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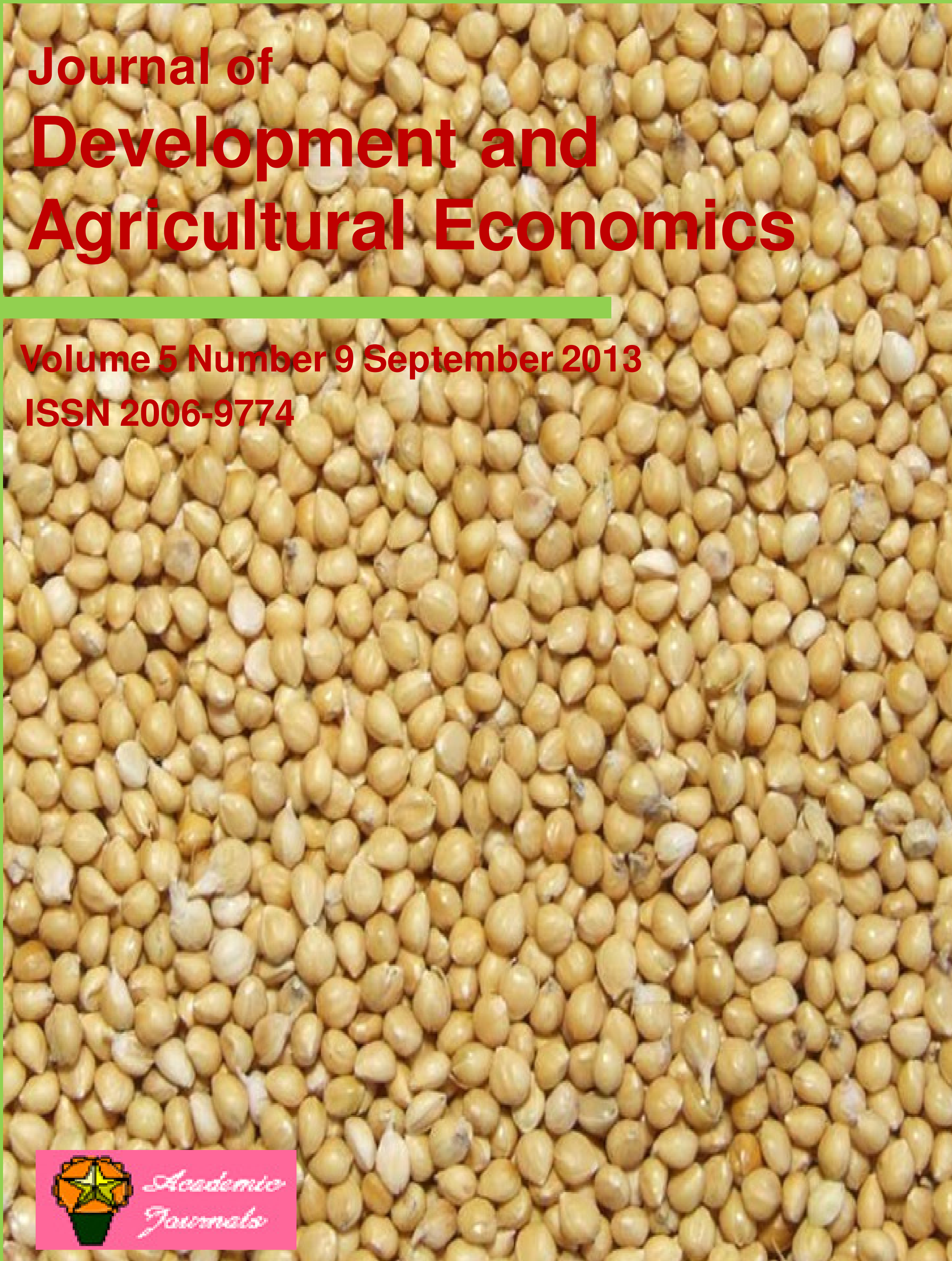

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Journal of Development and Agricultural Economics

Full Length Research Paper

Transaction costs and smallholder household access to maize markets in Zambia

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After liberalization of the Zambian economy, farmers were faced with the responsibility of finding the right buyers, negotiating prices and delivering produce leading to them incurring transaction costs. This study aimed at identifying and quantifying transaction costs factors and their impact on maize market participation for small holder farmers in Zambia. The study used primary data collected from a sample of 240 randomly selected households from Zambia's central Province. The Heckman's procedure was used to analyze factors affecting the likelihood and extent of participation in maize markets. The logit results (from the Heckman's two-stage process) show that ownership of assets such as radios and having access to alternative marketing channels increased the likelihood of market participation while the heckit results (OLS corrected for selectivity bias) shows that ownership of ox-carts, increased family size and experience in maize marketing were the factors that increased quantities of maize marketed. The study recommends provision of market information, improving accessibility to markets as well as increasing access to productive assets as means of alleviating impact of transaction costs.

Key words: Transaction costs, maize, market access, Zambia.

INTRODUCTION

Maize is one of the most important crops in Zambia. According to the Regional Agricultural Trade Expansion Support (2003), as a staple food, it comprises of up to 55% of the total dietary energy supply and affects food security and incomes of about 80% of the population. It also accounts for between 50 and 67% of the total area under cultivation (Central Statistical Office [CSO], 2002) and it is the single most important crop in the small scale sector in terms of gross value of production and crop sales. Although about 900,000 small-scale farmers account for over 65% of the total national production, they only contribute about 30% to the marketed surplus (Zulu et al., 2007). The smallholder maize market is also highly concentrated with more than 80% of the sales attributed to less than 30% of the sellers (Nijhoff et al., 2003). These low levels of market participation have been attributed to high transaction costs that make access to markets difficult (Kahkonen and Leathers, 1999). Due to differential access to assets, markets and information, transaction costs tend to be household specific and affects households differently leading to some being completely excluded from the markets.

The problems faced by smallholder farmers in marketing their produce have been linked to the liberalization of agricultural markets. For instance, Simatele (2006) argues that despite liberalization of the

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agricultural markets, the small-scale agricultural sector has been facing problems which are attributed to inadequacies in the marketing system for staples and agricultural inputs. Major among them, are the low prices of staples leading to problems of low real incomes for smallholder households and also food shortages (Nijhoff et al., 2003). Similarly, using historical trends in agricultural productivity, Yambayamba (2009) shows that since the market reforms of 1991, there has been a decline in absolute maize production, which they attribute to removal of fertilizer subsidies, the abolishment of pan-territorial pricing and the closure of maize collection depots in remote areas. These authors show that over the 12-year period between 1990/1991 and 2002/2003 seasons, the share of maize in total smallholder crop output declined from 76 to 55%. Similarly, Seshamani (1999) shows that the main adverse impact witnessed as a result of agricultural market liberalization were the negative supply response of the smallholder farmers due to the adverse impact on their incomes. This author shows that the index of maize production dropped from 145 in the 1989/90 growing season to 54 in the 1994/95 growing season. However, even though the area under maize cultivation fell by 4% in the 1996/1997 season compared to the previous (1995/1996) season, maize production fell by 32%, while maize sales fell by 53%. These declines in maize production and marketing are partly attributed to the fact that smallholder farmers experienced difficulties in accessing adequate and timely inputs, marketing of produce as well as in getting a fair price for their produce (Seshamani, 1999).

The above statistics show that low sales and non-participation in maize markets can be explained by both low production and reduced access to markets due to government withdrawal from providing support to smallholder farmers. For instance, whereas there have been several highly committed and well-funded efforts aimed at kick-starting a “green revolution” based on the understanding that agricultural productivity is a pre-condition for sustainable poverty reduction and improved living standards, they have been thwarted by their inability to anticipate and address downstream issues of marketing and governance (Jayne et al., 2007). Zambia's agricultural sector is also characterized by an inherent dichotomy in agricultural marketing, with smallholder traders facing an underdeveloped *informal* marketing system, and the more advanced large-scale traders and processers being part of a *formal* marketing system (Yambayamba, 2009).

Whereas the problem of low productivity has been extensively explored (Yambayamba*,* 2009; Zulu et al., 2007), the role that market access plays in leading to low maize productivity and sales has not received much attention, leading to misguided policies by government. For instance, government policies aimed at increasing the production of the national staple food (maize) have mostly revolved around increasing productivity through provision of subsidized inputs. To this effect, about 50% of the national agricultural budget has always been dedicated to provision of subsidized maize seed and fertilizer over the last eight years. This has been coupled with provision of extension services that are biased towards maize production. However, despite all these efforts aimed at increasing production, not much effort has been spent on assessing the role that access to markets play in stimulating production as well as market participation. This is despite some earlier studies (Kahkonen and Leathers, 1999) indicating that Zambian maize markets are riddled with high transaction costs leading certain potential participants being excluded from participating. As Seshamani (1999) points out, faced with a situation where government agents do not come to purchase his produce, the smallholder farmer has to go to the market centres to sell to them, which is not easy in view of the lack of transport to reach the markets. The author also shows that in the event that the farmer reaches the markets, he finds them to be buyers’ markets where the prices are not in his favor.

The fact that farmers do not only have to produce but also have to find the right buyers, they negotiate on prices and deliver their produce which leads them to incur transaction costs. According to Eggertson (1990), these are costs that arise when individuals exchange ownership rights for economic assets and enforce their exclusive rights[1]. They originate from activities such as searching for trading partners, screening partners, bargaining, monitoring, enforcement and transferring product (Key et al., 2000). These transaction costs may also include the costs associated with reorganizing of household labor and other resources in order to produce enough for the market (Makhura et al., 2001; Zaibet and Dunn, 1998). This paper attempts to explain the impact of transaction costs on maize market participation among the smallholder farmers in the Central Province of Zambia.

Transaction costs theory has been used to explain farmers’ behavior in both input and output markets. A study by de Janvry et al. (1991) showed that high transaction costs lead to missing markets for certain commodities. They concluded that in the absence of food markets households must be self-sufficient in terms of food, which confines their ability to reallocate land and labor to cash crops. These households tend to face wide margins between low selling price and high buying price. They also showed that the poorer the infrastructure, the less competitive the marketing systems, the less information is available, and the more risky the transactions which reduce the incentives.

In a study of household food marketing behavior in Senegal, Goetz (1992) used a range of factors to reflect the effect of transaction cost factors on the market participation in grain, both for buying and selling. For exogenous regressors, variables theoretically expected to

[1]Exclusive rights being defined as the power or in a wider sense, the right to perform an action or acquire a benefit and to permit or deny others the right to perform the same action or to acquire the same benefit.

affect quantities purchased and sold, as well as specific proxy variables for fixed transaction costs were used. These included ownership of carts for transportation to market, physical distance from market, number of persons in the household and a regional dummy variable separating study area into two regions with region being well integrated into the transport and communication infrastructure hence facing low information gathering costs while the other one was not. Other variables used included age of household head with older and more experienced heads expected to have greater contacts, which allow them to discover trading opportunities at low cost. An interaction term for information was also included. The study found that in the case of effects of fixed cost-type variables on market participation, better information plays an important role. For buyers, adding a person to the household raises the likelihood of market participation while ownership of assets was important in reflecting market access.

Key et al. (2000) extended Goetz's analysis by focusing on participation in maize markets in Mexico. Their study found that both fixed and variable transaction costs play a significant role in explaining household behavior. They also showed that ownership of assets such as transport equipment (pick-up) tends to reduce entry barriers into the market. Omamo (1998) used the transaction costs approach to determine households' decisions to rather devote resources to low-yielding food crops than to cash crops with higher market returns in Kenya. The analytical results show that transport costs are sufficient to explain the cropping choices. This implies that relatively more land is devoted to cash crops and less to food crops the closer the households are to markets. Matungul et al. (2001) used transaction costs theory to determine the determinants of crop marketing in South Africa. Using regression analysis, they found that the level of income generated from food crop sales by small-scale farmers is influenced by transaction costs and certain household and farm characteristics. Still in South Africa, a study to determine the role of transaction costs in participation of smallholder farmers in maize markets (Makhura et al., 2001) found out that transaction costs differ among households due to asymmetries in access to assets, market information, infrastructure and extension.

In Zambia, Kahkonen and Leathers (1999) analyzed changes in transactions costs for evidence of the private sector's ability to fill the vacancy left by government's withdrawal from agricultural marketing. Their assessment of the maize and cotton markets show that although there has been significant success in the private sector's response to liberalization, there are still many conditions that lead to inflated transactions costs especially at the farm level. They concluded that the limited competition among traders at the farm level in remote areas was the source of high transaction costs. Farmers are not well informed about prices in nearby markets, and find it difficult or impossible to search out alternative markets.

The factors contributing to these costs are the poor quality of roads, unavailability of transport, poor quality of communications infrastructure, and unavailability of credit. However, this study focused more on the impact of institutional arrangements (government interventions) on transaction costs, hence the need to study the farmer characteristics that influence the transaction costs they incur as they participate in the markets. This paper complements other studies by examining transaction costs at household level in Zambia. The objectives include identifying key transaction cost factors in the smallholder maize markets, examining their influence on the likelihood of market participation as well as their influence on quantities of maize marketed. In line with the Government's policy of increasing market access for smallholder farmers, this information would be useful to policy makers as an input in the design for interventions to enhance smallholder participation in maize markets.

METHODOLOGY

The study area, data sources and type

The study was carried out in Central province of Zambia. The dominant crops grown are maize, cassava, millet, groundnuts and beans. According to the 2010 population census (CSO, 2012) the population in the province was estimated at 1,307,111 which is about 10% of the national population. The population density is 10.7 persons per square kilometer. By stratifying the households into market participants and non-participants based on the 2005/06 agricultural season, 240 households were sampled using purposive quota sampling. Using a pre-tested structured questionnaire, data on socio-economic characteristics such as household, assets structure and factors like physical location and information access were collected. Household data included variables such as family size, age and education level of household head. Asset structure data comprised of ownership of assets such as bicycles, ox-carts, radios and televisions. These factors were used as proxies for transaction costs to test the main hypothesis that houses facing lower transaction costs had a high probability of market participation.

Theoretical framework

To incorporate transactions costs into an agricultural household model framework, it is convenient to specify market participation as a choice variable (Key et al., 2000). That is, in addition to deciding how much of each good i to consume c_i, produce q_i, and use as an input x_i, the household also decides how much of each good to "market" m_i (where m_i is positive when it is a sale and negative when it is a purchase). If there were no transactions costs, the household's objective would be to maximize the utility function:

$$u(c_a, c_m, c_l; z_u) \qquad (1)$$

where: c_a = household staple food (maize in this case); c_m = purchased good; c_l = home time
subject to:

$$\sum_{i=1}^{N} p_i^m m_i + T = 0 \qquad \text{(Cash constraint)} \qquad (2)$$

$$q_i - x_i + A_i - m_i - c_i = 0, \qquad i = 1,......,N$$ (Resource balance) (3)

$$G(q, x; z_q) = 0$$ (Production technology) (4)

$$c_i q_i, x_i \geq 0$$ (non-negativity constraint) (5)

where p_i^m is the market price of good *i*, A_i is an endowment in good *i*, *T* is exogenous transfers and other incomes, z_u and z_q are exogenous shifters in utility and production, respectively, and *G* represents the production technology.

Considering that in economic terms, transaction costs are costs paid by buyers but not received by sellers, and/or the costs paid by sellers but not received by buyers (Kissel, 2006), they effectively raise the price paid by a buyer and lower the price received by a seller (Minot, 1999). Although these costs are mostly unobservable and cannot be easily recorded (Key et al., 2000), factors that explain them can be observed (Heltberg and Tarp, 2001). Therefore, by introducing and expressing the transaction costs in monetary terms, the cash constraint becomes:

$$\sum_{i=1}^{N} \left[(p_i^m - t_{pi}^s(z_t^s)\delta_i^s + (p_i^m + t_{pi}^h(z_t^h))\delta_i^b \right] m_i + T = 0 \quad (6)$$

where δ_i^s is equal to one if $m_i > 0$ and zero otherwise, and δ_i^b is equal to one if $m_i < 0$ and zero otherwise. Introduction of transaction costs imply that the price effectively received by the seller is lower than the market price p_i^m by the unobservable amount t_{pi}^s, and the price effectively paid by the buyer is greater than p_i^m by the unobservable amount t_{pi}^b. Transaction costs are expressed as a function of observable exogenous characteristics, z_t^s and z_t^b, that affect these costs when selling and buying. As such, under transaction costs, the household's objective can be expressed by Equations (1) and (3) to (6), while to derive the supply and demand equations, we define the Lagrangian:

$$L = u(c; z_u) + \sum_{i=1}^{N} \mu_i (q_i - x_i + A_i - m_i - c_i)$$
$$+ \phi G(q, x; z_q)$$
$$+ \lambda \left[\sum_{i=1}^{N} [(p_i^m - t_{pi}^s)\delta_i^s + (p_i^m + t_{pi}^b)\delta_i^b] m_i + T \right] \quad (7)$$

where μ_i, φ, and λ are the Lagrange multipliers associated with the resource balance, the technology constraint, and the cash constraint, respectively. Because the transaction costs create discontinuities in the Lagrangian, the optimal solution cannot be found by simply solving the first order conditions (Key et al., 2000; Minot, 1999). The solution is decomposed in two steps, solving first for the optimal solution conditional on the market participation regime, and then choosing the market participation regime that leads to the highest level of utility. Under the usual assumptions for utility and technology, the conditional optimal supply and demand are obtained by solving for the first order conditions are as follows:

$$\frac{\partial u}{\partial c_i} - \mu_i = 0, \; i = \{i | c_i > 0\}$$ (for consumption goods) (8)

$$-\mu_i + \phi \frac{\partial G}{\partial q_i} = 0, \; i = \{i | q_i > 0\}$$ (for outputs) (9)

$$-\mu_i + \phi \frac{\partial G}{\partial x_i} = 0, \; i = \{i | x_i > 0\}$$ (for inputs) (10)

$$-\mu_i + \lambda \left[(p_i^m - t_{pi}^s)\delta_t^s + (p_i^m + t_{pi}^b)\delta_i^b \right] = 0$$ (for traded goods) (11)

The decision price p_i is given as: $p_i = p_i^m - t_{pi}^s$, if $m_i > 0$, for sellers; $p_i = p_i^m + t_{pi}^b$, if $m_i < 0$, for buyers; $\tilde{p}_i = \mu_i / \lambda$, if $m_i = 0$, For self-sufficient where $\tilde{p}_i$ is the autarky shadow price (ASP). Using the decision prices p_i and the first order conditions, utility maximization subject to the technological constraint leads to a system of output supply equations $q(p, z_q)$ and input demand equations $x(p, z_q)$. Utility maximization subject to the income constraint leads to a system of demand equations for consumer goods $c\ (p, y, z_u)$.

$$\sum_{i=1}^{N} p_i c_i = y = \sum_{i=1}^{N} [p_i (q_i - x_i + A_i) - t_{fi}^s \delta_i^b] + T \quad (12)$$

To derive the household supply curves for home produced goods as a function of the market price under fixed transaction costs (FTCs) and proportional transaction costs (PTCs)[2] (Figure 1), let $q(p^m, z_q)$ be the supply curve without transaction costs. Then with transaction costs, the supply curve is:

$$q^s = q(p^m - t_p^s, z_q)$$ for sellers (13)

$$q^b = q(p^m + t_p^b, z_q)$$ for buyers (14)

$$q^a = q(\tilde{p}, z_q)$$ for autarky (15)

Showing transaction costs shift the supply curve upward for sellers and downward for buyers. The supply curve is discontinuous with three distinct regions:

q^b = buyers supply curve for market prices below $\tilde{p} - t_p^b$ (16)

q^s = sellers supply curve for market prices below $\tilde{p} + t_p^s$ (17)

q^a = autarky price between the two thresholds (18)

[2]FTCs do not vary with the level of sales, while PTCs are those that vary with the level of sales.

