Farm Productivity and Technical Efficiency of Rural Malawian Households: Does Gender Make a Difference?

Krishna H. Koirala
32 Martin D. Woodin Hall
Dept. of Agricultural Economics and Agribusiness
Louisiana State University
Baton Rouge, LA 70803
E-mail: kkoira1@lsu.edu

Ashok K. Mishra
Professor
128 Martin D. Woodin Hall
Dept. of Agricultural Economics and Agribusiness
LSU, Baton Rouge, LA 70803
Phone: (225) 578 0262; Fax: (225) 578 2716
E-mail: amishra@agcenter.lsu.edu

&

Isaac Sitienei
36 Martin D. Woodin Hall
Dept. of Agricultural Economics and Agribusiness
Louisiana State University
Baton Rouge, LA 70803
E-mail: isitie1@lsu.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2015 Annual Meeting, Atlanta, Georgia, January 31-February 3, 2015

Farm Productivity and Technical Efficiency of Rural Malawian Households: Does Gender Make a Difference?

Krishna H. Koirala, Ashok K. Mishra, and Isaac Sitienei

Abstract

There is a growing interest in investigating gender-based farm productivity and efficiency issues across Africa. Maize is a staple food crop not only in Americas but also in sub-Saharan Africa. Using the third Integrated Household Survey data from Malawi and stochastic frontier production function estimation approach, we estimate maize productivity and technical efficiency in Malawi for male-headed and female-headed households, separately. Result shows that, contrary to expectations; technical efficiency is 15 percent higher for female-headed households compared to male-headed households.

1. Introduction

Agriculture in Malawi accounts for 30 percent of Gross Domestic Product (GDP), 80 percent of labor force, and over 80 percent of foreign exchange earnings. Agriculture provides 64 percent of the total rural household income, 65 percent of raw materials to manufacturing sector, and 87 percent of total employment.[1] The agricultural sector comprises of two sub-sectors—the smallholder sub-sector (70% GDP) and the estate sub-sector (30% GDP). The smallholder sub-sector is further divided into three distinct categories; net food buyers, intermediate farmers, and net food sellers. Farmers with less than 0.7 hectares of land are categorized as net food buyers; those farmers are unable to produce sufficient food for their needs. They are mostly dependent on off-farm activities. Farmers with land holding between 0.7 to 1.5 hectares and able to produce enough food for their needs are categorized as intermediate farmers. Net food sellers are farmers who can produce sufficient food than their needs and with land holding of more than 1.5 hectares (Chirwa, 2007; Chirwa et al., 2008; FAO, 2012).

"Maize is life"—a famous Malawian saying—shows the importance of maize in Malawi (Derlagen, 2012). The smallholder agricultural sub-sector accounts for 90% of total maize production to meet subsistence requirements, while the estate sub-sector accounts for less than 10%. Smallholder households are less likely to grow hybrid maize and maize yields are consistently lower than those of estate households (Chirwa et al., 2008). Maize, cassava, sweet potatoes, rice, sorghum, groundnuts, and pulses are important food crops. The priority of government action is transformation of subsistence agriculture to commercial agriculture (Jayne et al., 2008; Malawi Government, 2011; Chirwa, 2007).

[1] Report published by world Bank, Basic agricultural public expenditure diagnostic review (2000-2013) www.worldbanl.org/afr/agperprogram

Further, food security is another important issue that is much debated by policymakers in Malawi. Food security in Malawi is mainly defined in terms of access to maize, the main staple food. Therefore, high productivity and efficiency in maize production is critical to food security in the country. Maize is cultivated over 80 percent of the cultivated land. Low input use, inadequate access to agricultural credit, poor output and input markets, unfavorable weather, small land holdings, and lack of proper technology are the main reasons for lower agricultural productivity in Malawi (Malawi Government, 2011; Denning et al., 2009; Njuki et al., 2011). In addition to these factors, labor availability for farming operations is a critical issue in Malawi due to combined effects of the HIV/AIDS pandemic and constant migration of rural labor to urban areas[2] (Ngwira et al., 2012). Agricultural productivity in Malawi has fallen below its potential, given the available technology (Tchele, 2009).

During the 1960s and 1970s in Malawi, adoption of improved seed varieties, mainly hybrids and application of fertilizers increased productivity. Fertilizer use in Africa is low (8kg/ha) compared to East and Southeast Asia (96kh/ha) and South Asia (101 kg/ha). In order to boost maize production the government of Malawi since 2005, has been providing subsidies on improved seed varieties and fertilizer in an effort to (i) increase income of resource poor households, (ii) cash crop production, and (iii) achieve food self-sufficiency. The Farm Input Subsidy Program (FISP) has influenced the agriculture and food security policy in Malawi since its implementation in 2005/06.[3] It has been claimed that FISP has been successful in 2006 and 2007, led to major surpluses above national demand (Denning et al., 2009). Finally, the Malawian government enacted FISP to ensure benefits to female-headed households, however,

[2] Food insecurity encourages unsafe sexual practices leading to incidence of HIV/AIDS. See more details in Denning et al., 2009.

[3] IFPRI newsletter http://www.ifpri.org/sites/default/files/publications/massppn18.pdf

most beneficiaries were eventually male-headed households (Dorward and Chirwa, 2011; Chirwa, 2007).

