# Market Participation of Smallholder Farmers and Food Crop Productivity: Evidence from Burkina Faso

**Sugrinoma Aristide Ouedraogo[1, *], Pam Zahonogo[2], Ramatu Mahama Al-Hassan[3]**

[1]Department of Economics and Management, University of Ouahigouya, Ouahigouya, Burkina Faso

[2]Department of Economics and Management, Thomas Sankara University, Ouagadougou, Burkina Faso

[3]Department of Agricultural Economics and Agribusiness, University of Ghana, Accra, Ghana

**Email address:**

ouedarist@gmail.com (S. A. Ouedraogo), pzahonogo@gmail.com (P. Zahonogo), ramatu_mahama@yahoo.com (R. M. Al-Hassan)
[*]Corresponding author

**Abstract:** Subsistence farming is frequently viewed as a low yielding and inefficient to ensure sustainable food security in sub-Sahara Africa. Commercial agriculture induces profit maximization and promotes on-farm investment. However, for most farmers in Burkina Faso, home consumption is the main objective of the agricultural production activities. Using survey data collected over 1178 farm households, this paper analyses the effects of participation of smallholder farmers in the output market on input use and food crop productivity in Burkina Faso. We estimate a Tobit model of the relationship between market participation (measured by the proportion of crop sold) and fertilizer use. The results show that an increase in level of sale leads to an increase in the level of fertilizer adoption. We also estimate a model of production using the instrumental variable regression approach to correct for the endogeneity of the crop commercialization index. The findings indicate that agricultural commercialization has a positive and significant effect on food crop productivity. This means that higher integration of farmers to markets increases their incentives to adopt new technologies which results in yield growth. Therefore, the findings confirm the need for promoting market participation of smallholders to induce technological change and productivity growth of agriculture in Africa.

**Keywords:** Commercial Agriculture, Market Participation, Technology Adoption, Productivity, Burkina Faso

## 1. Introduction

The prevalence of subsistence farming in developing countries represents a key barrier for rural farm households to sustainably adopt productivity enhancing technologies. Yet, based on comparative advantage theory, commercialization in agriculture is seen as having the potential to increase specialization at farm household level which can result in gains in efficiency and farm households' welfare [1]. Furthermore, following the literature on international trade, the welfare gained through market participation is not only static as stated in the comparative advantage theory, but may also result from a dynamic technological change due to increased competition and adoption and better use of technology [2].

The empirical literature generally identifies two channels through which agricultural commercialization can affect productivity. First, orientation towards commercial farming enables farmers to acquire resources for food crop production that otherwise will not be available. This is particularly frequent in African countries where the failure of credit and input markets makes the adoption of non-food cash crop farming the primary means for acquiring inputs which are also used in the production of food crops. In addition, increased commercialization in agriculture attracts more investment that would benefit all farmers in the region regardless of whether they have commercial objectives or not. This is because commercial crop producers tend to adopt productive technologies, thereby attracting investment in agricultural innovations. Thus, Govereh and Jayne [3] find a strong evidence of positive effect of cash crop production on food crop productivity in Zimbabwe. Govereh, Jayne and Nyoro [4] also note that farmers who are engaged in commercial agriculture

adopt more productive technologies and achieve higher level of productivity in Kenya than those engaged only in subsistence farming. Numerous empirical studies that focused on a bi-directional relationship between agricultural productivity and farm productivity have also found a positive effect of commercialization on productivity [5–7].
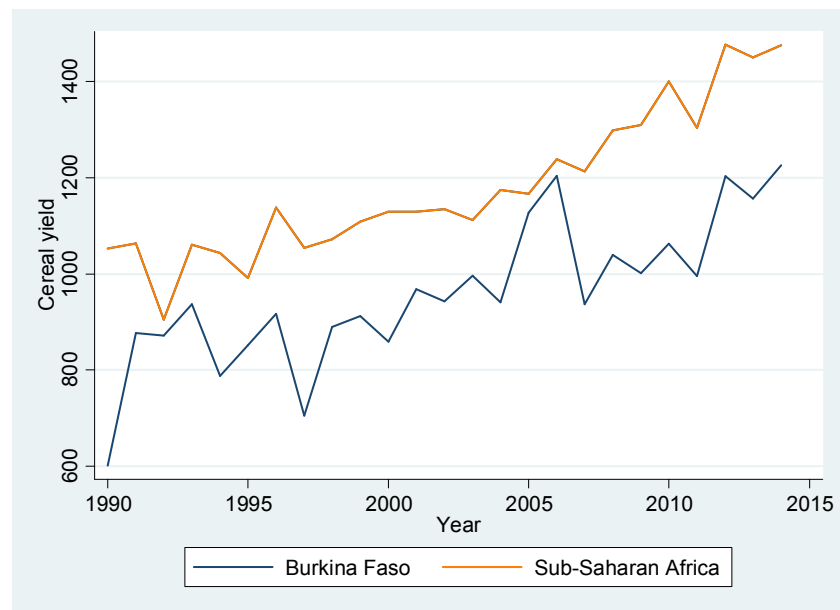
In Burkina Faso, agricultural productivity has always been subject to high fluctuation depending on climate conditions which is exacerbated by farmers' limited access to markets and improved technologies. However, improving productivity through sustainable adoption of technology in the context of subsistence farming is challenging. As argued by Binswanger [8], both agricultural commercialization and technological change are closely related in such a way that while access to improved technologies is required to increase productivity and market surplus, the profitability of adopting productivity enhancing technologies is also linked to the accessibility of farm households to markets and their level of commercialization. Thus, the low modern input use and low productivity in agricultural sector in Burkina Faso can be linked to the persistence and pervasiveness of subsistence farming among smallholder farmers. Empirical investigation into the link between agricultural commercialization and productivity is then required to guide policy making to sustainably raise agricultural productivity and farmers' income. The objective of this paper is therefore to analyze the effects of commercialization of smallholders in Burkina Faso on their input use and food crop productivity.