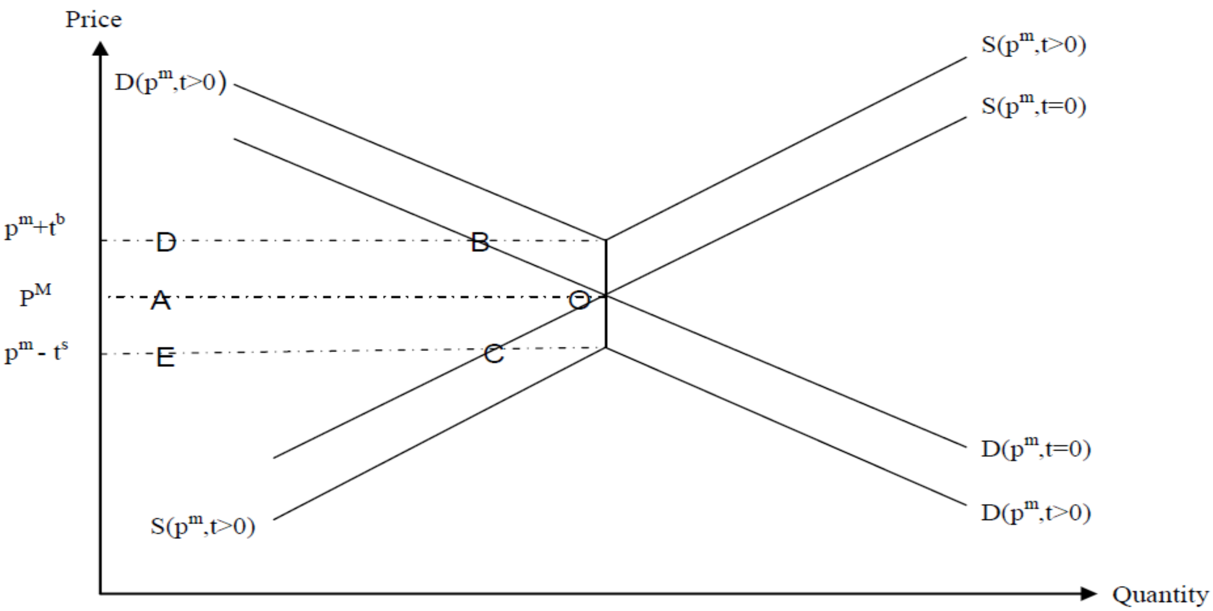

Figure 1. Household demand and supply under transaction costs. Source: Minot (1999).

This implies that fixed transaction costs delay entry into a market as a seller until market price reaches the higher level of $\tilde{p}+t_p^s$. Similarly, they delay entry into a market as a buyer until market price is as low as $\tilde{p}-t_p^b$. The household remains self-sufficient between these two thresholds. A household will switch from autarky to selling when the price that it receives is high enough to compensate for transaction costs.

Empirical model and estimation procedure

Assuming linear expressions:

$$q(p, z_q) = p\beta_m + z_q\beta_q \quad \text{(for supply functions)} \qquad (20)$$

$$t_p^s = -z_t^s\beta_p^t \quad \text{(for PTCs for sellers)} \qquad (21)$$

$$t_p^b = -z_t^b\beta_p^b \quad \text{(for PTCs for buyers)} \qquad (22)$$

This leads to linear expressions for the supply by sellers (q^s):

$$q^s = p^m\beta_m + z_t^s\beta_t^s + z_q\beta_q \qquad (23)$$

and by buyers (q^b):

$$q^b = p^m\beta_m + z_t^b\beta_t^b + z_q\beta_q \qquad (24)$$

and for autarky households supply (q^a):

$$q^a = z_q\beta_q^a + z_c\beta_c^a \qquad (25)$$

For production thresholds, linear expressions for $(\underline{q}^s)$ are used such that:

$$\underline{q}^s = z_t^s\alpha_t^s + z_q\alpha_q^s + z_c\alpha_c^s \qquad (26)$$

and for $(\underline{q}^b)$ such that:

$$\underline{q}^b = z_t^b\alpha_t^s + z_q\alpha_q^b + z_c\alpha_c^b \qquad (27)$$

The econometric specification is obtained by adding error terms to the supply equations:

$$q^s = p^m\beta_m + z_t^s\beta_t^s + z_q\beta_q + u_i \quad \text{(seller supply equation)} \qquad (28)$$

$$\equiv x_i\beta_i + u_i$$

$$\underline{q}^s = z_i^s \ \alpha_i^s \ + z_q\alpha_q z_c\alpha_c + u_2$$

(seller threshold equation) (29)

$$\equiv x_2\alpha_2 + u_2 \qquad (30)$$

Where x_i is a vector of exogenous explanatory variables such as household characteristics and location characteristics that influence market participation. The market participation indicator variable (q^s) for the commodity is defined as:

$\underline{q}^s = 1$, if $p^m \geq \tilde{p}+t_f^s$ or $p^m \leq \tilde{p}-t_f^s$ (when a household sells) (31)

Table 1. Variables used and hypothesized relationships.

Variable description	Variable	Hypothesized relationship	
		Participation decision	Participation level
Ownership of bicycle	D2	+	+
Ownership of ox-cart	D3	+	+
Ownership of radio	D4	+	
Availability of alternative channels	D5	+	+
Listening to agricultural programs	D6	+	+
Ownership of television	D7	+	
Membership to farmer associations	D8	+	+
Size of harvest	QHST	+	
Age of household head	AGE	+	+
Distance to nearest maize markets	DIST	-	-
Education level of household head	EDU	+	
Household size (number of adults)	HHS	+	+
Frequency of listening to radio	FRR	+	+
Experience in maize marketing	EXP	+	+

$q^s = 0$, if $\tilde{p} - t_f^s \leq p^m < \tilde{p} + t_f^s$ (when a household does not sell) (32)

Data analysis

Under transaction costs, households face a two-stage decision problem (Winter-Nelson and Temu, 2003; Key et al., 2000; Makhura et al., 2001; Goetz, 1992). The first decision, is whether to trade or not and the second is how much to trade and is conditional on participation as a buyer or seller. Because some households participate in the market while others do not, if ordinary least squares regression (OLS) is estimated, the non-participants will be excluded introducing a sample selection bias in the model (Gujarati, 2004). Therefore, in order to analyze the factors affecting the probability and extent of participation in maize markets, a two-step Heckman's procedure (Heltberg and Tarp, 2001; Makhura et al., 2001; Nkonya et al., 1998; Goetz, 1992) was used. This involved two estimation steps. In step one, a logistic regression model was estimated to give the estimated probability that a house *i* purchased or sold maize. In step two, the intensity of participation was estimated by running a heckits that is OLS corrected for selectivity bias. This was run on observations for which sales were greater than zero.

$$P(SAL) = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_4 D_{4i} + \alpha_5 D_{5i} + \alpha_6 D_{6i} + \alpha_7 D_{7i} + \alpha_8 D_{8i} + \beta_2 QHS + \beta_3 AGE + \beta_4 HHS + \beta_5 EDU + \beta_6 DIST + \beta_7 FRR + \beta_8 EXP + U_1 \quad (33)$$

The results from Equation (33) showed the influence of independent variables on the probability of maize marketing (*δPr/δx*). The second model (step two) was used to identify the factors affecting the quantities of maize sold and was expressed as:

$$QTY = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \alpha_5 D_{5i} + \alpha_9 D_{9i} + \beta_3 AGE + \beta_4 HHS + \beta_6 DIST + \beta_7 FLR + \beta_8 EXP + \sigma IMR + U_2 \quad (34)$$

Where *QTY* = Quantity of maize sold while all the other independent variables are the same as those used in step one except for dummies for radio and television as well as quantity harvested and education variables. This model was run using data from market participants only and included an inverse mills ratio (IMR) to correct for selectivity bias. It was used to estimate the impact of exogenous variables on quantities of maize sold. Table 1 shows the hypothesized relationships between the explanatory variables and probability of maize market participation as well as quantities of maize marketed.

RESULTS AND DISCUSSION

Quantitative factors affecting transaction costs

Comparisons show that the mean harvest size, mean asset value and mean land holding for market participants, were significantly higher (P ≤ 0.05) than for non-participants (Table 2). The mean distance from commercial centres and main roads for participating households was also significantly lower (P ≤ 0.05) than for non-participants. However, the average household age, mean household size and years of formal education attained by the household head were not significantly different between the two groups.

Effects of transaction cost on decision to participate in maize markets

Table 3 presents the results of the logit estimations of factors influencing the decision to sell maize. The model χ^2 (14) was 132.544 (and significant at the five percent level) implying that the model was predicting decision to sell better than if only the constant had been used. The R-Square of 0.708 indicates that 70.8% of the variation in the decision to sell maize can be explained by the independent variables in the model. The significant transaction costs factors influencing decisions to

Table 2. Comparison of quantitative transaction cost factors between market participants and non-market participants.

Variable	Non-participant (n = 105)	Participant (n = 135)	F-Statistic
Mean size of harvest (50 kg bags)	14.65	87.69	27.57**
Mean value of assets (million Kwacha)	3.15	8.89	15.34**
Mean age of household head (years)	46.60	45.72	0.13
Mean household size (number of adults)	6.45	6.78	0.04
Mean distances from commercial centres (km)	5.84	3.63	16.97**
Years of formal education completed by Household Head	8.05	9.00	0.09
Mean size of land holding (hectares)	5.17	19.07	6.99**

**Significant at 5%; *Significant at 10%.

Table 3. Factors determining households' decisions to participate in maize markets.

Variable	Coefficients	Standard error	*Exp(B)*
Constant	-1.859	1.664	0.264
Ownership of radio	2.191**	0.799	8.946
Ownership of television	2.479**	0.824	11.933
Own mobile phone	-2.436**	0.834	0.088
Listening frequency programs	-0.114	0.068	0.999
Distance to main markets	-0.372**	0.108	1.449
Ownership of bicycle	-0.185	0.831	0.539
Ownership of ox-cart	1.513*	0.853	4.540
Availability of multiple channels	1.818**	0.543	6.162
Education of household head	0.028	0.047	1.029
Age of household head	0.006	0.021	1.006
Household size (Number of adults)	-0.066	0.089	0.936
Size of maize harvest	0.093**	0.022	1.097
Membership to farmer groups	-0.114	0.575	0.892
Experience in maize marketing	-0.043	0.033	0.958
R^2=0.708 (Cox and Snell) $\chi^2(11) = 132.544^{**}$			

**p < 0.05, *p<0.10; Dependent variable: Sold maize in 2005/6 season; sample size: n= 220.

participate in maize markets were ownership of radio, ownership of television, availability of multiple maize marketing channels, distance to maize markets, ownership of ox-carts and the harvest size. Ownership of assets such as radio and television enables households to acquire market information at a lower cost thus reducing expenditure on search, negotiation and screening costs (Key et al., 2000; Goetz, 1992). This reduces the magnitude of the transaction costs thus increasing the probability of market participation for the household.

Presence of alternative marketing channels increases the efficiency of the marketing system through prevention of monopolistic tendencies (Minten, 1999; Kirsten and Vink, 2005) where short distance to markets reduces the magnitude of the transaction costs by reducing the amount of time and money spent in search for information. By reducing information asymmetry between buyers and sellers, these factors reduce the magnitude of transaction cost thus increasing the probability of maize market participation. Size of the harvest was found to significantly increase household's probability of maize marketing. This has been explained by the fact that those smallholder farmers who were faced with challenges in maize marketing responded by switching to other crops (Zulu et al., 2000; Seshamani, 1999). Similar results have been reported in South Africa (Matungul et al., 2001; Makhura et al., 2001) where households with larger maize harvests were likely to have surpluses for sale. Age and education level of the household head, maize marketing experience and membership to farmer organizations were not significant.

Effect of transaction cost factors on level of maize sales

Table 4 presents the results of the factors determining

Table 4. Factors influencing the quantities of maize sold by households.

Variable	Coefficient	Std. error	t-statistic
Constant	35.180	25.274	1.392
Experience in maize marketing	0.577*	0.323	1.777
Age of household head	-0.327	0.328	-0.995
Household size (Number of adults)	3.480**	1.515	2.298
Membership to farmer associations	-9.903	8.702	-1.046
Availability of alternative channels	-4.539	1.326	-0.440
Distance to commercial centers	-2.339	1.848	-1.265
Frequency of listening to radio	3.331**	1.139	2.925
Ownership of ox-carts	44.243**	10.272	4.304
Ownership of bicycles	1.398	9.264	-0.151
LAMBDA (IMR)	-26.145**	12.189	2.145
R^2	0.445		
Adjusted R^2	0.395		
S.E. of estimate	44.25		
F-Statistic	8.823		
Prob. (F-Statistic)	0.000		

** P < 0.05, *P<0.10. Dependent variable: Number of bags of maize sold; Sample size: n = 90.

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the quantities of maize sold by the households. The R^2 and adjusted R^2 were quite low (0.445 and 0.395 respectively) which is not unusual for cross sectional data, while the overall significant fit (F) was 8.823 indicating that the data correctly fits the model. The coefficient on the inverse mills ratio (lambda) was significant at five percent level indicating that correlation between the error terms of the decision to sell (u_1) and level of market participation (u_2) was different from zero, $\sigma_{\varepsilon u} \neq 0$. This implies that sample selection bias would have resulted if the level of maize sales had been estimated without taking into account the participation decision.

The significant transaction costs factors influencing the quantities of maize marketed were household size, experience in maize marketing, frequency of listening to agricultural programs on the radio and ownership of ox-carts. As the household size increased by one adult, the quantity of maize sold by the household would increase. Although family size has two opposing effects with large family size implying large food demand thus reducing marketable surplus, large family size also implies increased labor supply (Makhura et al., 2001). Considering that the sampled households depended on family members for labor supply, the larger the number of adults in the household, the more labor they had and the more maize they were likely to produce. An increase in maize marketing experience also increased the quantities of maize sold. Experience in maize marketing makes certain information and search costs low (Goetz, 1992; Makhura et al., 2001) due to prevalence of social networks. Experienced households may also have greater contacts and increased trust gained through repeated exchange with the same parties (Kirsten and Vink, 2005) allowing them to discover trading opportunities at lower costs.

By reducing the unit cost of production and delivering produce to the market, assets such as oxen reduces variable transaction costs faced by households leading to higher levels of market participation (Key et al., 2000). The regression results show that households that owned ox-carts marketed 2,200 kg more than those that did not own ox-carts. This observation may be explained by the fact that most transactions were being conducted either at the market centers or trader's premises with farmers bearing the cost of delivering the produce. Similar results have been reported in Mozambique (Heltberg and Tarp, 2001), Mexico (Key et al., 2000) and South Africa (Makhura et al., 2001).

CONCLUSION AND RECOMMENDATIONS

The results show that high transaction costs negatively influence the decision to participate in maize markets as well as the quantities marketed in Zambia. Based on these findings, it is recommended that information be provided for farmers, through existing government agencies such as the National Agricultural Information Services (NAIS) on who is buying maize, at what prices they are buying and the location of these buyers using mass media such as radio and television. To increase the likelihood of market participation, action should be taken to increase farmers' access to marketing channels through increased access to transport which also minimises the impact of distance on those farmers located far away from major maize trading centres. This can be achieved by improving on the quality of rural roads by rehabilitating feeder roads connecting villages to major trading centres and highways so as to encourage private transporters to venture into these rural areas. Furthermore, public investments that raise smallholders' productivity, such as improved seeds availability and innovative extension programs should be intensified while actions aimed at increasing household's productive asset base such as ox-carts should also be intensified through provision of affordable loans as well as work-for-asset programmes which are already being implemented in some areas.

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Food crop supply in sub-Saharan Africa and climate change

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This study estimates the impact of climate change on supply for the four most common crops (millet, maize, sorghum and cassava) in sub-Saharan Africa (SSA). The analysis relates crop supply, measured as cropped area, to weather, climate and prices. Crop supply functions are estimated using an error correction model (ECM) built on panel data. Crop supply through 2100 is predicted by combining estimates from the panel data analysis with climate change predictions from 20 general circulation models (GCMs). Results indicate climate change impacts on crop supplies ranging from -20 to +133% compared to a scenario of no climate change.

Key words: Food crop supply, climate change, error correction model.

INTRODUCTION

Food crop production is essential in developing countries, especially sub-Saharan Africa (SSA) where agriculture is the main source of food and livelihood (Badiane and Delgado, 1995). However, agriculture is particularly vulnerable to weather in SSA where 97% of agricultural land is rain fed (Rockström et al., 2004). The impact of climate change on crop supply is therefore a major concern in this region.

Crop supply analyses generally estimate the responsiveness of agricultural production to price incentives. In SSA, where most of the population is rural and depends on domestic food crop production for subsistence, the influence of price changes on production decisions is disputable. The effect of price on African cash crop supply response has been widely considered (Parikh, 1979; Bond, 1983; Hattink et al., 1998; Thiele, 2003; Douya, 2008). The small number of studies focusing on food crops concludes that price changes have a small effect on supply decisions (McKay et al., 1998; Rahji et al., 2008). Other factors, such as weather and climate, may be more important in determining supply in developing countries.

While several studies have assessed the impact of climate change in Africa, most studies focus on crop productivity (Ben Mohamed et al., 2002; Van Duivenbooden et al., 2002; Jones and Thornton, 2003; Thornton et al., 2009; Schlenker and Lobell, 2010). Studies estimating the impact of climate change on crop supply are scarcer and mainly consider impacts at the global level using computable general equilibrium (CGE) models (Adams et al., 1995; Darwin et al., 1995; Adams et al., 1999). Within the relatively small number of regional studies, most supply functions focusing on developing countries are estimated using econometric techniques, but do not consider the impact of climate change (de Vries 1975; Bond, 1983; Mendelsohn et al., 1994; Subervie, 2008). This study fills this gap by quantifying the effects of climate change on crop supply in SSA using an econometric analysis. The supply function can be estimated either at the aggregate level

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(Bond, 1983; McKay et al., 1998; Thiele, 2003) or at the commodity level (Parikh, 1979; Hattink et al., 1998; Douya, 2008; Rahji et al., 2008), while aggregation enables estimation of more general supply responses, it provides rather inelastic short run effects (Binswanger et al., 1987) and does not allow determination of the specific effect of one input on a particular output (Just et al., 1983). As crop supply responses to changes in inputs, and especially weather, may vary considerably from crop to crop, this study estimates separate supply functions for each of the four main cultivated crops in SSA: millet, maize, sorghum and cassava.