The socially constructed relationships, gender differences, can affect the distribution of resource and responsibilities between men and women. A gender difference is shaped by ideological, religious, ethnic, economic, and cultural determinants (Quisumbing, 1996). Females are head of households mainly in two different scenarios; either widowhood or husband is a migrant. A female-headed rural household is defined as those households where the women make the major of decisions on agricultural production and marketing (Njuki et al., 2011). A report presented to World Bank and UNDP, studied by Ngwira et al., (2003), acknowledges that one third of Malawi's rural households are female headed. Overall, women comprised of 51% of the total population. Additionally, about 97% of rural women are engaged in subsistence farming; therefore, women in both joint-headed and female-headed households are poor.

The dominance of female labor in agriculture and existence of gender gap in agricultural productivity are two key features that are prevalent in the agricultural sector in sub-Saharan Africa. The gender differentials in agricultural productivity is based on economic condition of the country, the representativeness of the data, the type of crop, and other related factors. Previous research found that gender differentials in agricultural productivity range from 4 to 40 percent (Palacios-Lopez and Lopez, 2014). Due to discrimination, female-headed households may be discouraged to participate in off-farm activities. Further lower access to productive inputs coupled with liquidity constraints may make female-headed households less productive than men-headed households (Njuki et al., 2011; Fletschner, 2008).

The differences in agricultural productivity are likely in African rural households between men and women because they pursue their own activities both on and off the farm. They also have different access and adoption of technologies, endowments of land rights, and different factor of production which impact efficiency of production (Oladeebo and Fajuyigbe, 2007). Though female-headed households are more likely to be poorer than male-headed households in the developing countries; however, due to matrifocal ethnic groups and women's participation in shifting agricultural systems, female-headed households are becoming richer than male-headed households in Malawi (Handa, 1995). Malawi has a matriarchal system where women are more involved in decision making process (Njuki et al., 2011).

There are a number of possible factors may lead to agricultural productivity and technical efficiency differences between male-headed and female-headed households in Malawi. Findings from previous studies points to some possible factors, (1) the quantity of inputs applied by male-headed and female-headed farm households, (2) the quality of inputs (such as land, soil quality), (3) crop choice, (4) shadow prices of inputs and access to credit. Therefore, the main objective of this study is to estimate the determinants of productivity and identify the factors that explain variations in technical efficiency. Particular attention is given to FISP and access to credit. However, previous studies have failed to estimate gender differential impact of FISP on maize productivity and technical efficiency. Our study specifically analyzes the average differences in agricultural productivity between plots belonging to male-headed households and those belonging to female-headed household, separately.

2. Literature Review

2.1. Agriculture in Malawi

Malawi is a landlocked tropical country and its economy is heavily dependent on agriculture (Denning et al., 2009). Malawi has always been vulnerable to food insecurity due to its limited resources, high population density, rainfed agriculture, and frequent droughts and floods; 84% of Malawians live in rural areas. About 11 million Malawians are engaged in smallholder subsistence farming. Due to mountains, forests, and rough pastures, only one-third of the land is suitable for agriculture. Maize, a major stale food, is grown by 97 percent of farming households and account for 60 percent of total calorie consumption in Malawi (Denning et al., 2009). The authors compared the average yield of maize of Malawi (1.3 metric tons per hectare) with average yield of rainfed maize in Iowa (10 metric tons per hectare) for 1997-2007 periods and concluded that absence of significant use of fertilizer was major cause behind such lower production.

Nonetheless Derlagen (2012), a technical note published by FAO, states that maize yields have increased from 0.99 to 2.3 tons per hectares in between 1990 to 2010. Total harvested area for maize increased from 1.14 million hectares to 1.65 million hectares in between 1980 to 2010 while production increased more than tripled from 1.2 million to 3.8 million tons in these periods. Total maize production was 3.64 million tons in 2013 and it is expected to be 3.9 million tons (8% more than 2013) in 2014.[4] Strong increase in production and yields was observed since 2006.[5] A continuation of the Farm Input Subsidy Program, a small expansion in planted area, and timely rainfall are the major reasons for increase in maize yield in 2014.

---

[4] FAO, Malawi http://www.fao.org/giews/countrybrief/country.jsp?code=MWI

[5] A Farm Input Subsidy program was effective since 2005/2006 harvest season and major cause of increase in maize production.

The 2004-2005 maize cropping seasons was worse in Malawi due to severe drought conditions in tasseling and ear development stages resulting very low national average maize production (0.76 tons per hectares). Total maize production was 24 percent less in 2005 compared to previous year production, which leads to rise if maize price in local markets and significant food deficits. Therefore, government of Malawi decided to provide subsidy for rural farmers with objectives to increase maize production. The objective of FISP is to increase access to improved agricultural inputs for resource poor smallholder farmers, subsequently achieving food sufficiency, intensifying maize production, and increased incomes in the long term.[6] A FISP support measures are primarily for a maize production. As a result, a Farm Input Subsidy Program (FISP) was first implemented during the 2005/06 cropping season and is still in existence (Denning et al., 2009; Derlagen, 2012; Chibwana et al., 2010). It is targeted to 1.5 million rural smallholders (about half of total farmers), provides each farmer with two coupons[7] (1 coupons=50 kilograms bags of fertilizer).