The rest of paper is organized as follow: The next section presents an overview of smallholder agriculture in Burkina Faso. The third section is devoted to empirical methods and data source. The fourth section presents and discusses the findings while the fifth section provides the conclusion and policy implications of the study.

## 2. Productivity of Smallholder' Agriculture in Burkina Faso

Agriculture is fundamental in the livelihood of rural households in Burkina Faso and represents a key sector that can strongly stimulate a pro-poor economic growth. The sector contributes about 35% to the nation's GDP and employs over 70% of economically active population. Being mainly rain fed, agricultural production is highly dependent on climate conditions. Cereal staple crops, such as sorghum, millet and maize represent the dominant crops produced in the country and occupy on average, about 65% of arable land [9]. The average annual growth of cereal production was about 3% between 2001 and 2010 led by maize which experienced a steady average annual growth of 10.17%. Sorghum and millet, on the other hand, experienced the lowest performance with an average growth of 1.63% [9]. Cotton represents the major crops produced for market but occupies only 11% of cultivated lands. As illustrated in Figure 1, cereal yield in Burkina Faso has been very low and characterized by high volatility compared to average yield of cereal in Sub Sahara Africa.

Production growth has been more related to land expansion than to productivity gains. In fact, farm households in Burkina Faso use 10 kg/ha of fertilizer on average, which is lower than the average of 15-20 kg/ha used in Sub-Saharan Africa and 70–150 kg/ha in the Caribbean and South-East Asian countries. However, due to soil degradation, population pressure and increase in opportunity costs of labor, production growth based on land expansion is becoming a less sustainable option and adoption of productivity enhancing technology is required to increase household agricultural production. This requires more integration of farmers into agricultural input and output markets.



Source: Constructed by the Author, based on FAO dataset (http://fao.org/faostat/en/#data)

*Figure 1. Trend of cereal yield (kg/ha) in Burkina Faso and in Sub-Sahara Africa, 1990-2015.*

# 3. Empirical Methods

## 3.1. Concept of Agricultural Commercialization

Globally, agricultural commercialization refers to increased engagement of farmers with markets in terms of crops (cash and food crops) and livestock production. On the input side, agricultural commercialization refers to using markets to obtain modern inputs, technical advice, as well as production factors such as hired labor, land and capital investment. This means that commercialization is a process which involves transformation from production for household subsistence to production for markets implying an increased integration of smallholder producers into regional, national and even the world market economy. As argued by Pingali [10], aside participation in output market, agricultural commercialization refers to the extent to which household production choice and input use are made based on the principle of profit maximization. This means that agricultural commercialization can be analyzed in terms of proportion of output brought to market or inputs purchased from market. Jayne, Haggblade, Minot and Rashid [11] defined agricultural commercialization as "a virtuous cycle in which farmers intensify their use of productivity-enhancing technologies on their farms, achieve greater output per unit of land and labor, produce greater farm surplus (or transition from deficit to surplus producers), expand their participation in markets, and ultimately raise their incomes and living standards". Thus, agricultural commercialization, also referred to as intensity of smallholders' market participation, can be quantitatively measured by the proportion of crop sale by farmers with respect to crop produced. This paper uses this latter definition but focuses only on the intensity of farmers' participation in rain-fed agricultural output markets as a measure of level of crop commercialization. Therefore, crop commercialization index as measure of farm household level of agricultural commercialization can be expressed as follows:

$$CCI_i = \left( \frac{\sum_{k=1}^{K} P_k S_{ki}}{\sum_{k=1}^{K} P_k Q_{ki}} \right) * 100 \qquad (1)$$

Where $P_k$ denotes the market price of the crop $k$, $S_{ki}$ and $Q_{ki}$ represent respectively the quantities sold and harvested of crop $k$ by household $i$.

## 3.2. Agricultural Commercialization and Fertilizer Use

### 3.2.1. Tobit Regression Model

Following Govereh and Jayne [3] and Strasberg *et al.* [12], to analyze the effect of farm households' market participation on fertilizer use, the model of fertilizer use is expressed as follows:

$$fert_i = \alpha_0 + \alpha_1 CCI_i + \delta X_{1i} + \vartheta_i \qquad (2)$$

Where $fert_i$ is the quantity of fertilizer (in kilogram) used by farm household $i$ per hectare of land under cultivation; $CCI_i$ represents the overall Crop Commercialization Index of farm household; $\alpha_1$ and $\delta$ denote the vectors of parameters to be estimated and $\vartheta_i$ the error term. $X_{1i}$ is a vector of other variables likely to influence the use of fertilizer by farm households.