Modeling framework

Functional form

Agricultural supply functions are generally estimated using either a profit maximization framework or econometric techniques. The profit maximization method is not suitable for this study as the assumption of profit maximization does not necessarily hold for African farmers (Ogbu and Gbetibouo, 1989; Udry, 1999) and input prices are not available for SSA. The Nerlovian model (Nerlove, 1956), which models farmers' supply decisions in terms of price expectations and/or partial area adjustments, has been extensively used to estimate agricultural supply response. However, several problems are associated with estimation of the Nerlovian model. The first issue relates to the partial adjustment representation through the inclusion of lagged output as an explanatory variable. Lagged output is likely to be linked to lagged prices through a demand function relationship. Therefore, estimates of the long-run supply elasticity may be biased (Braulke, 1982).

Moreover, as acknowledged by Nerlove (1979), the partial adjustment model implies that output at period t adjusts in an ad hoc fashion by a fraction of the change required to attain desired output. Also, the assumption that the desired output level is fixed is questionable. The second issue regards the estimation of long-run price responses. When both partial adjustment and adaptive price expectations are included in the model, it is not possible to estimate long-run elasticities unless certain restrictions are applied (Nerlove, 1958). Some issues regarding the estimation of the Nerlovian model have been addressed by modifying the original model (Leaver, 2004) and using panel data (Thiele, 2000).

The supply function can be reformulated as an error correction model (ECM). The ECM is preferable to the Nerlovian model for several reasons: (i) it addresses the problem of spurious regression that can be present when using non stationary time series; (ii) it enables separate estimation of short and long-run elasticities; and (iii) it relaxes the restrictive adaptive assumptions imposed by the dynamic specification of the Nerlovian model and is representative of 'forward-looking behaviour' (Thiele, 2000). ECMs have been preferred to partial adjustment models in many studies of agricultural supply response in SSA, both at the aggregate level (McKay et al., 1998; Muchapondwa, 2009) and the individual crop level (Alemu et al., 2003; Mose et al., 2007; Nkang et al., 2007).

Regression specifications

A general crop supply function can be specified as:

Ait = f (Priceit-1, Weatherit-1, Riskit-1)

Where for each crop i at time t, A represents the area harvested, Price is a vector of price variables, Weather is a vector of weather variables and Risk is a vector of risk factor.

According to Askari and Cummings (1977; p. 260) "planted acreage is generally the best available method of gauging how cultivators translate their price expectations into action." However, these authors also argue that farmers are more interested in adjusting output to price changes than area under cultivation. They assume that farmers can influence output levels by increasing other production factors such as fertilizer, labor and irrigation. However, when considering SSA, where fertilizer and irrigation are scarcely used, these output adjustment possibilities are limited. Additionally, area cultivated is a better indicator of production planning as it is independent of contemporaneous weather events (Coyle, 1993). Therefore, area cultivated is the preferred output measure in this study.

The effect of price on supply responses in Africa is usually estimated by considering agricultural aggregates (Bond, 1983; McKay et al., 1998; Thiele, 2003) or export and cash crops (Parikh, 1979; Hattink et al., 1998; Douya, 2008). The few statistical studies that consider the supply response of food crops to price incentives find small elasticities (McKay et al., 1998; Rahji et al., 2008). These small price effects are plausible in the SSA agricultural sector, which is mainly characterized by subsistence farming (Amissah-Arthur, 2005; NRC, 2008). African subsistence farmers have limited roads and transportation means, which isolate them from markets (NRC, 2008). Isolation and lack of spending possibilities further limits income needs and therefore price incentives. The effect of prices can also be hidden by crop rotation practices where crops are substituted form year-to-year independently of price changes (Bhagat, 1989). Alternatively, crop supply decisions can be influenced by the price of other potentially cultivable crops through a substitution effect. Cash crop prices can also have a complementary effect with food crops.

In Africa, inputs such as fertilizers are accessed mainly by cash crop farmers through commodity supporting institutions (e.g. cotton parastatals in Benin (Minot et al., 2000). Cash crop farmers may use part of their inputs to cultivate food crops. However, studies generally find low export crop price elasticities for food production in SSA (Jaeger 1991; McKay et al., 1998). The supply responses to price rises can differ from responses to price reductions. Asymmetric response studies generally demonstrate that farmers adapt their supply more readily to prices increases than to price decreases (Olayemi and Oni, 1972; Ngambeki and Idachaba, 1985). Crop supply is usually also influenced by input prices, but it is not necessarily applicable in SSA, as very little capital and other related inputs are used in traditional crop production (Wolman and Fournier, 1987). Labor, which is the major production factor in agricultural production (IAC, 2004) is composed mainly of family members (Upton, 1987). Input prices are therefore not included in the specification.

Farmers decisions regarding the area allocated to each crop can be influenced by weather expectations and observed climate change. Weather forecasts and their timing are important for farming decisions such as planting and harvesting (Smit and Skinner, 2002). However, their use for subsistence farmers in developing countries is a challenge due to credibility, geographic scale, understanding ability, broadcasting barriers and information range availability constraints (Patt and Gwata, 2002). For instance, based on field surveys of small farmers in semi-arid Kenya, Recha et al. (2008) reveal that the majority of farmers do not trust meteorological forecasts and only a small number make decisions based on climate forecasts. Given the low reliance of farmers on weather forecasts, farmers base their decisions on perceived climate change over previous years. African farmers appear to be good at detecting changes in climate. Based on a large survey of African farmers, Maddison (2006) and Nhemachena and Hassan (2007) revealed that a significant number of farmers correctly perceive changes in climate, especially experienced farmers. To account for the effect of weather on crop area decisions, studies generally consider previous year weather events (Brons et al., 2004) or weather events before planting (Lahiri and Roy, 1985; Alemu et al., 2003). Given the large number of countries considered in this study, and hence diversity in cropping seasons, weather events from previous years are considered to determine planting decisions.

African subsistence farmers are risk adverse (Bond, 1983) and endure remarkably greater risks than other farmers (Collier and Gunning, 1999). In SSA, weather and market dependency are the main risk factors considered in crop selection decisions (Bond, 1983). Aversion for weather risks can induce a preference for drought resistant crops rather than high-yield crops (Bond, 1983) or diversification of activities across food and cash crops, livestock and wage employment (Collier and Gunning, 1999). Some empirical crop supply analyses use the standard deviation of rainfall to represent weather risk (Savadatti, 2007). The risk of market failure to provide supplies and food discourages diversification of production in Africa (Bond, 1983), and price instability also affects investment decisions (Boussard et al., 2005). The effect of market risk on crop supply is usually investigated using the standard deviation of prices and has a negative effect on supply (Sangwan, 1985; Savadatti, 2007; Huq and Arshad, 2010).

Other constraints such as inadequate transportation infrastructure, communication channels, market structure and financial and agricultural services, limit access to supplies and services required by African farmers (Bond, 1983; Demery and Addison, 1987). These factors are not included in the analysis due to data limitations. Population density, which influences specialization and unit infrastructure costs (Boserup, 1965), is not considered as annual population data are obtained by interpolation from lower frequency data. Therefore, inter-annual variations cannot be accurately represented.

To estimate the supply function, two alternative specifications are considered. The first, called the LAG model, relates area cultivated to prices and weather effects from the previous year, as is common in the literature. The second, called the MAVG model, assumes farmers have a long-term memory and relates area cultivated to price and weather variables from multiple years. The LAG model is specified as:

$$\ln A_{it} = f(\ln CP_{it-1}, CPinc_{it-1}, \ln CCP_{it-1}, XPI_{t-1}, T_{it-1}, P_{it-1})$$

This specification includes the crop producer price, CP, from the previous year to avoid endogeneity issues. Price asymmetry is investigated by including a dummy variable, CPinc, equal to one when crop prices increase and zero otherwise. Additionally, the first lag of price of the main competing crop, CCP, is included to represent substitution effects between crops. An export crop price index, XPI, is included in the analysis to account for either complementarily or substitutability among the crop considered and export crops. The impact of weather is considered using precipitation and temperature variables, which are observable by farmers. Other weather variables such as carbon dioxide concentration and evapotranspiration also affect crop productivity (Cure and Acock, 1986; Maunder, 1992; Pandey et al., 2000; Abbas et al., 2005). However, these variables are excluded from this analysis as it is unlikely that farmers can perceive or measure changes in such factors and therefore base production decisions on these variables. Cumulative precipitation, P, and average temperature, T, variables are considered over a 12-month period. Given the wide range of cropping seasons within and across countries, it is not possible to include weather during pre-planting periods for each crop. Also, as area data are only available annually and at the country level, it is not possible to determine area allocation per growing season for countries having two growing seasons. Therefore, precipitation and weather are considered using annual averages over the previous year. The MAVG model is specified as:

lnAit = f (it, it , it , it, it, it)

In this specification, only the average of export crop prices over the previous five years is included to capture price effects. A period of five years is selected as it produces the highest coefficient of correlation between area cultivated and price variables. The model does not include own-crop price and competing crop price, as data is only available from 1966 and a 5 year average would greatly reduce the sample size. Climate is considered as a weather average over the previous 10 years, which produces the highest coefficient of correlation between areas cultivated and weather variables. Risks are accounted for by including standard deviations of prices, during the previous 5 years, and weather variables and during the previous 10 years.

In both LAG and MAVG specifications, area and price series are log transformed to obtain price elasticities. However, climatic variables are kept in levels to allow the interpretation of the influence of, say, an additional degree Celsius, more meaningful. The estimation procedure follows a general-to-specific strategy. Specifically, in the LAG model, crop price, price asymmetry and competing crop prices are excluded if they are insignificant from the full specification in order to obtain a larger sample, as all other variables are available over a longer time period (from 1961). In the MAVG model, risk and extreme event variables are excluded in the final specification if they are not significant.

Data

Area harvested for each crop at the country level are sourced from FAOSTAT (2007). Using area harvested to represent supply is not ideal as area harvested excludes area sown or planted that is not harvested due to, for example, natural calamities or economic considerations (FAO, 2010). However, planted area data are not available over long time periods and large regions. To account for differences between planted and cultivated area, drought and flood dummies for the current year are included as explanatory variables to represent extreme climatic events. Drought and flood variables are constructed following Blanc (2012). War dummies are included to account for area not harvested due to extreme political conditions. War data are obtained from the Uppsala Conflict Data Program/International Peace Research Institute (UCDP/PRIO) armed conflict dataset (Gleditsch et al., 2002).

Price data are sourced from FAOSTAT (2007) at the national level from 1966 to 2006. Competing crop prices series are created using the price series of the crop with the largest area harvested on average over the study period (1961 to 2002) in each country. If the crop with the largest area is the crop considered, then the competing crop is the crop with the second largest area harvested.

Crop prices are converted from local currency into a common unit (international dollars) using Summers and Heston's PPP real exchange rates extracted from the Penn World Tables version 6.2 (Heston et al., 2006). Export crops prices are represented by the agricultural export unit value index provided by FAOSTAT (2007) from 1961 to 2002.

Weather data are obtained from the CRU TS 2.1 dataset (Mitchell and Jones, 2005). Data at the 0.5 × 0.5 degree resolution are available over the period 1901 to 2002. Satellite-derived land cover data from Leff et al. (2004) are used to restrict weather data to crop production areas. Crop growing location data representative of the 1990s are also available at the 0.5 × 0.5 degree resolution. Weather data for each crop are weighted by area harvested for each crop in each grid cell, relative to the total area harvested.

Data summary statistics for each crop are reported in Table 1. Cultivated area increased for all crops and the most widely harvested crop is sorghum. Real crop prices are generally increasing over the study period. Export price index series increase until the 1980s, stagnate in the mid-1980s and a slowly decrease thereafter. Over the period 1961 to 2002, temperatures generally increased and precipitation decreased slightly.

METHODOLOGY

A panel analysis is preferred in this study to increase sample size, and because panel methods allow the user to control for time invariant unobservable factors that might affect the estimated coefficients. However, panel estimations assume that the set of determining factors and the impact of each factor on agricultural outcomes is the same for all countries, which is questionable when considering a large number of countries. Most SSA countries are low income countries (Diao et al., 2006) and while African countries generally share similar economic characteristics (Collier, 1993), various agricultural systems coexist (Dixon et al., 2001). Based on growth potential for these different farming systems and their prevalence in each country, Diao et al. (2006) distinguishes African countries with less favorable agricultural conditions (LFAC) from countries with more favorable agricultural conditions (MFAC). LFAC countries include Botswana, Burundi, Chad, Gabon, Madagascar, Mali, Mauritania, Namibia, Niger and Rwanda.

Parameter heterogeneity is investigated by interacting explanatory variables with LFAC dummies, where the LFAC dummy equals one for LFAC countries and zero for MFAC countries. Considering agricultural conditions also allows the analysis to account for the effect of different omitted parameters. For instance, LFAC countries have systems with low growth potential that can be characterized by small farm size, poor infrastructure, lack of resources and/or appropriate technologies, or slow market place development, which are not modeled. Alternatively, countries with more favorable conditions are composed of irrigated or inter-cropping systems that have a good agricultural growth potential. As a result, the effect of weather will be more important in LFAC countries and weather-LFAC interactions allow the regressions analyses to capture such differences.

Prior to estimating the production function, it is necessary to

Table 1. Summary statistics.

Variable	Name	Crop	Obs	Mean	Std dev	Min	Max
Area	A	Cassava	1428	233,070	456,849	0	3,446,000
		Maize	1554	387,204	608,123	936	5,472,000
		Millet	1302	457,671	980,445	0	5,814,000
		Sorghum	1386	467,515	1,092,950	375	7,809,000
Temperature	T	Cassava	1428	24.7	2.5	18.1	29.2
		Maize	1554	24.3	3.5	10.7	29.4
		Millet	1302	24.9	2.9	18.6	29.5
		Sorghum	1386	24.5	3.7	10.6	29.5
Precipitation	P	Cassava	1428	1260	541	218	3269
		Maize	1554	1061	482	79	2822
		Millet	1302	992	457	88	2960
		Sorghum	1386	987	474	60	2961
Crop price	CP	Cassava	555	290	311	31	2061
		Maize	555	413	283	39	2055
		Millet	444	507	357	47	2042
		Sorghum	481	436	343	41	2408
Competing crop price	CCP	Cassava	555	578	599	39	4122
		Maize	555	650	633	32	4122
		Millet	444	628	651	32	4122
		Sorghum	481	590	637	32	4122
Export price index	XPI	All crops	1470	101	70	8	483

determine whether or not the data are stationary (that is, the mean and variance remain constant over time) to determine whether 'standard' regression techniques can be used or if a cointegration approach is required to avoid finding a spurious relationship among variables. Stationarity is investigated using the Elliott-Rothenberg-Stock (ERS) test (Elliott et al., 1996). A constant and a time trend are included in the test as the data generating process is not known a priori. Initially, the test is performed on variables in first difference to ensure that the series are not integrated of an order higher than one, and thereafter performed on the level of the series. All variables that are not integrated of an order greater than one are tested for cointegration. Time series are said to be cointegrated if variables share the same stochastic trend so that a linear combination of them is stationary. In this case, a long-run relationship exists and the relationship is not spurious. To determine if a relationship exists between crop supply and postulated determinants, a formal test of cointegration is applied. A cointegration test developed by Westerlund (2007) is preferred as it allows for dependence within cross-sectional units.

The choice of estimator depends on the model to be estimated and the properties of the data. In this analysis, diagnostic tests are used to test for individual fixed effects (that is, the presence of permanent differences between countries), time effects (that is, the presence of effects that vary over time but not across countries), cross-sectional and serial correlation (spatially and temporally correlated errors can lead to underestimate standard errors), and homoskedasticity (standard errors are no longer valid when the assumption of homoscedasticity, that is, the variance of the error term is constant, is not satisfied). An F-tests is used to test for the significance of individual and time effects. The Breusch-Pagan (described in Greene, 2000; p. 601) and Pesaran (2004) tests are used to test for cross-sectional independence. Arellano and Bond (1991) test is applied to test for the absence of autocorrelation. Heteroskedasticity is tested using the panel heteroskedasticity test described by Greene (2000).

The estimation procedure is determined by the results of the different tests presented above. Depending on the stationarity and cointegration tests results, the specification is estimated in levels, first differences or using an ECM. The diagnostic tests outlined above are then implemented to determine the proper estimator for each regression.

REGRESSION RESULTS AND DISCUSSION

Results at the completion of the general-to-specific estimation procedure (final regression results) for the LAG model and the MAVG models are presented. A summary of the specification for each model is presented in Table 3. As mentioned earlier, we follow a general-to-specific estimation which consists of excluding insignificant control variables from the full specification (that is, crop price, price asymmetry and competing crop prices in the LAG and model and risk and extreme event variables in the MAVG model).

ERS unit root tests indicate that most series are

Table 2. Diagnostic tests statistics.

H_0	Model	Cassava	Maize	Millet	Sorghum
No cointegration	LAG	-11.405	-17.716***	-12.983	-16.822**
	MAVG	-22.372***	-20.866***	-18.46***	-20.562***
Cross-sectional independence	LAG	-0.082	0.387	-1.794*	-2.153**
	MAVG	2.919***	0.830	-2.596***	-1.839*
No autocorrelation of order 1	LAG	-1.052	-3.340***	-2.845***	-3.299***
	MAVG	-1.07	-3.340***	-1.799*	-3.299***
Homoskedasticity	LAG	16,678***	8,093***	3,963***	1081***
	MAVG	8,154***	5,966***	1,121***	1,105***

Note: ***, ** and * denote significance at the 1, 5 and 10% level, respectively.

stationary in first difference [that is, I(1)]. The models should be estimated using first differences except when a long-run relationship between the variables exists. Westerlund's (2007) panel cointegration test is therefore performed for each regional regression. Based on Westerlund's (2007) panel cointegration tests statistics reported in Table 2, ECMs are estimated for maize and sorghum in the LAG model (cassava and millet are estimated in first difference) and for all crops in the MAVG model. Guided by results from diagnostic tests, Driscoll and Kraay (1998) standard errors, which are robust to general forms of cross-sectional dependence, autocorrelation and heteroskedasticity, are estimated.

LAG model

Final regression results for the cassava LAG supply function are presented in Table 4. Coefficients for the error correction term, ECTt-1, are significant, supporting the cointegration test results for maize and sorghum presented in Table 2. The largest ECTt 1 coefficient is observed for maize (-0.26) and indicates that about a quarter of the disequilibrium is corrected each year.

The coefficient of own-crop prices and competing crop prices do not significantly influence cultivation decisions and are not reported in Table 4. This finding is consistent with the fact that the food crops considered are mainly grown for domestic consumption. The export crops price index (XPI) has a significant and positive effect on maize area, indicating a complementarity effect between maize and export crops. As noted earlier, inputs such as fertilizers are accessed mainly by cash crops growers in SSA. Therefore, an increase in export crop prices inducing an increase in cash crop supply entails, in parallel, an increase in food crop supply as farmers use part of their inputs to cultivate food crops. In LFAC countries, export crop price has a negative effect on sorghum acreage. This result can indicate that as the export crops price increases, farmers either replace sorghum with export crops, or substitute sorghum for another higher yielding but more fertilizer-demanding food crop.