A farmer receiving FISP should pay a small redemption fee, equating to a subsidy of two-thirds or more of the commercial fertilizer price. A smallholder farmer who cannot afford fertilizer at commercial price but has sufficient land and human resources to make effective use of subsidized inputs is eligible for this program (Amdt et al., 2013). In addition to this, FISP also focuses to vulnerable groups such as child or female-headed farm households; however, female-headed farm households and asset poor households are less likely to receive any type of coupons (Chibwana et al., 2010). FISP mandates to provide 150,000-170,000 metric tons of fertilizer per

---

[6] Basic agricultural public expenditure diagnostic review (2000-2013), a report published from World Bank. See more details in http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2014/07/17/000333037_20140717142122/Rendered/PDF/895110WP0P119400Box385284B00PUBLIC0.pdf

[7] Two coupons were provided.; One for a 50 kg bag of NPK (base fertilizer) and one for a 50 kg of urea (top dressing)

year; however, actual distribution peaked at 216,000 metric tons in 2007/08. Additionally, FISP provides improved seeds[8] to farmers, starting at 2-3 kilograms per farmer in 2005/06 and 5-10 kilograms in 2009/10. Thus, a full package FISP program includes 5-10 kg of seeds and 100 kg of fertilizer (Pauw and Thurlow, 2014).

There was a dramatic yield improvement in Malawi at the time FISP was introduced. Maize yields increased to 1.59 tons per hectares (2.58 million tons national production) in 2005/06, doubling the yield (0.76 t/ha) and production (1.23 million tons) of 2004/05. Higher yield was observed due to subsidy on fertilizer and seeds coupled with favorable weather (rainfall) during 2005/06. In the subsequent cropping season 2006/07, national maize production (3.44 million tons) and yield (2.04 t/ha) gain a remarkable improvement (Denning et al., 2009). According to Amdt et al., (2013) FISP generates modest direct returns in the form of higher maize productivity and production. Additionally, FISP also generates indirect benefits which are represented by economy-wide benefit-cost ratio in the national level. Findings from previous studies (Chibwana et al., 2010; Amdt et al., 2013; Derlagen, 2012) concluded that FISP program are successful in achieving food self- sufficiency.

Irrigation is very limited and agricultural production is mostly rainfed agriculture. Maize production has been fluctuating over the last two decades and one of the reason was drought condition and severe drought condition experienced in 1991/92, 1993/94, 1994/95, and 2000/01 (Edriss et al., 2004; Derlagen, 2012). Two binding constraints in agricultural productivity are land and poverty. Malawi's smallholder farmers are too poor to be able to benefit from any kind of government assisted credit program. Moreover, land constraints are so severe that even if they had access to adequate credit and inputs, any increase in productivity would still lag food

[8] FISP provides both composites and hybrid seeds to farmers. A farmer can choose between composite and hybrid seed varieties. Options are either 2 kg hybrid seeds or 4 kg open pollinated seed varieties. In 2009/10, FISP provides 90 percent of hybrid seeds.

demand (Diagne and Zeller, 2001; FAO, 2011b). Edriss et al., (2004) note that both the quantity and quality of land input was the major constraints for agricultural production in Malawi. The authors stated that the largest contributing factor to decline in maize productivity was a decrease in farm labor input share.

2.2. Previous Findings

There is growing literature concerning gender-based farm productivity and efficiency issues across Africa. Peterman et al., (2011) studied gender differences in agricultural productivity in Nigeria and Uganda using the 2004-2010 *Fadama II* data collected by IFPRI. Using Cobb-Douglas production function in the first stage and multivariate tobit models in the second state, the authors addressed gender differences. They found, female-owned plots and female-headed household tend to have lower productivity than men-owned plots and households, in Nigeria and Uganda; women were farming on resource poor farm land. Combaz (2013) studied unequal decision making power between male and female-headed farm households in Uganda and concluded that about 70 percent decisions regarding marketing are mainly made from men and 15 percent decisions are made jointly by men and women, showing the evidence of women have little authority over marketing, sales, income, and spending.

Conclusions from previous research on gender differences in agricultural productivity and technical efficiency are mixed. A number of studies in the late 1980s and early 1990s and some recent studies found no significant differences in technical efficiency of male and female-headed farms when differences in inputs are controlled (Peterman et al., 2001; Gilbert et al., 2002; Thapa, 2008; Horrell and Krishnan, 2007). Some of the previous studies found that female managed farms are more efficient than male-managed farms (Dadzie and Dasmani, 2010; Oladeebo and Fajuyigbe, 2007). For example, Oladeebo and Fajuyigbe (2007) studied technical efficiency of upland rice farmers in Osun State of Nigeria in female-headed and male-headed households using separate stochastic dominance production function. They found that women farmers are more efficient technically than men farmers. Age and years of education of farmers were two factors that had positive relationship with technical efficiency.

On the other hand, several studies have concluded that female-headed households or female managed plots in agriculture have lower productivity and were technically less efficient than that of male-managed plots (Udry, 1996; Quisumbing et al., 2001; Holden et al., 2001; Ogunniyi and Ajao, 2010). Udry (1996) studied gender, agricultural production and the theory of the household using four year panel data (1981-1985) from International Crops Research Institute for the Semi-arid Tropics (ICRIST) of Burkina Faso farm households. The author studied why female managed farms are less efficient and conclude that factor allocation (inputs) is not Pareto efficient across plots. A plots controlled by women are farmed much less intensively than similar plots controlled by men within the household and there is 6 percent of output was lost due to inefficient factor allocation within the household. Ogunniyi and Ajao (2010) studied gender and cost efficiency in maize production in Oyo State of Nigeria using two separate stochastic production function and concluded that female are more cost inefficient than their male counterparts. Additionally, they found that female farmers do not have access to as seeds and tend to use the seed from the previous harvest.

