Crop Productivity as Influenced by Commercial Orientation of Smallholder Farmers in the Highlands of Eastern Ethiopia

Alelign Ademe*, Belaineh Legesse, Jema Haji, and Degye Goshu

School of Agricultural Economics and Agribusiness, Haramaya University, Ethiopia.

Abstract: Smallholder farmers in Ethiopia are characterized by low crop production and productivity. As a result, production is primarily for self-consumption with a possibility of supplying only a small part of total output to the local markets. Despite their undisputed importance, most studies in Ethiopia focused on smallholder farmers' commercial orientation and analyzed the determinants of the proportion of output sold in crop markets and failed to analyze the relationship between crop productivity and commercial orientation. Therefore, this research was conducted to elucidate synergies existing between commercial orientation and total factor productivity (TFP) among smallholder farm households in the highlands of Eastern Ethiopia. The study was conducted in four districts: two districts, namely, Gurawa and Haramaya were selected from eastern highlands of the region, and two districts, namely, Tullo and Habro were selected from eastern Hararghe highlands). A total of 385 sample household heads were selected randomly and interviewed using a semi-structured questionnaire to elicit data pertaining to crop production input and output market during the year 2015. A two-stage least squares (2SLS) regression model was applied for the analysis. Results of the 2SLS regression indicated that total factor productivity was strongly and positively influenced by the endogenous commercial orientation index. In addition, the number of oxen owned, market distance, extension visits, amount of manure used, quantity of labor used, and location dummy influenced TFP.

Keywords: Commercial orientation; Total factor productivity; Two-stage least square

1. Introduction

The agriculture sector is the most important segment in the Ethiopian economy. This is because the share of the sector to the national gross domestic product (GDP) is 38.5%. Out of this, crop production accounts for 27.4% (NPC, 2016), and provides employment for 72.7% of the total population (UNDP, 2015). Moreover, Ethiopian agriculture is dominated by smallholder farming which accounts for 96% of the total area cultivated and 97% of agricultural output produced (MoARD, 2010). This shows that smallholder farming takes a major share in the overall efforts being exerted to realize the agricultural growth and development plan of the country.

Today, increasing the productivity of agriculture through commercialization is an inevitable reality throughout the world. As a result, Ethiopia has espoused a policy of commercializing smallholder agriculture as a strategy towards attaining economic transformation (MoFED, 2010; NPC, 2016). Empirical studies elsewhere indicate that increasing the rates of market participation or productivity could have bidirectional synergies, and increasing both could boost living standards of farmers (von Braun, 1995; IFAD, 2001, 2003; Barrett, 2008). Thus, an understanding of the effects of commercial orientation on crop productivity would provide policy makers with information on how to design programs or develop strategies that can contribute to increasing production potential among smallholder farmers.

Despite efforts made to commercialize and transform the Ethiopian agriculture from production of staple crops to that of high value crops, performance has been considerably below expectations (NPC, 2016). Many other studies reveal very low smallholder farmers' crop commercialization scale with differentiated factors determining commercial orientation decisions (Moti and Gardebroek, 2008; Adam, 2009; Adane, 2009; Bedaso *et al.*, 2012). Most importantly, it is of critical importance to generate up-to-date information on the relationship between smallholder farmers' commercial orientation and productivity. Therefore, this research was done to elicit data on commercial orientation of smallholder farmers and measure synergistic relationships existing between the commercial orientation and total factor productivity in the highlands of eastern and western Hararghe Zones in the Oromia Regional State, Ethiopia.

2. Methodology

2.1. Description of the study area

The study area, Hararghe highlands are situated in the Eastern part of Ethiopia, circumscribed by East and West Hararghe zones, Oromia Regional State and covers about 10% of the total population of highland farming systems in 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).

Farming system in the East and West Hararghe zones 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 major

*Corresponding Author. E-mail: alexs2003@yahoo.com

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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).

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 (CSA, 2009).

2.2. Data Sources and Sampling Frame

The study was conducted based on data obtained from primary and secondary sources. Secondary data regarding the priority of most important crops, livelihood strategy, population, type of credit and technology available were collected. The primary data were elicited through face-to-face personal interviews using semi-structure questionnaire. Thus, a two-stage sampling procedure was employed to draw sample households for an interview. In the first stage, a random sampling procedure was employed to draw the sample highland districts. Accordingly, two districts from eastern Hararghe Zone and two districts from western Hararghe Zone were randomly selected. In the second stage, a total of eight *kebeles* were randomly selected from the four districts. To determine the sample size, the formula given by Kothari (2004) was used as follows:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} = \frac{(1.96)^2(0.5)(0.5)(126382)}{(0.05)^2(126382) + (1.96)^2(0.5)(0.5)} \approx 383 \quad (1)$$

Where, n is the 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.

Finally, samples of 385 farm household heads were selected from eight *kebeles* using a random sampling procedure with probability proportional to size as shown in Table 1.