Previous year temperature (T) has a significant positive impact on planting decisions for maize, millet and sorghum. For instance, a 1°C increase in temperature in the previous year causes a 7.95, 7.44 and 4.21% increase in maize, millet and sorghum area, respectively. As temperature increases have a negative effect on yields for these crops in SSA (Yamoah et al., 1998; Odjugo, 2008), the positive impact of temperature on area could be explained by a yield loss compensation mechanism to maintain production levels when temperature increases. For cassava, however, an increase in temperature induces a decrease in cassava area cultivated in LFAC countries. This result seems contradictory to what is observed for the three other crops. However, cassava has a high optimum temperature (35°C) (Hillocks et al., 2001) and increased temperature can have a positive effect on cassava yields (Weite et al., 1998). Therefore, as desired production levels would be reached more easily following an increase in temperature, area planted in LFAC countries would decrease. The temperature coefficient for MFAC countries is positive and indicates that MFAC countries farmers would increase cassava production when temperature increases. These results are consistent with the observation that LFAC farmers have limited access to markets to sell excess production, whereas MFAC farmers have more buying and selling opportunities (Diao et al., 2006). However, the impact of temperature in LFAC countries is insignificant so it is not possible to draw any firm conclusions for these countries.

Precipitation (P) has similar consequences on cassava supply decisions. Previous year precipitation has a significant and positive effect in MFAC countries, and a significant and negative in LFAC countries. For example, a 100 mm increase in precipitation causes a 0.5% acreage

Table 3. Summary of regression specifications.

LAG model		MAVG model	
Variable	**Description**	**Variable**	**Description**
ΔXPI_{t-1}	Change in previous year export price index	$\Delta X\overline{P}I$	Change in export price index averaged over the past five years
ΔT_{t-1}	Change in previous year temperature	$\Delta\overline{T}$	Change in temperature averaged over the past ten years
ΔP_{t-1}	Change in previous year precipitation	$\Delta\overline{P}$	Change in precipitation averaged over the past ten years
		$\Delta\widetilde{P}$	Change in standard deviation of precipitation over the past ten years
$\Delta Drought_{t-1}$	Change in previous year drought	**ΔDrought**	Change in drought averaged over the past ten years
$\Delta(XPI \times LFAC)_{t-1}$	Change in previous year export price index for LFAC countries	$\Delta(X\overline{P}I \times LFAC)$	Change in export price index averaged over the past five years for LFAC countries
$\Delta(T \times LFAC)_{t-1}$	Change in previous year temperature for LFAC countries	$\Delta(\overline{T} \times LFAC)$	Change in temperature averaged over the past ten years for LFAC countries
$\Delta(P \times LFAC)_{t-1}$	Change in previous year precipitation for LFAC countries	$\Delta(\overline{P} \times LFAC)$	Change in precipitation averaged over the past ten years for LFAC countries
$\Delta(Drought \times LFAC)_{t-1}$	Change in previous year drought for LFAC countries	$\Delta(\widetilde{P} \times LFAC)$	Change in standard deviation of precipitation over the past ten years for LFAC countries
ECT_{t-1}	Previous year Error Correction Term	ECT_{t-1}	Previous year Error Correction Term

acreage increase in MFAC countries (that is, 5.05e-05×100) and a 0.6% acreage decrease in LFAC countries (that is, 5.05e-05 × 100 - 0.000113 × 100). Precipitation generally has a positive impact on crop yields (Larsson, 1996; Zaal et al., 2004; Fermont et al., 2009). When precipitation increases, farmers from LFAC countries reduce area cultivated as production targets are attained more easily under better rainfall conditions and opportunities to sell excess production are limited Alternatively, farmers from MFAC countries increase cassava area when rainfall increases as they can more easily sell excess production.

When considering rainfall and temperature decreases, the results imply that farmers in LFAC countries increase cassava area to compensate for a yield decrease, and farmers in MFAC countries switch to more suited crops or other activities, although this is not explicitly modeled in the analysis. Among the control variables included in initial specifications to account for differences between planted and cultivated area, only drought is significant for maize and sorghum. The drought coefficients have the expected sign in these regressions.

MAVG model

Regression results for the MAVG supply function are reported in Table 5. Based on cointegration tests results, ECMs are estimated for all crops. ECTt-1 coefficients obtained are all significant and support the existence of an adjustment toward a long-run equilibrium. The fastest adjustment is observed for maize where the ECTt-1 coefficient is equal to 0.262.

The average export crop price index ($X\overline{P}I$) is insignificant in all regressions, except cassava, where it has a significant negative effect on acreage response in LFAC countries. This result indicates a long-term substitution effect between export crops and cassava in LFAC countries. Export crop price risks are not significant and are removed from the final regressions. Average temperature ($\overline{T}$) has a significant positive impact on sorghum acreage only. For this crop, a 1ºC increase in ten-year average temperature causes a 46.6% increase in area dedicated to sorghum. As for the LAG model, the MAVG model indicates that in response to an increase in temperature, farmers increase sorghum area in order to compensate for yield losses. However, the temperature coefficient estimated for the MAVG model is slightly larger than the temperature effect estimated with the LAG model for sorghum. This result indicates that a persistent change in temperature is more influential on area planted than short term temperature changes.

Average precipitation over the previous 10 years ($\overline{P}$) is a significant determinant of maize and sorghum planting decisions. For these crops, a 100mm increase in precipitation over the last decade causes a 5.86% decrease in maize area and a 6.01% decrease in sorghum area. These results indicate that, as climatic conditions improve, farmers switch to better yielding but more water demanding crops, or (possibly only in LFAC

Table 4. LAG model regressions: dependent variable ΔlnA.

Parameter	Cassava	Maize	Millet	Sorghum
ΔXPI_{t-1}	-0.000267 (0.000343)	0.000402** (0.000150)	1.53e-06 (0.000170)	0.000213 (0.000215)
ΔT_{t-1}	0.0290 (0.0228)	0.0795** (0.0323)	0.0744* (0.0380)	0.0421* (0.0208)
ΔP_{t-1}	5.05e-05** (2.03e-05)	-1.62e-05 (2.92e-05)	-9.85e-06 (3.18e-05)	-1.25e-06 (3.55e-05)
$\Delta Drought_{t-1}$		-0.0861*** (-0.0234)		-0.0540* (-0.0276)
$\Delta(XPI \times LFAC)_{t-1}$	0.000584 (0.000409)			-0.00100** (0.000422)
$\Delta(T \times LFAC)_{t-1}$	-0.0524* (0.0270)			-0.0173 (0.0249)
$\Delta(P \times LFAC)_{t-1}$	-0.000113** (5.45e-05)			-8.38e-05 (0.000136)
$\Delta(Drought \times LFAC)_{t-1}$				-0.0245 (-0.0508)
ECT_{t-1}		-0.258*** (0.0293)		-0.211*** (0.0280)
Constant	0.0123* (0.00611)	0.0913*** (0.0251)	0.0734** (0.0292)	0.0139 (0.0150)
Observations	1,178	1,400	1,184	1,224
Number of groups	30	35	30	31
R^2	0.006	0.187	0.058	0.175
F	4.195***	195.6***	21.23***	2,099***
Time dummies	No	Yes	Yes	Yes
Fixed effect	No	Yes	No	Yes
ECM	No	Yes	No	Yes

Standard errors in parentheses; ***, ** and * denote significance at the 1, 5 and 10% level, respectively; Results for control variables are not presented in this table.

countries) that farmers can achieve production targets more easily and thus reduce area planted. A decrease in long-term rainfall would lead to an increase in planted area to compensate for yield losses.

An increase in precipitation risk ($\tilde{P}$) has a negative effect on cassava planting in MFAC countries but a positive effect in LFAC countries. For example, a one standard deviation increase in precipitation variability in the previous 10 years leads to a 0.08% decrease in cassava area in MFAC countries and a 0.05% increase in LFAC countries. This result could be explained by higher risk aversion of farmers where agricultural conditions are less favorable (in LFAC countries). In these countries, farmers will prefer cassava, which is drought resistant and better able to cope with precipitation changes than other crops. Also, farmers could increase area cultivated to ensure enough production as uncertainty in rainfall increases. In MFAC countries, however, farmers may decrease cassava cultivation as rainfall variability increases because they have alternative subsistence

Table 5. MAVG model regressions: dependent variable ΔlnA.

Parameter	Cassava	Maize	Millet	Sorghum
$\Delta\overline{XPI}$	-0.000686 (0.000759)	-.0007856 (0.000627)	0.000186 (0.000561)	0.000101 (0.000834)
$\Delta\overline{T}$	-0.00753 (0.191)	-0.0430 (0.185)	0.375 (0.252)	0.466** (0.197)
$\Delta\overline{P}$	-9.89e-06 (0.000212)	-0.000586** (0.000222)	-0.000173 (0.000312)	-0.000601** (0.000263)
$\Delta\tilde{P}$	-0.000799*** (0.000242)			
ΔDrought		-0.0606*** -0.0231		-0.0642** -0.0253
$\Delta(\overline{XPI} \times LFAC)$	0.00315*** (0.000990)			
$\Delta(\overline{T} \times LFAC)$	-0.0929 (0.289)			
$\Delta(\overline{P} \times LFAC)$	0.000213 (0.000406)			
$\Delta(\tilde{P} \times LFAC)$	0.00139* (0.000724)			
ECT_{t-1}	-0.115*** (0.0394)	-0.262*** (0.0333)	-0.208*** (0.0549)	-0.235*** (0.0270)
Constant	0.0714*** (0.00835)	0.0943*** (0.0116)	0.0973*** (0.0104)	0.143*** (0.0105)
Observations	1,062	1,260	1,068	1,104
Number of groups	30	35	30	31
R^2	0.109	0.182	0.147	0.181
F	21,357***	105***	2,603***	4,256***
Time dummies	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
ECM	Yes	Yes	Yes	Yes

Notes: standard errors in parentheses; ***, ** and * denote significance at the 1, 5 and 10% level, respectively; Results for control variables are not presented in this table.

means, such as waged employment. As for the LAG model, the drought variable is only significant in the maize and sorghum regressions. Again, the drought coefficients have the expected signs.

Climate change impact predictions

Climate change scenarios and data

Climate change predictions from five general circulation models (GCMs) are used in this study: CSIRO2 (Gordon and O'Farrell, 1997), HadCM3 (Gordon et al., 2000), CGCM2 (Flato and Boer, 2001), ECHAM4 (Roeckner et al., 1996) and PCM (Washington et al., 2000). For each model, four alternative future greenhouse gases (GHG) emissions scenarios (A1FI, A2, B1 and B2) proposed by the Intergovernmental Panel on Climate Change (IPCC, 2000) in their Special Report on Emissions Scenarios (SRES) are considered. These emission scenarios are used as inputs into the GCMs detailed above and

Table 6. RMSEs.

Crop	Individual models		Combined models	
	LAG	AVG	Equal weights	Bates and Granger'sweights
Cassava	0.18921	0.20109	0.18224	0.18227
Maize	0.28561	0.27474	0.23086	0.23089
Millet	0.24975	0.26477	0.25333	0.25334
Sorghum	0.25298	0.28617	0.24603	0.24600

postulate different economic, demographic and technologic futures. The combination of the five GCMs and the four scenarios produces 20 plausible futures, each with an equal likelihood of occurrence (Mitchell, 2007). The 20 permutations represent 93% of possible future changes in climate estimated by the Third Assessment Report of the IPCC (IPCC, 2001).

Data for the four climate scenarios under the five AOGCMs are extracted from the TYN SC 2.0 dataset (Mitchell et al., 2003) and are available at the global level at the 0.5 × 0.5 degree resolution. Weather variables under the 20 AOGCMs and scenarios permutations are constructed following the same procedure used in the regression analysis. Over the 21st century, temperature is predicted to increase under all scenarios. The smallest temperature increases by the late-2000s (2070 to 2099) compared to the late 1900s (1970 to 1999) are predicted under the PCM-B1 scenario (+1ºC), and the largest increases under the HadCM3-A1FI and ECHAM4-A1FI scenarios (+4.7 to +4.9ºC, respectively). There is greater divergence in precipitation predictions. By the late-2000s, precipitation changes are predicted to range from -75 mm under the CGCM2-A1FI scenario to +120 mm under the ECHAM4-A1FI scenario compared to the late-1900s.

Climate change impacts

Climate change impacts on area cultivated are predicted using both supply models estimated. As both models bring out different information regarding farmers' planting decisions, combining predictions from the two models expands the information set and improves predictions (Timmermann, 2006). Two weighting procedures are considered when combining models: (i) equal weight for each model and (ii) Bates and Granger's (1969) weights based on out-of-sample forecast variances. The predictive power of each model and the combination of both models are assessed using the root mean squared error (RMSE) computed using the leave-one-out cross-validation method (Michaelsen, 1987). RMSEs for individual and combined models under alternative weights are presented in Table 6. The calculations show that the predictive power of each model is improved when combining the models, and the smallest RMSEs are obtained using equal weights. Therefore, predictions are calculated using both models weighted equally.

Predictions are calculated using all coefficients used to fit the models. The EC term is dynamically estimated one period ahead by replacing the observed values of crop areas by the estimated values in an iterative fashion. Given the econometric-based nature of the analysis, it is not possible to account for future prices change in this study. When making predictions, prices are held at their 2002 values. To prevent area predictions from exceeding total arable land, total area for the four crops is limited to the amount of potential arable land in each country. Estimates of potential arable land by FAO Terrastat (2007) are used. This constraint binds for nine countries. The caveat is that, all potential arable land in these countries is allocated to the four crops. However, because of inter-cropping and cultivation on non-conventional land, it is plausible, to a certain extent, that the total area planted of all crops in one country may exceed the total surface of arable land in one country. Another caveat associated with this approach is that FAO do not provide future arable land estimates, which could be altered by climate change.

To simplify presentation of the results, predictions obtained using all AOGCMs are averaged over three 30-year periods: late-1900s (1970 to 1999), which represent the base period, and mid-2000s (2040 to 2059) and late-2000s (2070 to 2099) which represent prediction periods. Area cultivated is expected to increase for all crops in the 21st century compared to the late-1900s. However, these changes are mainly driven by the stochastic trend embodied in the constant. It is questionable that this trend observed in the late-1900s, will continue unabated during the 21st century. The most relevant results for determining the impact of climate change are given by comparing predictions with climate change to predictions without climate change (reference scenario). The range of predicted climate change impacts in the late-2000s on total area compared to the reference scenario are presented in Figure 1 for LFAC countries and in Figure 2 for MFAC countries.

Overall, these graphs indicate that predicted climatic change will worsen crop growing conditions for all crops. The largest climate change impacts are predicted under the A1FI scenario and the smallest impacts are predicted

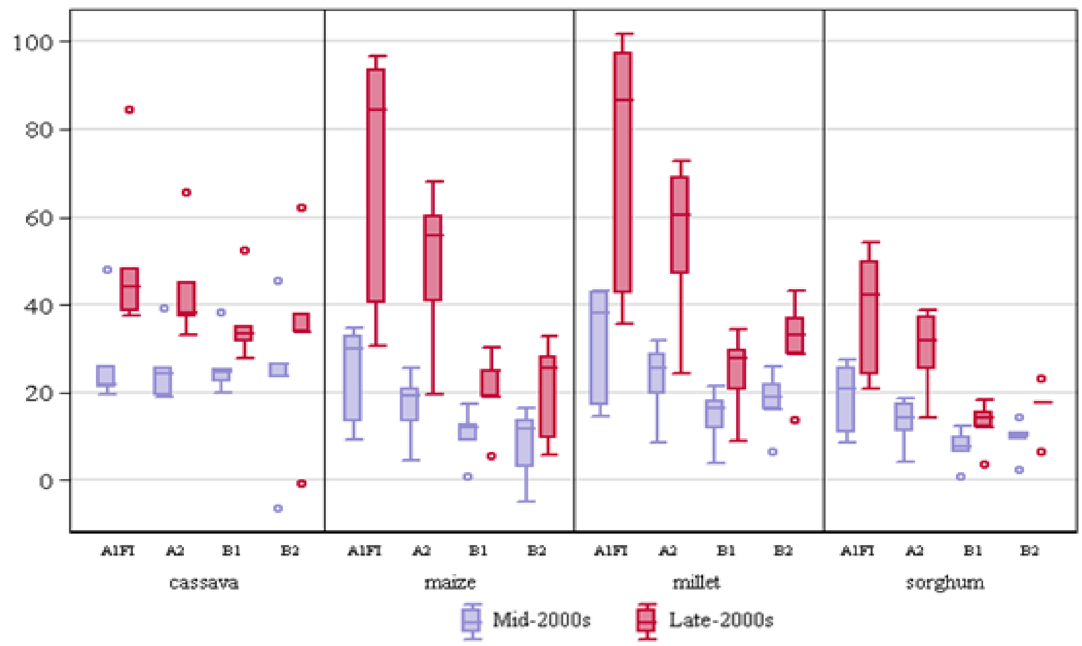

Figure 1. Predicted climate change impact for LFAC countries (in %) on total area compared to the reference scenario by mid- and late-2000s. Notes: The boxes represent the range of predictions across all AOGCMs between the 25th and 75th percentile for each crop and each scenario. The lines inside the boxes represent the median predictions. The whiskers represent upper and lower adjacent values, unless a prediction is classified as an outsider, which is represented by hollow circles.

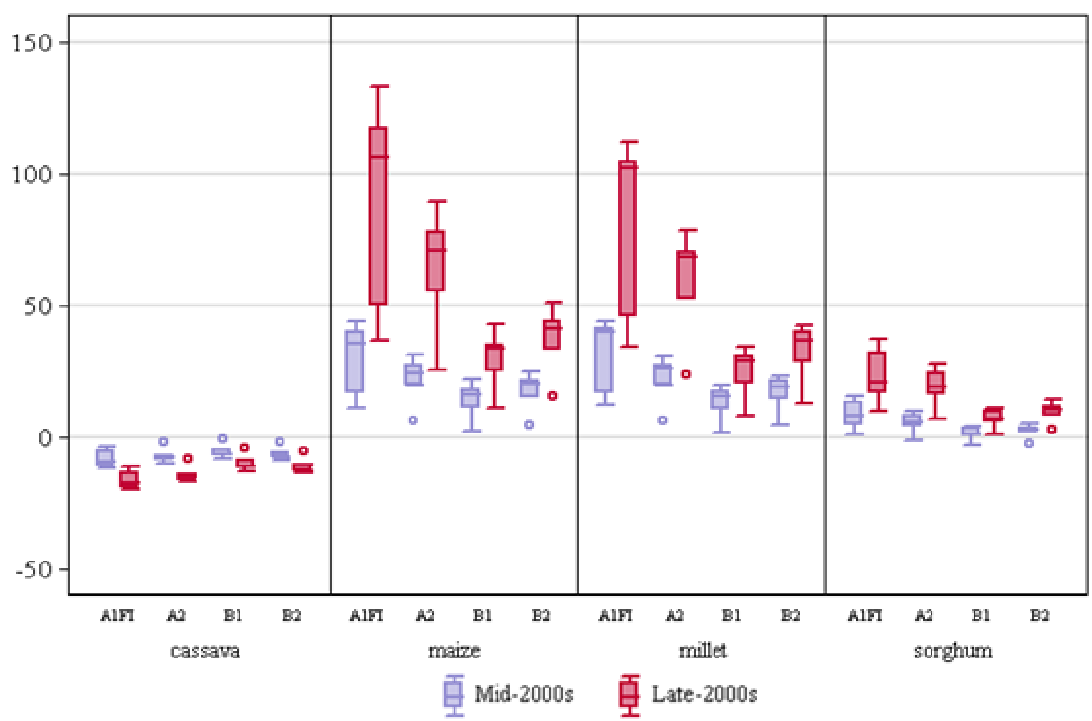

Figure 2. Predicted climate change impact for MFAC countries (in %) on total area compared to the reference scenario by mid- and late-2000s. Notes: The boxes represent the range of predictions across all AOGCMs between the 25th and 75th percentile for each crop and each scenario. The lines inside the boxes represent the median predictions. The whiskers represent upper and lower adjacent values, unless a prediction is classified as an outsider, which is represented by hollow circles.

under the B1 scenarios. More specifically, the graphs indicate that cassava area increases from 28% to 66% in LFAC countries (with outliers ranging from -1% to +84%) and decreases from 4% to 20% in MFAC countries by the late-2000s. These predictions indicate that farmers from LFAC countries will increase cassava planting to ensure food production, whereas farmers from MFAC countries will switch to other crops. Areas of the three other crops are expected to increase in both LFAC and MFAC countries to compensate yield losses.