Data on fertilizer use are censored because several farm households in the sample do not use fertilizer in their production system. Thus, it can be distinguished farm households with positive quantity of fertilizer use with households that did not use fertilizer and present zero values. Therefore, a censored model is more appropriate to estimate the parameters of the equation. A Tobit regression method with zero as a lower bound is then applied in order to take into account this issue.

*Table 1. Definition of variables and expected signs of model of fertilizer used.*

| Explanatory variables | Measurement | Expected signs |
|---|---|---|
| Crop commercialization index | Percentage (%) | + |
| Value of transportation asset | 10,000 FCFA | + |
| Agricultural credit received | 10,000 FCFA | + |
| Nonfarm income per adult | 10,000 FCFA | +/- |
| Distance to nearest markets | Kilometer | - |
| Existence of all-weather road | Binary (1=yes) | + |
| Household owns a communication asset | Binary (1=yes) | + |
| Age of household head | Years | +/- |
| Education level of household | No education, Primary or Secondary | + |
| Climate zonal dummy | Binary (1=South-Sudan zone and 0 if not) | + |

### 3.2.2. Explanatory Variables in the Model

Aside the variable of crop commercialization index, numerous variables are likely to influence the adoption of fertilizer. It is often argued that liquidity constraint represents one of the key factors of low use of improved technologies in developing countries. Therefore, the amount of credit received for agricultural activities and nonfarm income earned are included as explanatory variables. These variables are expected to yield positive signs on the intensity of fertilizer use. Accessibility to markets is also hypothesized to influence farm households' access to fertilizer. Thus, increase in distance to nearest market may reduce the intensity of fertilizer use while having transportation assets and existence of all-weather roads would have a reverse effect. Thus, the total value of households' transportation assets evaluated by the household head at the time of survey is included as an explanatory variable. Furthermore, holding communication

equipment may be a source of access to information on best agricultural practices and may influence the level fertilizer use. Therefore, a dummy variable taking the value 1 if household head owns a communication asset (radio, TV, or phone) and 0 if not is included. Finally, age and education level of household head are included to control for the influence of household characteristics on intensity of fertilizer use. All the explanatory variables included in the model, their unit of measurement and expected signs are presented in Table 1.

### 3.3. Agricultural Commercialization and Farm Productivity

#### 3.3.1. Specification of Productivity Model

The general formula of the productivity model to be estimated can be expressed as follows:

$$y_i = f(CCI, X, D; \beta) + \varepsilon_i \qquad (3)$$

Where $X$ represents a vector of production factors including household dependency ratio, farm size per worker, livestock ownership and the quantity of fertilizer used per hectare and a set of other variables that are likely to influence crop yield. These variables include age, gender and education level of household head. The variable 'education' used in this regression is categorized into three levels: No formal education (used as reference), primary level of education and finally secondary level. Thus, no education is used as basis of comparison and therefore does not appear in the estimation results. $D$ represents a vector of dummy variables including participation or not in nonfarm activities by household head, adoption of soil conservation techniques and location characteristics (agro-climatic condition). In Burkina Faso, several farm households are facing high degradation of land due to severe climate conditions particularly drought. To control for the effects of these shocks on production, some techniques are adopted to retain water on the farms and to reduce soil erosion[1]. Adoption of these techniques is expected to yield direct positive effect on the level of productivity. Thus, the productivity model is specified as follow:

$$\log(y_i) = \beta_0 + \beta_1 CCI_i + \sum_{j=2}^{J} \beta_j \log(x_{ji}) + \gamma D + \varepsilon_i \quad (4)$$

Where $CCI_i$ represents the crop commercialization index of the household $i$ and $\beta$ and $\gamma$ are vectors of unknown parameters to be estimated and $\varepsilon_i$ the error terms.
*Measurement of food crop productivity*

The dependent variable $y_i$ represents the yield per hectare of food crops. Food crops that are used in the computation of yield include maize, sorghum and millet which represent the most important staple crops produced by smallholder farmers in Burkina Faso. In numerous studies, the value of crops per hectare is used as measure of yield. This study follows Carter [13] and adopts instead a weighted measure of output to compute farm yield per hectare in sorghum equivalent. Based on the market price of the different crops, maize and millet are converted into sorghum equivalent. The quantity of crop $i$

produced is converted into sorghum equivalent (SE) according to the following formula:

$$SE_i = \left( \bar{P}_i \middle/ \bar{P}_s \right) * Crop_i \qquad (5)$$

Where $Crop_i$ denotes the quantity of crop $i$ (in kg), $\bar{P}_i$ the price of crop $i$ and $\bar{P}_s$ the price of sorghum at village level. Therefore, food crop yield for each household is computed as:

$$y_i = (sorghum + \textstyle\sum_i SE_i) \middle/ land \qquad (6)$$

Where $sorghum$ indicates the quantity in kilograms of sorghum produced by the farmer and $land$ the total land size in hectare devoted to the production of food crops.

