

Source: Author's computation from sample survey data (2015).

Costs of production inputs: The costs of production inputs are based on the quantity and quality of inputs used. These costs were obtained by adding the production costs of individual crops during the farming season (2014/15). The opportunity cost used to determine the cost of land was its rental value collected from individual farm households under study. The cost of other inputs was the market prices during the production period (2014/15). The mean annual rental value of land used vary depend on the size and quality of the soil type. Based on the result indicated in Table 13, there is a large deviation observed in the costs of land used for each crop. This is due to the variation in the size and quality of land allocated to individual crop by farm sample households.

As indicated above, the major sources of labor inputs were household labor, hired labor and non-cash exchange labor. In most cases, there arises a difficulty in quantifying the cost of household labor and non-cash exchange labors. Maximum effort was made to fully include the cost of these labors. Finally, the average daily wage for a laborer was used as the cost of household labor and non-cash exchange labors.

Agricultural production cannot be necessarily increased by expanding the farm land holding and accessing farm land to smallholder farmers, but the most important thing is the condition of holding fertile farmland. The most prominent inorganic fertilizers which are widely used in the study area are Diammonium Phosphate (DAP) and Urea. According to agricultural experts of the study area, almost all sample population used chemical fertilizer for agricultural production. However, this does not mean that they used sufficient amount of fertilizer. The costs of chemical fertilizers are almost similar except for few differences due to transportation and related costs.

Table 13. Descriptive statistics of production input costs for individual crops

Variables	Mean	Standard Deviation
Cost of Maize production inputs in Birr (n=374)		
Cost of land used	1859.60	633.20
Cost of seed used	386.16	177.47
Cost of labor used	559.40	273.44
Cost of fertilizer (n=359)	782.14	434.86
Cost of oxen-power (n=356)	399.08	245.81
Cost of Potato production inputs in Birr (n=272)		
Cost of land used	1239.59	572.44
Cost of seed used	760.61	374.86
Cost of labor used	351.69	198.52
Cost of fertilizer (n= 257)	603.07	446.52
Cost of oxen-power (n= 243)	305.16	255.06
Cost of Sorghum production inputs in Birr (n=269)		
Cost of land used	1269.26	472.52
Cost of seed used	351.81	136.25
Cost of labor used	400.27	243.55
Cost of fertilizer (n=258)	496.48	329.78
Cost of oxen-power (n=255)	313.90	216.52
Cost of Haricot bean production inputs in Birr (n=125)		
Cost of land used	909.21	857.51
Cost of seed used	167.58	133.57
Cost of labor used	203.35	148.71
Cost of fertilizer (n=66)	170.49	172.72
Cost of oxen-power (n=62)	129.79	153.10

Source: Author's computation from sample survey data (2014/15).

4.2. Econometric Analyses

4.2.1. Determinants of Smallholder Farmers' Crop Commercialization

4.2.1.1. Determinants of crop market orientation

To select the model that best fits to determine market orientation decision and intensity of market orientation, a series of model specification tests are carried out in the following sequence. First, the double-hurdle model is tested against the Heckman model and then the LR test of the double-hurdle model is tested against the Tobit specification.

Accordingly, the result from the Heckman two-step procedure suggests that there is no sample selectivity bias because the inverse mills ratio (IMR) is statistically insignificant. Moreover, the Heckman maximum likelihood model outputs suggested that the two equations are independent because the null that the market orientation decision and intensity of market orientation are independent is accepted (Appendix Table 1). The LR test of the double-hurdle model is tested against the Tobit model specification using joint decision criteria of log likelihood test and Akaike's Information Criteria (AIC). The test statistic for log likelihood is Γ= 1131.19 which by far exceeds the critical $\chi 2$ value of 81.89 at 20 degrees of freedom and at 1% level of statistical significance in favor of the double-hurdle model. The AIC also shows that the double-hurdle model is preferable as the value of the test statistic (2348.38) is much lower than that of Tobit (2656.58).

Thus, it can be concluded that both the standard Tobit and the Heckman specifications are inadequate to model market orientation. The tests reveal market orientation behavior follows two independent decision paths: the market orientation decision and intensity of market orientation. Therefore, the double-hurdle model is the best specification to identify the factors that influence the two stages. The double-hurdle model is estimated by maximizing the log-likelihood function (Equation 15) and the

results are presented in Table 14. The coefficients in the first hurdle indicate how a given variable affects the likelihood (probability) of market orientation decision. Those in the second hurdle denote intensity (level) of market orientation.

Determinants of household market orientation decision: Considering the results of the first-hurdle, sex of household head, farming experience, land allocated to *khat* and location dummy do negatively influence the decision of commercial orientation whereas cultivated land size, off/ non-farm income, amount of fertilizer used, household crop diversification and on-farm income (log) have positive role in making households' decision of commercial orientation.

Male-headed farm households were more likely to make market oriented decision than female-headed households. This may be due to the fact that female-headed households are exposed to resource constraints like labor, capital, and land for crops production. The other result indicated that farm households with more experience in crop farming had lower probability of making market oriented decisions as compared to low experience household heads. One possible reason is that households with higher experience are regarded as those who lose the capacity to engage in producing more and to make commercial oriented decisions. Moreover, those experienced households have large household members and hence, this may be considered as a triggering factor for making market orientation decisions due to assurance of risks of home consumption. The current result is consistent with findings of Adam (2009).

Off/non-farm income positively determines the households' market orientation decision. Though literature on the contributions of off/non-farm employment does not have unique conclusions, this study contradicts findings reported by Workneh and Michael (2002) and Adam (2009). Their arguments were; (1) farm households with more farm resources (better working capital) are less attracted to non-farm activities; and (2) diversifying their income through employment outside their farm have a reduced inclination towards making marketing orientation decision mainly due to depressed productivity or depressed income sources. Contrary to a priori expectations,

the present study result show that those farm households who diversify their income through off/non-farm employment have got a chance to get better capital to rent in land; to recruit more labor; to buy enough fertilizers, improved seeds, chemicals and other inputs. Thus, it is obvious that if households solve these financial constraints, then they will have a positive inclination towards producing crops for sale.

Land asset is an important determinant of commercialization as more land means that farmers are able to produce surplus crops for the purpose of sales. The result confirmed that as a household head gets larger size of cultivated land, it turns out to be a positive decision towards producing crops for sale. This is the fact that farm households with large land size could allocate their land partly for food crop production and partly for cash crop production giving them better decision to produce for sale. The current result is consistent with the findings of Mahelet (2007). The other more prominent factor in crop production has been identified as households' land allocation to *khat* crop. If households allocated more land to *khat* crop, the larger portion of their earnings would be from the sale of *khat* crop and their tendency to produce and sell major cereal crop would be low. Thus, this variable negatively affects the decision of farm household's to be market oriented.

Farm households in the study area do often to grow diversified types of crops. This is due to the nature of soil fertility type and an attempt to escape from natural circumstances such as unpredictable rainfall and declining land productivity. There were also few farm households who grow diversified crops by identifying as major cereal crops and for commercial reasons. Usually, farm households who produce potato and haricot beans sold out their outputs more than other crops produced in the study area. Adam (2009) indicated that crop diversification index positively influenced the decision and level of market orientation. The current result assured this finding and households who possessed large crop diversification index positively influenced market orientation decision.

It was expected that credit utilization may have positive effect on households' crop production and hence market orientation decisions. The arguments were, credit use enhance farmer capacity of purchasing inputs (planting materials, fertilizer and crop protection), pay wages, invest in farming tools, and hence leading to increase agricultural productivity, induce market participation and thus greater commercialization (Lerman, 2004; Martey *et al*., 2012). However, the result of the study found out that credit utilization negatively influences the decision to produce crops for commercial purpose. The reasons could be (1) those farm households who had utilized loans might be used the loan to solve financial constraints to cover different expenses such as clothing, school materials of their children, home consumption; or (2) they might be engaged in business like petty trade, livestock production, and fattening.

The amount of fertilizer used was found to be positively and significantly determine the probability of farm households' market orientation decisions. It is believed that fertilizer is an important element in boosting productivity. Thus, farm households' expectation of the high output was a precondition to make the initial commercial orientation decisions. Another sort of variable was on-farm income that positively and significantly determines the probability of farm households' market orientation decisions. The possible reasons are households with larger incomes may have the capacity to use productivity enhancing production inputs (like improved seeds and fertilizer) and also cultivate larger parcels of land than those with lower incomes. Consequently, high productivity and larger cultivated parcels of land result in the ability to produce crops for commercial purposes.

Furthermore, the location dummy is negatively and statistically significant, suggesting that, despite their relative distance from better market places and marketing services, farm households in east Hararghe highlands were more likely involved in market oriented decisions as compared to west Hararghe highlands.

Determinants of the level of market orientation: The above factors are identified as those factors affecting the probability of decision to produce crops for commercial purpose. However, it does not necessarily mean that all these significant factors are capable of passing to the two hurdles. This means what variables and the extent of the effect that each variable contributes is different for both market orientation decisions and level of market orientation. Thus, this section deals with results of truncated regression model estimating the determinants of the level of crop commercial orientation. Results of the second-hurdle indicated that level of crop market orientation of farm households, is negatively influenced by dependency ratio, social capital, land allocated to *khat* crop, distance from major town, and distance from main road. Moreover, levels of sales were positively influenced by proportion of irrigated land and on-farm income.

It was hypothesized that social capital positively determines level of market orientation. However, the result is contradicted to the hypothesis made that households' involvement in leadership activities of social organizations (such as religious activities, *edir*, etc.) does negatively and significantly influenced the level of farm household's market orientation. This is due to the fact that the entire involvement of farm households in such activities may restrict exhaustive use of labor for farming and then results in decline of crop yields.

The issue of household size with respect to agricultural development is debatable. Household size can affect agricultural development both negatively and positively. The negative impact of household size indicated that, an increase in household size may increase in the number of dependent household members which would in turn increase in the number of mouths to be feed and disproportionate level of production and hence contribute to a decrease in the level of market orientation. On the other hand, large household size may serve as an important source of labor implies positive impact on agricultural output. To avoid such controversy, the researcher had used dependency ratio and the result indicated dependency ratio affects market orientation

negatively and significantly. It is because farm households with large inactive members use the produce for consumption instead of supplying to the market.

Irrigation creates opportunities to supply more products than farmers without access to irrigation due to improvement in productivity. Moreover, access to irrigation minimizes the risk of crop loss that result from uncertain variability of rain and increase the confidence of farmers to use farm inputs and diversify into high value crops. The result revealed that proportion of irrigated land was found to be positive implication on the market orientation status at 1% significance level. This could have a big impact in the push for rural household's market orientation status to diversify their livelihood and generate better income. The current result is inconsistent with Moti (2007) and Sindi (2008).

Distance from the main town negatively influenced the level of market orientation of farm households. The implication is that farm households away from major towns lack accurate and up-to-date price information which exposes farmers to fraudsters resulted in who mislead farmers to sell their produce with low price that discourages market orientation behavior. Further, the result revealed that access to main road negatively and significantly influences the level of household's market orientation. The plausible reason is that households far away from main road may impose a negative bearing on the level of crop market orientation due to the high transaction cost that farm households perceive in terms of transportation and negotiation capacity.

Table 14. Double-hurdle model estimation results of factors influencing smallholder farmers' crop market orientation

Factors	Probit regression		Truncated regression	
	Coefficients	Std. Err	Coefficients	Std. Err
Dependency ratio	0.002	0.001	-0.022**	0.007
Sex of household head	-0.451*	0.27	2.062	2.114
Social capital	-0.178	0.213	-2.017*	1.128
Farming experience	-0.036**	0.012	-0.069	0.066
Livestock holding	-0.089	0.069	-0.389	0.359
Cultivated land size	6.281***	1.563	4.465	7.583
Land size for *khat*	-8.397***	2.494	-52.167***	11.516
Education status	-0.188	0.118	0.548	0.664
Off/ non-farm income	0.835**	0.316	-0.976	1.357
Proportion of irrigated land	16.446	488.516	18.613***	4.022
Chemical fertilizer	0.750**	0.335	0.188	1.177
Credit use	-0.525*	0.296	2.036	1.454
Distance to nearest market	-0.037	0.035	-0.052	0.178
Distance to main road	-0.03	0.058	-1.411***	0.414
Distance to FTC	0.017	0.168	0.008	1.158
Distance to major town	0.019	0.017	-0.230**	0.115
Extension contacts	-0.001	0.18	0.172	1.176
Crop diversification index	7.022**	2.76	-11.54	12.065
On-farm income	1.202**	0.384	6.143**	2.123
Location dummy	-1.562***	0.257	-0.607	1.488
Constant	-20.162***	4.785	-22.768	26.104

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; Std. Err = Standard Error; Wald χ^2 (17) = 196.46; Log likelihood=-1131.19; Prob.> χ^2=0.000.

Source: Author's computation from sample survey data (2015).

4.2.1.2. Determinants of crop outputs market participation and level of sales

Market participation is defined as quantity or proportion of harvested output that is marketed. Hence, households' market participation was expressed through sale of maize, sorghum, potato and haricot beans at different levels. Double hurdle, Tobit and Heckman models could be used to estimate the effect of hypothesized variables on market participation and level of sales. Hence, much emphasis had given to identify the relatively better econometric model that best capture the objective of the study.

Heckman two-stage selection econometric model was adopted because the estimation result of market participation and intensity of participation suggested that there is sample selectivity bias since the IMR is statistically significant at 5% significance level. If IMR is insignificant, interpretation of the results from the Heckman two-step procedure will not be relevant for the fact that the procedure is highly sensitive to model misspecification. The result of Heckman maximum likelihood model (ML) outputs also indicated that the two equations are interdependent because the null hypothesis that the market participation and intensity of participation are independent is rejected at 5% significance level. Consequently, the two equations are estimated simultaneously using Heckman selection model.

According to the model output, Lambda (IMR) or selectivity bias correction factor has negative impact on farm household's crop market participation at a 5% significance level. And, the negative sign of the IMR shows that there are unobserved factors that are negatively affecting both participation decision and level of crop output marketed. Moreover, rho is negative, indicates that unobservable factors are negatively correlated with one another (Table 15).

Estimation results of crop outputs market participation decision: As indicated in Table 15 farm household's decision to participate in crop output market is influenced by sex of household head, farming experience, livestock holding, cultivated land size, land allocated to *khat*, off/ non-farm income, fertilizer used, on-farm income, market distance, crop diversification and location dummy. This shows that almost all

determinant factors of commercial orientation similarly influenced market participation except livestock holding, and market distance that significantly affects market participation. Thus, the arguments and justifications of these common determinant factors are in similar fashion.

There are two opposing arguments made by different empirical studies regarding livestock ownership and crop output market participation. The first group argued that ownership of livestock reduces crop output market participation, since these livestock offer alternative sources of cash income and hence the relationship is negative (Gebremedihin and Jaleta, 2010). The second group claims that if households possess larger number of livestock, they can have sufficient or even surplus manure for crop production. Thus, livestock size has positive contribution to market participation decision (Berhanu *et al*., 2009; Habtamu, 2013; Degye, 2013). Finding of the present study is consistent with the first argument that concludes the number of livestock owned by a household offsets the probability to participate in crop output markets. The possible explanation is that households own higher number of livestock, the larger portion of their earnings would come from the sale of livestock and their decision to produce crops for participation in output market would be low.

Distance to the nearest market had a negative and significant effect on crop output market participation decision. Households residing in places far from markets are less likely to participate in markets probably because of higher transaction costs. Several authors have concurred that marketing costs directly expressed in terms of distance from the market limits the level of commercialization and even completely hinders smallholder market participation (Eleni, 2001; Barrett, 2008; Pender and Dawit, 2007; Alene *et al.,* 2008). Thus, households who are far away from market places expected to have lower output market participation or alternatively households closer to market outlets are more likely to participate in marketing activities.

Estimation results of the level of crop output market participation: Farm households' intensity of crop output market participation is influenced by proportion

of irrigated land, social capital, and dependency ratio. All the arguments and justifications are similar with that of market orientation (Section 4.2.1.1).

Table 15. Heckman selection model two-step estimates result of market participation

Factors	Market participation		Level of participation	
	Coefficients	Std. Err	Coefficients	Std. Err
Dependency ratio	0.001	0.001	-0.022**	0.009
Sex of household head	-0.540**	0.272	0.43	2.802
Social capital	-0.243	0.223	-2.589*	1.427
Farming experience	-0.040***	0.012	0.016	0.088
Total livestock holding	-0.128*	0.078	0.269	0.459
Cultivated land size	5.562***	1.643	-16.028	10.672
Land size for *khat*	-6.334**	2.566	-14.879	15.573
Education status	-0.185	0.122	1.534	0.961
Off/ non-farm income	0.543*	0.311	0.522	1.719
Proportion of irrigated land	22.057	-	40.853***	5.372
Chemical fertilizer	1.068**	0.368	2.408	1.481
Credit use	-0.266	0.315	1.659	1.799
Distance to nearest market	-0.074**	0.036	0.148	0.222
Distance to main road	-0.007	0.059	.	.
Distance to FTC	-0.010	0.166	.	.
Extension contacts	0.042	0.18	-0.169	0.513
Crop diversification index	5.297	3.037	-21.641	16.281
Gross on-farm income (log)	1.307**	0.417	-0.813	2.837
Location dummy	-1.418***	0.239	-2.334	2.087
Constant	-19.176***	5.14	67.025*	37.192
Mills| lambda	-7.159**	3.525		
Rho	-0.642			
Sigma	11.146			

Note: "*", "***" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; Std. Err = Standard Error; Wald χ^2 (18) = 191.65; Non-crop output market participant observations = 87; Participant observations = 298; Probability > χ^2 = 0.000.
Source: Author's computation from sample survey data (2015).

4.2.1.3. Determinants of crop input commercialization of smallholder farmers

There are limitations in setting a cutoff point for defining commercial orientation of smallholder farm households in terms of input purchases. Farm households in purchasing agro-chemicals and improved seeds were significantly low in the study area. Thus, chemical fertilizer was used as input side commercialization since it has been a good indicator of whether or not a given farm household is interested to grow crops for commercial purposes. Furthermore, chemical fertilizer is selected since the behavior the farm household expresses by exerting much of its effort and using valuable inputs for the production of a given commodity signifies that the household is working for a better return in commerce.