Among various reason of lower efficiency and productivity of female-managed farms, access to credit is one of major barriers. For example Fletschner (2008) studied women's access to credit and its effect to household efficiency[9] using non-parametric data envelope analysis method for 210 couples in Eastern Paraguay. Findings showed that stated women are unable to meet their needs for capital and their households experienced an additional 11% loss in

[9] Household efficiency includes Economic efficiency, Technical efficiency, and Allocative efficiency. For more details see Fletschner (2008).

household efficiency. Diaz and Sanches (2011) studied gender wage gap in Europe using stochastic frontier approach and data from European Community Household Panel Data, (1995-2001) and concluded that wage discrimination in women might be a reason for lower productivity and efficiency of female-manage plots. In spite of women having less productive in farming, the general consensus is that they are no less efficient than men in their use of resources. Similarly, access to extension services is another barrier for female farmers. Gilbert et al., (2002) studied gender analysis of a nationwide cropping system in Malawi using cross-sectional data of 1998-99 cropping season. From the study of Gillbert et al., (2002) in Malawi, agricultural extension services were biased toward male farmers i.e. 81 percent of the male farmers were chosen for complex agronomic trial by extension agent.

In Malawi, female-headed households have smaller landholdings than male-headed households. In general, family size is also smaller in female-headed households than male-headed households, due to the absence of the male (Quisumbing, 1994a). According to a report published by FAO (2011) females own less land and consequently use about 10 percent less total labor per hectare than their male counterparts. In some farming operation such as plowing and spraying, male labor is necessary. Consequently, female-headed households need more cash to hire male labor to perform those farming activities.

In the context of determinant of technical efficiency of maize producers in Malawi, there have been many studies that explain and highlight the important factors that can affect efficiency of farmers. For example, Chirwa (2007) analyzed technical efficiency of 156 maize farms in Southern Malawi using 2006 cross-sectional data from smallholder farmer questionnaire. He found that smallholder maize farmers were 46.23 percent technically efficient. The author stated that smallholder maize farmers in Malawi are inefficient and hybrid seeds and club membership could increase the efficiency of maize farmers. Farmers using hybrid maize seeds are more efficient than farmers using local maize seeds. Tchale (2009) studied the efficiency of smallholder agriculture in Malawi using stochastic production frontier model. The author found 53% average technical efficiency score and the determinants of efficiency were access to markets; access to extension services; fertilizer; improved seed varieties.

Similarly, Tchale and Sauer (2007) studied efficiency of maize farming household and plot level data using the 2003 survey data from Agricultural Development Divisions in Malawi. Using bootstrapped translog frontier the authors concluded that integrated soil fertility, access to agricultural input and output markets, credit provision, and extension services strongly influence smallholders' technical efficiency. Edriss et al., (2004) studied the impact of labor market liberalization on maize production and productivity using a frontier production function and Divisia Index. They found that between 1985-2000 total factor productivity declined at rate of 1.2% per annum. The largest contributing factors were decrease in farm labor input share and labor market liberalization. The labor market liberalization including labor market reform had directly or indirectly shifted allocation of labor from own farm to other farms or non-farm activities, resulting in a lower productivity and efficiency in maize production in Malawi.

In the context of gender and its relationship with markets in Malawi, Njuki et al., (2011) studied linkage of gender and intra-household dynamics and concluded that women have authority to control for those commodities that generates lower average revenues while men control commodities that have high revenue. Thus, women are significantly excluded from markets and opportunities for them to move from subsistence agriculture to commercial agriculture in Malawi. Lack of cultivatable and productive land ownership, lack of access to resources, unequal domestic decision-making power, a gendered division of labor and time are hindering factors leading to lower productivity of female-headed households' plots than male-headed households' plots.

3. Data

We used the third Integrated Household Survey (IHS3) data, conducted by the Government of Malawi through the National Statistical Office (NSO) in the period of March 2010 to March 2011. The NSO conduct the survey in every 5 years to monitor and evaluate the changing conditions of Malawian households. The IHS3 survey consists of four distinct questionnaire instruments; *the household questionnaire, the agriculture questionnaire, the fishery questionnaire,* and *the community questionnaire*. The household questionnaire includes economics activities, demographics, welfare, and other sectorial information of households and covers a wide range of topics. The agriculture questionnaire is carefully designed to provide consistency with the National Census of Agriculture and Livestock and other surveys in sub-Saharan Africa. In this study, we took data from household and agriculture questionnaire part.

The IHS3 survey includes all three major regions of Malawi, namely North, Center, and South. It is composed of 31 districts of Malawi. It does not include the island district of Likoma since it only represents about 0.1 percent of the total Malawian population. For the collection of cross-sectional data, households were visited only once. This survey data include output of maize and other food crops produced, inputs used in the production process such as— land, labor, capital, fertilizer, pesticides, seed; demographic, and socio-economic characteristics of the households. A total of 12,271 households observations were collected in the third Integrated Household Survey. Among 12,271 total households, cross-sectional data comprised of 9,024 households and rest of 3,247 households as panel data. In this study, we used only cross-sectional household's observation.