Table 1. Respondent sample households based on districts and *Kebele* administrations.

Sample District			Sample *Kebele*		
Districts	Total households	Sample households	*Kebeles*	Total households	Sample households
Gurawa	38545	117	Raasaa Jannata	803	43
			Leenca	1402	74
Haramaya	34732	106	Daamota	1483	62
			Finqilee	1041	44
Tullo	28832	88	Ifaa Handodee	635	43
			Kufa Kaas	676	45
Habro	24273	74	Haro-Chercher	876	34
			Bareda	1027	40
Total	126382	385		7,943.00	385

Source: Eastern Hararghe and western Hararghe Zones Bureaus of Agriculture and Rural Development, 2015.

2.3. Methods of Analyses

Data analyses were made following three steps indicated below:

(1) Measurement of crop productivity: Index of TFP involving elements of outputs and inputs were defined over gross values of crops output, labor and traction power, rental value of cultivated land and value of purchased inputs (fertilizer, chemicals and seeds) and then estimated by TFP Index Program version 1.0 which is a DOS computer program developed by Coelli and Battese (1998) and a widely used Tornqvist TFP index.

The general equation in its logarithmic form is:

$$lnTFP = ln\frac{O}{I} = lnO\text{-}lnI \quad (2)$$

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

$$\ln TFP_{io} = \underbrace{\left[\frac{1}{2}\sum_{i=1}^{n}(\omega_i + \omega_{io})(\ln y_{io} - \ln y_i)\right]}_{\text{Output}} - \underbrace{\left[\frac{1}{2}\sum_{j=1}^{m}(v_i + v_{jo})(\ln x_{jo} - \ln x_j)\right]}_{\text{Input}} \quad (3)$$

Where; ω = value share of outputs; v= 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 a scale neutral measure adapted from von Braun *et al.* (1994) and Strasberg *et al.* (1999). 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:

$$\alpha_k = \sum_{i=1}^{N} \frac{S_{ki}}{Q_{ki}} \;\; ; \; Q_{ki} \geq S_{ki} \text{ and } 0 \leq \alpha_k \leq 1 \qquad (4)$$

Where: a_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 farming system.

Then, household's market orientation index in land allocation is derived from equation (3) as:

$$MOI_i = \sum_{k=1}^{k=k} \alpha k \frac{L_{ik}}{tL_i} \;\; ; tL_i > 0 \text{ and } 0 < moicr_i \leq 1 \quad (5)$$

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.

(3) Establishing the mathematical relationship between commercial orientation and crop productivity: 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 (5) and (6) as follows:

$$Y_i = \alpha_0 + \alpha_1 \hat{c}_i + \alpha_2 x_{1t} + \varepsilon_{1t} \qquad (6)$$

$$c_i = \beta_0 + \beta_1 x_{1t} + \beta_2 x_{2t} + u_{1t} \qquad (7)$$

Where Y_i is productivity (measured as TFP) for agricultural crop production for household i, a_0, a_1, a_2, β_0, β_1 and β_2 are unknown parameters of interest, x_{1t} is a vector of common exogenous variables hypothesized to affect both TFP and market orientation, $\hat{c}_i$ is the predicted value of market orientation index, c_i is market orientation index itself, x_{2t} is a vector instruments for market orientation, ε_{1t} and μ_{1t} are error terms such that $E(\varepsilon_{1t})=0$ and $cov(\varepsilon_{1t}, \mu_{1t})=0$.

Variables description and expected sign of the hypothesized determinants are presented in Annex Table 1.

3. Results and Discussion

3.1. 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 results obtained from 2SLS confirmed that the use of IV estimation was assured because the Durbin χ^2 value of 24.61 enables us 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 a 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, we can tolerate a relative bias of 5%, 10%, 15%, 20%, or 25% and conclude 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 results confirmed that multicollinearity is not a problem in the estimated model since the largest VIF test result in the participation model is 2.81 and the Mean VIF is 1.66 (see Annex Table 2).

3.2. Results of the Synergies between Crop Commercial Orientations and TFP

The 2SLS estimation results (as shown in Table 2) 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 were commercial orientation 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), and Adam *et al.* (2010).

It is known that the effect of instruments on TFP is expressed through market orientation. Results of first-stage regression (Annex Table 3) indicated that increasing market orientation behavior of farm households through income from sales of food crops leads to improvements in crop productivity. In contrast, allocating more land to *khat* crop and farm distance from residence to the main road did not favor enhanced productivity since it negatively influenced households' market orientation index. Moreover, additional six variables were found to influence total factor productivity of crops beside their contribution to commercial orientation. These factors included the number of oxen owned, market distance from residence, extension visits, amount of manure used, labor used, 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. 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 with the unequal oxen distribution. However, this type of getting draft power might have negative impact on planting time and cultivation operations. Consequently, the results confirmed that farm households who owned higher numbers of oxen had higher crop productivity.