The greatest increase in crop area is predicted for maize in MFAC countries, where area is predicted to be 11 to 133% higher than under the reference scenario by the late-2000s. In LFAC countries, maize area is predicted to increase from 5 to 100% by the late-2000s. Areas allocated to millet are predicted to increase from 9 to 102% in LFAC countries and from 8 to 112% in MFAC countries by the late-2000s. Climate change causes sorghum area increases from 4 to 54% in LFAC countries and from 1 to 37% in MFAC countries in the late-2000s.

Conclusion

Supply function analyses provide interesting insights about farmers cropping decisions. The regression analyses suggest that, in general, SSA farmers do not adjust crop area allocation in response to crop prices. Alternatively, the analysis reveals that farmers respond to export crop prices. Substitution effects between food crops and export crops are found for sorghum in LFAC countries. Complementarity effects are found between export crops and maize in all countries and between export crops and cassava in LFAC countries.

The results also indicate that farmers' decisions are influenced by weather and climate. Specifically, when temperature and precipitation conditions become more favorable, farmers from MFAC countries increase crop supply and sell excess production. In LFAC countries, however, farmers' decrease their area allocation as production needs are reached more easily and access to market is limited. When temperature and precipitation conditions become less favorable, farmers from MFAC countries decrease crop supply and switch to other crops and activities. Alternatively, farmers from LFAC countries, which have limited alternative options, increase their area allocation to compensate for yield losses.

Considering 20 alternative climate change scenarios, the analysis shows that area cultivated is predicted to increase for all crops during the 21st century. Supply changes are predicted to be the largest under the A1FI scenario, which predicts the largest temperature increases and the largest precipitation changes (which increase or decrease depending on the AOGCM considered). Alternatively, the smallest changes in crop supply are predicted under the B1 scenario, which predicts the smallest increase in temperature and smallest precipitation changes. Compared to a scenario of no climate change, climate change will worsen crop growing conditions for all crops. In LFAC countries, farmers will increase area of all crops to compensate yield losses. In MFAC countries, however, farmers will decrease cassava supply and increase area devoted to other crops, especially maize.

The consideration of alternative scenario shows that impacts are smaller under the B1 scenario, which assumes reduced GHG emissions via, among other things, the introduction of clean and resource-efficient technologies and focusing on global solutions to economic, social and environmental sustainability. These results indicate that global policies will influence the welfare of people living in SSA.

Several limitations to this study should be noted before closing. First, uncertainties from climate modeling and future scenarios of GHG emissions due to incomplete or unknowable knowledge (New and Hulme, 2000) affect the reliability of climate change predictions. Second, parameter and modeling uncertainty affect econometric based projections. Third, regression-based predictions use past responses to weather and climate. Therefore, technological change and crop supply decisions in the future are expected to follow patterns similar to those observed in the past. This assumption represents a limitation for prediction purposes. Modeling potential alternative agricultural responses would involve alternative techniques, which would complement this analysis. Fourth, adaptation methods are not explicitly represented. Instead, the study implicitly assumed that adaption mechanisms adopted by famers in the past will be employed in the future. Fifth, price changes caused by climate change are not considered in the analysis. However, several studies show that price changes caused by climate change have an important impact on production (Reilly et al., 1994, 2007; Reilly, 2011). Estimates from this study could contribute to a CGE analysis that considers price changes induced by climate change. Finally, the study does not account for crop spatial migration outside the predetermined crop zones.

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Factors determining red meat trade to the Asian and African markets: Its implication to the Namibian red meat industry

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The primary objective of this study is to identify alternative export markets for Namibian meat and meat products. This study applied the Extended Gravity Model to a cross-sectional dataset of global trade for fresh beef and frozen beef, as well as sheep and goat meat, based on 2009 trade data to identify key determinants of the above-mentioned products trade flows in a regional perspective. The variables used in this study include the impact of income, per capita income, distance, and exchange rates, as well as dummy variables, for regional blocs' supply to the specific region or country partners. The results of this study have two significant policy implications for Namibia. Firstly, trade agreements – whether implemented unilaterally or bilaterally – will enhance potential trade flows between Namibia and other countries or regions. Equally, it is also important to protect and advocate productivity growth within the context of these trade arrangements. Secondly, GDP per capita was found to be positively related and significant in Southern and West Africa for fresh beef. Fresh beef was found significant in all cases, while goat and sheep meat was only significant in East Africa. The study revealed that a higher income per capita is a major indicator of potential export opportunity. Denser populated nations may have higher demand for protein commodities such as meat, but a higher population either increase or decrease trade, depending on GDP per capita. In Asian markets, per capita income was found to be significant at 1% and highly elastic, making these markets attractive export destinations. As far as Namibia's ability to compete with Oceania and North America is concerned, Namibia has a good opportunity to acquire a share of the Asian market.

Key words: Meat industry, extended gravity model, export destination.

INTRODUCTION

Although agriculture contributes only about 6% to the Gross Domestic Product (GDP), it is regarded as an important part of the Namibian economy due to the facts that: Firstly, it is considered as one of the means of a poverty alleviation strategy; secondly, it employs 37% of the work force, and lastly, it sustains 70% of the Namibian population (Mushendami et al., 2008).

Beef industry in Namibia is the main agricultural production sector in the country, with the value of production estimated at an annual $90 million, of which approximately $45 million is contributed by cattle weaner exports. The average number of cattle was estimated at around 2.3 million in 2006 (Meat Board of Namibia, 2007). The sector's contribution to the economy is

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estimated at about 75% to the total agricultural economy, 69% of which is estimated to be from commercial livestock production (Emongor, 2007). Beef production is the most important part of the sector, followed by small stock (sheep and goat) production.

The sector can be categorised into commercial and communal sectors. The commercial farming sector constitutes approximately 4,200 farmers and occupies 44% of the arable land, whereas communal farmers account for 41% of the agricultural land and are estimated to make up 67% of the total population, 90 % of who are dependent on subsistence agriculture for their livelihood (Emongor, 2007).

Cattle numbers in Namibia and exports in beef and veal have showed an increasing trend since 1996, while live export has declined as a result of government policy on the value addition concept (Kruger et al., 2008).

Namibia enjoys a beef export quota of 13,000 tons to the European Union under the EU/ACP trade agreement. The EU market accounts for 40% of Namibia's beef product exports (Emongor, 2007).

Therefore, within the above context, this research provides insight into the major central attractions for global meat exporters when it comes to exporting to specific regions or countries. This will help to identify key determinants/attributes that can contribute to increased trade volumes to different countries or regions, using the Extended Gravity Model (EGM) supported by the Weighted Least Square (WLS) econometrical model, applied to the 2009 United Nations

Conference on Trade and Development (UNCTAD) cross-sectional dataset on fresh or chilled beef (HS0201). This section provides possible export promotion efforts to the Namibian meat industry, considering important variables that can ensure successful world exports.

Problem statement and motivation of the study

Namibia is, and will remain, a net exporter of livestock and red meat products over the long term, but the current situation where Namibian exports are limited to only a few countries, including South Africa (SA; 46%), the EU (29%) and Norway (2%), is raising concerns due to the recent proposed termination of the provisional preferences in the Interim Partnership Agreement with the European Union by 2014. This forces Namibia to explore possible new export opportunities to diversify its export markets. Therefore, the primary objective of this study is to identify and analyse alternative export markets for the Namibian red meat industry besides the EU, SA and Norway (OECD/FAO, 2011).

With the expiry of the waiver notified to the World Trade Organization (WTO) by the European Union (EU) as part of the Cotonou Agreement at the end of 2007, preferential market access for Namibia into the EU theoretically came to an end. The succeeding Interim Economic Partnership Agreement (IEPA)[1] negotiated between certain Southern Africa Development Community (SADC) countries and the EU earmarked a WTO-compatible Free Trade Agreement which had to be initialled before the end of 2007 to maintain preferential market access for Namibian products to the EU markets. While negotiating an Economic Partnership Agreement (EPA), the EU offered Namibia, as well as Botswana and Swaziland, duty-free quota-free access for their beef products to the EU. A recent proposal by the European Commission envisages terminating the interim EPA by 2014.

To address the possible loss of preferential access to the EU market, the meat industry was informed by the Ministry of Trade and Industry (MTI) of a Cabinet decision that future reliance on one export destination is not in the interests of Namibia and that no single export destination should be responsible for more than 50% of all exports of a specific commodity. Consequently, the Ministry requested the meat industry to come up with a proposal for the diversification of the current markets for Namibian meat and meat products (Namibia Meat Board, 2012).

Diversifying meat exports by exporting to the existing markets, and exporting new products to new markets, will stimulate economic development and lower the sector's vulnerability to economic instability in export markets. Export development by means of market diversification could create trade by unlocking additional supply potential. However, if additional supply is not sufficient for the new export opportunities, trade diversion may occur. Hence, new export opportunities should be capitalised in conjunction with a sound supply strategy for the Namibian meat sector.

Food and Livestock Planning Inc. (2010), cited in Meat Board of Namibia (2012), conducted a study specifically looking at the export opportunities for Namibia in the US market. They found that there were opportunities for grass-fed Namibian beef, which were underpinned by potential customers, although these were limited by international competition, regulatory issues, and financial viability. Based on import-growth performance, the study also looked at the Central East, Ghana, Russia, China and the expansion of existing markets, without going into much detail (Namibia Meat Board, 2012).

In brief, some of the suggested international trade and meat industry policies, as cited in Meat Board of Namibia (2011) and the Namibia Agriculture Marketing and Trade Policy and Strategy (2nd draft 19 July-11), are for Namibia meat industry to:

1. Utilize its policy space to preserve breeding material and discourage uncontrolled/unrestricted exports of livestock;
2. Promote value addition to diversify the product range;

[1] SADC EPA Configuration of Southern African countries that negotiate together on trade in goods with the EC: Angola, Mozambique (SADC member states); Botswana, Lesotho Namibia, Swaziland and South Africa (SACU member states)

3. Promote the optimal utilization of the domestic market for Namibian products;
4. Develop, promote, maintain and where appropriate improve sanitary requirements, and ensure compliance with standards and quality of livestock and livestock products exported from Namibia;
5. Support and ensure that Namibian products meet local standards;
6. Devise, maintain and improve where appropriate an efficient and effective marketing system for livestock and livestock products in order to stimulate production;
7. Develop domestic livestock and livestock products markets through, amongst others, promotion of local consumption of locally originating meat and meat products;
8. Promote integration of the informal market into mainstream economy;
9. Promote the development of a competitive agro-industry; and
10. Ensure equitable/equal/fair distribution of benefits across the value chain.

DATA USED AND METHODOLOGY

The gravity model of trade has been used widely as a baseline model for estimating the impact of a variety of policy issues, including regional trading groups, currency unions, political blocs, patent rights, and various trade distortions. Typically, these events and policies are modelled as deviations from the volume of trade predicted by the baseline gravity model and, in the case of regional integration, are captured by dummy variables. The fixed effects gravity equation, one of the popular methodologies used, allows for unobserved or miss-specified factors that simultaneously explain trade volume between two countries and, for example, the probability that the countries will be in the same regional integration regime (Cheng and Wall, 2005). Gravity models with fixed effects have also been used by Glick and Rose (2001) and Pakko and Wall (2001) to estimate the trade effects of currency unions, and by Millimet and Osang (2004) to estimate the effects of borders on trade.

These models are restricted versions of a general gravity model, which has a log-linear specification but places no restrictions on the parameters. In the general model, the volume of trade between countries *I* and *j* in year *t* can be characterized by:

$$\ln X_{ijt} = a0 + a_t + a_{ij} + b¢ijt + Zijt + e_{ijt}\ , t = 1,\ldots,T. \quad (1)$$

Where ijt is exports from country *i* to country *j* in year *t* and Z¢ijt = [*zit*, *zjt* …] is the 1 × *k* vector of gravity variables (gross domestic product [GDP], population, and distance). The intercept has three parts: One common to all years and country pairs, a0; one specific to year *t* and common to all pairs, a*t*; and one specific to the country pairs and common to all years, a*ij*. The disturbance term, e*ijt*, is assumed to be normally distributed with zero mean and constant variance for all observations. It is also assumed that the disturbances are pair-wise uncorrelated. Obviously, one observation, it is not useful for estimation unless restrictions are imposed on the parameters. The standard single-year cross-section model (CS) imposes the restrictions that the slopes and intercepts are the same across country pairs, that is, a*ij* = 0 and bijt=bt,

$$\text{(CS)}\ \ln X_{ijt} = \alpha_0 + \alpha_t + \beta'_t Z_{ijt} + \varepsilon_{ijt}\ , t = 1,\ldots,T \quad (2)$$

where a0 and a*t* cannot be separated. Assuming that all the classical disturbance-term assumptions hold, the CS model is estimated by ordinary least squares (OLS) for each year. The other standard estimation method is a pooled-cross-section model (PCS), which imposes the further restriction on the general model that the parameter vector is the same for all *t*, b1 = b2 = bT = b, although it normally allows the intercepts to differ over time:

$$\text{(PCS)}\ \ln X_{ijt} = a0 + a_t + b¢\ Zijt + e_{ijt}\ , t = 1,\ldots,T \quad (3)$$

This is estimated by OLS using data for all available years. Nearly all estimates of the gravity model of trade use either the CS or the PCS model, which, as we show below, both provide biased estimates.

To address bias in the equation, it can equate to maintain the restriction that the slope coefficients are constant across country pairs and over time. Specifically, we estimate the fixed effects (FE) model of Cheng and Wall (2005):

$$\text{(FE)}\ \ln X_{ijt} = a0 + a_t + a_{ij} + b¢\ Zijt + e_{ijt}\ , t = 1,\ldots,T \quad (4)$$

Note that the country-pair effects are allowed to differ according to the direction of trade (that is, a*ij* # a*ji*). The FE model is a two-way fixed-effects model in which the independent variables are assumed to be correlated with a*ij* and is a classical regression model that can be estimated using LSDV (least squares with a dummy variable for each of the country pairs).

As mentioned previously, others have proposed alternative fixed-effects models to handle country pair heterogeneity, each of which can be modelled as a restricted version of the FE model above. The Symmetric Fixed-Effects (SFE) model of Glick and Rose (2001) differs from FE only in that it imposes the restriction that the country-pair effects are symmetric (that is, a*ij* = a*ji*).

In the Cheng and Wall (2005) model, call it DFE, the differences in the dependent and independent variables are used to eliminate the fixed variables, including the country-pair dummies and distance. As with the FE specification, this model allows for the most general fixed effects possible. But rather than estimating the fixed effects using LSDV, it eliminates by subtracting out. Specifically,

$$\text{(DFE)}\ D\ln X_{ijt} = g0 + g_t + b¢DZijt + \mu_{ijt}\ , t = 1,\ldots,T \quad (5)$$

Where D is the difference operator and g0 + g*t* = a*t*– a*t* –1. In this model, the intercept has two parts: g0 is the change in the period-specific effect that is common across years and g*t* is the change that is specific to year *t*.

When there are no time dummies, such a differencing model yields results identical to a model with dummy variables to control for fixed effects. However, with time dummies it is necessary to impose restrictions on the time effects to avoid collinearity, which in turn makes the DFE estimation a restricted form of the FE estimation.

If the collinearity restriction is that the first time dummy in the DFE model is equal to zero, this is equivalent to restricting the common component of the change in the period-specific effects as equal to the difference in the first two period-specific effects (that is, g0 = a2 – a1). If, instead, the collinearity restriction is that the sum of the time dummies in the DFE model is zero, this is equivalent to restricting the common component as equal to the difference between the first and last time dummies (that is, g0 = a*T* – a1) (Mátyás, 1997).

According to Brülhart and Kelly (1999), typical gravity models include the following variables as determinants of trade:

1. Export supply, captured by economic factors (national output or output per capita) affecting trade flows in exporting countries;
2. Import demand, captured by economic factors (income or income

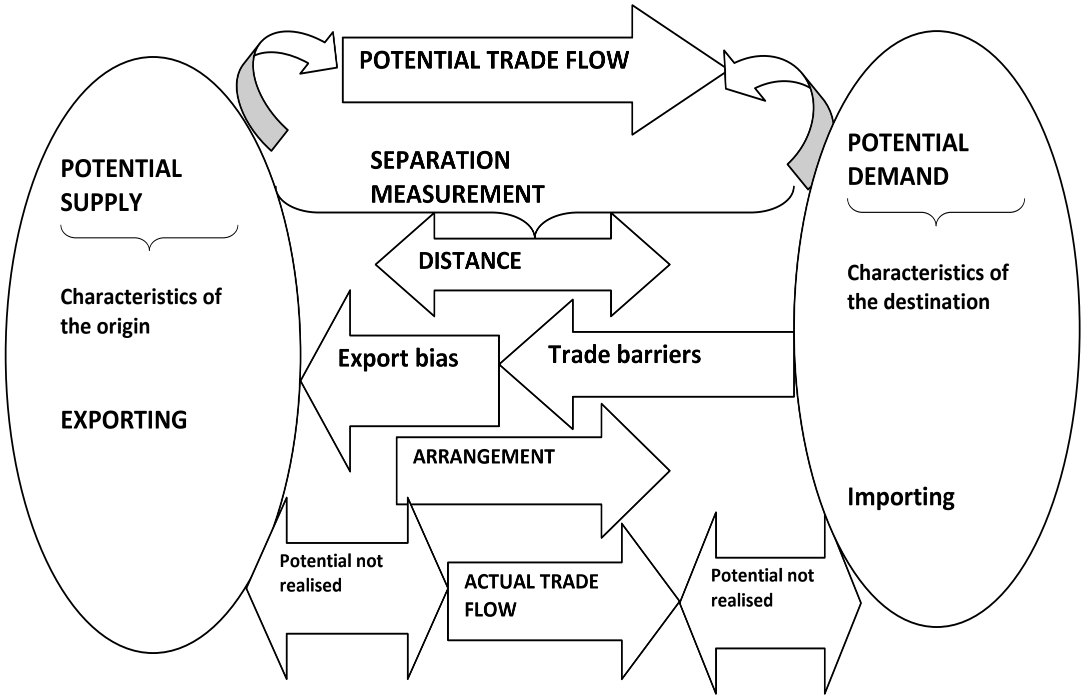

Figure 1. Design of the gravity model. Source: Teweldemedhin and van Schalkwyk (2010).

per capita) affecting trade flows in the importing countries; and
3. Transportation costs, captured by geographical distance and other variables representing policy and cultural barriers to trade.