4. Method

Production functions have been widely used to in the literature to estimate gender differences in productivity and technical efficiency. Two-step estimation approach was criticized for inconsistency between the independency assumptions of u_{it} (inefficiency term) in the first step and the dependency assumption in the second step. Another criticism is that firm's knowledge of its level of technical inefficiency affects its input choice due to which inefficiency may be dependent on the explanatory variables. Therefore, we use one stage simultaneous estimation approach in which the inefficiency effects are expressed as an explicit function of a vector of firm-specific variables (Chirwa, 2007). The mean of u_{it} is assumed to depend on exogenous variables. In African societies, where men and women manage separate plots, estimation of technical efficiency difference is feasible on those plots (Quisumbing, 1996). We used a separate stochastic production frontier approach for male-headed households and female-headed households and then compared the parameters of production function and coefficient of technical efficiency across gender specification. The production of a farm manager i in household j is given by equation

$$Y_{ij} = f(V_i, X_i, Z_j) \quad (1)$$

where Y_{ij} is the quantity produced; V_i is a vector of inputs used by farm manager i; X_i is a individual attributes; and Z_j are household characteristics. This production function assumes that land quality is same between male-headed households and female-headed households and they produce same output which is maize. The Battese and Coelli (1995) model is

$$Y_{it} = f(X_{it}; \beta)\exp\,(v_{it} - u_{it}) \quad (2)$$

where Y_i is a vector of valued of production for farms $\{\ t = (f, m)\}$ managed by females Y_f and males Y_m; X_i is the set of inputs; β is vector of parameters to be estimated, $v_i$is a vector of twosided error term assumed to be identically and independently distributed; u_i is a vector of non-negative technical inefficiency component of the error terms.

The stochastic production frontier can be defined as

$$lnY_{fi} = \alpha_0 + \sum_k \beta_k \, lnX_{fik} + v_i - u_i(z_{fi}, \delta') \quad (3)$$

$$lnY_{mi} = \alpha_0 + \sum_k \beta_k \, lnX_{mik} + v_i - u_i(z_{mi}, \delta') \quad (4)$$

where the subscripts $f, i, k,$ and m represents female, farm, inputs, and male. The dependent variable in equation 1 lnY_{fi} is the log-transformed output of maize in female managed farms (in kilograms).

5. Results

A growing population pressure and off-farm employment opportunities for man have led to an increasing proportion of women becoming head of households in Africa. Table 1 shows the summary statistics of the variables used in this analysis. Data reveals that in Malawi, about 80 percent of rural households are headed by males, with 1.15 hectares in maize; about 0.97 hectares of maize farm for female-headed households. A plot managed by male-headed farm household have higher lands rent and land value compared to female-headed farm households. A female-headed farm households use more fertilizer (418 kg) than male-headed farm households (353 kg). Pesticide use is minimal for both male and female-headed farm households. A ganyu, informal off-farm labor opportunities, is a best possible option for survival strategies for the rural poor people is common practices in Malawi.

Total sold quantity and total value of sales was higher for male-headed farm household compared to than female-headed households. However, data reveals that the average quantity of maize output (414 kg per year) was higher for female-headed farm households compared to male-headed farm households (335 kg per year). Similarly, total income for female-headed households (2220 MK) was higher than male-headed households (2045 MK). Malawi had an average family size of 4 persons, mean of 5 for female-headed households and average of 4 for male-headed households. In Malawi, the heads of households had some primary education. Thus, in spite of having less land area—cultivate area, female-headed rural households have higher income and total output, indicating that female-headed households are more productive than male-headed rural households.

We performed mean comparison test. Table 2 shows the results of mean comparison test for all variables. In the mean comparison test, we found land area, land value, land rental value, inorganic fertilizer, months of gyanu, farming experience, household size, capital, educational level, seed, total hired labor, age, maize output, total sales of livestock, irrigation cost, off-farm income, subsidies, extension services, and access to credit are significant at 5 percent level of significance between female-headed households and male-headed households, while pesticide use is found to significant at 10 percent level. Variable such as organic fertilizer, maize sold quantity, total value of sales, medical cost, seed cost, number of farm visit by extension agent, income, transportation cost for sales, marital status are not significant. The female-headed households in Malawi do more livestock transaction than male-headed households. The argument here could be that, male value livestock ownership—for cultural reasons such as payment of dowry, sign of wealth etc. unlike female who strictly keep livestock for transactions. Njuki et al., (2011) also stated that livestock ownership and marketing of livestock was managed and controlled by women. Results from this test show that there is statistically significant in use of capital between female-headed households and male-headed households. Female-headed households used more capital than male-headed households in agriculture production.

We applied separate one-stage stochastic production frontier function each for female-headed farm households and male-headed farm households. A Cobb-Douglas production function was estimated using half-normal distribution model. Parameter estimates of both female-headed and male-headed farm households are presented in table 3. The estimated signs of the parameters are as expected. Result indicates that output of maize for female-headed farm households is affected by amount of seed, land area, and rental value (capital). Total use of labor (days) is not significant. In case of male-headed farm households, output of maize is affected by land area, rental value of land (capital), and labor days. Amount of seed use is insignificant in case of male-headed farm households.