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 (Lerman, 2004; Berhanu *et al.*, 2006). Frequent extension visits in giving technical advice on productivity enhancing inputs encourage farmers to think of acquiring the particular inputs (Adam *et al.*, 2010). The results of this study assured that the coefficient of number of extension contacts was positive and statistically significant, implying that those sample farm households who got large number of extension contacts also experienced improved crop productivity.

Market distance affected crop TFP negatively and significantly. Sample farm households that were located relatively far away from market places are expected to be less productive probably due to their relative inaccessibility to inputs and outputs (Adam, 2009). Concurrent with this postulation, in this study, distance from market was found to be a transaction cost that worked against productivity. Thus farmers that were located relatively far away from the nearest markets were less productive than those that were located nearby. The other important factor that affected crop productivity was labor (in man-days). Labor available for agricultural production affects TFP negatively probably due to the unemployment caused by capacity limitation in access to physical capital (Adam, 2009; Adam *et al.,* 2010). The coefficient of labor used is negative and the result of the current study assured the previous results.

Manure, locally called *dike*, is widely used as means to improve soil fertility and is considered by farmers as one of the major practices that enhance crop productivity in the study areas. The finding confirmed that crop TFP increased with increased use of manure. Furthermore, the agro-ecological variable expressed in the location dummy had a positive and significant influence on the TFP. This implies that farmers in eastern Hararghe highlands are less fortuitous in crop productivity than their counterparts, i.e. farmers in western Hararghe highlands.

Table 2. 2SLS estimation results of factors influencing TFP.

Factors influencing productivity (TFP)	2SLS Estimation	
	Coefficients	Std. Err.
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
Non-oxen livestock owned	-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
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 income (log)	0.005	0.006
Location dummy	0.344***	0.056
Constant	1.567***	0.276
Waldχ^2 (16)	162.280	
Prob > χ^2	0.000	
R^2	0.087	
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. Conclusion

The findings of this study indicated that commercial orientation of farm households described by their respective indices of increased volume of crop sales is a requirement for increased crop productivity. This is an indication for households who are more commercial oriented are found to be higher in crop productivity because commercial orientation provides cash that allows households to purchase productivity enhancing inputs. The findings of this study also demonstrated that strategies aimed at improving crop productivity of smallholder farmers in the study area should fully address other determining factors (such as oxen ownership, market distance, extension visits, amount of manure used, and labor used) in addition to commercial orientation. Further, the current study could not verify the reverse causality of productivity on commercial orientation behavior of farm households instead it suggests this concern for future research outlooks.

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7. ANNEXES

Annex 1. Variables description and expected sign of the hypothesized determinants.

Variable Description	Measurement	Expected sign
Sex of household head	Binary (0- female, 1- male)	+/-
Educational status	Binary (1-literate, 0 otherwise)	+
Farming experience	Continuous (years)	+/-
Commercial orientation index	Continuous (%)	+/-
Active members to land ratio	Continuous (%)	+/-
Off /non-farm income	Continuous (ETB)	+
Income from livestock	Continuous (ETB)	_
Non-oxen livestock owned	Continuous (TLU)	+
Number of oxen owned	Continuous (TLU)	+
Amount of fertilizer used	Continuous (qt/ha)	+
Amount of credit used	Continuous (ETB)	+
Number of extension visits	Discrete (count)	_
Distance to nearest market	Continuous (km)	+
Amount of manure used	Continuous (qt)	+
Amount of labor used	Continuous (Man- days)	+
Annual livestock income	Continuous (ETB)	+/-
Location dummy	Binary (0- East Hararghe, 1- otherwise)	+/-

Note: TLU-Tropical Livestock Unit; qt-quintal; ETB-Ethiopian Birr; km-kilometer; ha-hectare

Annex 2. Diagnostic test for multicollinearity using VIF.

Variable	VIF	1/VIF
Annual crop income (log)	2.81	0.36
Amount of manure used	2.7	0.37
Number of oxen owned	2.29	0.44
Non-oxen livestock owned	2.24	0.45
Quantity of labor used	1.81	0.55
Amount of fertilizer used	1.78	0.56
Location dummy	1.6	0.62
Annual livestock income (log)	1.59	0.63
Farming experience	1.49	0.67
Active members to land ratio	1.43	0.7
Education status	1.4	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)	1.2	0.83
Number of extension visits	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	

Annex 3. First-stage regressions result expressing the effect of instruments on market orientation.

Market orientation index	RC	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
Non-oxen livestock owned	0.0002	0.004	0.959
Number of oxen owned	0.009	0.01	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
Distance to nearest market	0.002	0.004	0.524
Extension contacts	-	0.002	0.979
Location dummy	-0.052***	0.013	0.000
Amount of manure used	-0.001*	0.001	0.08
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: RC = Robust Coefficients * 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*