#### 3.3.2. Estimation Strategy: Instrumental Variable (IV) Approach

Previous empirical studies have stressed that household crop commercialization index is likely to be endogenous in agricultural productivity model [5]. The problem of endogeneity is generally related to the omission of relevant explanatory variables, measurement errors or problem of simultaneity between the dependent variable and explanatory variables. The latter seems to particularly characterize the endogeneity issue in this model because some variables such as household asset endowment and agro-climatic condition may affect both productivity and the level of household commercialization. As argued by [2], a household's decision to use modern inputs to increase productivity and the quantity of market supply depend both on the opportunity of profit offered by the markets but also on the level of household's assets. Thus, this may cause a problem of simultaneity and failing to correct it would lead to inconsistent estimates of the impact of commercial farming on food crop productivity. To solve this issue of endogeneity, this model will be estimated using the instrumental variable approach as adopted by Govereh and Jayne [3] and Govereh, Jayne and Nyoro [4].
*The choice of instrumental variables*

The correction of endogeneity bias by instrumental variable regression methods, requires finding instruments that affect productivity only indirectly through their effect on farm households' market participation. Rios, Shively and Masters [5], in a similar work used ethnic group that the household belong to, ownership of transportation equipment, and road accessibility as instrumental variables. The assumption is that these variables facilitate crop sale because belonging to the same tribe facilitates cooperation and communication while owning transportation assets and the quality of roads reduce marginal cost of movement. In this study, the selected instruments include distance to nearest market, population in the village, household's ownership of communication equipment and household's market orientation index. The distance to nearest market increases transaction costs and may affect the intensity of the household's crop supply. Thus,

---

1 The common techniques used and identified in the survey include "Zaï", Diguettes or cordon pierreux, Demi-Lune, Haies vives. The variable, adoption of soil conservation techniques takes a value one if the farmer adopts any one of these techniques.

households that are closer to market are likely to bear low costs and thus have more incentive to increase their market participation. In addition, ownership of communication assets and the number of inhabitants in the village may greatly influence the intensity of market supply but may not have a direct impact on productivity.

Finally, the last instrument used is a computed index of market orientation of the various crops. In fact, it is evident that there is some difference in the level of tradability of crops produced by farmers. For instance, cotton is more highly marketable than cereals. Among cereal crops, maize is more market oriented than sorghum and millet. Thus, difference in households' level of commercialization may depend on the extent to which resources such as land, labor and capital are allocated to the commodities that are highly market oriented. However, this cropping pattern per se does not influence cereal yield but would necessarily influence the intensity of households' market participation. For instance, allocation of more land to cotton, which is highly market oriented will necessarily result in the increase in a household's level of commercialization. However, this allocation of resource does not have a direct effect on the yield of food crop. Therefore, following Gebremedhin and Jaleta [14], an index of household market orientation is computed and will be used as one of the instruments for crop commercialization index. For each crop, a crop-specific commercialization index is first estimated as the ratio of a given crop sold to total quantity of this crop produced by households. Let $CSI_i$ denote the crop-specific commercialization index:

$$CSI_j = \left. \sum_{i=1}^{N} S_{ji} \middle/ \sum_{i=1}^{N} Q_{ji} \right. \qquad (7)$$

Where $Q_{ji}$ and $S_{ji}$ represent respectively the quantity of crop $j$ harvested and sold by the household $i$. $CSI_j$ will tend to one if the crop $j$ is essentially produced for market while for those mainly produced for consumption $CSI_j$ will have values that are closer to zero. A more market oriented farm household is then likely to allocate a significant share of its resources to the more commercialized crops in the country. Therefore, using crop-specific commercialization index, market orientation index is here constructed in terms of household land allocation pattern weighted by the commercialization index of each crop as follows:

$$MOI_i = \left. \sum_{j=1}^{J} CSI_j T_{ji} \middle/ T_i \right. \qquad (8)$$

$MOI_i$ represents household market orientation index, $T_{ji}$ denotes the quantity of land devoted to crop $j$ and $T_i$ the total land size of household farms. This index refers to the extent to which households' resource allocation (especially land) is towards more marketed crops. The higher ratio of land the farmer devotes to the more tradable crops, the more market oriented is the household.

Various tests will be conducted to assess the validity and relevance of these instruments that will be used to estimate the model described.

*Test of endogeneity of household level of crop commercialization*

The issue of choice between OLS and IV regression is generally discussed using Durbin-Wu-Hausman (DWH) tests. These tests basically consist of estimating the model by OLS and IV and comparing the vector of coefficients obtained through these regressions. The objective is to test whether a variable presumed to be endogenous could be treated as exogenous or not. If the assumed endogenous regressors are revealed as exogenous by the test, then the OLS estimator will be more efficient and there will be no need to adopt IV regression approach. Hausman tests of endogeneity is then performed to check if the intensity of household level of commercialization is exogenous.