A bottom part of table 3 provides the estimates for the factors that affect technical inefficiency of maize farmers. We found that similar results and signs for both female-headed farm households and male-headed farm households. Technical inefficiency is mainly affected by subsidies coupon, months of ganyu, marital status, credit constraints, food security, age, and education. Technical inefficiency has positive relation with food security, age of farm operators, and months of informal labor (ganyu), while it has negative relation with subsidies, marital status, credit constraints, and educational level of farm operators. Table 4 shows the summary statistics for technical efficiency for female-headed and male-headed farm households. We found a mean technical efficiency score of about 0.78 with standard deviation of 0.32 for female-headed farm households, while a mean technical efficiency is 0.64 with standard deviation of 0.29 for male-headed farm households. Technical efficiency is higher for female-headed farm households than male-headed farm households. Table 5 shows the distribution of technical efficiency for female-headed and male-headed farm households.

6. Conclusions

The majority of smallholders in Malawi are characterized by average landholding of less than 1 hectare; do not grow enough food to feed them. Maize is the major food crop and tobacco is the major cash and export crop in Malawi. This paper explores the relative efficiency of maize producing farms in Malawi by particularly focusing the male-headed households and female-headed households.

In most of African countries, male-headed households had significantly higher fertilizer use, cash crop area and total field area than female farmers resulting higher levels of land, labor, and cash available to the male farmers. There is need of change in discriminatory laws and policies that constrain women's access to factors of production to improve women farmers' productivity in the sub-Saharan Africa. Our analysis shows that the TE level of female-headed farm households in about 15 percent higher than male-headed farm household under similar condition of farming. Maize production is mainly affected by amount of seed, land area, capital, and labor. Technical efficiency is increased with subsidies coupon, which implies subsidies has positive impact to technical efficiency of maize farmers. Additionally, barriers to credit constrains has also positive relation with technical efficiency of maize farmers. Interestingly, extension dummy does not have any effect to technical efficiency of maize farmers.

References

Arndt, C., Pauw, K., & Thurlow, J. (2013). The economywide impacts and risks of Malawi's Farm Input Subsidy Program. In *4th International Conference of the African Association of Agricultural Economists, Hammamet, Tunisia*.

Chibwana, C., Fisher, M., Jumbe, C., Masters, W., & Shively, G. (2010). Measuring the impacts of Malawi's farm input subsidy program. In *Contributed paper presented at the African Association of Agricultural Economists (AAAE) conference, Cape Town, South Africa*.

Chirwa, E. W. 2007. Sources of Technical Efficiency among Smallholder Maize Farmers in Southern Malawi. The African Economic Research Consortium. ISBN: 9966-778-17-9

Chirwa, E. W., Kumwenda, I., Jumbe, C., Chilonda, P., & Minde, I. 2008. Agricultural growth and poverty reduction in Malawi: Past performance and recent trends. *ReSAKSS-SA Working Paper*, *8*.

Combaz, E. (2013). Women's and girls' benefits from market-oriented agriculture in Uganda. GSDRC Helpdesk Research Report 998, University if Birmingham, UK

Dadzie, S. K., & Dasmani, I. (2010). Gender difference and farm level efficiency: Metafrontier production function approach. *Journal of Development and Agricultural Economics*, *2*(12), 441-451.

Denning, G., Kabambe, P., Sanchez, P., Malik, A., Flor, R., Harawa, R., & ... Sachs, J. (2009). Input Subsidies to Improve Smallholder Maize Productivity in Malawi: Toward an African Green Revolution. *Plos Biology*, *7*(1), e23. doi:10.1371/journal.pbio.1000023

Derlagen, c., 2012. Analysis of Incentives and Disincentives for Maize in Malawi. Techinical notes series, Monitoring African Food and Agricultural Policies (MAFAP), FAO, Rome Available at: www.fao.org/mafap

Diagne, A., & Zeller, M. (2001). Access to Credit and Its Impact on Welfare in Malawi. Research Report 116, Washington, DC: International Food Policy Research Institute.

Díaz, M., & Sánchez, R. (2011). Gender and potential wage in Europe: a stochastic frontier approach. *International Journal of Manpower*, *32*(4), 410-425. doi:10.1108/01437721111148531

Dorward, A., & Chirwa, E. 2011. The Malawi agricultural input subsidy programme: 2005/06 to 2008/09. *International journal of agricultural sustainability*, *9*(1), 232-247.

Edriss, A., Tchale, H., & Wobst, P. (2004). The impact of labour market liberalization on maize productivity and rural poverty in Malawi. *Project paper. Available at http://www. pasad. uni-bonn. de*.

FAO. (2011). The state of food and Agriculture. Women in agriculture: closing the gender gap for development. Food and Agriculture Organization of the United Nations. Rome. Retrieved from http://www.fao.org/docrep/013/i2050e/i2050e.pdf

Fletschner, D. (2008). Women's Access to Credit: Does It Matter for Household Efficiency? *American Journal of Agricultural Economics*, 90(3), 669-683.

Gilbert, R.A., Sakala, W.D. & Benson, T.D. (2002). Gender analysis of a nationwide cropping system trial survey in Malawi. *African Studies Quarterly*, 6(1).

Handa, S. 1996. Expenditure behavior and children's welfare: An analysis of female headed households in Jamaica. *Journal of Development Economics*, 50(1), 165-187.