An alternative explanation of the gravity model is presented in Figure 1, using a simple supply-and-demand framework. According to Teweldemedhin and van Schalkwyk (2010), exporting and importing countries are the main objects in a gravity model. In Figure 1, the gravity model is presented graphically to show the potential supply and demand, determined by the sizes of the economies, to predict the potential trade flow between the countries as trading partners. This flow is subject to certain trade resistance factors that are improved by trade arrangements.

Following the above theoretical background in this study as Bikker (2009) used Gravity Model (EGM) to examine bilateral trade flows considering four sets of variables, namely supply, demand, allocation and index system equations:

1. Supply side: Variables indicating the total potential supply of the exporting country i;
2. Demand side: Variables indicating the total potential demand of the importing country j;
3. Related to allocation index: Geographical distance between the countries' capitals (or economic centres); and
4. Variables aiding or hindering trade between the importing and exporting countries.

Therefore, for estimation purpose, Equation (3) above can be expressed in log linear form as follows:

$$\ln Exp = \ln GDPc + \ln POP + D1 + D2 + \ln DIS + \ln SUPP + \ln EX + \varepsilon ij \quad (6)$$

Where: Exp represents export supply of a specific exporting country to a specific region; GDPc is the GDP per capita of the importing countries; D1 is a dummy variable for influence of regional trade agreement; D2 is a dummy variable for export to the specific region/countries; SUPP indicates the total supply contribution of exporting countries to world; EX presents exchange rate of specific importing countries against the US dollar; DIS is the distance of export origin to destinations; εij is a random error term, usually taken to be normally distributed.

To determine the contributors to trade to certain African regions or countries, an Ordinary Least Square (OLS) econometrical model was applied to 2009 cross-sectional data on fresh or chilled beef (HS0201), frozen beef (HS0202) and fresh, chilled or frozen mutton, lamb and goat meat fresh, chilled or frozen mutton, lamb and goat meat (HS0204). This tool is useful for measuring key economic drivers to export or trade patterns. Therefore, this study explores the key drivers of trade to specific African regions or countries and the level of specialisation and/or diversification of the global meat industry. Table 1 presents the variables influencing meat exports to different destinations as a dependent variable, with possible factors influencing the dependent variables, with the expected sign in the EGM.

Gravity has long been one of the most successful empirical models in economics. Incorporating deeper theoretical foundations of gravity into recent practice has led to a richer and more accurate estimation and interpretation of the spatial relations described by gravity. Wider acceptance has followed. However, it is important to point out the limitations and superiority of the model:

1. The major limitation of the gravity model is the narrow focus on trade volume and the inability to generate predictions in direction of trade or distributional impacts and the failure to account relative to Preferential Trade Agreements (PTAs) and their effect on changes in trade policy. In addition, explicit links between changing production/consumption patterns and trade structure only rely on setting to one or more PTA dummy variables. This approach is problematic as the dummy variables may or may not capture a range of other effects.
2. Another criticism of gravity studies is their inability to take into account the terms-of-trade adjustments accompanying preferential

Table 1. Expected sign and explanation of variables.

Variable	Code	Sign	Explanation	Source of data
Importer GDP per capita	GDPc	+	Economically larger countries import more	World Bank (2009)
Population	POP	±	A higher output per person indicates a higher import demand, but a larger population may both increase and decrease trade	World Bank (2009)
Distance	DIST	-	Appears to explain transportation costs.	UNCTAD (2009)
Dummy intra exports within the same region	D1	±	If present, trade agreements will enhance trade between those countries – otherwise the opposite	
Dummy EU countries' trading partners	EU	-	Trade agreements will enhance trade between these countries, but with EU farmers being subsidised will discourage export from the rest of the world	UNCTAD(2009)
Total supply of exporting countries to the world	SUPP	±	Diversification in the export orientation will have a negative effect, leading to low supply and demand, while non-diversification will have a positive effect on the region.	UNCTAD (2009)
Real exchange rates	EXE	±	Appreciation in the importing country's currency promotes exports from that country and hinders imports	IMF (2009)
Population	POP	±	A higher output per person indicates a higher import demand, but a larger population may both increase and decrease trade	World Bank (2009)
Distance	DIST	-	Appeared to explain transportation costs.	UNCTAD (2009)
Dummy exports from Africa to Africa	AFRI	±	If present, trade agreements will enhance trade between those countries – otherwise the opposite.	
Dummy EU countries' trading partners	EU	-	Trade agreements will enhance trade between these countries, with being EU farmers subsidised will discourage export from the rest of the world	
Total supply of exporting countries to the world	SUPP	±	Diversification in the export orientation will have a negative effect, leading to low supply and demand, while non-diversification will have a positive effect on the region	UNCTAD (2009)
Real exchange rates	EXE	±	Appreciation in the importing country's currency promotes exports from that country and hinders imports	IMF (2009)

Source: Hellvin and Nilsson (2000) cited in Teweldemedhin and van Schalkwyk (2010).

liberalization, which can have significant effects on changes in trade flows and welfare (Burfisher et al., 2004, cited in Teweldemedhin, 2010).

As reported in Teweldemedhin (2010), notwithstanding the above-mentioned shortcomings of the gravity model, the approach has enjoyed continued popularity due to its two major advantages: Firstly, ease of implementation and superior empirical performance. The data requirements of the traditional model are low and rely on widely available information, while the estimation procedure is straightforward through OLS. Secondly, the empirical success of gravity models in forecasting the volumes of bilateral trade is well documented. Rose (2002), cited in Teweldemedhin (2010), has noted that the gravity-estimated "elasticities of trade with respect to both income and distance are consistently signed correctly, economically large, and statistically significant in an equation that explains a reasonable proportion of the cross country variation in trade." Furthermore, the gravity equation has provided "some of the clearest and most robust empirical findings in economics." In addition, the argument that gravity models cannot clearly trace the links between trade policy and changes in trade flows does not disprove the validity of the gravity equation as long as one interprets the PTA coefficient(s) as the ex-post total effect on trade, reflecting not only the tariff reduction clauses of a PTA but also other provisions that may enhance or diminish the liberalization potential of an agreement, along with possible implementation problems. Finally, a number of recent studies have gone a long way towards addressing many of the criticisms of the model.

RESULTS AND DISCUSSION

Determinants of export to Africa

Once the necessary statistical test was conducted, the relationship among the variables was estimated to identify factors influencing global trade to Africa. However, applying Ordinary Least Square (OLS) to both the cross-sectional and pooled data created a heteroscedasticity problem. To remedy this problem, Weighted Least Square (WLS) was applied to the cross-sectional (data 2009 from UNCTAD), countries exporting destinations to Africa. The product groups used in the model namely: fresh or chilled beef (HS0201), frozen beef (HS0202) and fresh, chilled or frozen fresh, chilled or frozen mutton, lamb and goat meat (HS0204).

Table 1A to 3A (in the Annexure) shows how the gravity model explains the factors relating to exports to Africa from the rest of the world, based on cross-sectional observation of the year 2009. The overall explanatory power for export determinants range from 22 to 57% in all cases: While what the variables highlighted in red colour show is not significant to be reported (Table 1A to 3A in the Annexure), all other variables highlighted with black colour were found to be statistically significant at the specified level of significance. Furthermore, all variables were found to hold the expected sign.

GDP per capita of importing African countries

The effect of GDP or GDP per capita is an indication of the growth of the economy and the success of international trade. A higher GDP would most likely affect the coefficient positively (Teweldemedhin and Schalkwyk, 2010). The positive and statistically significant coefficients of the importing country's GDP for the gravity model are consistent with the theory behind the conventional gravity model, suggesting that the size of the economies should enhance the amount of trade between trading partners.

Fresh and chilled beef (HS0201) were found to be statistically significant towards the Southern and West African and the Southern African Development Community (SADC) markets at 5 and 10% respectively. Frozen beef (HS0202) was found to be statistically significant in all regional blocks in Africa. Moreover, it is a highly elastic export to Central and Northern Africa. This suggests that income per capita is much better in these regions and that consumer also prefer frozen beef. However, for sheep and goat meat (HS0204) demand the influence of Gross Domestic Product (GDP) per capita were only found to be significant at 10% in the case of Eastern Africa, Southern and West Africa. This implies that Southern and West Africa show good economic growth that attracts exports, mainly due to the economic growth as a result of oil discovery (examples of countries exporting oil are Ghana and Nigeria in West Africa and Angola in Southern Africa). For example, in this regions a 1% increase in the importing country's GDPc in Southern and West African would create an increase in trade volumes of 0.72%, thus making exports to the rest of the world more attractive. The results reveal that the demand for meat in Southern and West Africa countries is inelastic. However, considering that food trading in general is inelastic by its nature, this implies that it might now be a good opportunity to further explore Namibian meat as a commodity for increasing export potential to Southern and West Africa. It must be kept in mind that these regions are proportionally among the fastest growing nations in terms of income per capita and population (Table A1 to A3 in the Annexure).

In addition to this, the United Nations report (UN, 2011) shows that the economic growth forecast for sub-Saharan Africa stood at 5.3% in 2011 due to the recovery of the global economy and an improved outlook for oil-producing countries such as Nigeria and Angola. Growth is expected to be driven by continued recovery in the global economy, and domestic demand will continue to play a dominant role in the economic growth of most African countries, which could lead to an increase in GDPc.

The International Monetary Fund (IMF, 2011) report shows that a 7.1% increase in the economic growth for Nigeria, the region's second-largest economy and the continent's largest oil producer, from a previous estimate of 5.7%. Government spending on infrastructure projects and growth in non-oil industries should have helped to support the economy, which was expected to grow by 6.2% in 2012. Angola, sub-Saharan Africa's second-largest oil producer, was expanded by about 6.7% in 2011 and by 7.5% in 2012 (IMF, 2011).

The outlook in Kenya, East Africa's biggest economy, was described as 'remains favourable', with 5.2% growth expected in 2011 and 5.5% in 2012. While Kenya was benefiting from increased trade with the rest of the region, drought was forecast as possibly damaging agricultural output, thus derailing the growth outlook (IMF, 2011).

The greatest risk to Africa's growth prospects is another slump in the global economy, as most countries on the continent have 'depleted the fiscal space they had created during the pre-crisis period and have not had time to rebuild it' (World Bank, 2011).

The EGM results of this study for GDPc, and the above-mentioned report, reconfirm that Africa is indeed a lucrative market for the Namibian meat industry. There is a need for specific attention to the West African market and Africa at large, considering the following points:

1. Urbanisation and rising incomes have fuelled faster

growth in domestic demand in West African nations.

2. Economic management has improved, while government revenues have been bolstered in recent years by high commodity prices and rapid economic growth in most African countries.

3. Countries such as Uganda and Kenya are growing more rapidly than before, without having to depend on mineral exports.

4. African countries are working toward high levels of sustainable economic growth in order to make significant progress in terms of poverty reduction, to generate productive jobs and livelihoods for the 7 to 10 million young people entering the labour force each year, through commodity exports to achieve substantial poverty reduction and also meet the millennium development goals (MDGs).

Population

As shown in the Annexure, population was found to be significant and positive at identified levels (Tables A1 to A3 in the Annexure). For example, fresh and chilled beef (HS0201) were significant towards markets in the Central and Northern Africa, as well as in Southern and West Africa. Frozen meat fresh, chilled or frozen mutton, lamb and goat meat (HS0204) were only significant at 1% in Southern and West Africa, with a positive estimated coefficient; and Frozen beef (HS0202) was found to be significant in all regions (Tables A1 to A3 in the Annexure).

This suggests that population is extremely important when it comes to an attractive export potential. A densely populated nation means a greater demand for protein commodities such as meat. As mentioned previously, the West African countries of Nigeria and Ghana and the Southern African country of Angola have seen an increase in population in proportion to a reduction in income inequality. This evidence, combined with the results of the EGM used in this study, validate or reconfirm that Namibia is in good standing to extend or explore African markets.

Distance

A country that lies geographically further from exporting countries is expected to influence the profitability and as a result such a country becomes less attractive as export destination, particularly due to transport costs. The coefficients indicate that this is indeed the case. For example, in the case of fresh and chilled beef (HS0201) export, distance was found to be significant and negative estimated coefficient with highly elasticity for all cases/regions, with the exception of the East African market (Table 1A to 3A in the Annexure). This implies transportation cost is a major constrain for export capacity; as far from major trading partners will adversely affect trade volume. The poor infrastructure in most African countries and the bureaucratic red tape involved in clearing goods through the ports could aggravate the matter further or discourage exports to Africa. Since Namibia is adjacent to many export destination countries in Africa, other highly competitive meat-exporting countries may be discouraged by distance, which constitutes a good opportunity for Namibia to increase export volumes. This could be a good indicator for Namibia, since being closer in distance is an important factor in determining trade (Figure A1 in the Annexure).

Exchange rate

The magnitude effect of this coefficient is relatively smaller than the other variables. Rapid short-term depreciations of local currency will overshoot the potential export although over the long term the exchange rate effect becomes less severe compared with the other variables. In addition to this, a result this variable was not significant in most cases, since the data is in cross section and it is very difficult to see the impact in one year. To derive an inclusive implication on this variable, it requires a longer period for an observation experiment.

The dummy variables “Africa and EU export origin” and the dummy variable “trading within African nations” were found not to be significant in explaining exports, whereas the “EU” dummy variable was found to be significant to influence African market, implying that trade liberalisation with the EU region is an important variable in explaining trade. The “EU” dummy variable (export origin from EU) appeared to be significant in all products and regions, with relatively higher elasticity with negative estimated coefficient. The negative relationship might be due to the fact that trade liberalisation and trade agreement between the EU and Africa will discourage exports potential exports originating from other exporting nations, although Oceania seems to have a comparative advantage in frozen beef exports to Africa (Tables A1 to A3 in the Annexure).

Determinants of meat exports to Asian countries

GDP per capita of importing Asian countries

This variable is significant in all regions for all products at specified level and positively related (with the exception of South Asia). For example, estimated coefficients show highly elastic at 1.54, 1.03, and 1.29 for fresh or chilled beef (HS0201), frozen beef (HS0202) and fresh, chilled or frozen mutton, lamb and goat meat (HS0204), respectively (Table A4 to A6 in the annexure). This implies that a smaller change in income in this region would lead to a greater change in attracting export potential to the region. For example, the largest importer of fresh meat in Central and East Asia is Japan at 83%, followed by Korea at 13% and China and Hong Kong at only 4%. This clearly shows that a higher income society can have a major influence. However, as a result of the location proxy, Oceania (Australia and New Zealand) and North America are the largest trading partners, accounting for 78 and 21%, respectively, of the total imports to Asia (Figure A2 in the Annexure).

Although Japan seems a promising prospective market for Namibian meat exports, the Japanese market will require much exploration. As the model shows, a 1% increase in mean income would attract an additional export potential of 1.54% to Central and East Asia. For example, Chinese consumers tend to be conservative and price sensitive. Exceptions are spending on education, medical care, gifts, entertainment and children. Hence, for high-end food products, the most potential exists in the hospitality market. Food safety has become a major issue, especially in the urban areas. The notion that food can be unsafe has increased and is more prevalent amongst higher-income consumers, who rely more on processed and pre-packed foods. Hence, these consumers place a premium on famous brands or retailers with a solid reputation. Furthermore, this market segment is more health and nutrition conscious. Urban households' expenditure on food has doubled in the last five years. Expenditure on meat has risen sharply, whereas the expenditure on grains has fallen (USDA, 2009).

The strengths and opportunities for meat products in the Chinese food market can be summed up as follows (USDA, 2009):

1. Chinese consumers spend nearly half of their disposable income on food and beverages.
2. Imported goods are generally perceived as safe and high in quality.
3. New markets for imported foods are arising in fast-growing cities throughout China.
4. Overseas retail chains are expanding quickly, offering more imported products and house brands.
5. Food is an essential part of Chinese culture and social life. Key life events revolve around food and little expense is spared.
6. There is a very large market with millions of people joining the middle-class each year.
7. Trends in the food market can shift *en masse*.
8. Chinese consumers prefer fresh foods.
9. Increases in personal ownership of refrigerators and microwaves have boosted the sales of frozen and heat-to-eat products.
10. Small, 'economy' size, attractive, and branded food packaging is preferred.

Population

This was found to be significant at the specified significance level, positive and inelastic in all regions, with the exception of West Asia for fresh and frozen beef and South East Asia for sheep or goat meat. Since population alone is not the determinant factor influencing exports, but should rather be interpreted in conjunction with the income level. However, this is an indication that nations with denser populations are attractive as export destinations. It is important to take note again that it is not only population growth that matters, but also economic growth (Table A4 to A6 in the annexure).

In the Asian market, despite the significant increase of meat consumption, there still exists a huge potential for expansion as the per capita consumption of the 1.3 billion people is relatively low. In urban areas the per capita annual meat consumption is about 37 kg, and about 18 kg in the rural areas, for example as in China. This, together with the optimistic economic prospects and increasing consumer expenditure, provides a good outlook for meat exports to China (USDA, 2009).

Distance

With the exception of Central and East Asia, all regional blocs were found not to be significant for fresh or chilled beef HS0201. For frozen meat, South Asia and West Asia were found to be significant at 1% and had negative coefficients at 1.40 and 0.95, respectively. This implies distance has greater impact to influence trading to these regions. Sheep or goat meat, on the other hand, was found to be significant at 10% with an estimated coefficient of 0.64 in West Asia (Table A4 to A6 in the annexure).

It is important to interpret the above gravity model results for distance in conjunction with other factors that influence the beef market. For example, the Asia market (specifically China) is a moderately accessible market with regard to transport. The shipping time for a 40 ft reefer from Namibia is up to 69 days (including domestic time). Of these, 45 days are international shipping time. However, these transport times impede the export of fresh and chilled meat products. In addition to this, in China there is a 12% import duty on frozen, bone-in sheep meat and a 15% import duty on frozen, boneless sheep meat. Goat meat faces an import levy of 20%, whereas animal fats are subject to an import duty of only 4%. Non-tariff barriers mainly revolve around import regulations and food safety standards.

Exchange rate

This variable was found to be significant in Asia and Southeast Asia at 1% with an inelastic behaviour estimated coefficient, that is, one unit of change in the exchange rate would lead to less than one unit of change in export attraction. The other regions were found to be not sufficiently significant to influence the dependent variable. However, for frozen beef and sheep or goat meat, exchange rate was found to be significant in South East Asia and West Asia (Table A4 to A6 in the annexure). The theoretical literature on exchange rate, beginning with Clark (1973), as cited in Tang (2011), asserts that a risk-adverse firm facing increased exchange rate volatility will reduce its exports due to the uncertainty in its future profitability. Other models show that the negative relationship between exchange rate volatility and trade may not always hold under different conditions. For example, the presence of hedging instruments or accessibility to mature forward markets can alleviate the impact of exchange rate volatility on trade. On the other hand, an opposite (positive) relationship can exist when highly risk-adverse firms faced with volatile exchange rates increase their exports due to stronger income over substitution effects, and when high costs are involved in entering and exiting export markets.

As a result, Namibia recently signed an agreement with its Chinese counterpart, paving the way for quota-free access to the Asian market for locally produced and processed beef, mutton, fish, and also fruit. The agreement between Namibia and China will be valid for five years and will be eligible for renewal (The Namibian newspaper, 2011).