The approximate definition of input side commercialization given by von Braun *et al.* (1994) was adapted in computing the commercialization index of chemical fertilizers purchased. Thus, the value of chemical fertilizers purchased that is expressed as proportion of the value of aggregate crop production of each household has been used as a basis to assess the farm input commercial orientation of the smallholder farm households.

It was proposed to apply a two-step analytical approach involving the factors influencing farm household participation in fertilizer purchases and the extent of fertilizer purchases. However, almost all sample farm households (about 95%) were involved in the fertilizer purchases, and hence there is no need to estimate the phase of participation. Tobit model is used in large number of applications where the dependent variable is observed to be zero for some individuals in the sample. Accordingly, the Tobit regression model was applied to quantify the magnitude and direction of the effects of the factors influencing farm household participation in fertilizer purchases.

Thus, the dependent variable for the Tobit model is represented by the value of farm household's commercialization index of fertilizer purchases. Extent of farm household's participation in annual crop fertilizer market as buyer is influenced by the

amount of cultivated land, land allocated to *khat* crop, off-farm and non-farm income (log), amount of manure used and distance to the main road. The result for the extent of commercialization index of chemical fertilizer purchased is presented in Table 16.

Before the estimation process, an appropriate test such as Lagrange Multiplier (LM) or score test suggested for the normality assumption in the Tobit model was performed. The LM-statistic test was carried out for testing the Tobit specification, against the alternative of a model that is non-linear in the regressors and contains an error term that can be heteroskedastic and non-normally distributed. The test is carried out by taking a Box-Cox transformation of the dependent variable $(y^{\lambda}-1)/\lambda$ and testing whether the parameter λ equal to 1 or not. A rejection of the null suggests that the Tobit specification is unsuitable, as an alternative value for λ would be required to return the linearity, homoskedasticity and normality assumptions that are necessary for consistent estimation. Critical values are obtained via the parametric bootstrap, where the regressors are assumed to be stochastic. The result revealed that bootstrap critical values displayed for 1%, 5% and 10% level tests are 11.79, 6.13 and 3.86, respectively, and these values are less than the LM-statistic (23.96). Hence, the LM test suggests that the Tobit model is suitable for the data.

It was believed that households with larger landholding are able to produce marketable surplus and hence participate more in the input purchases. However, the extent of farm households' participation in chemical fertilizer purchase further shows that participation was significantly very low on the part of those farm households who increased land for the production of non-commercial crops. The result is consistent with the findings reported by Adam (2009). The scenario may entail that an increase in cultivated land size needs additional cost to smallholder farmers to purchase more fertilizer, i.e., the gain from non-commercial crops does not compensate the gain from applying fertilizer on such crops. On the other hand, farm households' land allocation to *khat* positively influenced the extent of farm households' participation in chemical fertilizer purchased. This is because if a household allocated more land to *khat* crop,

he/she might earn more cash income from the sale of *khat* and their tendency to purchase chemical fertilizer would increase.

It was anticipated that households with higher off/ non-farm income are more likely to increase purchase of chemical fertilizer. The argument was an increase in off/non-farm income was expected to positively determine the decision to produce more crops for market since these incomes create better opportunity to purchase production inputs. However, the result is on contrary and as the income earned from off/non-farm employment increases, the quantity of chemical fertilizer purchased declines. The plausible explanation is that households do often invest their off/non-farm earnings to meet households' needs other than purchase of chemical fertilizer.

Physical proximity to market places negatively influences the resource allocation behavior of smallholder farm households to market related activities to a greater extent when basic infrastructure service such as road is poor. Thus, the farther the farm households are dwelling from the main road the more it may impose a negative bearing on input market participation due to the high transaction costs that farm households incur in terms of transportation and negotiation. The result revealed that access to road significantly and negatively influenced the extent of household's commercialization of chemical fertilizers purchased. Similarly, households who were living near the major towns tend to get production inputs with a low price as compared to households who were far away from major towns. The result is consistent with previous studies including Adam (2009) and Berhanu and Moti (2010) who claimed market distance detracts from crop input market participation due to its effect on increasing marketing costs.

Organic fertilizer (like manure) is regarded as crucial factor for crop production among small-scale farmers. Manure usually comes from animal excreta and the possession of livestock by a household usually implies its availability. The study tried to address the relationship between organic manure and commercialization of chemical fertilizer purchased. The level of farm households' participation in fertilizer

purchase is found to negatively and significantly affect the quantity of manure used at 5% significance level. Because manure plays an important role in maintaining soil fertility and consequently offsets the use of chemical fertilizers.

Table 16. The marginal effect of Tobit estimation results of fertilizer purchases

Variables	**Marginal Effect**	**Standard Error**
Dependency ratio	-0.001	0.001
Sex of household head	-0.224	0.319
Farming experience	-0.01	0.009
Cultivated land size	-0.779**	0.401
Land size for *khat*	3.071**	1.397
Total livestock holdings	0.013	0.05
Education status	-0.013	0.107
Off /non-farm income (log)	-0.050**	0.024
Credit use (log)	0.382	0.239
Distance to nearest market	-0.009	0.024
Distance to nearest town	-0.054***	0.012
Distance to nearest road	-0.148***	0.042
Extension contacts	0.087	0.063
Amount of manure used	-0.020**	0.008
Prediction	4.227	

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1%, respectively.
Source: Author's computation from sample survey data (2015).

4.2.2. Effects of Farmers' Commercial Orientation on Crop Productivity

Endogeneity and Instrumental Variable (IV) Estimation Tests: Before the decision to use IV regression to evaluate the effects of market orientation on TFP, the necessary tests for endogenity and instrumental variables (such as tests of endogeneity, under-identification and weak-instruments and over-identifying

restrictions) were made. These tests were applied to make sure whether households' market orientation index is simultaneously determined by TFP that usually geared towards markets.

Test result undertaken for 2SLS confirmed that the use of IV estimation was assured because the Durbin χ^2- value of 24.61 enables to reject the null hypothesis that commercial orientation index is exogenous at conventional significance level (p=0.000). Similarly, the robust regression-based test of Wu-Hausman F-statistic of 25.06 does reject the null hypothesis of exogeneity at 1% significant level. Thus, the significant χ^2 and F-statistic results confirmed the assumption that commercial orientation indices and TFP of crops are endogenous.

The under-identification is checked using the Lagrange multiplier (LM) test of whether the equation is identified or not, i.e., the excluded instruments are relevant, meaning correlated with the endogenous regressors. The test is essentially the test of the rank of a matrix. Anderson (1951) canonical correlation test (=52.95) indicated the rejection of the null (P=0.000) and confirmed the matrix is full column rank, i.e., the model is identified.

Sargan score test and Basmann tests of over-identifying restrictions were performed and resulted values of 3.46 (p=0.18) and 3.32 (p= 0.19), respectively predicated the errors being independently distributed. Moreover, Wooldridge's robust score test of over-identifying restrictions was also made and resulted a value of 4.31 (p=0.12) which is insignificant and hence no over-identification is confirmed.

Stock and Yogo (2005) test result of weak-instruments indicated that the value of test statistic (=19.46) exceeds all the critical values of 2SLS relative bias. Thus, a relative bias of 5%, 10%, 15%, 20%, or 25% can be tolerated and conclude that the instruments used are not weak. Furthermore, from the result of Stock and Yogo's (2005) second characterization of weak instruments, we can reject the null hypothesis of weak instruments since the value of test statistic (=19.46) exceeds the rejection rate of 10% (=6.46). This assures the instruments are not weak.

In addition to the above tests, diagnostic test for multicollinearity that seriously affects the parameter estimates was conducted among explanatory variables. The result confirmed that multicollinearity is not a problem in the estimated model since the largest VIF test result is 2.81 and the mean VIF is 1.66 (see Appendix Table 3).

Results of the Synergies between Crop Commercial Orientations and TFP: The 2SLS estimation results, as shown in Table 17, assured that farm households' market orientation index, when instrumented by road distance, annual crop income and land allocated to *khat*, strongly and positively influenced TFP. This indicates that households who are more commercial oriented are found to be higher in crop productivity. The reasons behind could be that commercial orientation behavior may provide a source of cash that allows households to overcome key agricultural production constraints such as purchase of inputs. Further, farm households' participation in increased crop sales would allow them to acquire resources for reinvestment to improve agricultural productivity and obtain income. The result is consistent with (Strasberg *et al*., 1999; Govereh and Jayne, 2003; Adam *et al*., 2010).

It is known that the effect of instruments on TFP is expressed through market orientation. Result of first-stage regression (Appendix Table 4) indicated that increasing market orientation behavior of farm households through income from sales of food crops lead to improvements in crop productivity. In contrast, allocating more land to *khat* crop and farm distance from residence to the main road have negative effect on productivity since it negatively influenced household's market orientation index. Moreover, additional six variables were found to influence TFP of crops besides their contribution to commercial orientation. These factors included oxen ownership, market distance, extension visits, manure, labor, and location dummy.

Oxen availability, being the main sources of draught power, plays a crucial role in crop production at smallholder level in Ethiopia (Melaku, 2011). Although a pair of oxen is normally required to carry out the normal task of ploughing, oxen ownership patterns were not evenly distributed in the study area. Even though those farm

households who did not own oxen might have other ways of getting draft oxen power, such as sharing and/or hiring arrangements so as to cope up with the unequal oxen distribution, though it might have negative impact on planting time and cultivation operations. Consequently, the result confirmed that farm households who owned large size of oxen tend to have higher crop productivity.

Often times, the role of extension services has been to support and facilitate people engaged in agricultural production to obtain information, skills, and technologies to solve problems and to improve the livelihoods and well-beings of farmers. Frequent extension visits in giving technical advice on productivity enhancing inputs encourage farmers to think of acquiring the particular inputs. The evaluation result assured that the coefficient of number of extension visits was positive and statistically significant implying that those sample farm households who got large number of extension contacts were associated with improvements in crop productivity.

Market distance affected crop TFP negatively and significantly. Those sample farm households that were located relatively far away from market places were expected to be less productive probably due to the relative inaccessibility of input and output markets. Moreover, market distance as a transaction cost was a factor working against productivity in that those farmers that were located relatively far away from the nearest markets were less productive than the other farmers and locations close to markets. The other important factor that affects crop productivity was labor in man-days. Labor available for agricultural production affects TFP negatively probably due to the under employment caused by capacity limitation in access to physical capital. The current result is consistent with observations of Adam *et al.* (2010).

Use of manure, locally called *dike*, was the widely practiced means of soil nutrient replenishment and considered as one of the crop productivity enhancing factors in the study areas. Despite the fact that manure application rates should be no greater than the nutrient needs of the crop(s) to be grown, the finding confirmed that crop TFP increased with the increase in amount of manure used. Furthermore, the agro-ecological variable expressed in the location dummy had a positive and significant

influence on the TFP. This implies that farmers in East Hararghe highland areas were less fortuitous in crop productivity than their counterparts, i.e. farmers in West Hararghe highlands.

Table 17. 2SLS estimation results of factors influencing TFP

Factors influencing productivity (TFP)	**2SLS Estimation**	
	Coefficients	**Standard Error**
Commercial orientation index	2.756***	0.54
Sex of household head	0.029	0.069
Active members to land ratio	0.011	0.012
Farming experience	0.003	0.003
Livestock owned (excluding ox)	-0.018	0.016
Number of oxen owned	0.064*	0.035
Education status	-0.014	0.026
Credit use (log)	-0.006	0.008
Off/non-farm income (log)	-0.004	0.006
Extension contacts	0.041***	0.007
Distance to nearest market	-0.029*	0.016
Location dummy	0.344***	0.056
Amount of manure used	0.004*	0.002
Amount of fertilizer used	-0.001	0.00
Quantity of labor used	-0.299***	0.078
Annual livestock cash income (log)	0.005	0.006
Constant	1.567***	0.276
Wald χ^2 (16)	162.280	
Probability > χ^2	0.000	
Root MSE	0.396	

Note: "*", "**" and "***" represent statistical significance of factors at 10%, 5% and 1% levels, respectively.

Source: Authors computation from sample survey data (2015).

4.2.3. Efficiency Analysis Using DEA Method

This section endeavors to evaluate the extent of farm households' TE, AE, and EE of crop production in the study area. Keeping in mind the widely accepted way of carrying out DEA in efficiency analysis, it was opted for executing multiple inputs and outputs and avoided the possibility of encountering problems associated with functional form misspecifications. The output variables were crop productions defined as quantity of maize, sorghum, haricot bean and potato harvested in kilograms whereas the inputs were land, labor, seed, fertilizer and agrochemicals.

Data Envelopment Analysis Program (DEAP) Version 2.0 was applied to compute the efficiency of crop production. DEAP did not process zero inputs and hence in the event the data contained a zero value of inputs were replaced by a very small positive number near to zero. Battese (1997) suggested that it is possible to estimate production frontier by assigning very small value greater than zero. Similarly, Fekadu (2004) also assigned a small value equal to 0.01 for those farmers who did not apply fertilizer in wheat production. Fried *et al.* (2008) also indicated that zero inputs are more problematic in DEA and they recommended substituting a very small positive number near to zero.

Outliers' detection: Since DEA attributes all the deviations from the frontier to inefficiency, it is likely to be sensitive to the input-output outliers. The tests for the sensitivity of DEA efficiency scores to input-output outliers are, therefore, crucial to verify the robustness of the efficiency results. Primarily, z-score and box plot method had employed and confirmed the data are normally distributed. Further, to verify robustness of efficiency results of DEA model to input-output outliers, we employed, among others, the method used by Retsi (1997). After solving the DEA problems using all the observations composing the sample, all farm households that are fully efficient were deleted and DEA problems were solved once more on the new sample. The high and positive significance correlation test result (>0.5) between efficiency scores obtained from the original sample and reduced efficiency scores indicates the robustness of efficiency results.

According to the DEAP model results, there exists a difference in efficiency scores among the three efficiency measures. TE scores range from 28.4% to 100% whereas both AE and EE scores ranges from 17% to 100%. From the total sample households 13% had a TE score of 1.0 indicating full efficiency whereas 87% were less efficient or inefficient since their efficiency scores below 1.0. Such low efficiencies in production indicated potential for improvements in crop production given the current levels of technology among the farmers. The DEA result of AE and EE scores confirmed that almost all farm households (99%) were less efficient or inefficient.

The DEA model results indicated that the average farm households' TE of 0.66, indicating farm households are producing 34% less of potential output given their prevailing level of technology and input use. Alternatively, the farmers could still produce their current outputs of these crops with fewer inputs if they were more efficient. Under the assumption of CRS, the efficiency scores remain the same in both input orientation (input minimization) and output orientation (output maximization). Thus, if we had chosen to keep inputs constant and measure efficiency in output increasing direction the efficiency score is also indicating that outputs should be increased by 34% to become efficient.

The average farm households' AE was found to be 0.72, indicating the AE of farm households revealed 28% increase in output by improving AE, with the existing technology. The combined effect of TE and AE factors shows that the average EE level to be 0.46. This result indicated that if these farmers operate at full efficiency levels, they could, on average, reduce their costs of production by 54% and still produce the same level of output. Therefore, this result shows the existence of significant technical, allocative and economic inefficiency in crop production among smallholder farmers in the study area. The mean levels of efficiencies were comparable to those from other similar studies in Ethiopia (Seyoum *et al.*, 1998; Arega and Rashid, 2005; Jema, 2008; Endrias *et al.*, 2010; Sisay *et al*., 2015).

Clustering Based Efficiency Scores: As highlighted in the literature part, the applications of DEA models had some draw backs. The first problem is that the DEA models assume all DMUs are homogenous and identical in their operations. If the heterogeneous DMUs are assessed by DEA without any modifications, the DEA yields a biased performance scores and inaccurate analyses. Hence, it needs to modify the DEA and the study made use of cluster based efficiency scores for the analysis.

The cluster groups were formed using dendrograms by re-assignment of observations based on the degree of belonging and the cut-off, and the cluster groups are mostly of similar size. Thus, 7 mutually exclusive clusters (that never have overlapping scores) appropriate for the subsequent DEA analysis were formed. The results obtained from clustering based efficiency score clearly indicated that there are considerable similarities within a cluster and differences between clusters. As indicated in Figure 5, at the bottom of the dendrogram, each observation is considered its own cluster. Vertical lines extend up for each observation, and at various (dis)similarity values, these lines are connected to the lines from other observations with a horizontal line. The height of the vertical lines and the range of the (dis)similarity axis give visual clues about the strength of the clustering. Long vertical lines at the top of the dendrogram indicate that the groups represented by those lines are well separated from one another. Shorter lines indicate groups that are not as distinct.