*Test of Validity and Relevance of Instruments*

The validity and relevance of instruments used are crucial for the quality of the estimation. Valid instrumental variables must satisfy two requirements. Firstly, the vector of instruments $Z$ (distance to nearest market, population in the village, household's ownership of communication equipment and household's market orientation index) must be strongly correlated with the endogenous variables, that is $(cov(CCI_i; Z)) \neq 0$. This means that $Z$ must be statistically different from zero in the first stage regression of $CCI_i$ on the exogenous variables $X$ and $Z$. Secondly, the instruments must be orthogonal to the error terms $\varepsilon_i$ in the productivity model in Equation (4), that is $E(Z\varepsilon) = 0$. The first requirement is called the relevance condition and the second is the exogeneity or validity condition of instruments.

The F-test of excluded instruments and KP LM statistics of weak identification test are used to assess the relevance of the instruments used. Concerning the second condition of independence between error terms and the instruments, the Hansen's J statistics of over identification of instruments is used to check this requirement. The null hypothesis states that the model is over-identified, meaning that it contains at least as many valid instruments as the number of endogenous variables. Therefore, failing to reject this hypothesis means that the instruments used are valid.

### 3.4. Data Source and Descriptive Statistics

Data used in this study come from a survey undertaken in rural Burkina Faso in 2011 by the Department of Economics of University Thomas Sankara on a sample of 1178 farm households selected across the country. Two-stage and randomized sampling approaches were used to select the sample to be surveyed. In the first stage, villages were selected across the 13 regions according to the representativeness of each regions in the country making a total of 270 villages. Within each village, households were stratified according to their ownership and use of animal traction and randomly selected within each stratum. The final total sample size was 1178 households, distributed across 270 villages of the 13 regions of the country. Further description of the data can be found in Ouedraogo *et al.* [15].

The descriptive statistics show that the average level of

commercialization is 16.97%. This means the production is predominantly oriented toward home consumption. In addition, the average farm size is estimated at 1.15 ha meaning that the majority are smallholder farmers. However, many are involved in non-farm income and gain on average 74 000 FCFA per year. The distance to the nearest market is about 7.18 km. Even if this distance seems not to be high, some farmers may still experience some difficulties in accessing to markets due to the poor road conditions or the lack of means of transportation.

*Table 2. Descriptive statistics of the variables.*

| Variables | Mean | Standard Deviation |
|---|---|---|
| Crop commercialization index | 16.97 | 22.87 |
| Household size | 8.805 | 4.024 |
| Dependency ratio (dependent/active) | 1.563 | 0.846 |
| Farm size per worker (ha/adult) | 1.158 | 0.584 |
| Fertilizer use (kg/ha) | 11.24 | 34.50 |
| Per capita food expenditure (1000 FCFA) | 10.99 | 0.018 |
| Food crop yield (kg/ha) | 540.59 | 9.901 |
| Per capita non-farm income (1000 FCFA) | 74.54 | 15.27 |
| Distance to nearest market (km) | 7.186 | 6.235 |
| Cereal price (FCFA/kg) | 131.7 | 18.41 |
| Observations | 1178 | |

# 4. Results and discussion

## 4.1. Effect of Agricultural Commercialization on Fertilizer Use

Table 2 reports the Tobit regression results of the effect of agricultural commercialization on fertilizer used by smallholders in rural Burkina Faso. The findings show that, at 1% level of significance, an increase in the level of agricultural commercialization increases the quantity of fertilizer use. Therefore, agricultural commercialization represents a pathway to improved farm performance through technological change. Indeed, commercialization directly increases farm households' income and, therefore, their ability to invest in farm production. This finding corroborates the point of Barrett [2] and Binswanger [8] who argue that there exists a positive relationship between agricultural commercialization and technological change, sustaining the importance of promoting farm households' commercial orientation for sustainable technological change. Similar results are also found by Strasberg *et al.* [12] on food production among smallholders in Kenya.

The results show also that the value of transportation assets affects positively and significantly the quantity of fertilizer used by farmers as well as the existence of good roads. Thus, the quantity of fertilizer used is higher among farm households located in villages that are accessible compared to those located in less accessible areas. In addition, owning valuable transportation assets can help mitigate the negative effect of remoteness by facilitating households' accessibility to markets.

This means that by reducing the cost of access to fertilizer, improved market access affects indirectly productivity through its positive effect on input use. This is similar to the findings of Damania *et al.* [16] who showed for the case of Nigeria that improved market access (i.e. decreasing transport costs) increases the production of crops using high input leading to increase in the intensity of input use. Alene *et al.* [17] also found that among smallholder maize farmers in Kenya, the likelihood of fertilizer demand increases with closeness to market and ownership of transportation equipment. Furthermore, the effect of ownership of communication equipment on fertilizer use is positive and significant. This suggests that households that own communication equipment would be better informed about the price and accessibility of modern inputs and therefore more likely to adopt inputs intensively. The amount of credit received by farm households has a positive effect on fertilizer use, at 1% level of significance. Lack of credit access is frequently identified in the literature as a major constraint of low adoption of new technology among smallholder farmers [18, 19].