Holden, S., Shiferaw, B., & Pender, J. (2001). Market Imperfections and Land Productivity in the Ethiopian Highlands. *Journal of Agricultural Economics*, *52*(3), 53-70.

Horrell, S., & Krishnan, P. (2007). Poverty and productivity in female-headed households in Zimbabwe. *The Journal of Development Studies*, *43*(8), 1351-1380.

Jayne, T. S., Mangisoni, J., & Sitko, N. (2008). Social Analysis of Malawi's Maize Marketing Reforms. *Report prepared for the World Bank/Malawi. Michigan State University, East Lansing, Mi*.

Kilic, T., Palacios-Lopez, A., & Goldstein, M. (2013). Caught in a Productivity Trap. *op. cit*.

Malawi Government, 2011. Malawi Agricultural Sector Wide Approach: Malawi's prioritised and harmonised agricultural development agenda: 2011-2015. Lilongwe: Ministry of Agriculture and Food Security. www.moafsmw.org

Ngwira, A. R., Aune, J. B., & Mkwinda, S. (2012). On-farm evaluation of yield and economic benefit of short term maize legume intercropping systems under conservation agriculture in Malawi. *Field crops research*, *132*, 149-157.

Ngwira, N., Kamchedzera, G., & Semu, L. (2003). Malawi Strategic Country Gender Assessment (SCGA). 33774

Njuki, J., Kaaria, S., Chamunorwa, A., & Chiuri, W. (2011). Linking Smallholder Farmers to Markets, Gender and Intra-Household Dynamics: Does the Choice of Commodity Matter? *European Journal of Development Research*, *23*(3), 426-443.

Ogunniyi, L. T., & Ajao, A. O. (2010). Gender and cost efficiency in maize production in Oyo state of Nigeria. *Tropical and subtropical agroecosystems*, *12*(2), 333-338.

Oladeebo, J. O., & Fajuyigbe, A. A. (2007). Technical efficiency of men and women upland rice farmers in Osun State, Nigeria. *Journal of Human Ecology*, *22*(2), 93-100.

Palacios-López, A., & Lopez, R. 2014. Gender Differences in Agricultural Productivity: The Role of Market Imperfections (No. 164061). Department of Agricultural and Resource Economics, the University of Maryland.

Pauw, K., & Thurlow, J. (2014) Malawi's Farm Input Subsidy Program: Where Do We Go from Here? International Food Policy Research Institute. Policy Note 18 http://www.ifpri.org/sites/default/files/publications/massppn18.pdf

Peterman, A., Quisumbing, A., Behrman, J., & Nkonya, E. (2011). Understanding the Complexities Surrounding Gender Differences in Agricultural Productivity in Nigeria and Uganda. *Journal of Development Studies*, *47*(10), 1482-1509. doi:10.1080/00220388.2010.536222

Quisumbing, A. R. (1996). Male-female differences in agricultural productivity: Methodological issues and empirical evidence. *World Development*, *24*(10), 1579-1595.

Quisumbing, A. R., Payongayong, E., Aidoo, J., & Otsuka, K. (2001). Women's Land Rights in the Transition to Individualized Ownership: Implications for Tree-Resource Management in Western Ghana. *Economic Development & Cultural Change*, *50*(1), 157.

Tchale, H. (2009). The efficiency of smallholder agriculture in Malawi. *African Journal of Agriculture and Resource Economics*, *3*(2), 101-121.

Tchale, H., & Sauer, J. 2007. The efficiency of maize farming in Malawi: A bootstrapped translog frontier.

Thapa, S. (2008). Gender differentials in agricultural productivity: evidence from Nepalese household data. Working paper. University of Trento, Trento, Italy.

Udry, C. (1996). Gender, agricultural production, and the theory of the household. *Journal of Political Economy*, 104(5), 1010.

Udry, C. C., Hoddinott, J. J., Alderman, H. H., & Haddad, L. L. (1995). Gender differentials in farm productivity: implications for household efficiency and agricultural policy. *Food Policy* 20(5):407-423.

Table 1 Summary Statistics of Variables Used

Variables	Female-headed households Mean	S.D.	Male-headed households Mean	S.D.
Land area (hectares)	0.97	0.79	1.15	9.59
Land value	48154.26	83845.95	53222.78	130939
Land rent	3369.64	4591.36	3701.10	7352.28
Inorganic fertilizer (Kg)	54.04	45.61	58.28	95.28
Organic fertilizer (Kg)	277.67	776.49	273.79	704.71
Total fertilizer	417.51	996.05	352.22	724.52
Pesticide	0.08	1.95	0.15	5.36
Months for ganyu (off-farm)	3.95	3.08	4.05	3.08
Sold quantity (Kg)	49.16	150.48	56.54	244.29
Total value of sales	19048.4	40035.1	20835.56	49966.79
Farming experience (years)	21.26	18.10	14.40	13.31
Household size (number)	4.70	2.47	3.86	1.86
Capital	4705.89	25405.44	3569.01	20716.57
Medical cost	4104.96	6755.93	4988.55	18427.13
Education level (years of school)	2	1.27	1.40	0.96
Seed (kg)	14.14	50.27	20.19	78.98
Seed cost (MK)	1113.73	1683.06	1137.32	3292.77
No of farm visit by extension agent	1.68	1.86	1.38	2.05
Total hired labor (days)	1.41	7.09	1.53	6.61
Income	2219.59	63160.86	2045.01	15130.51
Age of household head (years)	48	18.79	43	11.28
Output (kg)	414.39	1369.95	335.18	673.70
Transpiration cost for sales	1163.26	5517.469	1056.69	5090.53
Total sales of livestock	243551.5	1321651	3186.54	13252.75
Irrigation (=1 if yes, 0=rainfed	0.005	0.07	0.004	0.062
upland (=1 if yes, 0=otherwise)	0.83	0.38	0.81	0.38
Marital sta. (=1 if unmarried, 0=others)	0.78	0.33	0.67	0.29
Off-farm (=1 if yes, 0=otherwise)	0.95	0.21	0.96	0.17
Subsidies (=1 if yes,0= otherwise)	0.28	0.45	0.30	0.46
Ext. service (=1 if yes, 0=otherwise)	0.82	0.36	0.83	0.37
Access to credit (=1 if yes, 0=access)	0.91	0.27	0.92	0.26
Food security (=1 if yes, 0= otherwise)	0.51	0.49	0.74	0.44