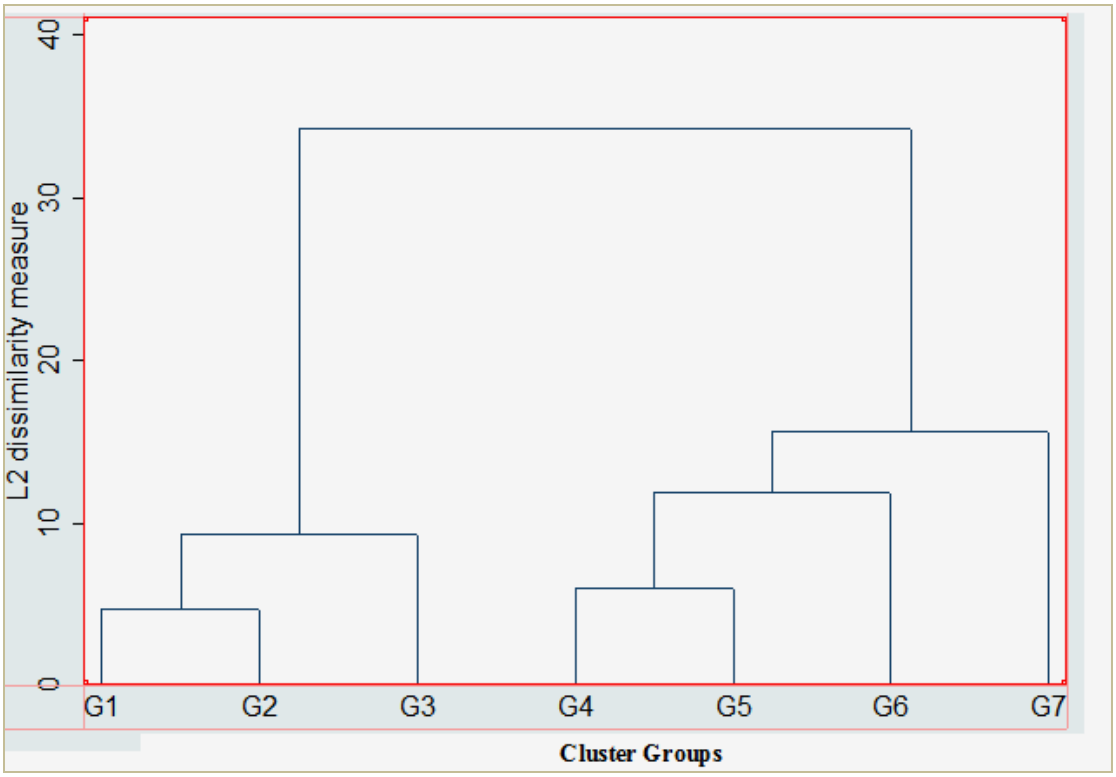

Figure 5. Dendrograms for hierarchical cluster analysis of efficiency scores

Source: Author's computation from efficiency scores of the survey data (2015).

The results of individual clusters obtained from cluster based efficiency scores are summarized in Table 18 and the discussions on each cluster are presented here under:

Cluster G_1 (consist of 12% of the sample): In this cluster, the average farm households' TE, AE and EE were found to be 0.44, 0.89 and 0.39, respectively. Even though farm households' crop production efficiency in this cluster was allocativelly better, they were poor in TE aspect. Thus, in this cluster a typical farm household to reach the EE level of his/her most efficient counterpart could experience on the average 64% increase in output by improving both EE and AE, with the existing technology.

Cluster G_2 (consist of 15.3% of the sample): TE, AE and EEs of a typical farm household in this cluster were found to be 0.57, 0.82 and 0.47, respectively. This indicated that if the average farm household in the sample was to reach the EE level of

his/her most efficient counterpart, then the average farm household could experience a 65% increase in output by improving both EE and AE, with the existing technology.

Cluster G_3 (consist of 22.6% of the sample): In this cluster, the average farm households' TE, AE and EE were found to be 0.48, 0.68 and 0.32, respectively. This result indicated that if the average farm household in the sample was to reach the EE level of his/her most efficient counterpart, then the average farm household could experience a 50% increase in output by improving both EE and AE, with the existing technology.

Cluster G_4 (consist of 14% of the sample): In this cluster, the average farm households' TE, AE and EE were found to be 0.69, 0.67 and 0.46, respectively. This result indicated that if the average farm household in the sample was to reach the EE level of his/her most efficient counterpart, then the average farm household could experience a 56% increase in output by improving both EE and AE, with the existing technology.

Cluster G_5 (consist of 12.5% of the sample): As it has been seen, the efficiency values resulting from the average farm households' were found to be 0.75, 0.81 and 0.61 for TE, AE and EE, respectively. This result indicated that if a typical average farm household in the sample was to reach the EE level of his/her most efficient counterpart, then the average farm household could experience a 71% increase in output by improving both EE and AE, with the existing technology. It is also noted that cluster 5 was the second best next to cluster G_6.

Cluster G_6 (consist of 8.6% the sample): When looking at the efficiency results, farm households' included in this cluster were much better as compared to other clusters. That is, the average farm households' TE, AE and EE were found to be 0.98, 0.82 and 0.81, respectively. Consequently, a typical farm household to reach the EE level of his/her most efficient counterpart could experience on the average 82% increase in output by improving both EE and AE, with the existing technology.

Cluster G_7 (consist of 15.1% the sample): In this cluster, the average farm households' TE, AE and EE were found to be 0.91, 0.45 and 0.41, respectively. This implies that a typical farm household to reach the EE level of his/her most efficient counterpart could experience on the average 43% increase in output by improving both EE and AE, with the existing technology. Even though farm households' crop production efficiency in this cluster was technically better, the AE of which are very low indeed. It may be due to the fact that maximum TE occurs when output is maximized from a given quantity of inputs without considering the right mix of inputs price. Thus, farm households' categorized in this cluster incurred more prices for the use of inputs that reflects the lower AE. Consequently, those farm households categorized in this cluster were the least efficient.

Table 18. Summary of the cluster groups DEA efficiency score results

Cluster Groups	Cluster weight (%)	Eff. Scores	Mean	Std. Dev.	Minimum	Maximum
G_1	12.0	TE_1	0.44	0.04	0.37	0.52
		AE_1	0.89	0.05	0.80	0.99
		EE_1	0.39	0.04	0.31	0.50
G_2	15.3	TE_2	0.57	0.03	0.52	0.63
		AE_2	0.82	0.07	0.71	0.97
		EE_2	0.47	0.05	0.40	0.60
G_3	22.6	TE_3	0.48	0.07	0.28	0.62
		AE_3	0.68	0.10	0.48	0.90
		EE_3	0.32	0.05	0.21	0.40
G_4	14.0	TE_4	0.69	0.07	0.59	0.83
		AE_4	0.67	0.04	0.56	0.73
		EE_4	0.46	0.05	0.37	0.55
G_5	12.5	TE_5	0.75	0.07	0.64	0.87
		AE_5	0.81	0.07	0.67	0.97
		EE_5	0.61	0.06	0.50	0.73
G_6	8.6	TE_6	0.98	0.03	0.89	1.00
		AE_6	0.82	0.11	0.65	1.00
		EE_6	0.81	0.12	0.65	1.00
G_7	15.1	TE_7	0.91	0.10	0.65	1.00
		AE_7	0.45	0.13	0.17	0.64
		EE_7	0.41	0.12	0.17	0.63

Note: Eff. Scores= Efficiency scores; $G_{1\text{-}7}$=Cluster groups from 1 to 7; Std. Dev. = Standard Deviation.

Source: Authors computation result from sample survey data (2015).

4.2.4. Estimation Results of Sources of Inefficiency

Understanding the sources of TE, AE and EE and its extent is very important for policy making to address the problem of farm households. In this regard, demographic, socio-economic farm and farmer-specific and institutional variables were hypothesized to affect level of inefficiency of crop growing farmers in the study area. Accordingly, the inefficiency model parameters were estimated by using Tobit model. Before explaining the model, multicollinearity test was made and the mean VIF was 1.20 and a maximum VIF of 1.37. This shows that there is no problem of multicollinearity in the data set (Appendix Table 5).

However, the Breusch-Pagan test for heteroskedasticity indicated that the null of the constant variance variables is rejected implying the occurrence of heteroskedasticity problem. Heteroskedasticity causes standard errors to be biased. Hence, when heteroskedasticity is present, robust standard errors tend to be more trustworthy. The robust option addresses the problem of errors that are not independent and identically distributed. The use of robust standard errors will not change the coefficient estimates provided by OLS, but they will change the standard errors and significance tests. Robust regression, on the other hand, deals with the problem of outliers that causes outliers to have less impact on the estimates of regression coefficients. Hence, the robust Tobit regression was used to solve these problems.

After measuring levels of households' efficiency and determining the presence of efficiency differences among households, finding out factors causing inefficiency disparity among households was the next most important step of this study. The result of the Tobit model showed that TE was significantly influenced by market distance, distance to FTC, crop diversification, oxen and other livestock holdings. Moreover, sex, market distance, distance to FTC, oxen and other livestock holdings were important factors influencing EE of crop producing households in the study area. AE was also significantly influenced by sex, market distance, land allocated to *khat,* and oxen holdings (Table 19).

There were significant differences in allocative and economic efficiencies among male-headed and female- headed farm households. Male headed households are more likely to be efficient than female headed farm households. This is due to the fact that female-headed households have additional responsibilities within the household, such as caring for children and this may affect the relative crop productivity of females.

Livestock holdings (excluding ox) had a positive and significant effect on TE and EE in crop production. Farmers who owned large number of livestock were technically and economically more efficient in crop production. This is because livestock provides manure fertilizer and also a source of income that can be used to purchase agricultural inputs. Possessing a large number of livestock is crucial to increase TE and EE in crop production in the study areas. Thus, a unit increase in the value of TLU would have an overall increase in the level of TE and EE. The current result is consistent with the findings of Abdulahi and Eberlin (2001), Ahmed *et al*. (2002), Alemu *et al*. (2004), Beyene (2004), Tesfay *et al. (*2005), Solomon (2012) and Sisay *et al*. (2015) in their respective studies with different crops.

Oxen holdings had a positive and significant relationship on TE, AE and EE in crop production. This is because oxen provides a draught power, manure fertilizer and is a source of income. Thus, possessing a large number of oxen is crucial to increase TE, AE and EE in crop production in the study areas. Each unit increase in the number of oxen would an overall increase in the level of TE, AE and EE by 4.1, 5.2 and 6.6%, respectively. The result is consistent with the findings of Endrias *et al.* (2010) on maize efficiency.

Another factor worth considering, as a variable affecting TE, AE and EE, is proximity to factor markets. The hypothesis in this study is that households located near markets are expected to have higher TE, AE and EE than those located in remote areas. This might be due to the fact that as farmers are located far from market, there would be limited access to input and output markets and market information. The other possible argument can be access to markets may increase the non-farm employment opportunities with higher returns than from farming, leading them to reallocate labor

from farm to non-farm activities. Longer distance from market also leads to higher transaction cost that reduces the efficiency of crop producing farmers. Similar result was found in the work of Alemu *et al. (*2004), Essa *et al.* (2011) and Musa (2013).

Farmers' Training Centers (FTC) is expected to provide farmers with new information, training, and demonstrations to encourage best farming practices. Thus, the study considered distance to FTC as one factor of efficiency and there were statistically significant negative relationship between distance to FTC and technical and allocative efficiencies among farm households. Thus, the result revealed that a 1km increase in the distance from farm household residents to FTC would have an overall decline in the probability and level of TE and EE by 1.5 and 1.2%, respectively.

Farm households in the study area experienced to grow diversified crops to minimize drought risks resulted from shortage of rainfall. However, the result revealed that having more number of diversified crops negatively and significantly influencing farm households' technical and economic efficiencies. The result confirmed that if a typical household add one more crop to grow from the existing crops, then there would have an overall decline in the probability and level of TE and EE by 6.4 and 3%, respectively. A plausible reason for this observation can be attributed to the fact that under diversified cropping systems, farm households needs to make use of more inputs like fertilizer, seeds and labor, which implies increasing cost pressure more than attaining productivity that contributes the existence of substantial technical and economical inefficiency. The current result contradicts the findings of Shumet (2011).

Table 19. Inefficiencies and marginal effects (uncensored part) of change in explanatory variables

Variables	Technical Inefficiency		Allocative Inefficiency		Economic Inefficiency	
	Marginal Effect	Std. Err.	Marginal Effect	Std. Err.	Marginal Effect	Std. Err.
Sex of household head	-0.059	0.042	0.076**	0.035	0.038*	0.022
Household size	0.004	0.006	-0.002	0.004	0.003	0.004
Farming experience	-0.001	0.001	0.0002	0.001	-0.0003	0.001
Market distance	0.016***	0.003	0.004*	0.003	0.015***	0.002
Education level	-0.003	0.004	0.003	0.003	0.001	0.003
Extension visits	-0.005	0.011	0.007	0.008	0.003	0.007
Distance to FTC	0.015*	0.009	-0.001	0.008	0.012**	0.005
Credit access	0.008	0.031	0.028	0.021	0.023	0.020
Off/non-farm income	0.018	0.029	-0.019	0.020	0.002	0.016
Land allocated to *khat*	-0.251	0.174	0.381***	0.100	0.142	0.106
Livestock holding (excluding ox)	-0.013**	0.006	0.004	0.004	-0.008*	0.004
Number of oxen holding	-0.041**	0.015	-0.052***	0.009	-0.066***	0.009
Diversification of crops	0.064***	0.016	-0.004	0.011	0.030**	0.010
Prediction	0.323		0.281		0.537	

Note: "*", "**" and "***" represent statistical significance of factors at 10%, 5% and 1% levels, respectively.

Source: Authors computation result from sample survey data (2015).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

The agricultural sector in Ethiopia would continue to be the main source of economic development and the growth of this sector would originate from smallholder farmers. Thus, this study was initiated with the view to contribute information on commercial orientation and crop productivity of smallholder farmers. The overall objective of the study was to generate information on the important factors influencing the commercial behavior of crop productivity, efficiency and commercialization of smallholder farm households in the highlands of East and West Hararghe Zones of Oromia Regional State, Ethiopia.

To this end, a series of informal and formal field surveys were carried out during the year 2014/15 crop season on a total of 385 sample farm household heads that were randomly drawn from 8 *Kebeles* in four *Weredas* through a multi-stage sampling technique. Secondary data were also collected from published and unpublished sources to support the primary data and describe the study area. Descriptive statistics and econometric models were used to analyze the data. The econometric models including double-hurdle model, Heckman two-step selection model, Tobit model, 2SLS regression model, and DEA model were employed.

The descriptive analyses of the study provided outline of issues related to the socio-economic and institutional characteristics of sample farm households. Moreover, indicators of commercialization, productivity and efficiency were also discussed using descriptive statistics. Individual attributes of sample farm households showed that most of the sample household heads (66%) were educated at least at basic education level. The households had large average household size of six members with high mean total dependency ratio of 1.28. Considering the socio-economic profile, farm households under study generate their main income from sales of *khat*, livestock, crops, and off/non-farm activities. A typical sample household owned 0.82 ha on

average and this is lower than the national land holding size average of about 1.17 ha per household indicating the scarcity of land in the study area. Moreover, a household under study owns 3.63 TLU on average and the number of oxen owned per household had not been enough to plowing since the average is below 2. Thus, farmers in the study area are familiarized to use daily laborers and share-cropping arrangements to accomplish major farming activities.

Empirical analysis of market orientation of smallholder farm households computed by double-hurdle model pointed out different determinants impacting the market orientation probabilities and intensities. To this effect, result of the first-hurdle showed that sex, farming experience, land allocated to *khat* and location dummy negatively and significantly influenced the decision of commercial orientation, whereas, size of cultivated land, off/non-farm income, fertilizer used, crop diversification and on-farm income positively and significantly influenced households' commercial orientation decision. On the other hand, results of the second-hurdle indicated that level of crop market orientation, is negatively influenced by dependency ratio, social capital, land allocated to *khat*, distance from towns and roads.

Heckman two-step selection model was employed to examine smallholder farmers' crop output market participation decision and level of participation. Farm household's decision to participate in crop output market was significantly influenced by sex, farming experience, livestock holding (excluding ox), cultivated land size, land size of *khat*, off/non-farm income, fertilizer used, on-farm income, market distance, crop diversification and location dummy. Moreover, farm households' intensity of crop output market participation was influenced by proportion of irrigated land, social capital, and dependency ratio.

Tobit regression model was employed to estimate the factors affecting household's commercialization of fertilizer purchases. Based on the results, extent of farm household's participation in annual crop fertilizer market as buyer is influenced by the amount of cultivated land, land allocated to *khat*, off/non-farm income, amount of manure used and distance to the main road.

The current study also evaluates the relationships that may exist between smallholders' crop commercial orientation and TFP using 2SLS regression model. Results of 2SLS regression indicated that TFP was strongly and positively influenced by the endogenous commercial orientation index. This is due to the fact that increased level of commercial orientation of households is likely to increase the financial capacity to purchase key agricultural production inputs. In addition, number of oxen owned, market distance, extension visits, amount of manure used, quantity of labor used, and location dummy influenced TFP.

The overall average farm households' TE, AE and EE obtained from DEA model results were 66, 72 and 46%, respectively indicating that farmers have attained a relatively better AE but lower technical and economic efficiencies. The result also indicates that if these farmers operate at full efficiency levels, they could, on average, reduce their costs of production by 54% and still produce the same level of output.

The study found the existence of considerable technical, allocative and economic inefficiencies among crop producing farm households in the study area. Understanding the sources of inefficiencies and its extent is very important for policy making to address the problem of farm households. In this regard, the result obtained from Tobit model confirmed that TE was significantly influenced by market distance, distance to FTC, crop diversification, oxen and other livestock holdings. Moreover, sex, market distance, distance to FTC, oxen and other livestock holdings were important factors influencing EE of crop producing households in the study area. AE was also significantly influenced by sex, market distance, land allocated to *khat,* and oxen holdings.

5.2. Conclusions and Recommendations

Descriptive analyses of farm households' socio-economic characteristics showed that market participation records for most of the market participant farm households fall in semi-commercial and non-commercial orientation. On average, about 82% of the sample households under study participated in one or more of the crops output

markets as sellers. Based on the proportion of total amount of the four major crops sold to the total production, only 29.7% of annual crop produce has been sold. The fact that none of the aggregate crops market orientation indices were fallen in the commercialized levels, much attention has to be given to the specific households and target the mechanism of supporting farm households to become commercial oriented producers.

The male headed households were more likely market oriented and participated in crop output markets than female headed households. The reason was female headed households have resource constraints, lacking access to productive assets (land, labor and capital), which limits their production capabilities. Therefore, policies should aim at supporting female headed households through different policy initiatives and interventions to boost their production and productivity and improve their market oriented decisions.

Land as an asset is the important determinant of commercialization as the more the land farmers possess the more surplus the crop they are able to produce for the purpose of sales. The result confirmed that as a household gets larger size of cultivated land, it turned out to be a positive decision towards producing crops for sale. This is the fact that farm households with large land size could allocate their land partly for food crop production and partly for cash crop production giving them better decision to produce for sale. Therefore, it is recommended that the policy should improve the functioning of the land lease market and development of the land sales market. It can be achieved through land reform programs that allow buying, selling, and renting; legalization of voluntary exchange of farm lands among farmers; and creations of agricultural cooperatives and work in groups.