Conclusion

This paper has evaluated, analysed and classified the significance of determinants affecting meat exports globally, using the extended gravity model. Consideration was also given to investigating the impact of income, per capita income, distance, exchange rates and dummy variables for export origin from the specific regional blocs' supplies or countries' trading partners to capture the impact of trade agreements or preference on the trade volumes with the specific country or region. The model found all variables to be significant at the specified significance level with the expected sign in most cases.

The results of the EGM have several important policy implications for Namibia. Firstly, trade agreements – whether implemented unilaterally or bilaterally – will enhance potential trade flows between Namibia and other countries or regions. It is also important to protect and advocate product growth within the context of fair agreement. Secondly, from an export promotion standpoint, distance in the model results showed that the importing countries' per capita income is elastic and significant in determining exports in most cases. It is therefore important for Namibia to consider further detailed studies into the behaviour and consumer preferences of the specific markets, as high per capita income can realise export potential.

Within Africa, GDPc was found to be positively related and significant in Southern and Western Africa for fresh or chilled beef (HS0201), implying export opportunities. Fresh or chilled beef (HS0201) was found to be significant in all cases, while goat and sheep meat, fresh, chilled or frozen mutton, lamb and goat meat (HS0204) were only significant in East Africa, showing that product preferences with relation to trade differ within Africa. Population was also found to be an important variable influencing meat trade within Africa; population is positively related to the dependent variable. This suggests that a higher income per capita is a major indicator of potential as an export destination and that a densely populated nation will have a greater demand for protein commodities such as meat, although a larger population can both increase and decrease trade, depending on GDP per capita.

In the second category, distance and exchange rate, as well as regional trade agreement influence on meat trading in Africa, were found to be significant at the specified level in most cases. The first two variables (distance and exchange rate) were found to be negatively related to meat export capacity to Africa and distance is elastic. Poor infrastructure in most African countries and the bureaucratic red tape involved in clearing goods through the ports could further discourage exports to Africa. However, Namibia's geographic location could be a competitive advantage over other highly competitive meat-exporting countries.

In East Asia, income per capita was found to be significant at 1% and highly elastic (with a coefficient of 2.29), suggesting it as a good export destination. The biggest importer of meat in East Asia is Japan, accounting for 83%, followed by Korea (13%) and China and Hong Kong at only 4%. Given this, Japan could be a good market, considering the higher income of its society. However, Oceania (Australia and New Zealand) and North America are the main trading partners with an export capacity of 78 and 21%, respectively. Although Japan seems like a good prospective market for meat exports, it is advisable to explore the market further. The recent earthquake and tsunami in Japan disrupted global supply chains, and high oil prices slowed consumption in all advanced economies. In terms of Namibia's ability to compete with Oceania and North America, once the Japanese economy has recovered, Namibia will have a good opportunity to acquire a market share.

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ANNEXURE

Table A1. Determinants of fresh beef export to Africa (code 0201): EGM approach.

Coefficients	Africa		East Africa		Central and Northern Africa		Southern and West Africa		SADC	
	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.42**	(0.08)	0.10	(0.28)	0.59	(0.49)	0.72**	(0.35)	0.72***	(0.38)
POP	0.18**	(0.08)	0.05	(0.28)	0.45***	(0.28)	0.39*	(0.13)	0.21	(0.18)
DIST	-1.07*	(0.52)	-1.08	(0.75)	-1.29***	(0.64)	-2.47**	(0.60)	-2.02**	(0.77)
AFRI	-0.095	(0.63)	-0.05	(1.23)	0.67	(1.11)	-0.66	(0.90)	0.40	(1.09)
EU	-1.02**	(0.36)	-1.44	(0.95)	-0.75	(0.92)	-1.40**	(0.67)	-1.69***	(0.98)
SUPP	0.24*	(0.09)	0.40**	(0.16)	0.30**	(0.15)	-0.04	(0.130)	1.14	(0.16)
EXE	-0.25*	(0.19)	-0.47**	(0.28)	0.16	(0.18)	-0.13	(0.12)	-0.35	(0.22)
(Constant)	10.96*	(3.94)	16.5**	(7.3)	5.35	(8.7)	21.9*	(6.40)	18.7**	(8.7)
R^2	0.53		0.61		0.57		0.75		0.71	
Adjusted R^2	0.28		0.37		0.33		0.57		0.50	
ANOVA	0.00		0.019		0.03		0.00		0.03	
F-test	6.87		2.85		2.56		6.91		4.15	
No. of observation	133		41		44		44		36	

*, ** and *** significant level at 1, 5 and 10% respectively; Standard error indicated at the parenthesis.

Table A2. Determinants of frozen beef export to Africa (code 0202): EGM Approach.

Coefficients	Africa		East Africa		Central and Northern Africa		Southern and West Africa		SADC	
	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.66*	(0.10)	0.77*	(0.16)	1.09*	(0.29)	0.29***	(0.18)	0.92*	(0.25)
POP	0.33*	(0.06)	0.35*	(0.11)	0.91*	(0.20)	0.24**	(0.11)	0.39*	(0.14)
DIST	-0.47***	(0.25)	-1.59*	(0.47)	0.26	(0.40)	-0.80***	(0.48)	-1.73*	(0.61)
EXE	-0.14*	(0.04)	-0.21*	(0.09)	0.01	(0.10)	-0.14**	(0.07)	0.05	(0.14)
SUPP	0.31*	(0.06)	0.34*	(0.13)	0.68*	(0.15)	0.21*	(0.08)	0.18	(0.13)
D1. AFRI	-0.90***	(0.52)	-2.54*	(0.89)	0.24	(0.95)	-1.12	(1.09)	-2.40**	(1.16)
D2. EU	-1.34*	(0.31)	-1.49*	(0.50)	-1.18**	(0.56)	-1.23**	(0.53)	-1.77*	(0.70)
D2. L .AM	0.05***	0.30	-0.33	(0.55)	-0.68	(0.47)	0.02	(0.51)	0.38	(0.65)
D4. Oceana	-1.68*	(0.44)	-1.09	(0.72)	-3.66*	(0.72)	-1.45***	(0.85)	-0.59	(0.85
(Constant)	-3.08	(2.76)	5.86	(5.23)	-26.54*	(7.00)	4.48	(4.61)	5.74	(7.16)
R^2	0.37		0.42		0.57		0.22		0.37	
Adjusted R^2	0.36		0.37		0.53		0.16		0.30	
ANOVA	0.00		0.00		0.00		0.00		0.00	
F-test	21.95		8.24		14.55		3.59		4.87	
No. of observation	341		111		107		121		83	

*, ** and *** significant level at 1, 5 and 10% respectively; Standard error indicated at the parenthesis.

Table A3. Determinants of sheep and goat meat export to Africa (0204): EGM approach.

Coefficients	Africa		East Africa		Central and Northern Africa		Southern and West Africa		SADC	
	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.59*	(0.13)	0.27***	(0.17)	0.44	(0.29)	0.39***	(0.21)	-0.08	(0.08)
POP	0.30*	(0.07)	0.19	(0.13)	0.25	(0.24)	0.27*	(0.09)	-0.09	(0.07)
DIST	-0.80**	(0.33)	-0.59***	(0.35)	-0.89	(0.70)	-0.99***	(0.55)	-0.01	(0.45)

Table A3. Contd.

SUPP	-0.06	(0.05)	0.08	(0.08)	-0.12	(0.11)	-0.080	(0.07)	-0.13	(0.10)
EXE	0.33*	(0.07)	0.13	(0.14)	0.33**	(0.13)	0.20***	(0.11)	0.04	(0.05)
D1. AFRI	-1.29**	(0.64)	-1.94**	(0.88)	-2.44**	(1.01)	0.43	(1.07)	-0.97	(0.66)
D2. EU	-1.50*	(0.43)	-1.68***	(1.03)	-2.42*	(0.69)	0.57	(0.81)	-2.16*	(0.57)
L .AM	-0.49	(0.53)	2.74	(2.41)	-1.66**	(0.72)	0.42	(1.08)	1.58	(1.15)
Oceana	0.46	(0.53)	2.22	(1.90)	-1.12	(0.83)	3.37*	(1.04)	2.30**	(1.06)
(Constant)	-0.17	(3.49)	0.86	(2.20)	4.81	(8.88)	2.68	(5.53)	4.75	(5.11)
R^2	0.42		0.61		0.42		0.51		0.61	
Adjusted R^2	0.39		0.50		0.35		0.44		0.54	
ANOVA	0.00		0.00		0.00		0.00		0.00	
F-test	15.19		5.97		5.70		7.29		8.42	
No. of observation	199		44		80		73		57	

*, ** and *** significant level at 1, 5 and 10%, respectively; Standard error indicated at the parenthesis.

Table A4. Determinants of fresh beef export to Asia (code 0201): EGM approach.

Coefficients	Asia		Central and East Asia		South Asia		South East Asia		West Asia	
	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.79*	(0.12)	2.29*	(0.35)	-0.29	(0.74)	1.54*	(0.34)	0.44**	(0.21)
POP	0.34*	(0.09)	0.68*	(0.16)	0.46***	(0.27)	0.47**	(0.34)	0.27	(0.18)
DIST	-0.56**	(0.25)	-1.09***	(0.68)	-0.71	(0.67)	-0.43	(0.51)	-0.50	(0.40)
EXE	0.09*	(0.03)	0.17	(0.16)	0.36	(0.46)	0.45*	(0.11)	0.50	(0.07)
SUPP	0.41*	(0.07)	0.32*	(0.23)	0.68**	(0.27)	0.50*	(0.13)	0.54*	(0.09)
Asia. dummy	1.7*	(0.61)			2.68	(1.73)	3.41*	(1.24)	1.98*	(0.60)
L. Amer. dummy	1.2***	(0.72)			1.94	(1.94)	2.29**	(1.10)	1.22**	(0.63)
EU. dummy	-1.70*	(0.70)							-2.18*	(0.64)
OCE. dummy	2.31*	(0.70)	4.06*	(0.77)	-1.50	(1.71)	4.12*	(0.71)	1.35**	(0.66)
N. Amer. dummy	0.96	(0.78)	3.18*	(0.83)			2.75*	(0.84)		
(Constant)	-4.54	(2.99)	-19.12**	(7.53)	12.04	(10.2)	-18.9**	(7.7)	2.04	(4.45)
R^2	0.45		0.75		0.61		0.67		0.45	
Adjusted R^2	0.43		0.72		0.40		0.61		0.41	
ANOVA	0.00		0.00		0.04		0.00		0.00	
F-test	22.38		20.6		2.85		10.71		12.37	
No. of observation	279		53		22		56		145	

*, ** and *** significant level at 1, 5 and 10% respectively; Standard error indicated at the parenthesis.

Table A5. Determinants of frozen beef export to Asia (code 0202): EGM model approach.

Coefficients	Asia		Central and East Asia		South Asia		South East Asia		West Asia	
	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.43*	(0.10)	0.60**	(0.29)	-0.33	(0.45)	1.03*	(0.28)	0.34*	(0.14)
POP	0.18**	(0.08)	-0.04	(0.16)	-0.28***	(0.17)	0.87*	(0.21)	0.07	(0.13)
DIST	-0.69*	(0.19)	0.07	(0.44)	-1.40*	(0.44)	-0.80	(0.44)	-0.95*	(0.29)
SUPP	0.07***	(0.04)	0.05	(0.14)	1.10*	(0.20)	0.15	(0.08)	-0.06	(0.06)
EXE	0.47*	(0.05)	0.12	(0.09)	-0.03	(0.11)	0.80*	(0.12)	0.68*	(0.08)
D1. ASIA	1.02	(1.15)	5.68	(4.70)	1.37***	(1.79)			0.53	(1.25)
D2. L. AM	1.10	(1.22)	5.08	(4.74)	5.44**	(2.16)	-1.12	(0.95)	0.01	(1.40)
D3. AFRI	1.29	(1.41)	3.26	(5.18)			1.83	(1.45)	0.25	(1.57)
D4. EU	-1.03	(1.17)	2.73	(4.73)	3.59***	(1.85)	-3.89*	(0.95)	-1.97***	(1.25)
D5. OCEANA	1.06	(1.24)	7.55	(4.78)	3.08	(2.21)	-1.18***	(0.73)	-0.55	(1.45)

Table A4. Contd

D6. N.AM	0.85	(1.25)	6.90	(4.79)	4.20***	(2.28)	-1.06	(1.01)	-1.10	(1.42)
(Constant)	-0.80	(2.33)	-4.59	(6.99)	17.71*	(6.20)	-18.55*	(6.21))	2.40	(3.54)
R^2	0.36		0.50		0.76		0.61		0.45	
Adjusted R^2	0.34		0.41		0.69		0.57		0.42	
ANOVA	0.00		0.00		0.00		0.00		0.00	
F-test	19.54		5.52		10.92		13.01		13.10	
No. of observation	400		72		45		92		188	

*, ** and *** significant level at 1, 5 and 10% respectively; standard error indicated at the parenthesis.

Table A6. Determinants of sheep and goat meat export to Asia (code 0204): Extended gravity model approach.

	Asia		Central and East Asia		South Asia		South East Asia		West Asia	
Coefficients	B	Std. error	B	Std. error	B	Std. error	B	Std. error	B	Std. error
GDPc	0.62*	(0.12)	1.88**	(0.81)	-0.22	(0.40)	1.29*	(0.39)	0.47*	(0.17)
POP	0.29*	(0.09)	0.86**	(0.35)	-0.25***	(0.15)	0.36	(0.33)	0.77*	(0.16)
DIST	-0.01	(0.23)	-1.52	(1.31)	0.16	(0.65)	-0.59	(0.89)	-0.64***	(0.34)
SUPP	0.01	(0.05)	-0.44*	(0.11)	0.27	(0.22)	0.31**	(0.13)	-0.08	(0.07)
EXE	0.40*	(0.07)	0.08	(0.23)	0.18	(0.12)	0.48*	(0.14)	0.57*	(0.09)
D1. ASIA			-3.18**	(1.41)			-0.40	(1.48)		
D2. L. AM	-0.85	(0.58)	-2.60	(1.64)	-0.17	(1.25)	-0.58	(1.65)	-0.45	(0.70)
D3. AFRI	-0.61	(0.56)					-0.99	(2.37)	-0.71	(0.55)
D4. EU	-2.38*	(0.37)	-4.37*	(0.98)	0.67	(1.06)	-2.47**	(0.97)	-3.24*	(0.43)
D5. OCEANA	0.02	(0.49)			0.09	(1.47)			0.26	(0.64)
D6. N.AM	-2.79*	(0.69)	-5.33*	(1.86)	1.55	(1.32)	-2.15	(1.40)	-3.22	(0.96)
(Constant)	-7.97*	(2.58)	-8.80	(9.43)	5.81	(6.61)	-1.2.45	(9.33)	-10.13**	(4.27)
R^2	0.47		0.85		0.38		0.57		0.58	
Adjusted R^2	0.44		0.80		0.16		0.47		0.55	
ANOVA	0.00		0.00		0.14		0.00		0.00	
F-test	22.50		16.72		1.72		5.34		18.93	
No. of observation	269		36		34		50		146	

*, ** and *** significant level at 1, 5 and 10% respectively, Standard error indicated at the parenthesis.

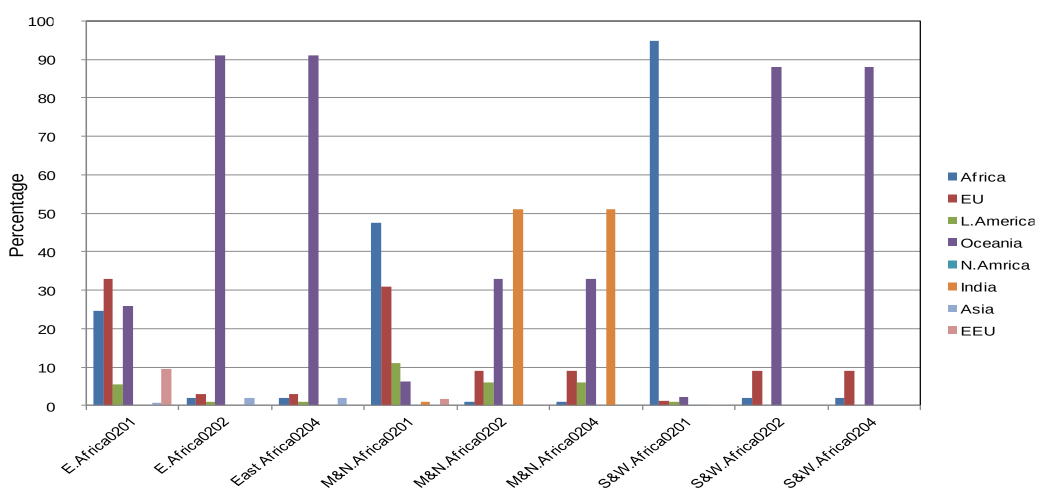

Figure A1. Distribution of meat export destinations to Africa from different regions; Source UNCTAD (2009).

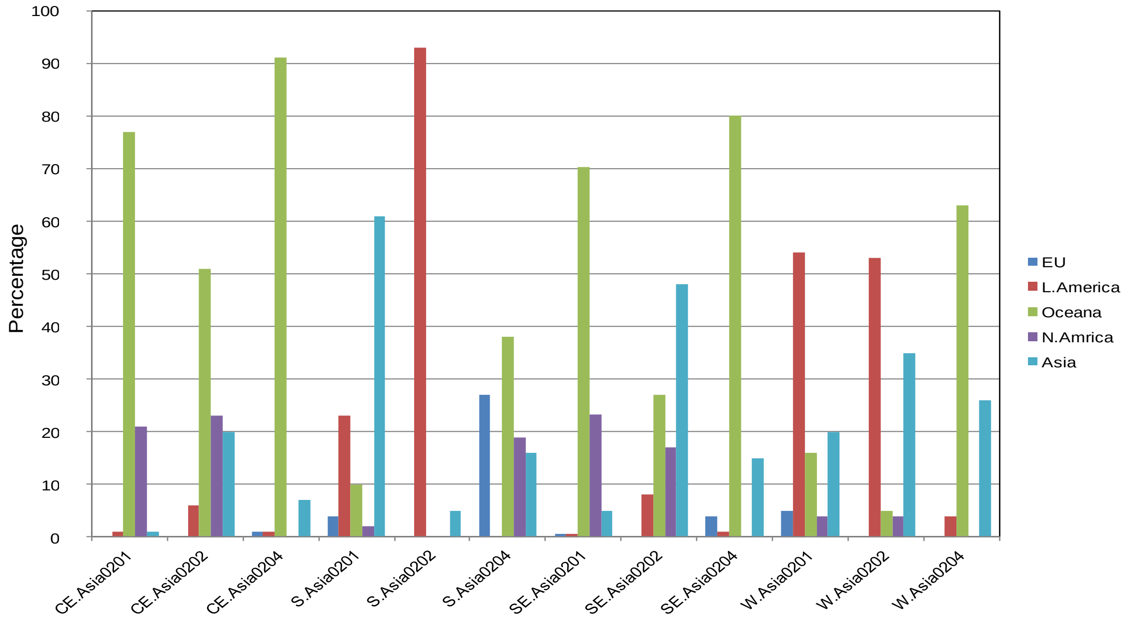

Figure A2. Distribution of meat export destinations to Asia from different regions; Source UNCTAD (2009).