Table 2 Mean comparison test

Variables	Mean			
	Entire sample	Female HH	Male HH	T/Z score
Land area	1.13	0.97	1.15	-2.72**
Land value	52471.86	48154.26	53222.78	-5.10**
Rental value	3652.01	3369.64	3701.10	-5.95**
Inorganic fertilizer	57.68	54.03	58.28	-4.90**
Organic fertilizer	274.26	277.67	273.79	0.22
Total fertilizer	359.53	417.52	352.22	2.81**
Pesticide	0.14	0.08	0.15	-1.79**
Months of gyanu	4.04	3.95	4.05	-2.53**
Sold quantity	55.46	49.16	56.54	-1.14
Total value of sales	20572.01	19048.4	20835.56	-1.32
Farming experience	15.72	21.26	14.40	37.91**
Household size	4	5	4	57.61**
Capital	3735.28	4705.89	3569.02	7.18**
Medical cost	4815.27	4104.96	4988.51	-1.19
Educational level	1.45	1.82	1.40	50.80**
Seed	19.37	14.14	20.19	-4.69**
Seed cost	1134.12	1113.74	1137.33	-0.44
No. of farm visit by ext. age	1.42	1.68	1.38	1.24
Total hired labor	1.51	1.41	1.53	-2.46**
Income	2070.55	2219.59	2045.01	0.84
Age	43.21	47.7	42.5	57.54**
Output	346.07	414.39	335.18	6.14**
Transportation cost for sales	1072.41	1163.26	1056.69	0.77
Total sales of livestock	20962.73	243551.5	3186.54	4.40**
Irrigation	0.004	0.005	0.003	2.84**
Wetland	0.83	0.83	0.83	0.43
Marital status	0.69	0.78	0.67	0.56
Off-farm	0.96	0.95	0.96	-10.41**
Subsidies	0.30	0.28	0.30	-7.40**
Extension service	0.83	0.83	0.83	2.5**
Access to credit	0.92	0.91	0.92	-2.62**
Food security	0.71	0.51	0.74	-6.78**

Notes: * and ** indicate significance at the 10 and 5 percent level of significance, respectively.

Table 3. Estimation of maize production and technical efficiency in the Malawi

Variable	Female-headed farm households	Male headed farm households
Seed (kg)	0.85**(8.92)	0.56 (1.92)
Land area	0.18**(3.10)	0.22** (3.56)
Labor	-0.0008 (-0.76)	0.35** (3.76)
Land rental value	-0.52**(-3.22)	-0.423** (-2.22)
Constant	8.75**(6.28)	4.30**(4.80)
$\text{Ln}\sigma_v^2$	-0.92**(-5.46)	-0.87**(-5.21)
	Inefficiency components	
Subsidies coupon	-5.67**(-2.83)	-6.20** (-3.33)
Months of ganyu	0.78**(2.19)	0.81**(2.91)
Marital status	-10.74**(-3.48)	-6.54** (-2.48)
Extension dummy	0.17(0.73)	0.16 (0.63)
Credit constraints	-17.95**(-3.58)	-9.27** (-2.30)
Food security	9.89**(2.87)	7.40** (3.41)
Age	0.32**(3.09)	0.42**(3.19)
Education	-0.28(-0.08)	-0.18 (-0.07)
Constant	-6.77 (-1.35)	-7.19 (-1.45)

Notes: * and ** indicate significance at the 10 and 5 percent level of significance, respectively. Parentheses have *t*-statistics.

Table 4. Summary of technical efficiency

Summary statistics	Female-headed farm households	Male-headed farm households
Mean	0.78	0.64
Standard deviation	0.32	0.29
Min.	0.04	0.12
Max.	0.95	0.89

Table 5. Distribution of the TE of Malawi maize farmers

Range of TE	Female-headed farm households		Male-headed farm households	
	Frequency	%of farms in TE interval	Frequency	%of farms in TE interval
0.30<TE<=0.40	89	4.00	280	3.88
0.40<TE<=0.50	112	6.00	878	12.17
0.50<TE<=0.60	236	13.00	2056	28.51
0.60<TE<=0.70	445	24.53	3190	44.24
0.70<TE<=0.80	712	39.25	460	6.38
0.80<TE<=0.90	195	10.74	250	3.5
0.90<TE<=1.00	25	2	96	1.5
Total	1814	100	7210	100
TE	0.78		0.64	