Farm households with high dependent members negatively affect the level of sale and level of commercial orientation and the tendencies of the level of sales. It is due to the fact that an increase in the number of dependents increases the need for home consumption than serve as source of labor. Therefore, it needs interventions aimed at

promoting family planning may be needed to control the problem of increased dependency ratio in the long-run.

Diversification of income sources from off/non-farm income positively determines the decision to produce crops for market. This is because farm households who diversify their income through off/non-farm employment have got a chance to get better capital to rent in land; to recruit more labor; to buy enough fertilizers, improved seeds, chemicals and other inputs. Therefore, Strategies to diversify and improve the roles of livestock and non-farm income generating activities are required to support and enhance the performance of the crop sub-sector and farmers' commercialization decision.

Access to markets as measured by distance from farm to market places has become negative determinant of farmers' participation in the crop output markets. Further, access to main road is positioned to influence the level of household's market orientation negatively and significantly. The plausible reason is households far away from main roads and market places may impose a negative bearing on the level of crop market orientation and market participation due to the high transaction costs that farm households perceive in terms of transportation and negotiation capacity. Thus, location differences as a proxy for transaction cost may be alleviated through establishment of good market places in farming areas, form cooperatives, establish contract farming and support infrastructure development programs.

The findings of this study pointed out that land allocated to *khat* offset commercialization of the four considered crops in the study. Livestock holding also negatively influenced the probability to participate in crop output markets. This is because the larger portion of households' earnings would come from the sales of *khat* and livestock. Strategies aimed at targeting crop commercialization should consider *Khat* and livestock production since these are alternative income sources to absorb and fully engage both the under-employed and the unemployed farmers in the study area. Hence, there should be integrated and differentiated policy interventions along with crop commercialization, *khat* and livestock productions.

Farm households' commercial orientation index, ceteris paribus, generally has a significant and positive effect on crop TFP. Despite the much lower level of productivity and commercial orientation of farm households described by their respective indices, increased sales of crops is a requirement for increased productivity. Therefore, any policy design aimed at enhancing farmers' crop productivity in the study area should consider the performance of crop commercialization activities. Further, the current study could not verify the reverse causality of productivity on commercial orientation behavior of the sample farm households and it is, therefore, important to carry out a study that can verify this causality.

The current findings indicated that crop productivity increases as the amount of manure used increases. Moreover, it is believed that the application of organic manure is encouraging from the side of climate change aspect. It is, therefore, necessary to give technical support to smallholders on how to make and implement manures, such as vermicomposting, with low costs. Furthermore, far market distance was found to be a constraint to enhance productivity, probably due to transportation costs of purchasing inputs and sale their outputs. Thus, it needs to create access to markets and other input delivery mechanisms.

The existence of technical, allocative and economic inefficiencies among crop producing farm households indicates that there is a room for improvement in efficiency even at the existing level of technological inputs if policy measures are taken. Thus, integrated development efforts that will improve the existing level of input use and policy measures that will decrease the present level of inefficiency will have paramount importance in improving productivity of smallholder agriculture and their living standards.

Farm households who owned more oxen and other livestock were found to be more efficient than those who did not since it systematically influence farmers' efficiency level through equipping the farmer to have more income used for financing crop production inputs and better opportunity to have draught power. Therefore,

intervention is necessary to improve and strengthen the existing livestock production system through providing better health service and nutrition, targeted credit, and providing other necessary supports.

Even if results confirmed the decision of farm HHs to grow diversified crops play a positive role to be commercial oriented and risk aversion due to adverse effect in farming, it is regarded as a negative effect for TE and EE. It may be due to unwise resource allocation among different crops and this may also depend on the nature of the crops chosen. Thus, it needs further researches on the common determinant factors of efficiency and commercialization to be guaranteed for policy recommendation.

6. REFERENCES

Abafita, J., Atkinson, J. and Kim, C.S. 2015. Smallholder Commercialization in Ethiopia: Market orientation and participation. *International Food Research Journal*, 23(4): 1797-1807.

Abdourahmane, T., Bravo-Ureta, B. and Teodoro, E. 2001. Technical efficiency in developing country agriculture: A meta-analysis. *Agricultural Economics,* 25: 235-243.

Abdulai, A. and Eberlin, R. 2001. Technical efficiency during economic reform in Nicaragua: Evidence from farm household survey data. *Economic Systems,* 25:113-125.

Adam Bekele, Belay Kassa, Belayineh Legesse, Tesfaye Lemma. 2010. Effects of crop commercial orientation on productivity of smallholder farmers in drought-prone areas of the Central Rift Valley of Ethiopia. *Journal of Rural Development*, 33(4): 105-128.

Adam Bekele. 2009. Determinants of commercial orientation of smallholder farm households in risk prone areas of Ethiopia: analysis of the Central Rift Valley. PhD Dissertation, Haramaya University, Haramya, Ethiopia.

Adane Tufa. 2009. Impact of perennial cash cropping on food crop production and productivity. *Ethiopian Journal of Economics,* 18(1): 1-34.

Ahmed, M. M., Berhanu Gebremedhin, Benin, S. and Ehui, S. 2002. Measurement and source of technical efficiency of land tenure contracts in Ethiopia. *Environmental and Development Economics,* 7: 507-528.

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

Alemu Bamlaku, Nuppenau, A. and Boland, H. 2004. Technical efficiency of farming systems across agro-ecological zones in Ethiopia: An application of stochastic frontier analysis. PhD Dissertation presented to department of environmental management and market research, Justus-Liebig University of Giessen, Germany.

Alene, A.D., Manyong, V.M., Omanya, G., Mignouna, H.D., Bokanga M. and Odhiambo, G. 2008. Smallholder market participation under transaction costs: maize supply and fertilizer demand in Kenya. Food Policy.

Ana, R.R., Gerald, E.S, and William, A.M. 2009. Farm productivity and household market participation: Evidence from LSMS Data**.** *Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference,* Beijing, China, August 16-22, 2009.

Anderberg, M.R. 1973. *Cluster Analysis for Applications*. New York: Academic Press.

Antle, J.M. and Capalbo, S.M. 1988. An introduction to recent developments in production theory and productivity measurement. pp.17-95. In: Capalbo, S.M. and Antle, J.M. (eds.), *Agricultural Productivity Measurement and Explanation.* Resources for the Future, Washington D.C.

Arega Alene and Rashid, H. 2005. The efficiency of traditional and hybrid maize production in Eastern Ethiopia: An extended efficiency decomposition approach. *Journal of Agricultural Economics,* 15(1): 91-116.

Arega Alene, Victor, M.M. and James, G. 2006. The production efficiency of intercropping annual and perennial crops in Southern Ethiopia: A comparison of distance functions and production frontiers. *Journal of Agricultural Systems*, 91: 51–70.

Arega Demelash and Rashid, M. 2005. The efficiency of traditional and hybrid maize production in eastern Ethiopia: An extended efficiency decomposition approach. *Journal of African Economies*, 15(1): 91-116.

Aye, G.C. and Mungatana, E.D. 2011. Technological innovation and efficiency in the Nigerian maize sector: Parametric stochastic and non-parametric distance function approaches, Agrekon: *Agricultural Economics Research, Policy and Practice in Southern Africa*, 50:4, 1-24.

Azam, M, Imai, K. and Gaiha, R. 2012. Agricultural supply response and smallholders market participation- the case of Cambodia. Kobe University. *Discussion Paper Series*. DP2012-09.

Bach, F.C. and Per, P.A. 2008. Agriculture, growth and employment in Africa: Civil society input to the Africa commission on effective development cooperation with Africa. Discussion paper II.

Banker, R.D., Charnes, A. and Cooper, W.W. 1984. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 30(9): 1078-1092.

Bardhan, P. and Udry, C. 1999. *Development Microeconomics*. Oxford: Oxford University Press.

Barrett, C.B. 2008. Smallholder market participation: Concepts and evidence from Eastern and Southern Africa. *Food Policy*, 33(2008): 299–317.

Battese, G.E. 1997. A note on the estimation of Cobb-Douglas production functions with some explanatory variables having zero values. *Journal of Agricultural Economics*, 48 (2): 250-252.

Becker, G. S. 1965. A theory of allocation of time. *Economic Journal,* 75: 493–517.

Bedaso Taye, Wondwosen Tsegaye and Mesfin Ketema. 2012. Commercialization of Ethiopian smallholder farmer's production: Factors and Challenges behind. Paper presented on the Tenth International Conference on the Ethiopian Economy*, Ethiopian Economics Association*, July 19-21, 2012, Addis Ababa, Ethiopia.

Bellemare, M.F. and Barrett, C.B. 2006. An ordered Tobit model of market participation: evidence from Kenya and Ethiopia. *American Journal of Agricultural Economics*, 88(2): 324-337.

Bembridge, T.J. and Williams, J.L. 1990. Factors affecting adoption of maize in small- scale farmer support programs. *South African Journal of Agricultural Extension*, 13: 47-52.

Berhanu Gebremedhin and Moti Jaleta. 2010. Commercialization of smallholders: Does market orientation translate into market participation? ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia.

Berhanu Gebremedhin and Moti Jaleta. 2012. Market orientation and market participation of smallholders in Ethiopia: Implications for commercial transformation. *Selected Paper prepared for presentation at the International*

Association of Agricultural Economists (IAAE) Triennial Conference, Foz do lguacu, Brazil, 18-24.

Berhanu Gebremedhin, Moti Jaleta and Hoekstra, D. 2009. Smallholders, Institutional Services and Commercial transformation in Ethiopia. *Agricultural Economics*, 40: 773-787.

Berhanu Gebremedihin, Hoekstra, D. and Azage Tegegne. 2006. Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator. (IPMS) of Ethiopian farmers project Working Paper I. ILRI, Nairobi, Kenya.

Betre Alemu. 2006. Geography of smallholders' commercialization: The Case of food grains in Ethiopia. Paper submitted for ESSP Policy Conference 2006. Bridging, Balancing, and Scaling up: Advancing the Rural Growth Agenda in Ethiopia 6-8 June 2006, Addis Ababa, Ethiopia.

Betty, K. 2005. Technical efficiency in Kenyan's maize production: An application of the stochastic frontier approach. M.Sc. Thesis, Colorado State University, Colorado.

Beyene Tadesse. 2004. The impact of policy reform and institutional transformation on agricultural performance: An economic study of Ethiopian Agriculture. Development Economics and Policy. Doctoral Dissertation, University of Hohenheium, Germany.

Bezu, S., Holden, S. and Barrett, C.B. 2009. Activity choice in rural non-farm employment: Survival versus accumulation strategy. *Paper presented at the 8th Nordic Conference in Development Economics,* Oscarsborg, Drobak, Norway, June 18–19, 2009.

Bliss, C.J., and Stern, N.H. 1982. Palanpur: The economy of an Indian village. Delhi and New York: Oxford University Press.

Bozec, R., Dia, M. and Breton, G. 2006. Ownership-efficiency relationship and measurement selection bias. *Accounting and Finance*, 46 (5): 733 -754.

Charnes, A. and Cooper, W.W. 1962. Programming with linear fractional functional. *Naval Research Logistics Quarterly*, 15: 517–522.

Charnes, A., Cooper, W.W. and Rhodes, E. 1978. Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2: 429-444.

Chavas, J.P. and Cox, T. 1992. A nonparametric analysis of the influence of research on agricultural productivity. *American Journal of Agricultural Economics*, 74: 583-591.

Chen, M. A. and Dunn, E. 1996. Household economic portfolios. Assessing the Impact of Microenterprise Services (AIMS). *Management Systems International*, Washington, D.C. 20024-2488.

Coelli T.J., Rao, D.S.P. and Battese, G.E. 1998. *An Introduction to Efficiency and Productivity Analysis.* Kluwer Academic Publishers, USA.

Coelli, T.J, Rao, D.S.P., O'Donnell, C. and Battese, G. 2005. *An Introduction to Efficiency and Productivity Analysis*, *2nd Edition.* Springer, New York.

Coelli, T.J, Sandura, R. and Colin, T. 2002. Technical, allocative, cost and scale in Bangladesh rice production: A non-parametric approach. *Journal of Agricultural Economics*, 53(3): 607-626.

Coelli, T.J. and Rao, D.S.P. 2003. Total factor productivity growth in agriculture: A Malmquist index analysis of 93 countries 1980-2000. In: *Proceedings of the 25th International Conference of Agricultural Economists*. Reshaping Agricultural Contribution to Society, 115-134.

Cook, W.D. and Zhu, J. 2008. CAR-DEA: Context dependent assurance regions in DEA. Operations Research, forthcoming.

Cragg, J. 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica*, 39: 829-844.

CSA. 2008. Agricultural sample survey (separately for years 2000/01-2007/08). Report on area and production of crops: private peasant holdings, *Meher* season. Addis Ababa, Ethiopia.

CSA. 2009. Agricultural sample survey report on area and production of crops 2008-2009(2001 E.C), Addis Ababa, Ethiopia.

CSA. 2012. Central Statistical Authority of Ethiopia, reports of the 1994 and 2007 population and housing census and 2012 inter-central survey.

CSA. 2014. Agricultural sample survey 2013/14 (2006 E.C.). Volume IV: Report on land Utilization by Private Peasant Holdings. *Statistical Bulletin, number* 446. Central Statistical Agency, Addis Ababa, Ethiopia.

Dasgupta, P. 1993. An inquiry into well-being and destitution. Oxford: Clarendon Press.

Degye Goshu, Belay Kassa and Mengistu Ketema. 2012. Measuring Smallholder Commercialization Decisions and Interactions in Ethiopia. *Journal of Economics and Sustainable Development*, ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online), 3(13): 2012.

Degye Goshu. 2013. Agricultural technology adoption, diversification, and commercialization for enhancing food security in eastern and central Ethiopia. PhD Dissertation, Haramaya University, Haramya, Ethiopia.

Denison, E. 1987. Growth accounting. In: Eatwell, J., Milgate, M. and Newman, P. (eds.), *The New Palgrave Dictionary of Economics,* vol. 2. Stockson Press, New York.

Diewert, W. and Nakamura, A. 2005. Concepts and measures of productivity: An introduction. In: Lipsey, R.E. and Nakamura, A. (eds.), *Services, Industries and the Knowledge Based Economy*. University of Calgary Press.

EEA. 2006. Evaluation of the Ethiopian agricultural extension with particular emphasis on the Participatory Demonstration and Training Extension System (PADETES), Addis Ababa, Ethiopia.

Eleni Gabre-Madhin. 2001. Market institutions, transaction costs, and social capital in the Ethiopian grain market. Research Report 124. IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Ellis, F. 1998. Household strategies and rural livelihood diversification. *Journal of Development Studies*, 35(1): 1-38.

Ellis, F.1992. *Peasant Economics*. Cambridge: Cambridge University Press.

Endrias Geta, Belay Kassa, Ayalneh Bogale, Eyasu Elias. 2010. Productivity and efficiency analysis of smallholder maize producers in Southern Ethiopia. *Journal of Human Ecology*, 41(1):67-75.

Essa Chanie, 2011. Resource use efficiency of smallholder crop production in the central highlands of Ethiopia. M.Sc Thesis Presented to Department of Agricultural Economics and Business Management, Egerton University, Kenya.

Ethiopia Bellmon Analysis Reprt. 2015. Ethiopia Bellmon Analysis 2015/16 and reassessment of crop production and marketing for 2014/15.

Ethiopian Economic Policy Research Institute (EEPRI). 2002. Land tenure and agricultural development in Ethiopia. Addis Ababa: EEPRI.

FAO. 2011. Food and Agriculture Organization Ethiopia country programming framework. Office of the FAO Representative in Ethiopia to AU and ECA-Addis Ababa 2011.

FAO. 2014. Socio-economic context and role of agriculture. Information reported derived from and prepared by the Food and Agriculture Policy Decision Analysis (FAPDA) team. Country fact sheet on food and agriculture policy trends, October 2014, available at http://www.fao.org/3/a-i4181e.pdf and accessed on September, 2016.

Färe R., Grosskopf S. and Lovell, C.A.K. 1985. Technical efficiency of Philippine agriculture. *Applied Economics*, 17: 205 – 214.

Farrell, M. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society Series A (General),* 120 (3): 253–281.

Favero, C. A. and Papi, L. 1995. Technical efficiency and scale efficiency in the Italian banking sector: A non-parametric approach. *Applied Economics*, 27(6): 385-395.

Fekadu Gelaw. 2004. Analysis of technical efficiency of wheat production: A study in Machakel Woreda, Ethiopia. Unpublished MSc Thesis, Alemaya University.

Fried, H. O., Lovell, A.K., and Schmidt, S.S. 2002. Accounting for environmental effects and statistical noise in DEA. *Journal of Productivity Analysis*, 17(1/2): 157-174.

Fried, H.O., Lovell, C.A. and Schmidt, S.S. 2008. The measurement of productive efficiency and productivity growth. Oxford University Press Inc., New York.

Fulginiti, L. and Perrin, R. 1998. Agricultural productivity in developing countries. *Agricultural Economics,* 19: 45–51.

Gezahegn Ayele, Mekonnen Bekele and Samia Zekeria. 2006. Productivity and efficiency of agricultural extension package in Ethiopia. The Ethiopian Development Research Institute (EDRI) Research Report 5, Addis Ababa, Ethiopia.

Goetz, S. 1992. A Selectivity Model of Household Food Marketing Behavior in Sub-Saharan Africa. *American Journal of Agricultural Economics*, 74(2): 444-452.

Govereh, J. and Jayne,T.S., 2003. Cash cropping and food productivity: Synergies or tradeoffs? *Agricultural economics*, 28: 39-50.

Greene, W. H. 1997. Frontier production functions. In Pesaran, M. H. and Shmidt, P., (eds.), *Handbook of Applied Econometrics*, volume II: Micro-econometrics. Blackwell Publishers Ltd.

Greene, W. H., 2012. *Econometric Analysis, (7th Edition)*. New Jersey: Pearson Hall, USA.