*Table 3. Results of Tobit regression of effect of agricultural commercialization on intensity of fertilizer Used.*

| Dependent variable: fertilizer used (kg/ha) | | | |
|---|---|---|---|
| VARIABLES | Coefficients | Robust Std. err | P-Value |
| Crop commercialization index | 1.021*** | 0.157 | 0.000 |
| Agricultural credit received | 1.475*** | 0.431 | 0.001 |
| Nonfarm income per adult | -0.002 | 0.013 | 0.902 |
| Value of transportation assets | 0.326*** | 0.096 | 0.001 |
| Distance to nearest market | -0.638 | 0.432 | 0.141 |
| Existence of all-weather road | 16.983*** | 5.109 | 0.001 |
| Own Communication assets (1=yes) | 18.001** | 7.351 | 0.014 |
| Age of household head (HH) | -0.281** | 0.143 | 0.049 |
| Education level of HH (ref: None) | | | |
| Primary | -7.538 | 6.615 | 0.255 |
| Secondary | 2.273 | 10.582 | 0.830 |
| Climatic zone (1=South-Sudan) | 11.713** | 5.093 | 0.022 |
| Constant | -65.804*** | 16.567 | 0.000 |
| Observations | 1,178 | | |
| Log pseudo likelihood | -2485.414 | | |
| F (11, 1167) | 8.97 | | |
| Prob > F | 0.000 | | |
| Sigma | 57.448*** | 11.604 | |

Note: (*), (**) and (***) indicate the levels of significance of the corresponding coefficients at 10%, 5% and 1% respectively. Robust Standard Errors are adjusted for the 217 village clusters.

In the case of Burkina Faso, access to credit remains of crucial importance to purchase fertilizer, since there are numerous constraints for smallholders to obtain subsidized fertilizer. In addition, even where the subsidized fertilizer exists, smallholders in many cases are still unable to afford because of liquidity constraints. Finally, household characteristics such as age of household head significantly affect the quantity of fertilizer used. Thus, the older the household head, the lower the quantity of fertilizer is used. This suggests that households headed by the aged are less innovative than those headed by the youth. In the next sub-section, the results and discussion on the findings on the relationship between agricultural commercialization and yield of food crops are presented.

## 4.2. Effect of Agricultural Commercialization on Food Crop Productivity

The results of the effect of agricultural commercialization on food crop productivity are reported in Table 3. The results of OLS regression in the first column indicate a positive effect of market participation on food crop productivity, significant at 1%. However, these results may be biased because the intensity of households' market participation measured by crop commercialization index is potentially endogenous in this regression and this is confirmed by Hausman test of endogeneity at 1% level of significance. To solve the issue of inconsistency of the estimate due to endogeneity, instrumental variable (IV) regression approach is then adopted and the estimation results are reported in the second column (Table 3).

The tests performed and reported in Table 4 assess the relevance and the validity of instruments used. The F-test of excluded instruments is greater than 10 and significant at 1%. Therefore, the null hypothesis that the excluded instruments used are not correlated with the endogenous variable is rejected, meaning that the instruments used are relevant. In addition, the KP LM statistic rejects the hypothesis of weak identification of instruments. Thus, the instruments used have a strong explanatory power over the endogenous variable.

*Table 4. Regression Results of Effect of Agricultural Commercialization on Food Crop Yield.*

| Dep. variable: Log of staple yield (kg/ha) | OLS regression (1) | | IV regression (2) | |
| --- | --- | --- | --- | --- |
| VARIABLES | Coefficients | Robust SE | Coefficients | Robust SE |
| Crop commercialization Index | 0.0018** | 0.001 | 0.0065*** | 0.001 |
| Log of Fertilizer use per hectare (kg) | 0.1028*** | 0.012 | 0.0799*** | 0.013 |
| Log of Farm size per adult (ha) | -0.8251*** | 0.061 | -0.8178*** | 0.062 |
| Log of Livestock ownership (TLU) | 0.1518*** | 0.023 | 0.1355*** | 0.024 |
| Nonfarm income per adult | 0.0004 | 0.0001 | 0.0003 | 0.0002 |
| Dependency ratio | 0.1106*** | 0.020 | 0.1111*** | 0.020 |
| Adoption of conservation techniques (1=yes) | 0.0623* | 0.036 | 0.0829** | 0.036 |
| Age of Head of Household (HH) | -0.0009 | 0.001 | -0.0003 | 0.001 |
| Gender of Head of Household (1=man) | -0.0264 | 0.076 | -0.0265 | 0.075 |
| Education (reference: None) | | | | |
| Highest education level of HH (1=Primary) | 0.1203** | 0.050 | 0.0903* | 0.051 |
| Highest education level of HH (1=Secondary) | 0.0750 | 0.109 | 0.0426 | 0.112 |
| South-Sudan climate zone (1=yes) | 0.1353*** | 0.032 | 0.1040*** | 0.034 |
| Constant | 6.1164*** | 0.104 | 6.0448*** | 0.104 |
| Observations | 1,178 | | 1,178 | |
| F (12, 1165) | 37.71 | | 39.44 | |
| Prob>F | 0.000 | | 0.000 | |
| R-squared | 0.249 | | 0.222 | |
| Tests of Validity and relevance of instruments used in the IV regression | | | | |
| | Test stat | | P-Value | |
| Relevance test of excluded instruments: | | | | |
| Sanderson-Windmeijer F test, F (4, 1145) | 176.41 | | 0.000 | |
| Weak identification test | | | | |
| Kleibergen-Paap rk LM statistic | 183.11 | | 0.000 | |
| Cragg-Donald Wald F statistic | 215.27 | | | |
| Over identifying tests: Hansen J stat | 2.378 | | 0.497 | |
| Hausman tests of endogeneity: Score chi2 (1) | 27.239 | | 0.000 | |