Habtamu Yesgat. 2013. Transformation in smallholder agriculture through intensification in Ethiopia: Determinants and implications. *International Journal of Agricultural Science, Research and Technology,* 2(3): 123-128.

Haddad, L. 1994. Strengthening food policy through intra-household analysis. *Food Policy*, 19(4): 347-356.

Haddad, L., Hoddinott, J. and Alderman, H. 1997. Intra-household resource allocation in developing countries: Methods, models, and policy. Johns Hopkins University Press, Baltimore.

Haileselassie Amare. 2005. Analysis of Technical efficiency in sorghum production: The case of smallholder farmers in Raya-Azebo District, Southern Tigray, Ethiopia. M.Sc Thesis Presented to the School of Graduate Studies of Alemaya University, Ethiopia.

Hall, A.R., Rudebusch, G.D. and Wilcox, D.W. 1996. Judging instrument relevance in instrumental variables estimation. *International Economic Review,* 37(2): 283-298.

Hassen Beshir, Bezabih Emana, Belay Kassa and Jema Haji. 2012a. Economic efficiency of mixed crop-livestock production system in the north eastern highlands of Ethiopia: the stochastic frontier approach. *Journal of Agricultural Economics and Development,* 1(1): 10-20.

Hassen Beshir, Bezabeh Emana, Belay Kassa and Jema Haji. 2012b. Determinants of chemical fertilizer technology adoption in north estern highlands of Ethiopia: The double-hurdle approach. *Journal of Research Economics and International Finance,* 1(2): 39-49.

Heckman, J.J., 1979. Sample selection bias as a specification error. *Econometrica*, 47(1): 153-161.

Hensher, M. 2001. Financing health systems through efficiency gains. CMH Working Paper Series. Paper No. WG3: 2.

Hinderink, J. and Sterkenbur, J.J. 1987. Agricultural commercialization and government policy in Africa. KPI Limited, New York.

Hjalmarsson, L., Kumbhakar, S. and Hesmati, A. 1996. DEA, DFA and SFA: A Comparison, *Journal of Productivity Analysis*, 7: 303-327.

Holden, S., Shiferaw, B. and Pender, J. 2004. Non-farm income, household welfare and sustainable land management in a less-favored area in the Ethiopian highlands. *Food Policy*, 29: 369–392.

Hollingsworth, B. 2008. The measurement of efficiency and productivity of health care delivery. *Health Economics,* 17(10): 1107–1128.

Holloway, G., Barrett, C.B. and Ehui, S. 2005. The double-hurdle model in the presence of fixed costs. *Journal of International Agricultural Trade and Development*, 1: 17-28.

Hussein Hamda. 2007. Farm household economic behavior in imperfect financial markets: empirical evidence and policy implications on saving, credit and production efficiency in southeastern Ethiopia, Doctorial Dissertation, Faculty of Natural Resource and Agricultural Sciences, Department of Economics, Uppsala, Sweden.

IFAD (International Fund for Agricultural Development). 2003. Promoting market access for the rural poor in order to achieve the millennium development goals. Discussion paper 2003, Rome.

Immink, M.D.C and Alarcon, J.A. 1993. Household income, food availability, and commercial crop production by smallholders farmers in the western highlands of Guatemala. *Economic Development and Cultural Change,* 41: 319-342.

Ismat, A., Begum, J. Buysse, M. Jahangir A. and Van Huylenbroeck, G. 2009. An application of data envelopment analysis to evaluate economic efficiency of poultry farms in Bangladesh: contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China.

Israel, G.D. 1992. Sampling the evidence of extension program impact. Program evaluation and organizational development, IFAS, University of Florida. PEOD-5.

Jema Haji and Andersson. H. 2006. Determinants of efficiency of vegetable production in smallholder farms: The case of Ethiopia. *Food Economics*, 3: 125-137.

Jema Haji. 2008. Economic efficiency and marketing of vegetable production in eastern and central parts of Ethiopia. Doctoral Dissertation, University of Swedish, Sweden.

Kaleab Kebede. 2010. Analysis of technical efficiency, empirical evidence from wheat producing smallholder farmers and commercial farms in Bale Zone of Oromiya, Ethiopia. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.

Kan, I., Kimhi, A. and Lerman, Z. 2006. Discussion paper on farm output, non-farm income, and commercialization in rural Georgia, University of Hebrews.

Kaufman, L. and Rousseeuw, P.J. 1990. Finding groups in data: An introduction to cluster analysis. Wiley, New York.

Keith, O.F. 2010. The shifting patterns of agricultural production and productivity worldwide. *The Midwest Agribusiness Trade Research and Information Center*, Iowa State University, Ames, Iowa.

Key, N., Sadoulet, E. and de Janvry, A. 2000. Transaction costs and agricultural household supply response. *American Journal of Agricultural Economics*, 82(2): 245-59.

Kindie Teshome. 2005. Technical efficiency of maize production: A case of smallholder farmers in Assosa District. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.

Kokkinou, A. 2010. A note on theory of productive efficiency and stochastic frontier models. *European Research Studies*, 13(4): 109-118.

Koopmans, T.C. 1951. An analysis of production as an efficient combination of activities, in Koopmans, T.C. (ed.). *Activity Analysis of Production and Allocation*, Cowles Commission for Research in Economics Monograph No. 13. New York: John Wiley and Sons.

Kothari, C.R. 2004. *Research Methodology*: *Methods and Techniques*, 2nd Edition. New Age International, New Delhi, India.

Krasachat, W. 2009. Technical efficiency of shrimp farms in Thailand under good agricultural practice system. A contributed paper for Tropentag 2009 Conference on International Research on Food Security, Natural Resource Management and Rural Development.

Leavy, J. and Poulton C. 2007. Commercialization in agriculture: A typology. Paper presented at the Fifth International Conference on the Ethiopian Economy, Ethiopian Economic Association (EEA), USA. pp. 79-99.

Lerman Z. 2005. The impact of land reform on rural household incomes in Transcaucasia and Central Asia.

Lerman, Z. 2004. Policies and institutions for commercialization of subsistence farms in transition countries. *Journal of Asian Economics,* 15: 461–479.

Lerman, Z. 2005. The Impact of land reform on rural household incomes in Transcaucasia and Central Asia.

Leykun Birhanu and Jemma Haji. 2014. Econometric analysis of factors affecting market participation of smallholder farming in Central Ethiopia. *Journal of Agricultural Economics, Extension and Rural Development,* 2(6): 084-104.

Lijia, S., House, A.L. and Gao, Z. 2011. Consumer structure of the blueberry market: A double hurdle model approach. In *Selected Paper prepared for presentation at the Agricultural and Applied Economics Association and NAREA Joint Annual Meeting,* Pittsburgh, Pennsylvania: 24-26 July.

Lipton, M. 1968. The theory of the optimizing peasant. *Journal of Development Studies*, 4(3):327-51.

Lipton, M. 2004. New directions for agriculture in reducing poverty: The DFID Initiative.

Lovell, C.A.K. 1993. Production frontiers and productive efficiency. In: Fried, H.O., Lovell C.A.K. and Schmidt S.S. (Eds.), *The Measurement of Productive Efficiency: Techniques and Applications*. Oxford: Oxford University Press, New York, 3-67.

Luis, R. M. Z and Juan, V.C. 2000. The use of parametric and non-parametric frontier methods to measure the productive efficiency in the industrial sector. Discussion Papers in Economics, No. 2000/17.

Maddala, G.S. 1999. *Limited Dependent Variable in Econometrics*. Cambridge University Press, New York.

Mahelet Fikru. 2007. Factors affecting commercialization of smallholder farmers in Ethiopia: The Case of North Omo Zone, SNNP region. *Paper Presented at the Fifth International Conference on the Ethiopian Economy*, June, 7-9, 2007, Addis Ababa, Ethiopia.

Makhura, M.T. 2001. Overcoming transaction costs barriers to market participation of smallholder farmers in the northern province of South Africa. PhD Dissertation Research Submitted to the University of Pretoria, South Africa.

Martey, E. Al-Hassan R.M. and Kuwornu, J.K.M. 2012. Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research,* 7(14): 2131-2141.

Martey, E., Al-Hassan, R.M. and Kuwornu, J.K.M. 2012. Commercialization of smallholder agriculture in Ghana: A Tobit regression analysis. *African Journal of Agricultural Research,* 7(14): 2131-2141.

Mbanasor, J. and Kalu, K.C. 2008. Economic efficiency of commercial vegetable production system in Akwa Ibom State, Nigeria. *Journal of Tropical and Subtropical Agroecosystems,* 8(3): 313-318.

Mekdes Abera, 2011. Analysis of Technical efficiency of irrigated Lentil (Lens Culinaris Medikus) Production: The case of Gimbichu District, Ethiopia. M.Sc Thesis, Haramaya University, Haramya, Ethiopia.

Melaku Tefera. 2011. Oxenization versus tractorization: Options and constraints for Ethiopian framing system. *International Journal of Sustainable Agriculture*, 3(1): 11-20.

Mendola, M. 2007. Farm household production theories: A review of institutional and behavioral responses. *Asian Development Review*, 24(1): 49-68.

Mengistu Ketema and Siegfried, B. 2011. Determinants of Manure and Fertilizer Applications in Eastern Highlands of Ethiopia. *Quarterly Journal of International Agriculture*, 50(3): 237-252.

MoFED (Ministry of Finance and Economic Development). 2010. The Federal Democratic Republic of Ethiopia. Growth and Transformation Plan (GTP) 2010/11-2014/15, Addis Ababa.

Mooi, E. and Sarstedt, M. 2011. A concise guide to market research. The process, data, and methods using IBM SPSS statistics. Heidelberg: Springer.

Morduch, J. 1995. Income smoothing and consumption smoothing. *Journal of Economic Perspectives*, 9(3):103–14.

Moti Jaleta and Gardebroek, C. 2008. Crop and market outlet choice interactions at household level. *Ethiopian Journal of Economics*, 7(1): 29-47.

Moti Jaleta. 2007. Econometric analysis of horticultural production and marketing in Central and Eastern Ethiopia. PhD Thesis, Wageningen University.

Musa Hasen. 2013. Economic efficiency of smallholder farmers in maize production: The case of Arsi Negelle District, Oromia National Regional State, Ethiopia. M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia.

Nadezda, R., Urquieta, A. and Alwang, J. 2012. Women role: potato markets, cellular phones and access for information in the Bolivian highlands. *Agricultural Economics* 43(2012): 405-415.

NPC (National Planning Commission). 2016. Federal Democratic Republic of Ethiopia Growth and Transformation Plan II (GTP II) (2015/16-2019/20).Volume I: NPC May, 2016, Addis Ababa.

Nyagaka D.O., Obare, G.A. and Nguyo, W. 2009. Economic efficiency of smallholder Irish Potato producers in Kenya: A Case of Nyandarua North District. Contributed paper prepared for presentation at the International Association of Agricultural Economists' Conference, Beijing, China.

OECD (Organization for Economic Co-operation and Development). 2001. Measuring productivity: measurement of aggregate and industry-level productivity growth. OECD Manual.

Okazaki, S. 2006. What do we know about mobile internet adopters? A cluster analysis. *Information and management*, 43: 127–141.

Okezie, C.A., Nwosu, A.C. and Okezie, C.R. 2008. An Assessment of the extent of the commercialization of agriculture in Abia State, Nigeria. *Agricultural Journal,* 3(2): 129- 133.

Olayide, S.O. and Heady, E.O. 1982. *Introduction to Agricultural Production Economics*, 1st Edition. Ibadan: Ibadan University Press.

Omiti, J.M., Otieno, D.J., Nyanamba, T.O. and McCullough, E. 2009. Factors influencing the intensity of market participation by smallholder farmers: A case study of rural and peri-urban areas of Kenya. *African Journal of Agricultural and Resource Economics*, 3:71.

Orden, D, M. Torero and A. Gulati, 2004. Agricultural markets and the rural poor. Background paper for workshop of the Poverty Reduction Network (POVNET), March 5, 2004.

Otieno, D., Omiti, J. Nyanamba T. and McCullough, E. 2009. Market Participation by Vegetable Farmers in Kenya: A comparison of Rural and Peri-Urban Areas. *African Journal of Agricultural Research*: 4(5): 451–460.

Ouma E., Jagwe J., Obare, G.A., Abele, S. 2010. Determinants of smallholder farmers' participation in banana markets in Central Africa: The role of transaction costs. *Agricultural Economics*, 41:111–122.

Pender, J. and Dawit Alemu. 2007. Determinants of smallholder commercialization of food crops: Theory and evidence from Ethiopia. Discussion Paper No. 75, IFPRI (International Food Policy Research Institute), Washington, DC, USA.

Pender, J., Ehui, S. and Place, F. 2006. Conceptual framework and hypotheses. In strategies for sustainable land management in the East African Highlands, ed. J. Pender, F. Place, and S. Ehui. *International Food Policy Research Institute*, Washington, D.C.

Pingali, P.L, and Rosegrant, M.W. 1995. Agricultural commercialization and diversification: Process and polices. *Food Policy,* 20(3):171-185.

Pingali, P.L. 1997. From subsistence to commercial production system: The transformation of Asian agriculture. *American Journal of Agricultural Economics,* 79 (2): 628-634.

Pingali, P.L. 2001. Environmental consequences of agricultural commercialization in Asia. *Environment and Development Economics,* 6:483–502.

Portes, A. 1998. Social Capital: Its origins and applications in modern sociology. *Annual Review of Sociology*, 24:1-24.

Pritchard, R. D. 1990. Measuring and improving organizational productivity. New York, Westport, Connecticut.

Rai, A., Tang, X., Brown, P. and Keil, M. 2006. Assimilation patterns in the use of electronic procurement innovations: A cluster analysis. *Information and management*, 43: 336−349.

Ralph, K. 2004. Hararghe Farmers on the cross-roads between subsistence and cash economy. United Nations Development Programme (UNDP), Emergencies Unit for Ethiopia (EUE).

Ralph, K. 2004. Hararghe farmers on the cross-roads between subsistence and cash economy. United Nations Development Programme (UNDP), Emergencies Unit for Ethiopia (EUE).

Resti, A. 1997. Evaluating the cost-efficiency of the Italian banking system: What can be learned from the joined application of parametric and non-parametric techniques. *Journal of Banking and Finance* 2, 221-250.

Rios, A.R., Masters, W.A. and Shively, G.F. 2008. Linkages between market participation and productivity: Results from a multi-country farm household sample. Paper presented at the American Agricultural Economics Association Annual Meeting, Orlando, Florida, USA, July 27–19, 2008.

Rogers, M. 1998. The definition and measurement of productivity. The University of Melbourne, Australia, Melbourne institute of applied economics and social research. Working paper 9/98.

Roumasset, J. 1976. Rice and risk: Decision making among low-income farmers. Amsterdam: North-Holland Publishing.

Samoilenko, S. and Osei-Bryson, K.M. 2008. Increasing the discriminatory power of DEA in the presence of the sample heterogeneity with cluster analysis and decision trees. *Expert systems with applications*, 34(2): 1568–1581.

Samuel Gebreselassie and Ludi, E. 2007. Commercialization of smallholder agriculture in selected Tef-growing areas of Ethiopia. *Ethiopian Journal of Economics,* 16(1): 57-88.

Samuel Gebreselassie and Sharp, K. 2007. Agricultural commercialization in coffee growing areas of Ethiopia. *Ethiopian Journal of Economics*, 16(1): 89-118.

Schultz, T.W. 1964. *Transforming Traditional Agriculture.* Chicago: University of Chicago Press.

Seyoum E, Battese G, Fleming, E. 1998. Technical efficiency and productivity of maize producers in Eastern Ethiopia: A study of farmers within and outside the Sasakawa- Global 2000 project. *Journal of Agricultural Economics,* 19:341-348.

Sharp, K., Ludi, E. and Samuel Gebreselassie. 2007. Commercialization of farming in Ethiopia: Which Pathways? *Ethiopian Journal of Economics,* Volume XVI, No1, April 2007. Paper presented at the Fifth International Conference on the Ethiopian Economy, Addis Ababa, June 7-9, 2007.

Sheng, Y., Jackson, T., Zhang D. and Zhao, S. 2013. Measuring output, input and total factor productivity in Australian agriculture: An industry-level analysis. Paper prepared for the IARIW-UNSW conference on productivity: Measurement, drivers and trends. Sydney, Australia, November 26-27, 2013.

Shumet Asefa. 2011. Analysis of technical efficiency of crop producing smallholder farmers in Tigray, Ethiopia. *MPRA Paper Number 40461,* available at https://mpra.ub.uni-muenchen.de/40461/1/MPRA_paper_40461.pdf and accessed on October, 2016.

Sindi, J.K. 2008. Kenya's domestic horticulture subsector: What drives commercialization decisions by rural households? MSc. Thesis, Michigan State University.

Singh, I., Squire, L. and Strauss, J. 1986. Agricultural household models: Extensions and applications. Baltimore: Johns Hopkins University Press.

Singh, S.R. 1986. Technical parameters in agricultural production function. Ashish Publishing House, New Delhi.

Sisay Debebe, Jema Haji, Degye Goshu and Abdi-Khalil Edriss. 2015. Technical, allocative, and economic efficiency among smallholder maize farmers in Southwestern Ethiopia: Parametric approach. *Journal of Development and Agricultural Economics,* 7(8):282-291.

Siziba, S, Nyikahadzoi, K, Dagne, A, Fatunbi, A.O. and Adekunle, A.A, 2011. Determinants of cereal market participation by sub-Saharan Africa smallholder farmer. *Learning Publics Journal of Agriculture and Environmental Studies,* 2(1):180-193.

Smith, L.C. and Chavas, J.P. 1999. Supply response of West African agricultural households: Implications of intra-household preference heterogeneity. FCND discussion paper no. 69. International Food Policy Research Institute. U.S.A.

Solomon Bizuayehu. 2012. Economic efficiency of wheat seed production: The case of smallholders in Womberma *Woreda* of West Gojjam Zone. M.Sc Thesis, Haramaya University, Haramya, Ethiopia.

Stock, J. H. and Yogo, M. 2005. Testing for weak instruments in linear IV regression. pp.80-108. In: Andrews, D.W.K. and Stock, J.H. (eds.), *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg.* New York: Cambridge University Press.

Storck, H., Bezabeh Emana, Berhanu Adenew, Borowiecki, A. and Shimeles W/Hawariat. 1991. Farming systems and farm management practices of the

smallholders in the Hararghe highlands: A baseline survey. *Farming Systems and Resource Economics in the Tropics*, 11:1991-195.

Strasberg, P.J. 1997. Smallholder cash-cropping, food-cropping and food security in Northern Mozambique. PhD Dissertation, Michigan State University.

Strasberg, P.J., Jayne, T.S. Yamano, T. Nyoro, J. Karanja D. and Strauss, J. 1999. Effects of agricultural commercialization on food cop input use and productivity in Kenya. *MSU International Department of Agricultural Economics Development Department of Economics*. Working paper number 71. Michigan, USA: MSU.

Tesfay, G., Ruben, R., Pender, J. and Kuyvenhoven, A. 2005. Resource use efficiency on own and sharecropped plots in Northern Ethiopia: determinants and implications for sustainability.

Thorner, D., Kerblay, B. and Smith, R.E.F. 1966. *Chayanov on the Theory of Peasant Economy*. Homewood, IL: Richard D. Irwin.

Timmer, C. P. 1997. Farmers and markets: The political economy of new paradigms. *American Journal of Agricultural Economics*, 79(2): 621–627.

Tobin, J. 1958. Estimation of relationships for limited dependent variables. *Econometrica*, 31: 24-36.

UNDP. 2015. Ethiopia: Key economic and social indicators. UNDP Ethiopia's policy advisory unit, 2015, No. 2.

von Braun J., Bouis H. and Kennedy, E. 1994. Conceptual framework. pp. 11-36. In: von Braun, J. and Kennedy, E. (eds.). *Agricultural Commercialization, Economic Development, and Nutrition*. The Johns Hopkins Press Ltd., Maryland.

von Braun, J. 1995. Agricultural Commercialization: Impacts on income and nutrition and implications for policy. *Food Policy,* 20 (3): 187-202.

Von Braun, J. 2005. Small-scale farmers in a liberalized trade environment. *In:* T. Huvio, J. Kola, and T. Lundström (eds.) *Small-scale farmers in liberalized trade environment*, Proceedings of the seminar, October 18–19, 2004, Haikko, Finland. Department of Economics and Management. Helsinki: University of Helsinki Agricultural Policy.

von Braun, J. and Kennedy, E. 1994. *Agricultural Commercialization, Economic Development and Nutrition*. The Johns Hopkins University Press, Baltimore and London.

Walker, T., and Jodha, N. 1986. How Small Farmers Adapt to Risk. In: Hazell, P., Pomareda, C. and Valdez, A. (eds.), *Crop Insurance for Agricultural Development. Baltimore*. Johns Hopkins University Press.

WB. 2007. African Development Indicators, World Bank Report, Washington D.C.

WB. 2008. World Development Report 2008: Agriculture for development. 1818 H Street, NW, Washington, DC 20433, USA.

WB. 2013. The United Nations Population Division's World Population Prospects, World Development Indicators, census report.

WHO and FAO. 1985. Energy and protein requirements. Technical Report Series 724. Geneva.

Wiebe, K., Soule, M.J. Narrod, C. and Brenneman, V.E. 2003. Resource quality and agricultural productivity: A multi-country comparison in land quality, agricultural productivity and food security: Biophysical processes and economic choices at local, regional and global levels. Edward Elgar publishing.

William, W. 2003. Farmers of Ethiopia turn to *khat* as world coffee prices tumble. Financial times, December 8, 2003.

Wooldridge, J.M. 2006. *Introductory Econometrics: A Modern Approach, 3rd Edition*. South-Western College Publishing.

Workneh Negatu and Michael, R. 2002. Intensification and crop commercialization in north eastern Ethiopia. *Ethiopian Journal of Economics*, 11(2): 83-105.

Zepeda, L. 2001. Agricultural Investment and Productivity in Developing Countries. Rome: FAO, 2001.

Zhou S., Minde I.J. and Mtigwe, B. 2013. Smallholder agricultural commercialization for income growth and poverty alleviation in southern Africa. *African Journal of Agricultural Research*, 8(22): 2599-2608.

7. APPENDICES

Appendix 1: Appendix Tables

Appendix Table 1. Heckman estimation results of market orientation

Factors	Decision of market orientation		Level of market orientation	
	Coefficients	Std. Err	Coefficients	Std. Err
Dependency ratio	0.002	0.006	-0.003*	0.002
Sex of household head	15.790***	2.849	-0.407	0.728
Social capital	3.170**	1.120	-0.406	0.25
Farming experience	-0.006	0.055	-0.003	0.014
Total livestock holding	0.009	0.255	-0.034	0.076
Cultivated land size	-27.589***	7.565	0.411	1.681
Land size for *khat*	12.383	11.479	-7.925***	2.466
Education status	-1.321**	0.665	0.219	0.139
Off/ non-farm income	1.558	1.218	-0.057	0.292
Proportion of irrigated land	-7.187**	3.229	2.251**	0.815
Chemical fertilizer	3.747***	0.990	0.146	0.284
Credit use	-1.214	1.249	0.434	0.299
Distance to nearest market	-0.281*	0.163	0.03	0.04
Distance to main town	.	.	-0.109***	0.031
Distance to main road	.	.	-0.251**	0.1
Distance to FTC	-1.048	1.305	-0.580*	0.344
Extension contacts	1.313	1.332	0.463	0.338
Crop diversification index	-25.989**	9.670	-4.542*	2.74
On-farm income	0.521	2.464	1.466**	0.487
Location dummy	0.019	1.477	0.476	0.314
Constant	67.088**	27.859	-10.390*	5.811
Mills| lambda	.	.	-0.22	0.363
Rho	.	.	3.342	0.313
Sigma	.	.	-0.736	1.242

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; LR test of independent eqns.(rho=0): $\chi^2(1) = 0.33$; Prob>χ^2=0.566

Source: Author's computation from sample survey data (2015).

Appendix Table 2. Tobit estimation results on factors affecting fertilizer purchases

Variables	**Coefficients**	**Standard Error**
Dependency ratio	-0.001	0.001
Sex of HH head	-0.224	0.319
Farming experience	-0.01	0.009
Cultivated land size	-0.779**	0.401
Land size for *khat*	3.071**	1.397
Total livestock holdings	0.013	0.050
Education status	-0.013	0.107
Off-farm /non-farm income (log)	-0.050**	0.024
Credit use (log)	0.382	0.239
Distance to nearest market	-0.009	0.024
Distance to nearest town	-0.054***	0.013
Distance to nearest road	-0.148***	0.042
Extension contacts	0.087	0.063
Amount of manure used	-0.020**	0.008
Constant	6.317***	0.471
Sigma	-0.001	0.001

Note: "*", "**" and "***" represent statistical significance of factors at 10, 5 and 1% levels respectively; LR χ^2 (15) = 45.21, Prob > χ^2 = 0.000; Log likelihood = -729.517; Pseudo-R^2 = 0.030: Number of observation=385.

Source: Author's computation from sample survey data (2015).

Appendix Table 3. Multicollinearity test on factors determining commercial orientation and productivity

Variable	**VIF**	**1/VIF**
Annual crop income (log)	2.81	0.36
Amount of manure used	2.70	0.37
Number of oxen owned	2.29	0.44
Livestock owned (excluding ox)	2.24	0.45
Quantity of labor used	1.81	0.55
Amount of fertilizer used	1.78	0.56
Location dummy	1.60	0.62
Annual livestock income (log)	1.59	0.63
Farming experience	1.49	0.67
Active members to land ratio	1.43	0.70
Education status	1.40	0.71
Land allocated to *khat*	1.35	0.74
Distance to nearest market	1.34	0.75
Distance to nearest road	1.34	0.75
Credit use (log)	1.20	0.83
Number of extension contacts	1.18	0.85
Sex of household head	1.15	0.87
Off/non-farm income (log)	1.14	0.88
Mean VIF	**1.66**	

Source: Author's computation from sample survey data (2015).

Appendix Table 4. First-stage regression results expressing the effect of instruments on market orientation

Market orientation index	Coefficients	Robust Std. Err.	P>t
Sex of household head	-0.009	0.018	0.607
Active members to land ratio	-0.009**	0.003	0.008
Farming experience	-0.0003	0.001	0.646
Livestock owned (excluding ox)	0.0002	0.004	0.959
Number of oxen owned	0.009	0.010	0.389
Education status	0.003	0.007	0.669
Credit use (log)	0.0003	0.002	0.858
Off/non-farm income (log)	0.003**	0.001	0.029
Number of extension contacts	0.002	0.004	0.524
Distance to nearest market	-	0.002	0.979
Location dummy	-0.052***	0.013	0.000
Amount of manure used	-0.001*	0.001	0.080
Amount of fertilizer used	0.0001**	0.0002	0.005
Quantity of labor used	0.067***	0.016	0.000
Annual livestock income (log)	0.001	0.001	0.400
Distance to nearest road*	-0.011***	0.003	0.001
Annual crop income (log)*	0.082***	0.023	0.000
Land allocated to *khat**	-0.343***	0.066	0.000
Constant	-0.860***	0.204	0.000

Note: "*" indicates instruments; Number of observation = 385; F (18, 366) = 21.21; Probability>F=0.000; R^2 =0.411; Adjusted-R^2=0.382; Root MSE=0.096.

Source: Author's computation from sample survey data (2015).

Appendix Table 5. Multicollinearity diagnostic tests of inefficiency factors using VIF

Variable	VIF	1/VIF
Diversification of crops	1.37	0.73
Education level	1.31	0.76
Farming experience	1.31	0.77
Household size	1.28	0.78
Land allocated to *khat*	1.24	0.81
Livestock owned (excluding ox)	1.24	0.81
Number of oxen holding	1.22	0.82
Credit access	1.16	0.86
Market distance	1.12	0.89
Off/non-farm income	1.12	0.90
Sex of household head	1.11	0.90
Distance to FTC	1.11	0.90
Extension visits	1.08	0.93
Mean VIF	1.2	

Source: Author's computation from sample survey data (2015).

Appendix Table 6. Maximum likelihood estimates of the Tobit model

Variables	Technical Inefficiency		Allocative Inefficiency		Economic Inefficiency	
	Coefficients	Robust Std. Err.	Coefficients	Robust Std. Err.	Coefficients	Robust Std. Err.
Sex	-0.059	0.042	0.076**	0.035	0.038*	0.022
Household size	0.004	0.006	-0.002	0.004	0.003	0.004
Farming experience	-0.001	0.001	-0.0002	0.001	-0.0003	0.001
Market distance	-0.016***	0.003	-0.004*	0.003	-0.015***	0.002
Education level	-0.003	0.004	0.003	0.003	0.001	0.003
Extension visits	-0.005	0.011	0.007	0.008	0.003	0.007
Distance to FTC	0.015*	0.009	-0. 0002	0.008	0.012**	0.005
Credit access	0.008	0.031	0.028	0.021	0.023	0.020
Off/non-farm income	0.018	0.029	-0.019	0.020	0.002	0.016
Land allocated to *khat*	-0.251	0.174	0.381***	0.100	0.142	0.106
Livestock owned (excluding ox)	-0.013**	0.006	0.004	0.004	-0.008**	0.004
Oxen holding	-0.041**	0.015	-0.052***	0.009	-0.066***	0.009
Diversification of crops	0.064***	0.016	-0.004	0.011	0.030**	0.010
Constants	0. 243**	0.084	0. 258***	0.063	0. 490***	0.055
/sigma	0.203	0.009	0.154	0.006	0.132	0.007
Number of observation	385		385		385	
Prob > F	0.000		0.000		0.000	
F(13, 372)	5.03		3.91		9.91	
Log likelihood	-0.829		166.947		223.371	

Note: *, ** and *** represent statistical significance of factors at 10%, 5% and 1% levels, respectively.

Source: Authors computation from sample survey data (2015).

Appendix Table 7. Conversion factors to compute tropical livestock unit (TLU)

No.	Livestock Type	Conversion factors (TLU per head)
1	Camel	1.25
2	Horse	1.10
3	Cow and Oxen	1.00
4	Heifer	0.75
5	Donkey (adult)	0.70
6	Donkey (young)	0.35
7	Weaned calf	0.34
8	Calf	0.25
9	Sheep and goat (adult)	0.10
10	Sheep and goat (young)	0.06
11	Chickens	0.01

1 TLU (Tropical Livestock Unit) is calculated for an animal of 250kg live-weight.
Source: Storck *et. al*., 1991.

Appendix Table 8. Conversion factors to compute adult equivalents

	Conversion factor	
Age (year)	Males	Females
< 1	0.33	0.33
1-1.99	0.46	0.46
2-2.99	0.54	0.54
3-4.99	0.62	0.62
5-6.99	0.74	0.7
7-9.99	0.84	0.72
10-11.99	0.88	0.78
12-13.99	0.96	0.84
14-15.99	1.06	0.86
16-17.99	1.14	0.86
18-29.99	1.04	0.8
30-59.99	1.00	0.82
≥ 60	0.84	0.74

Source: WHO and FAO (1985).

Appendix Table 9. Market participation, market orientation and TFP indices

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
1	0.323	0.320	1.000	36	0.215	0.123	1.629
2	0.433	0.325	0.873	37	0.253	0.139	1.170
3	0.375	0.333	1.558	38	0.067	0.043	1.420
4	0.293	0.190	1.175	39	0.250	0.148	1.233
5	0.308	0.234	0.925	40	0.158	0.104	1.251
6	0.372	0.333	0.924	41	0.000	0.000	1.286
7	0.327	0.136	0.606	42	0.000	0.000	1.486
8	0.199	0.127	1.524	43	0.218	0.114	1.262
9	0.209	0.163	1.201	44	0.392	0.302	1.377
10	0.206	0.181	1.502	45	0.243	0.182	1.320
11	0.250	0.100	0.944	46	0.206	0.147	1.568
12	0.455	0.328	1.271	47	0.400	0.247	1.133
13	0.251	0.156	1.189	48	0.194	0.167	1.105
14	0.000	0.000	1.083	49	0.424	0.196	1.166
15	0.233	0.218	1.554	50	0.231	0.125	0.670
16	0.028	0.021	1.488	51	0.381	0.317	1.479
17	0.175	0.124	1.423	52	0.357	0.293	1.017
18	0.123	0.057	0.953	53	0.206	0.171	0.654
19	0.000	0.000	1.211	54	0.174	0.164	0.696
20	0.587	0.479	1.375	55	0.276	0.222	0.708
21	0.201	0.118	1.361	56	0.210	0.196	0.658
22	0.492	0.361	1.447	57	0.243	0.152	0.876
23	0.311	0.227	1.292	58	0.000	0.000	0.836
24	0.000	0.000	0.857	59	0.000	0.000	0.583
25	0.000	0.000	1.009	60	0.287	0.125	0.893
26	0.255	0.173	1.065	61	0.211	0.119	1.135
27	0.278	0.207	1.175	62	0.251	0.142	0.938
28	0.433	0.366	1.170	63	0.000	0.000	1.167
29	0.280	0.150	1.054	64	0.181	0.149	1.186
30	0.365	0.333	0.909	65	0.179	0.096	1.726
31	0.303	0.222	1.355	66	0.247	0.125	1.175
32	0.203	0.092	1.569	67	0.116	0.089	1.380
33	0.335	0.246	0.968	68	0.127	0.087	1.215
34	0.260	0.170	1.251	69	0.257	0.150	1.071
35	0.285	0.190	1.189	70	0.191	0.119	0.932

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
71	0.000	0.000	1.070	106	0.255	0.117	1.075
72	0.259	0.236	1.253	107	0.149	0.086	1.055
73	0.184	0.134	1.622	108	0.213	0.104	1.018
74	0.237	0.192	1.628	109	0.000	0.000	0.733
75	0.271	0.150	0.839	110	0.155	0.100	0.796
76	0.300	0.214	0.905	111	0.257	0.150	0.995
77	0.270	0.194	0.970	112	0.186	0.104	1.007
78	0.207	0.197	0.949	113	0.292	0.154	0.988
79	0.000	0.000	0.839	114	0.353	0.143	0.671
80	0.389	0.242	1.053	115	0.177	0.182	1.217
81	0.000	0.000	0.754	116	0.024	0.015	1.354
82	0.208	0.250	1.110	117	0.000	0.000	1.130
83	0.135	0.108	1.023	118	0.167	0.148	1.035
84	0.215	0.171	0.836	119	0.201	0.175	1.191
85	0.090	0.223	0.735	120	0.000	0.000	1.046
86	0.263	0.119	0.623	121	0.180	0.133	1.243
87	0.233	0.150	0.725	122	0.268	0.182	1.157
88	0.345	0.222	0.931	123	0.370	0.311	0.949
89	0.397	0.330	1.030	124	0.264	0.133	0.741
90	0.243	0.215	1.382	125	0.162	0.092	0.715
91	0.310	0.133	0.921	126	0.375	0.194	0.899
92	0.263	0.167	0.591	127	0.000	0.000	1.091
93	0.311	0.117	1.203	128	0.478	0.250	1.038
94	0.257	0.111	0.917	129	0.249	0.125	0.857
95	0.204	0.141	0.881	130	0.549	0.206	1.489
96	0.530	0.356	1.015	131	0.252	0.121	0.901
97	0.346	0.104	0.774	132	0.310	0.117	0.796
98	0.073	0.037	0.823	133	0.167	0.076	0.583
99	0.367	0.147	0.881	134	0.435	0.221	0.985
100	0.185	0.114	1.036	135	0.000	0.000	0.681
101	0.218	0.156	0.883	136	0.458	0.331	0.763
102	0.146	0.075	1.236	137	0.108	0.088	0.978
103	0.269	0.108	0.973	138	0.228	0.170	1.076
104	0.184	0.128	0.842	139	0.436	0.320	0.828
105	0.462	0.188	1.049	140	0.403	0.150	0.594