Note: (∗), (∗∗) and (∗∗∗) indicate the levels of significance of the corresponding coefficients at 10%, 5% and 1% respectively.

Furthermore, the F statistic of Cragg-Donald Wald which is significant at 5% according to Stock-Yogo's table suggests that at least 95% of OLS bias is corrected by the IV regression which is highly acceptable. Finally, for the instruments to be valid, they must be orthogonal to the error terms of productivity model. Thus, the Hansen J test of over-identification is performed to check this requirement. The P-value of the J statistic is equal to 49.7%, greater than 10%. Therefore, the null hypothesis of over-identification of instrument cannot be rejected which means that the instruments used are not correlated with the error terms of the structural model of productivity.

Therefore, the instruments used in the regression are valid. As the model passes all the tests of validity and relevance of instruments, the adoption of IV regression provides more robust estimates of the effect of market participation on food crop productivity than the OLS estimation. Finally, robust standard errors are reported to correct the existence of possible

heteroskedasticity in the model.

The results of IV estimation show a positive effect of commercialization on food crop productivity, significant at 1% level. Moreover, the magnitude of the estimate is higher in this regression than in the OLS regression. This means that failing to control for the endogeneity underestimates the parameters of commercialization effect. In fact, an increase of one unit in the intensity of farm households' level of crop commercialization improves food crop productivity by 0.65%. Similar results were found by Govereh and Jayne [3] in Northern Zimbabwe, Bekele et al. [20] in Ethiopia and Ochieng et al. [7] in a study on Central Africa (Rwanda and DRC).

This suggests that one of the benefits of commercial orientation of smallholders is its great potential to transform agricultural sector and raise yield of food crops. The finding also suggests that increase in agricultural commercialization does not necessarily compete with food crop productivity but rather induces an important technological change and increase in farm yield. This is also reinforced by the positive and significant effect of fertilizer used by farmers on crop yield

Other factors that influence the level of food crop yield include the ownership of livestock, adoption of land conservation techniques, and the agro-climatic conditions in which farm households are located. The adoption of good practices such as soil conservation techniques significantly increases the yield of food crops. Land degradation due to population pressure and climate change is frequently cited as a key challenge of agricultural productivity growth in many semi-arid African countries. In Burkina Faso, most farmland is becoming less fertile and farm households are often constrained to adopt land conservation and restoration practices. Our results show a positive and significant effect of these techniques on food crop yield.

Moreover, the stock of livestock assets measured by tropical livestock unit (TLU) significantly increases the yield of food crops. Livestock represents an important production factor for agriculture in Burkina Faso by providing manure and traction service. Therefore, an integration of livestock production and crop cultivation represents a promising strategy to improve yield of food crops. In addition, income gained from livestock sale increases the capability of farmers to invest in productivity enhancing technology. Finally, the results indicate that the level of formal education of household head has a positive influence on productivity. Household heads with at least primary level of education, are more productive than those with no education.

## 5. Conclusion and Policy Implications

Food crops, the most important crops produced by many smallholders in Sub-Saharan Africa experience very low levels of productivity. Furthermore, it is generally admitted that subsistence farming entails inefficiency and keeps smallholders in low equilibrium of low input use and low yield. Thus, based on data collected on a sample of 1178 farm households in Burkina Faso, this paper analyzed the effects of agricultural commercialization on input use and food crop

yield. The results indicate that the intensity of fertilizer use per hectare increases with the level of smallholders' agricultural commercialization. Other variables that positively influence farm household access to fertilizer include the value of transportation assets, the amount of credit received for farm activities, the existence of all-weather road that link households to urban areas and the household head ownership of communication assets. Moreover, estimating a productivity function using instrumental variables regression approach, the results showed that farm households' crop commercialization index has a significant and positive effect on crop yield.

Therefore, promoting agricultural commercialization will lead to a positive technological change in agricultural sector and an increase in food crop productivity. To promote structural transformation of agricultural sector and increase farm productivity, public policy should provide incentives to increase smallholders' market integration. Thus, enhancing farmers access to credit and transportation facilities can enhance access to markets, input use and productivity.

The structure of agricultural markets in Africa has important implications on farmers' investment and crop choice. Well-functioning markets can stabilize output price and improve farmers' income. Thus, increasing farmers' participation in markets represents a great avenue to achieving these goals. Thus, policy makers in Africa need to provide support to overcome agricultural markets imperfection. Improving rural infrastructure can improve farmers' accessibility to markets and increase their incentive to invest in agriculture.