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
141	0.065	0.054	1.132	176	0.514	0.214	1.103
142	0.577	0.288	0.955	177	0.000	0.000	1.255
143	0.350	0.179	0.780	178	0.375	0.172	1.318
144	0.562	0.330	1.346	179	0.390	0.209	1.240
145	0.000	0.000	0.501	180	0.531	0.360	1.642
146	0.000	0.000	0.521	181	0.395	0.200	1.157
147	0.303	0.133	0.616	182	0.546	0.313	1.457
148	0.040	0.034	1.068	183	0.232	0.168	0.995
149	0.000	0.000	0.907	184	0.460	0.318	1.249
150	0.035	0.024	0.926	185	0.563	0.429	1.249
151	0.000	0.000	0.817	186	0.481	0.389	2.087
152	0.000	0.000	0.802	187	0.430	0.208	1.469
153	0.000	0.000	0.797	188	0.563	0.414	1.411
154	0.000	0.000	1.218	189	0.526	0.190	0.803
155	0.631	0.373	1.604	190	0.257	0.189	1.042
156	0.000	0.000	0.977	191	0.385	0.242	1.307
157	0.460	0.150	1.188	192	0.426	0.267	1.331
158	0.000	0.000	0.882	193	0.561	0.360	1.764
159	0.000	0.000	1.403	194	0.549	0.369	1.705
160	0.583	0.275	1.316	195	0.000	0.000	0.950
161	0.399	0.236	0.954	196	0.607	0.265	1.435
162	0.324	0.208	1.155	197	0.602	0.444	1.370
163	0.417	0.165	0.970	198	0.568	0.303	1.591
164	0.000	0.000	0.900	199	0.544	0.313	1.481
165	0.299	0.133	1.102	200	0.379	0.187	1.115
166	0.459	0.201	1.448	201	0.000	0.000	1.457
167	0.619	0.290	1.248	202	0.639	0.483	1.491
168	0.563	0.256	1.377	203	0.345	0.191	1.017
169	0.252	0.150	1.047	204	0.642	0.385	1.273
170	0.282	0.240	1.357	205	0.520	0.310	1.652
171	0.594	0.194	1.636	206	0.546	0.260	0.939
172	0.488	0.263	1.162	207	0.610	0.256	2.391
173	0.162	0.129	1.059	208	0.480	0.343	1.795
174	0.211	0.115	1.347	209	0.565	0.292	2.109
175	0.391	0.170	1.422	210	0.400	0.195	1.369

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
211	0.394	0.300	2.222	246	0.000	0.000	0.913
212	0.331	0.209	1.627	247	0.129	0.067	1.941
213	0.427	0.213	1.976	248	0.136	0.083	3.036
214	0.542	0.375	2.879	249	0.163	0.088	2.545
215	0.570	0.316	1.580	250	0.116	0.071	2.113
216	0.313	0.190	1.255	251	0.000	0.000	1.343
217	0.650	0.356	2.035	252	0.083	0.063	1.376
218	0.610	0.250	1.524	253	0.000	0.000	1.154
219	0.631	0.361	2.095	254	0.000	0.000	1.243
220	0.375	0.347	2.057	255	0.063	0.049	1.298
221	0.380	0.325	1.599	256	0.000	0.000	1.282
222	0.587	0.407	2.772	257	0.367	0.302	1.765
223	0.571	0.296	1.663	258	0.000	0.000	1.085
224	0.068	0.051	1.415	259	0.000	0.000	1.219
225	0.000	0.000	1.361	260	0.000	0.000	1.237
226	0.000	0.000	1.346	261	0.121	0.098	1.883
227	0.000	0.000	1.189	262	0.000	0.000	2.115
228	0.000	0.000	1.203	263	0.000	0.000	1.181
229	0.174	0.120	1.478	264	0.222	0.167	1.404
230	0.000	0.000	1.110	265	0.231	0.194	1.788
231	0.000	0.000	0.783	266	0.212	0.134	1.923
232	0.000	0.000	1.268	267	0.000	0.000	0.930
233	0.000	0.000	1.209	268	0.044	0.030	1.294
234	0.048	0.026	1.105	269	0.109	0.075	2.085
235	0.000	0.000	1.091	270	0.039	0.033	1.519
236	0.000	0.000	1.375	271	0.000	0.000	1.143
237	0.320	0.310	1.545	272	0.036	0.027	1.583
238	0.164	0.104	1.302	273	0.000	0.000	1.303
239	0.292	0.234	1.357	274	0.230	0.000	1.768
240	0.000	0.000	1.681	275	0.148	0.000	1.875
241	0.118	0.125	2.280	276	0.000	0.000	1.261
242	0.000	0.000	1.299	277	0.000	0.000	1.595
243	0.000	0.000	1.061	278	0.000	0.000	2.919
244	0.000	0.000	1.399	279	0.000	0.000	1.970
245	0.000	0.000	1.378	280	0.000	0.000	1.653

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
281	0.000	0.000	1.389	316	0.306	0.313	1.453
282	0.392	0.378	2.531	317	0.230	0.167	1.488
283	0.000	0.000	1.483	318	0.271	0.156	1.551
284	0.000	0.000	1.632	319	0.289	0.302	1.887
285	0.000	0.000	1.812	320	0.211	0.171	1.858
286	0.000	0.000	1.428	321	0.000	0.000	1.334
287	0.000	0.000	1.343	322	0.350	0.306	1.453
288	0.000	0.000	1.350	323	0.080	0.077	1.586
289	0.067	0.052	2.084	324	0.000	0.000	1.027
290	0.000	0.000	1.557	325	0.304	0.303	1.647
291	0.084	0.000	1.578	326	0.167	0.133	1.715
292	0.302	0.000	1.876	327	0.198	0.146	1.565
293	0.000	0.000	1.185	328	0.167	0.200	1.296
294	0.000	0.000	1.592	329	0.225	0.114	1.535
295	0.154	0.000	1.740	330	0.328	0.323	1.621
296	0.000	0.000	1.330	331	0.363	0.316	1.737
297	0.000	0.000	1.712	332	0.307	0.314	1.844
298	0.048	0.031	2.201	333	0.290	0.213	1.374
299	0.000	0.051	1.433	334	0.311	0.311	1.486
300	0.000	0.000	1.377	335	0.443	0.391	1.991
301	0.000	0.000	0.923	336	0.382	0.321	1.548
302	0.272	0.185	1.374	337	0.302	0.319	1.375
303	0.000	0.000	1.420	338	0.220	0.200	1.151
304	0.013	0.008	1.621	339	0.148	0.109	1.641
305	0.000	0.000	1.290	340	0.294	0.214	0.779
306	0.214	0.128	1.896	341	0.263	0.139	1.218
307	0.105	0.111	1.255	342	0.243	0.120	1.083
308	0.143	0.100	1.392	343	0.228	0.150	0.972
309	0.000	0.000	1.109	344	0.314	0.304	1.573
310	0.037	0.023	1.450	345	0.222	0.185	1.486
311	0.036	0.021	1.872	346	0.154	0.094	1.135
312	0.000	0.000	1.209	347	0.217	0.119	1.133
313	0.314	0.233	1.363	348	0.278	0.214	0.877
314	0.383	0.316	1.754	349	0.433	0.179	0.951
315	0.375	0.307	1.402	350	0.565	0.609	1.536

HH ID	COMPI	MOI	TFP	HH ID	COMPI	MOI	TFP
351	0.326	0.143	1.365	369	0.157	0.100	1.103
352	0.038	0.018	3.605	370	0.362	0.318	1.415
353	0.444	0.300	1.000	371	0.324	0.313	1.040
354	0.299	0.222	0.963	372	0.205	0.201	1.197
355	0.276	0.200	1.108	373	0.192	0.252	1.499
356	0.269	0.178	1.062	374	0.212	0.188	0.970
357	0.427	0.337	1.126	375	0.000	0.000	1.111
358	0.357	0.205	1.058	376	0.255	0.160	0.956
359	0.276	0.167	1.127	377	0.371	0.311	1.691
360	0.292	0.179	1.330	378	0.278	0.190	1.111
361	0.318	0.185	1.161	379	0.289	0.339	2.243
362	0.332	0.338	1.315	380	0.110	0.069	1.104
363	0.417	0.368	1.664	381	0.343	0.324	1.279
364	0.293	0.173	0.942	382	0.259	0.157	1.017
365	0.233	0.188	1.022	383	0.191	0.133	0.852
366	0.281	0.229	1.113	384	0.171	0.107	0.931
367	0.000	0.000	0.963	385	0.197	0.133	0.962
368	0.233	0.150	1.121	**Mean**	**0.230**	**0.151**	**1.284**

Note: HH ID-Sample household identification; COMPI– Crop Output Market Participation Index; MOI-Market Orientation Index.

Source: Authors computation from sample survey data (2015).

Appendix Table 10. Efficiency scores summary of sample households

HH ID	TE	AE	EE	HH ID	TE	AE	EE
1	0.432	0.833	0.359	36	0.538	0.896	0.482
2	0.416	0.763	0.317	37	0.398	0.888	0.353
3	0.732	0.715	0.523	38	0.633	0.639	0.405
4	0.556	0.758	0.421	39	0.605	0.549	0.332
5	0.453	0.718	0.325	40	0.541	0.645	0.349
6	0.543	0.555	0.301	41	0.425	0.967	0.411
7	1.000	0.170	0.170	42	0.524	0.806	0.423
8	0.542	0.868	0.470	43	0.595	0.523	0.311
9	0.497	0.711	0.354	44	0.543	0.696	0.378
10	0.544	0.896	0.488	45	0.489	0.816	0.399
11	0.565	0.561	0.317	46	0.624	0.676	0.422
12	0.590	0.686	0.405	47	0.435	0.739	0.321
13	0.488	0.820	0.400	48	0.539	0.643	0.347
14	1.000	0.356	0.356	49	0.484	0.711	0.344
15	0.605	0.851	0.516	50	0.817	0.242	0.198
16	0.551	0.793	0.437	51	0.599	0.691	0.414
17	0.625	0.617	0.385	52	0.874	0.491	0.429
18	0.431	0.576	0.248	53	0.414	0.494	0.205
19	1.000	0.378	0.378	54	0.390	0.600	0.234
20	0.632	0.688	0.435	55	0.512	0.478	0.244
21	0.711	0.595	0.424	56	0.381	0.606	0.231
22	0.517	0.964	0.498	57	0.526	0.641	0.337
23	0.548	0.769	0.421	58	1.000	0.210	0.210
24	0.858	0.207	0.178	59	0.345	0.659	0.228
25	1.000	0.225	0.225	60	0.501	0.684	0.343
26	1.000	0.264	0.264	61	0.587	0.785	0.461
27	0.436	0.816	0.356	62	0.480	0.795	0.382
28	0.544	0.587	0.319	63	0.651	0.722	0.470
29	0.362	0.773	0.280	64	0.515	0.858	0.442
30	0.358	0.720	0.258	65	0.947	0.695	0.658
31	0.459	0.877	0.403	66	0.549	0.834	0.458
32	0.630	0.716	0.451	67	0.736	0.811	0.597
33	0.445	0.597	0.266	68	0.574	0.857	0.492
34	0.472	0.753	0.355	69	0.499	0.852	0.425
35	0.482	0.590	0.284	70	0.426	0.906	0.386

HH ID	TE	AE	EE	HH ID	TE	AE	EE
71	1.000	0.362	0.362	106	0.641	0.622	0.399
72	0.779	0.561	0.437	107	0.594	0.732	0.435
73	0.822	0.821	0.675	108	0.534	0.757	0.404
74	0.768	0.805	0.618	109	0.510	0.508	0.259
75	0.376	0.915	0.344	110	0.478	0.657	0.314
76	0.386	0.936	0.361	111	0.456	0.900	0.411
77	0.512	0.723	0.370	112	0.520	0.777	0.404
78	0.491	0.697	0.342	113	0.554	0.738	0.409
79	0.502	0.742	0.373	114	0.547	0.555	0.304
80	0.618	0.667	0.412	115	0.580	0.790	0.458
81	0.716	0.476	0.341	116	0.710	0.877	0.622
82	0.555	0.673	0.374	117	0.544	0.768	0.418
83	0.498	0.735	0.366	118	0.446	0.874	0.390
84	0.596	0.510	0.304	119	0.577	0.758	0.438
85	0.347	0.817	0.283	120	0.468	0.931	0.435
86	0.284	0.898	0.255	121	0.583	0.866	0.504
87	1.000	0.204	0.204	122	0.495	0.907	0.449
88	0.604	0.571	0.345	123	0.858	0.407	0.349
89	0.577	0.748	0.432	124	0.411	0.690	0.284
90	0.737	0.684	0.504	125	0.362	0.818	0.297
91	0.624	0.616	0.384	126	0.511	0.714	0.365
92	0.512	0.509	0.261	127	0.765	0.526	0.402
93	0.807	0.670	0.541	128	0.749	0.701	0.525
94	0.827	0.468	0.387	129	0.376	0.910	0.342
95	0.717	0.495	0.355	130	1.000	0.648	0.648
96	0.570	0.775	0.442	131	0.535	0.620	0.332
97	0.875	0.360	0.315	132	0.444	0.711	0.316
98	0.402	0.872	0.350	133	1.000	0.316	0.316
99	0.428	0.859	0.367	134	0.601	0.682	0.410
100	0.552	0.748	0.413	135	0.339	0.806	0.273
101	0.844	0.407	0.344	136	0.597	0.504	0.301
102	0.602	0.688	0.414	137	0.423	0.856	0.362
103	0.488	0.767	0.374	138	0.481	0.809	0.390
104	0.429	0.742	0.318	139	0.612	0.525	0.322
105	0.708	0.734	0.520	140	0.344	0.751	0.258

HH ID	TE	AE	EE	HH ID	TE	AE	EE
141	0.749	0.509	0.381	176	0.619	0.808	0.500
142	0.899	0.575	0.517	177	0.460	0.969	0.446
143	0.358	0.798	0.286	178	0.596	0.917	0.546
144	0.964	0.548	0.528	179	0.501	0.963	0.482
145	1.000	0.256	0.256	180	0.819	0.817	0.669
146	0.665	0.310	0.206	181	0.623	0.699	0.436
147	0.811	0.400	0.324	182	0.898	0.596	0.535
148	0.699	0.628	0.439	183	0.507	0.660	0.334
149	1.000	0.329	0.329	184	0.534	0.873	0.467
150	0.735	0.432	0.318	185	0.742	0.611	0.454
151	1.000	0.413	0.413	186	0.891	0.895	0.797
152	0.585	0.772	0.452	187	0.679	0.818	0.555
153	1.000	0.479	0.479	188	1.000	0.382	0.382
154	1.000	0.616	0.616	189	0.533	0.555	0.296
155	1.000	0.763	0.763	190	0.601	0.613	0.369
156	1.000	0.627	0.627	191	0.586	0.828	0.485
157	0.701	0.730	0.511	192	0.574	0.880	0.505
158	0.423	0.736	0.312	193	1.000	0.701	0.701
159	0.594	0.842	0.500	194	0.836	0.804	0.673
160	0.959	0.709	0.680	195	0.866	0.321	0.278
161	0.556	0.665	0.370	196	0.595	0.968	0.576
162	0.476	0.914	0.435	197	0.675	0.866	0.585
163	0.514	0.760	0.391	198	0.730	0.815	0.595
164	0.496	0.631	0.313	199	0.734	0.821	0.603
165	0.511	0.751	0.384	200	0.525	0.793	0.416
166	0.945	0.616	0.583	201	1.000	0.531	0.531
167	0.765	0.771	0.590	202	0.783	0.731	0.573
168	0.848	0.721	0.611	203	0.448	0.857	0.384
169	0.521	0.705	0.367	204	0.774	0.683	0.529
170	0.840	0.499	0.419	205	0.739	0.802	0.593
171	0.998	0.912	0.910	206	0.432	0.806	0.348
172	0.843	0.452	0.381	207	1.000	1.000	1.000
173	0.459	0.864	0.397	208	0.795	0.813	0.647
174	0.663	0.748	0.496	209	0.938	0.838	0.787
175	0.825	0.668	0.551	210	0.553	0.900	0.498

HH ID	TE	AE	EE	HH ID	TE	AE	EE
211	1.000	0.771	0.771	246	1.000	0.518	0.518
212	0.806	0.625	0.504	247	0.938	0.866	0.812
213	0.748	0.942	0.705	248	0.822	0.763	0.627
214	1.000	1.000	1.000	249	1.000	0.973	0.973
215	0.700	0.854	0.598	250	1.000	0.954	0.954
216	0.567	0.776	0.440	251	0.672	0.765	0.514
217	1.000	0.826	0.826	252	0.656	0.684	0.449
218	0.822	0.749	0.616	253	0.551	0.696	0.384
219	1.000	0.786	0.786	254	0.741	0.616	0.457
220	0.823	0.891	0.733	255	0.568	0.774	0.440
221	0.763	0.686	0.523	256	0.630	0.711	0.448
222	1.000	0.995	0.995	257	0.922	0.642	0.592
223	0.624	0.912	0.569	258	0.944	0.428	0.404
224	0.636	0.603	0.383	259	0.496	0.842	0.417
225	0.554	0.795	0.440	260	0.560	0.726	0.407
226	0.581	0.869	0.505	261	1.000	0.662	0.662
227	0.510	0.678	0.346	262	1.000	0.844	0.844
228	0.517	0.854	0.442	263	0.770	0.538	0.415
229	0.714	0.683	0.487	264	0.935	0.552	0.516
230	0.617	0.550	0.340	265	0.849	0.725	0.616
231	0.413	0.585	0.241	266	1.000	0.744	0.744
232	0.757	0.507	0.384	267	0.457	0.678	0.310
233	0.530	0.723	0.383	268	0.649	0.777	0.505
234	0.645	0.430	0.277	269	0.975	0.757	0.739
235	0.558	0.522	0.291	270	0.783	0.686	0.537
236	0.590	0.731	0.431	271	0.609	0.665	0.405
237	0.804	0.523	0.420	272	0.792	0.690	0.546
238	0.481	0.866	0.416	273	0.666	0.680	0.453
239	0.563	0.789	0.445	274	1.000	0.588	0.588
240	0.978	0.508	0.497	275	0.936	0.754	0.706
241	1.000	0.710	0.710	276	1.000	0.600	0.600
242	0.534	0.831	0.444	277	0.638	0.872	0.556
243	0.693	0.783	0.543	278	1.000	1.000	1.000
244	0.681	0.645	0.439	279	1.000	0.683	0.683
245	0.648	0.652	0.423	280	0.869	0.578	0.503

HH ID	TE	AE	EE	HH ID	TE	AE	EE
281	0.800	0.577	0.461	316	0.528	0.887	0.469
282	1.000	0.918	0.918	317	0.686	0.712	0.488
283	0.884	0.600	0.530	318	0.649	0.767	0.498
284	0.812	0.744	0.604	319	0.762	0.856	0.652
285	0.860	0.769	0.662	320	0.692	0.945	0.654
286	0.760	0.654	0.497	321	0.587	0.867	0.509
287	1.000	0.458	0.458	322	0.662	0.668	0.442
288	1.000	0.783	0.783	323	0.588	0.922	0.542
289	0.903	0.832	0.752	324	0.544	0.658	0.358
290	0.700	0.716	0.501	325	0.701	0.846	0.593
291	0.666	0.721	0.480	326	0.765	0.785	0.601
292	1.000	0.771	0.771	327	0.666	0.854	0.569
293	0.496	0.710	0.352	328	0.560	0.813	0.455
294	0.683	0.864	0.590	329	0.626	0.666	0.417
295	1.000	0.485	0.485	330	0.650	0.874	0.568
296	1.000	0.407	0.407	331	0.772	0.889	0.686
297	0.857	0.670	0.574	332	0.802	0.821	0.658
298	1.000	0.862	0.862	333	0.611	0.777	0.475
299	0.677	0.680	0.461	334	0.570	0.870	0.496
300	0.677	0.871	0.590	335	0.940	0.734	0.690
301	0.472	0.695	0.328	336	0.704	0.686	0.483
302	0.576	0.948	0.546	337	0.575	0.814	0.468
303	0.748	0.696	0.521	338	0.593	0.691	0.410
304	0.868	0.803	0.697	339	0.870	0.725	0.631
305	0.679	0.769	0.522	340	0.337	0.738	0.248
306	1.000	0.606	0.606	341	0.564	0.733	0.414
307	0.672	0.616	0.414	342	0.434	0.854	0.371
308	0.583	0.719	0.419	343	0.538	0.595	0.320
309	0.566	0.710	0.402	344	0.692	0.830	0.574
310	0.733	0.704	0.516	345	1.000	0.585	0.585
311	1.000	0.736	0.736	346	0.464	0.869	0.404
312	0.590	0.722	0.426	347	0.473	0.779	0.369
313	0.602	0.809	0.487	348	0.371	0.801	0.297
314	0.765	0.769	0.589	349	0.479	0.668	0.320
315	0.633	0.651	0.412	350	0.585	0.853	0.499

HH ID	TE	AE	EE	HH ID	TE	AE	EE
351	0.593	0.808	0.479	369	0.455	0.975	0.443
352	1.000	1.000	1.000	370	0.568	0.948	0.538
353	0.567	0.595	0.337	371	0.417	0.848	0.353
354	0.396	0.778	0.308	372	0.432	0.986	0.426
355	0.483	0.750	0.362	373	0.631	0.950	0.599
356	0.479	0.759	0.364	374	0.392	0.912	0.358
357	0.473	0.789	0.373	375	1.000	0.457	0.457
358	0.445	0.954	0.425	376	0.386	0.860	0.332
359	0.461	0.845	0.389	377	0.670	0.885	0.593
360	0.536	0.863	0.463	378	0.548	0.692	0.379
361	0.472	0.978	0.461	379	0.858	0.686	0.589
362	0.543	0.949	0.516	380	0.470	0.965	0.453
363	0.746	0.974	0.726	381	0.571	0.862	0.492
364	0.408	0.785	0.321	382	0.408	0.859	0.351
365	0.426	0.832	0.355	383	0.366	0.857	0.313
366	0.450	0.898	0.404	384	0.440	0.804	0.353
367	1.000	0.360	0.360	385	0.405	0.837	0.339
368	0.430	0.940	0.405	**Mean**	**0.661**	**0.718**	**0.463**

Results from DEAP Version 2.1; Cost efficiency DEA; Scale assumption: CRS.

Source: Authors computation from sample survey data (2015).

Appendix 2: Stata Commands and Estimation Procedures

All econometric estimation results in this dissertation manuscript can be replicated by the Stata syntax and estimation procedures presented hereunder.

1. Commercial Orientation of Smallholder Households- Double-hurdle model

- craggit comst depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy, second(MOI depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy)

Model diagnostic test for the relevancy of double-hurdle model:

a. Heckman two-stage models

- heckman MOI depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt ftc ext hcrdidx lnagrinc farmsy, select(comst = depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy)
- heckman MOI depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt ftc ext hcrdidx lnagrinc farmsy, twostep select(comst = depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy)

b. Decision to participate (probit regression)

- probit comst depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy, robust
- estat ic
- linktest

c. Level of participation (Truncated regression)

- truncreg comst depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt town road ftc ext hcrdidx lnagrinc farmsy, ll(0)
- estat ic
- linktest

d. Level of participation (Tobit regression)

- estat ic
- linktest

2. Estimation results of crop market participation- Heckman two-stage models

- heckman MPI depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt ftc ext hcrdidx lnagrinc farmsy, twostep select(mpstatus = depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt road ftc ext hcrdidx lnagrinc farmsy)
- heckman MPI depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt ftc ext hcrdidx lnagrinc farmsy, select(mpstatus = depr sex social expr ttlu landc landkhat educ pnfincom pirrig fertqt credit mrkt road ftc ext hcrdidx lnagrinc farmsy)

3. Determinants of crop input (fertilizer) purchases

- tobit comfrtp depr sex expr landc landkhat ttlu educ lnnfincom credit mrkt town road ext manureqt, ll robust
- mfx, predict(e(0,.))

Model diagnostic tests made to check the appropriateness of Tobit model:

a. LM test of Tobit specification

- tobit comfrtp depr sex expr landc landkhat ttlu educ lnnfincom credit mrkt town road ext manureqt, ll robust
- bctobit, nodots

b. Normality

- tobit comfrtp depr famsz sex expr landc landkhat ttlu educ lnnfincom credit mrkt town road ext manureqt, ll robust
- histogram comfrtp, normal bin(19) xline(0.52631579)
- histogram comfrtp, discrete freq

4. Analysis of the Effect of Commercial Orientation on Crop Productivity-2SLS

- ivregress 2sls tfp sex activlnd expr tlu oxen educ lncreditq lnnfincom mrkt ext farmsy manureqt frtpha lnlabrMD lnincoml (moic = road lnincomcr landkhat)

a. Tests of endogeneity

- ivregress 2sls tfp sex activlnd expr tlu oxen educ lncreditq lnnfincom mrkt ext farmsy manureqt frtpha lnlabrMD lnincoml (moic = road lnincomcr landkhat), vce(r)
- estat endogenous

b. Test of overidentified restirictions

- ivregress 2sls tfp sex activlnd expr tlu oxen educ lncreditq lnnfincom mrkt ext farmsy manureqt frtpha lnlabrMD lnincoml (moic = road lnincomcr landkhat)
- estat overid

c. First-stage regression summary statistics

- ivregress 2sls tfp sex activlnd expr tlu oxen educ lncreditq lnnfincom mrkt ext farmsy manureqt frtpha lnlabrMD lnincoml (moic = road lnincomcr landkhat)
- estat firststage

d. Test of multicollinearity

- regress moic activlnd expr tlu oxen lncreditq lnnfincom mrktd ext farmsy manureqt frtpha lnlabrMD lnincoml road lnincomcr landkhat
- vif

e. First-stage regression

- ivregress 2sls tfp sex activlnd expr tlu oxen educ lncreditq lnnfincom mrkt ext farmsy manureqt frtpha lnlabrMD lnincoml (moic = road lnincomcr landkhat), vce(r) first

5. Efficiency Analyses

a. Hierarchical clustering DEA analysis

- cluster wardslinkage te - ce, measure(L2)
- cluster generate clus = groups(7), name(_clus_1) ties(error)
- tabstat te - ce, by(clus)
- cluster dendrogram _clus_1, cutnumber(7)

b. Inefficiency Analyses

- tobit te sex famsz expr mrktd grade ext ftc credit pnfincom landkhat tlu oxen ncroph, ll(0) ul(1) robust
- mfx, predict(ystar(0,.))
- tobit ae sex famsz expr mrktd grade ext ftc credit pnfincom landkhat tlu oxen ncroph, ll(0) ul(1) robust
- mfx, predict(ystar(0,.))
- tobit ce sex famsz expr mrktd grade ext ftc credit pnfincom landkhat tlu oxen ncroph, ll(0) ul(1) robust
- mfx, predict(ystar(0,.))

Appendix 3. Sample Survey Interview Schedule

CROP PRODUCTIVITY, EFFICIENCY AND COMMERCIALIZATION OF SMALLHOLDER FARMERS IN THE HIGHLANDS OF EASTERN ETHIOPIA

PhD Dissertation Research Survey Questionnaire

Postgraduate Program Directorate, Haramaya University

General instruction for Enumerators

1. Please introduce yourself before starting the interview.
2. Inform the purpose of the study, which is to collect the first hand data that will be used only for PhD dissertation writing on the above indicated topic.
3. Please careful on the estimates that exact measurements are not available.
4. Carefully read and follow the instructions while you are starting the interview.

General Information

Date _____

Household ID (001-395): _____

Regional State _____Administrative zone: _____

District _____ *Kebele* _____

Name of the enumerator: _____ Signature: _____

Name of supervisor: _____ Signature: _____

Part I: Household Characteristics

1. Name of the respondent (Household head) _____
2. Sex of the household head (M/F) _____ Age _____years
3. Marital status:
   a) Single b) Married c) Divorced d) Widow
4. Religion:
   a) Muslim b Orthodox) c) Protestant d) Catholic e) Other_____
5. Educational status of the household head
   a) Illiterate b) Read and write c) Formal education (_____Grade)
6. Families/household composition and characteristics

List of household *	Age	Sex **Code A**	Educational level **Codes B**	Working in the farm **Code C**	Kinship

- ✓ **Codes A:** 1. Male 0. Female
- ✓ **Codes B:** 0. Illiterate 1. Read and write, Give formal education Grade to those posses.
- ✓ **Codes C:** 1. working full time 2. Working part time 3. Not working at all.
- ✓ List of household *- it is no need to list out the names of the members.

7. Experience in producing selected commodities since formed a household (years):

   a) Maize ..... yr
   b) Sorghum ..... yr
   c) Potato ..... yr
   d) Haricot beans ..... yr

8. Distance from home of household to Infrastructure

No	Type of infrastructure	Distance in km
1.	Nearest market	
2.	Cooperative office	
3.	Farmer training center	
4.	Road	
5.	Major town	
6.	DA office	

9. Do you have contact with extension agents

a) Yes b) No

10. If yes, how often do you contact the extension worker last year?

a) Weekly b) Monthly c) Quarterly d) Other, specify----------

11. Do you have access to credit?

a) Yes b) No

If yes, for what purpose did you borrow money for the 2014/5 production season?

S/N	Purpose		Amount	Source
1.	Fertilizer	DAP		
		Urea		
2.	Seed			
3.	School			
4.	Medicine			
5.	Basic needs			
6.	Fattening			
7.	Livestock production			
8.	Beehives			
9.	Chemicals			
10.	Others			

12. Membership to any associations in the last 2 years

Type of institutions a household has been a member (**Codes A**)	Association or group functions (**Codes B**)	Year joined	Role in the institution (**Codes C**)	Still a member now? (**Codes D**)

Codes A	**Codes B**	**Codes C**	**Codes D**
1. Input Supply/service coops /union	1. Produce marketing	1. Elected official	1. Yes
2. Crop producer and marketing coops.	2. Input access/ marketing	2. Ordinary member	0. No
3. Local administration (*Kebele*)	3. Seed production	3.Agricultural Cadre	
4. Women's Association	4. Farmer Research Group	4. Model farmer	
5. Youth Association	5. Savings /Credit/*Ekub*	5. Cashier	
6. Mosque/Church Association	6. Funeral Group (*Edir*)	6. Coordinator	
7. Saving and credit group	7.Tree Planting/ nurseries	7. Secretary	
8. Funeral Association (*Idir*)	8.Soil and Water conservation	8. Militia	
9. Government team	9. Input credit	9. Store keeper	
10. Water User's Association	10. Other, specify….	10.Executive committee member	
11. Other, specify….		11. Other specify…	

Part II: Household Land Holding Pattern

1. Please tell me your land holding size?

Land holding	Total land in (ha)	Value of land in Birr in a year basis*
Own land		
Rented in land		
Common land		
Sharecropped		
Household or any other land		
Total		

**Take rental value since it is the best proxy for price of land*

2. If involved in share cropping/renting during 2014/15 production season, what is the size and rate?

Description	In kind		In cash		Other, specify _____	
	Size(ha)	Rate/Proportion	Size(ha)	Amount(Birr)	Size (ha)	Rate
Rent in						
Rent out						
Share in						
Share out						

3. Plot size, fertility status and distance of cultivated land from home.

Plot number	**Crop grown (Codes A)**	**Crop variety (Codes B)**	**Area of plot** (ha)	**Fertility status** 1. good, 2.medium, 3. poor	**Distance from home (km)**
Plot land 1					
Plot land 2					
Plot land 3					
Plot land 4					
Plot land 5					
Plot land 6					
Plot land 7					
Plot land 8					

- ✓ **Codes A:** 1. Maize 2.Sorghum 3. Potato 4. Haricot beans 5. Khat
- ✓ **Codes B:** 1. Improved 2. Local

Part III: Household Income and Production

1. Did you participate in off/nonfarm activities?

a) Yes b) No

2. Did anyone of your household member participates in off/nonfarm income?

a) Yes b) No

3. What are the main sources of off/non-farm income for the household? If any

S/N	Source	No of hh engaged	No of days worked	Income per working day	Total annual income
1	Daily labor				
2	Selling local drink				
3	Selling fire wood				
4	House servant				
5	Pension payments				
6	Carpenter				
7	Rent from assets				
8	Trading				
9	Clothes making				
10	Others				

4. Annual income from agricultural production

A. Livestock resources and Income from the sale of livestock

S/N	Type of livestock		Number owned	Livestock sold (Birr)	Total income
1.	Oxen				
2.	Cow				
3.	Heifer				
4.	Horse				
5.	Donkey				
6.	Sheep				
7.	Bull				
8.	Calve				
9.	Goats				
11.	Hen				
12.	Chickens				
13.	Beehives	Modern			
		Local			

B. Perennial crops and annual income

S/N	Type of perennial crop	No of trees	Unit measurement	Amount produced	Quantity sold	Unit price	Total Value
1.							
2.							
3.							

C. Major crops produced under irrigation and rain-fed and annual income in 2014/5

Crop types	Irrigation		Rain-fed season		Quantity sold (qt)	Unit Price (Birr)	Total Value
	Land (ha)	production (qt)	Land (ha)	production (qt)			
Maize							
Sorghum							
Potato							
Haricot beans							

✓ *(Units of measurement for production must be changed to kilogram or quintal)*

Part IV: Input and Output Data

1. Cost of newly purchased farm tools and equipment used in selected crops reduction

Equipment	Number	Cost of new item (Birr)	Estimated life Span	Cost for Production (office work)
Plough tools				
Hand hoe				
Axle				
Shovel /spade				
Knapsack sprayer				
Water pump				
Chemical sprayer				
Others				
Total				

2. Marketing cost for major inputs purchased (2014/15)

Plot code	Ownership	Crop grown	Fertilizer				Seed			Field chemical		Other Costs in Birr/unit		
			DAP		Urea		Own (kg)	Bought						
	Codes A	**Codes B**	Kg	Value (Birr)	Kg	Value (Birr)	Own (kg)	Amount (kg)	Birr/kg	Litres	Birr/lt	Fuel*	Transport	Tax
Plot 1														
Plot 2														
Plot 3														
Plot 4														
Plot 5														
Plot 6														
Plot 7														
Plot 8														

- ✓ Code A: 1. Own, 2. Share in, 3. Share out, 4. Rent in 5. Rent out
- ✓ Code B: 1. Maize 2. Sorghum 3. potato 4. Haricot beans
- ✓ *Fuel is applied for irrigation purpose

3. Operation cost items producing the farm household's major crops in production season (2014/5) (select only one large plot for each crop)

Activities	Plot No	Animal labor (# of paired oxen)				Tractor rent		Household labor (Number) in man equivalent				Hired labor (Number)			
		Maize	Sorghum	Potato	Haricot beans	Maize	Sorghum	Sorghum	Sorghum	potato	Haricot beans	Maize	Sorghum	potato	Haricot beans
Ploughing 1															
Ploughing 2															
Sowing															
Fertilizer application															
Chemical application															
Weeding 1															
Weeding 2															
Weeding 3															
Irrigation/pumping	x	x	x	X	X	X	x								
Harvesting															
Threshing															
Transportation															

4. Cost of manure if applicable

Crop type	**Amount used** (Qt)	**Estimated price (Birr**/Qt)	**Total cost in Birr**
Maize			
Sorghum			
Potato			
Haricot beans			

Part V: Data on Commercial Behavior

1. Farmer's major objectives of crop production (in per cent)

Type of crop	Market	Home use	Indistinct	Total
Maize				
Sorghum				
Potato				
Haricot beans				

2. Who makes production and marketing decisions in the household?

Types of crops	Production decision maker*	Marketing decision maker*
Maize		
Sorghum		
Potato		
Haricot beans		

✓ *1= Head of household, 2= Wife, 3= Consensus

3. How do the farmers perceive or judge land allocation decision based on different expectations?

Source of risk expected	Land allocation decision (0 decrease, 1 increase)			
	Maize	Sorghum	Potato	Haricot beans
Inadequate rainfall				
Decrease in product price				
High input costs				

The End!