## References

[1] Timmer CP. Farmers and markets: The political economy of new paradigms. *Am J Agric Econ*. 1997; 79 (2): 621. doi: 10.2307/1244161

[2] Barrett CB. Smallholder Market Participation: Concepts and Evidence from Eastern and Southern Africa. *Food Policy*. 2008; 33 (4): 299-317. doi: 10.1016/j.foodpol.2007.10.005

[3] Govereh J, Jayne TS. Cash cropping and food crop productivity: synergies or trade-offs? *Agric Econ*. 2003; 28: 39-50.

[4] Govereh J, Jayne TS, Nyoro J. Smallholder Commercialization, Interlinked Markets and Food Crop Productivity: Cross-Country Evidence in Eastern and Southern Africa. *Work Pap Dep Agric Econ Dep Econ Michigan State Univ*. 1999. http://www.aec.msu.edu/fs2/ag_transformation/atw_govereh.

[5] Rios AR, Shively GE, Masters WA. Farm Productivity and Household Market Participation: Evidence from LSMS Data. *Contrib Pap Prep Present Int Assoc Agric Econ Beijing, China*. 2009. http://www.researchgate.net/publication/228340824_Farm_Productivity_and_Household_Market_Participation_Evidence_from_LSMS_Data/file/d912f5075df4e5fd19.pdf.

[6] Asfaw S, Shiferaw B, Simtowe F. Does Technology Adoption Promote Commercialization? Evidence from Chickpea Technologies in Ethiopia. 2010: 1-27.

[7] Ochieng J, Knerr B, Owuor G, Ouma E. Commercialisation of Food Crops and Farm Productivity: Evidence from Smallholders in Central Africa. *Agric Econ Res Policy Pract South Africa*. 2016; 55 (4): 458-482. doi: 10.1080/03031853.2016.1243062

[8] Binswanger H. Technological change and commercialization in Agriculture: The effects on the Poor. *Oxford Univ Journals*. 1991; 6 (1): 57-80.

[9] INSD. Annuaire statistique 2015. *Inst Natl la Stat la Démographie*. 2016: 1-383.

[10] Pingali PL. From subsistence to commercial production systems: Transformation of Asian agriculture. *Am J Agric Econ*. 1997; 79 (2): 628-634. doi: 10.2307/1244162.

[11] Jayne TS, Haggblade S, Minot N, Rashid S. Agricultural Commercialization, Rural Transformation and Poverty Reduction : What have We Learned about How to Achieve This ? *Synth Rep Prep African Agric Mark Program Policy Symp Alliance Commod Trade East South Africa*. 2011.

[12] Strasberg PJ, Jayne TS, Yamano T, Nyoro J, Karanja D, Strauss J. Effect of Agricultural Commercialization on Food Crop Input use and Productivity In Kenya. *MSU Int Dev Work Pap*. 1999; (71).

[13] Carter MR. Environment, Techology, and the Social Articulation of Risk in West African Agriculture. *Econ Dev Cult Change*. 1997; 45 (3): 557-590.

[14] Gebremedhin B, Jaleta M. Commercialization of Smallholders: Is Market Participation Enough? *Contrib Pap Present Jt 3rd African Assoc Agric Econ 48th Agric Econ Assoc South Africa Conf Cape Town, South Africa*. 2010.

[15] Ouedraogo SA, Al-hassan RM, Amegashie DPK, Zahonogo P, Sarpong DB. Analyzing smallholders' agricultural commercialization in Burkina Faso: the role of transaction costs and households' assets. *Rev Agric Appl Econ*. 2018; 21 (2): 22-31. doi: 10.15414/raae/2018.21.02.22-31

[16] Damania R, Berg C, Russ J, Federico Barra A, Nash J, Ali R. Agricultural Technology Choice and Transport. *Am J Agric Econ*. 2016: 1-20. doi: 10.1093/ajae/aav073

[17] Alene AD, Manyong VM, Omanya G, Mignouna HD, Bokanga M, Odhiambo G. Smallholder Market Participation under Transactions Costs: Maize Supply and Fertilizer Demand in Kenya. *Food Policy*. 2008; 33 (4): 318-328. doi: 10.1016/j.foodpol.2007.12.001

[18] Croppenstedt A, Demeke M, Meschi MM. Technology Adoption in the Presence of Constraints: the Case of Fertilizer Demand in Ethiopia. *Rev Dev Econ*. 2003; 7 (1): 58-70. doi: 10.1111/1467-9361.00175

[19] Nishida K. Agricultural Productivity Differences and Credit Market Imperfections. *J Int Trade Econ Dev*. 2014; 23 (8): 1262–1276. doi: dx.doi.org/10.1080/09638199.2013.812135

[20] Bekele A, Belay K, Legesse B, Lemma T. Effects of Crop Commercial Orientation on Productivity of Smallholder Farmers in Drought-Prone Areas of the Central Rift Valley of Ethiopia. *J Rural Dev*. 2010; 33 (4): 105-128.