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Adoption of New Rice for Africa (NERICA) technology in Ogun State, Nigeria

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This study was carried out with the aim to find out the level and socio-economic determinants of the adoption of New Rice for Africa (NERICA) using Ewekoro Local Government Area of Ogun State in Nigeria as a case study. One hundred and sixteen rice farmers were randomly selected in this area, twenty eight of which adopted NERICA rice varieties within 2009/2010 cropping season. Information was gathered through the use of well structured questionnaire and personal interview of the farmers. Descriptive statistics, ordinary least-squares (OLS) regression analysis and T-test statistics were used for the analysis of the data collected. It was discovered through the findings that the rate of adoption was 33.36%, while the socio-economic determinants of the adoption of the technologies include farming experience, age of the farmer, frequency of contact with the officials of Agricultural Development Programme (ADP) in the state and farm size. Moreover, the findings show that the non-adopters of NERICA technological package had higher average output and average yield than the adopters of the technologies. Lastly, the study gave valuable recommendations which could be helpful toward enhancing improved rate of adoption of NERICA rice technologies by the farmers in the study area.

Key words: New Rice for Africa (NERICA), adoption, rice, socio-economic determinants, technologies.

INTRODUCTION

Since the introduction of New Rice for Africa (NERICA) in the mid 1990's, the NERICA has carved a special niche for itself among upland rice farmers in sub-Saharan Africa (SSA). Today, it is a symbol of hope for food security in SSA, the most impoverished region in the world where a staggering one-third of the people are under-nourished and half of the population struggle to survive on US $1 a day or less (Think Quest Team, 2006). The NERICA is a group of rice varieties resulting from the inter-specific crossing between the Asian rice (*Oryza sativa*) and the African rice (*Oryza glaberrima*). They are the output of the hybridization breeding programme started in 1991 by the Africa Rice Centre (WARDA). The NERICA varieties promises to raise significantly the productivity, income and food security of rain fed upland rice farmers in SSA. The NERICA varieties were introduced to rice farmers starting from 1996 in West Africa through participatory varietal selection (PVS) trials (Tiamiyu, 2008). Till date, up to eighteen (18) NERICA varieties have been disseminated in numerous countries across SSA such as Nigeria, Sierra-Leone, Gambia, Ghana, Guinea, Mali, Cote

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d'Ivoire and Togo through informal channels by farmers and by development projects. These rice varieties which are suited to dry lands were distributed and sown on more than 200,000 ha during the last five years in several African countries notably Guinea, Nigeria, Cote d'Ivoire and Uganda, according to African Rice Centre (2008). Though this represents a major advancement, it is still projected to fall short of meeting the growing demands for rice as a food staple.

In order to improve and encourage the increased production of rice in Nigeria, some varieties bred by WARDA for upland ecologies were introduced to farmers through the participatory varietals selection (PVS) trials in 1999 and 2001. The PVS was conducted in nine States which included Ogun State and Federal Capital Territory. The apparent success of these trials led to the release of NERICA varieties. The Federal Government launched the Multinational NERICA Rice Dissemination Project (MNRDP) in 2003. This was aimed at promoting the use of NERICA seed varieties and complementary production technologies packaged with it among farmers (Tiamiyu, 2008). In 2003, MNRDP started the implementation activities for the dissemination of NERICA in six States including Ogun State where the area of this study was located. According to the MNRDP project, the NERICA rice varieties embody improved seed technology and management practices of agrochemicals in terms of biological and chemical technologies. The NERICA varieties cultivated in the study area are NERICA 1 to 8. The production parameters of the adopters of these technologies can be used to solve the problem of low yield, low productivity and rice self-insufficiency in Nigeria.

Statement of problem

The world food problem is a serious issue especially in Africa. Population increase is escalating, and increase in crop production is becoming an uphill task. Recently, in order to resolve the problem, NERICA was developed in West Africa. However, certain problems bother the mind of the researchers. The growth in consumption which has become most substantial in Africa's rapidly growing cities, where rice is increasingly becoming the staple diet of the poor urban households. Rice has therefore become a staple of considerable strategic importance. At present, rice imports are still significant because the region is yet to be self sufficient in rice production. As a result of the increment in the consumption of rice in the country, the imported rice is being used to bridge the gap existing between production of the local rice and the domestic demand of the consumers. The demand-supply gap of rice is becoming a major problem which requires attention in Nigeria's agricultural economy. Moreover, high exchange rate involved in importation of rice is a serious issue that requires quick attention if an economy would achieve any significant development. Hence, the adoption of NERICA rice by the farmers is believed to have potential to lead to an increase in productivity of rice in the country, result in reducing demand-supply gap, increase rice self sufficiency and enhance improved foreign exchange earnings.

Objectives of study

The objective of this study is to determine the socio-economic factors influencing the adoption of the NERICA technology and to examine the level of adoption of NERICA rice by farmers in the study area.

Statement of hypotheses

i) There is no statistically significant difference in the output level of NERICA adopters and non-adopters.
ii) There is no statistically significant difference in the level of yield of NERICA adopters and non-adopters.

LITERATURE REVIEW

Much evidence has been provided attesting the productive performance of the agricultural sector in Africa and factors influencing it, but there is still little evidence on crop-specific and sub-regional productive performance. An assessment of crop-specific efficiency, productivity and adoption analysis should be of more interest to policy makers implementing liberalization policy than overall aggregates. The adoption of the new agricultural technology that led to the green revolution in Asia can also lead to significant increases in agricultural productivity in Africa, and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008). Mendola (2006) observes that the adoption of the high yielding variety has positive effect on household well-being in Bangladesh. More recently, Kijima et al. (2008) conducted a study on the impact of NERICA in Uganda and found that NERICA adoption reduces poverty without deteriorating the income distribution. A study carried out by De Janvry and Sadoulet (1992) shows a positive impact of adoption of agricultural technologies. In contrast, a study in Bangladesh by Hossain et al. (2003) shows that the adoption of high yielding varieties of rice has a positive effect on the richer households but had negative effects on the poor. In Zimbabwe, Bourdillon et al. (2002) observe that the adoption of high yielding varieties of maize increases the crop incomes of adopters only modestly. These conflicting findings justify the need for further research on this issue. There is suggestion that the promotion of NERICA cultivation can contribute to improving expenditure/income of farmers and consequently to poverty reduction. This is consistent with the study of Irz et al. (2001), who show that a close relationship exists between farm productivity and household poverty.

In his study, Diagne (2006a) determines the rates of adoption and rates of diffusion of NERICA rice varieties in some West African countries which include Cote d'Ivoire, Guinea and Benin. He also employs econometric analysis to show the socio-economic determinants of adoption of NERICA in Cote d'Ivoire. He shows that the main factors which positively influence the adoption of NERICA include growing rice partially for sale, household size, growing upland rice, past participation in PVS trials and living in a PVS-hosting village. On the other hand, he discovers that age of the farmers and having a secondary occupation had a negative impact on adoption (Diagne, 2006b). In Guinea, Diagne et al. (2007) show that the main socio-economic determinants of adopting NERICA with positive effects were participation in training programme and living in a village where NGO SG2000 has had activities. In Benin, land availability and living in PVS-hosting village were found to have positive effects on adoption. It was also found that varietal attributes such as swelling capacity and short growing cycle were important determinants of adoption of NERICA (Adegbola et al., 2005).

MATERIALS AND METHODS

Study area and sampling technique

This study was conducted in Ewekoro Local Government Area of Ogun State, Nigeria. This is a major rice-producing area in the state, comprising of Wasimi and Arigbajo which serve as major villages in the area. Major crops cultivated include maize, rice, cassava and melon while sugarcane is the major cash crop of the inhabitants of the Local Government Area. Majority of the people living in this locality were involved in farming activities either on a part time or full time basis. One hundred and sixteen small-scale rice farmers were sampled in the study area by using simple random sampling technique.

The data were collected during the 2008/2009 farming year through the use of well structured questionnaire which was administered by personal interview conducted for the selected farmers. Descriptive statistics and multiple regression analysis were used in meeting the objectives of this study. The descriptive statistics entails the frequency tables which show the distribution of the socio-economic characteristics of the farmers such as sex, age, household size, farming experience, educational qualification and proximity to ADP official village of residence. The regression analysis shows the socio-economic factors that determine the level of adoption of NERICA technology. The model of the regression analysis is as follows:

$$Q = a_o + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6 + a_7X_7 + a_8X_8$$

Where Q = level of NERICA technology adoption of farmers; the level of adoption was measured using the proportion of utilisation of each component that constitutes the NERICA technological package; these include cultivation of NERICA varieties, appropriate fertilizer application, mechanization and pesticide/herbicide application. The summation of the proportion of utilization of each of these components determines the level of NERICA technology adoption of the farmers. X_1 = sex (dummy: male = 1, female = 0); X_2 = age (years); X_3 = household size; X_4 = farm size (acres); X_5 = proximity to ADP official village of residence (dummy: farmer residing in ADP official resident village = 1; otherwise = 0); X_6 = education (years); X_7 = farming experience (years); X_8 = frequency of ADP contact; a_o = constant; $a_1 – a_8$ = parameters to be estimated.

RESULTS AND DISCUSSION

The result of the descriptive statistics of the sampled rice farmers

From Table 1, it could be observed that over 55% of the farmers were male while less than 45% were female. The average age of the farmers is observed to be 41.42 years, as majority of them (about 69%) falls within ages 30 to 59 years. There is a relatively low level of education among the farmers: the average year of formal education among the sampled paddy farmers was 2.86, as almost 70% of the farmers had no formal education. The average household size is 6.14, and most of the paddy farming households had sizes ranging between 1 and 10. The average year of farming experience was found to be 19.71 years, while the average farm size was 4.41 acres. Most of the farmers (about 80%) cultivate on 5 acres of land or lesser. About two-third of the farmers had no contact with Agricultural Development Project (ADP) officials, while less than 10% had contact with the ADP officials at least once a month. Consequently, this could be the reason for the low adoption level of NERICA by less than 25% of the rice farmers.

The items that are involved in NERICA technology adoption level include cultivation of NERICA seed, fertilizer application, mechanization and herbicide/pesticide application. Moreover, the stages of adoption are itemized to range from 'not aware', 'aware', 'thinking about it', 'interested', 'ready to adopt', to 'adopted'. These are coded from 0 to 5. A farmer that adopts all the four components of the technology mentioned earlier is scored 20 (4 × 5) scores, while a farmer that is not aware of all the four technologies is scored 0 (4 × 0). The adoption level (*x*) of a farmer could be determined using the following formula:

$$x = \frac{a}{20} \times 100$$

a represents the adoption score given to an individual farmer. For this study, any farmer that does not cultivate NERICA seed variety was not considered as an adopter of NERICA technology. The value *x* serves as the regress and for the exogenous variables. To determine the mean adoption level, this study adopts the formula:

$$\text{Average adoption level} = \sum fx/N$$

Where *f* = frequency of each value observed; *N* = number of observations of the variable *x.*

Table 1. Socio-economic characteristics of the selected rice farmers.

Socio-economic characteristics	Frequency	Percentage	Mean
Sex			
Male	64	55.17	
Female	52	44.83	
Total	116	100.00	
Age (years)			
20-29	16	13.79	
30-39	24	20.69	
40-49	30	25.86	
50-59	26	22.41	41.42
60-69	14	12.07	
70 & above	6	5.17	
Total	116	100.00	
Educational qualification			
Non-formal	80	68.97	
Primary	30	25.86	2.86
Secondary	6	5.17	
Total	116	100.00	
Household size			
1-5	48	41.38	
6-10	54	46.55	6.14
11-15	14	12.07	
Total	116	100.00	
Farm size (acres)			
0.01-2.50	62	53.45	
2.51-5.00	30	25.86	
5.01-7.50	4	3.45	
7.51-10.00	6	5.17	4.41
10.01-12.50	10	8.62	
12.51-15.00	4	3.45	
Total	116	100.00	
Farming experience (years)			
1-10	44	37.93	
11-20	28	24.14	
21-30	30	25.86	
31-40	4	3.45	19.71
41-50	6	5.17	
51-60	4	3.45	
Total	116	100.00	
Frequency of ADP contact			
Weekly	4	3.45	
Monthly	6	5.17	
Quarterly	14	12.07	
Yearly	16	13.79	
Not at all	76	65.52	
Total	116	100.00	

Table 1. Contd.

Adopted rice variety		
Local	88	75.86
NERICA	28	24.14
Total	116	100.00

Source: Field survey (2010).

Table 2. Comparison of the output (in bags) and average yield (bags/acre) of paddy farmers based on NERICA rice adoption type.

Farmer category	Average output (bags)/average yield (bags/acre)	Standard deviation	Standard error
Adopter	3.5043	3.3830	0.3606
	8.2045	2.3643	0.2520
Non-adopter	9.6741	9.5578	1.0189
	18.3409	11.7678	1.2545

Source: Field survey (2010).

The average level of adoption in the area of study was observed to be 33.36%.

The result of the regression analysis showing the socio-economic factors influencing the level of adoption of NERICA technology in the study area

$$Q = \underset{(9.249)}{71.125^{**}} + \underset{(2.447)}{2.435X_1} - \underset{(1.280)}{1.807X_2^{*}} - \underset{(0.401)}{0.124X_3} + \underset{(0.364)}{1.310X_4^{**}} + \underset{(3.075)}{2.987X_5} - \underset{(0.376)}{0.068X_6} - \underset{(0.117)}{0.459X_7^{**}} + \underset{(1.235)}{5.954X_8^{**}}$$

Where, ** - 1% significance level; * - 5% significance level.

From the regression analysis computed using SPSS 15.0, it was observed that age of the farmers, farm size, farming experience and frequency of ADP contact were the most significant socio-economic variables influencing the level of adoption of the farmers. The younger farmers tend to have higher adoption level than the older farmers; this is in conformity with literatures. Also, farmers with larger farm holdings seem to have higher adoption level than those cultivating on smaller pieces of land. Moreover, rice farmers with fewer years of experience tend to adopt NERICA technologies more than the more experienced farmers in the study area. More importantly, increased contact with the ADP officials has a tendency to improve the level of adoption of the farmers in the area of study.

Comparison of the performance of the adopters and non-adopters of NERICA technologies in the study area

From Table 2, it could be observed that the non-adopters had higher output and yield than the adopters of NERICA technologies. This may not be as a result of lower potential of the technology but rather due to the incidence of pests such as rodents and birds, according to the information obtained through personal interviews with the farmers. It was observed that the pests have preference for NERICA varieties paddy output over the local rice varieties paddy output; hence, the lower output and yield were recorded by the rice farmers in the study area. Moreover, through personal interviews, some of the adopters of the technologies were observed to show possibility of discontinuation of the technologies in the preceding seasons. The mean values of the output and yield of the adopters and non-adopters of NERICA varieties were used to conduct the T-test statistics presented in Table 3. From the result of the T-test conducted, it could be deduced that there is statistically significant difference in the output and yield levels of NERICA adopters and non-adopters in the study area.

CONCLUSION AND RECOMMENDATIONS

The study shows that younger farmers have tendency to adopt improved technologies than the older farmers, and it was discovered that about two-thirds of them were 40 years and above. This is not a good omen for instituting an improved technology if the discoveries in the literatures are anything to go by. Farmers that operate on relatively small scale level are discovered to have lower adoption level, and it is a known fact that the agricultural production in developing economies mainly depends on small production scale. Almost four-fifth of the sampled farmers in the study area operates on less than 5 acres of land, while the average farm size was 4.41 acres. It

Table 3. Test of hypotheses using T-test.

Hypothesis (H_0)	Degree of freedom	Critical value	T-value	Decision
There is no statistically significant difference in the output level of NERICA adopters and non-adopters.	0.05, 43	2.02	5.412	Reject H_0
There is no statistically significant difference in the level of yield of NERICA adopters and non-adopters.	0.05, 43	2.02	7.658	Reject H_0

Source: Data analysis (2010).

was also revealed that those paddy farmers with fewer years of experience tend to adopt NERICA technologies. A little less than 40% of the rice farmers in the study area had farming experience of ten years or less. Contact with the ADP officials serves as an important factor that could enhance higher level of adoption of improved technologies by the farmers in the area of study. However, only about 8% have contact with the ADP officials at least once in a month, and about two-thirds have no contact at all with any ADP or extension agents. Consequently, there appears to be a relatively low level of adoption of NERICA technology among the paddy farmers.

In conclusion, NERICA technological package would only be of great benefit to our agricultural economy, if and only if the technologies are directed towards the right direction, and there is increase in farmers-extension agent ratio. Also, it is not enough to introduce a new technological package but to sustain such package is very essential for a successful agricultural production system. Therefore, this study offers the following recommendations toward helping the agricultural policy makers:

i) Strategies should be developed toward reaching the older farmers on the field, since they form a larger proportion of the farmers remaining in agricultural production. This also applies to the relatively more experienced farmers; extension agents should endeavor to introduce every approach possible with the aim of convincing them to adopt improved technological packages.

ii) Improved agricultural technologies should be made available and affordable to the small scale farmers since they produce the bulk of the agricultural produce in the developing world economies.

iii) Any serious-minded government should consider a significant increase in the number of agricultural extension agents, if there would be a successful and timely dissemination of newly introduced agricultural technological packages. It is only through such attitude would there be an initiation of a move toward economic development. Also, NGOs with agricultural-related functions should consider the enhancement of information dissemination and extension services as part of their obligations, as this would help to bridge the gaps between already existing farmers and government-employed extension workers.

iv) The agricultural researchers, especially those involved in the development of NERICA rice varieties, should look into developing varieties that would pass the test of pest attacks especially rodents which form an obstacle against increased productivity of the varieties in the study area.

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Participation in land market and technical efficiency in Southern Ethiopia: A case study after 2005 land proclamation of Ethiopia

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Agriculture is the mainstay of the Ethiopian economy contributing 45% to GDP and 80% to employment opportunity. Majority of the farmers in Ethiopia are smallholder farmers possessing less than a hectare of land. Land transfer mechanism in Ethiopia is limited to temporal land rental market and lease. Land sale and long term lease by farmers is outlawed by proclamation. The present study examines the technical efficiency of farmers who are operating under different tenurial structures and explains why some farmers (plots) are more efficient than the others. A stochastic frontier was used to estimate technical efficiency using data from 1786 parcel of land from 3 districts located in Oromia and Southern Regional Sates of Ethiopia The result of the analysis revealed that, the plot level technical efficiency ranged from 0.208 to 0.932 with mean value of 0.809. The study contested Marshalian conception of share tenancy as an inefficient institutional arrangement; it was found that, both share cropped in and out plots were more efficient than pure owner operated plots. The possible explanation for this finding is that, most of the share cropping arrangement was made between blood relatives that might evade the pervasive moral hazard problem in such tenurial arrangements. In addition most of the share cropping recipients was near landless and the productive use of the land is the only-option for them to meet their food security. The results of technical inefficiency model showed that, with the exception of slope other plot level characteristics which include; soil type and soil quality have significant positive effect on technical efficiency. While receiving land certificate, investment on soil conservation measures significantly reduces technical inefficiency, shallow soil depth has positive effect on technical inefficiency. The result accentuates that; the government should encourage temporal land transfer from less productive to efficient and from land surplus to land constrained households through land market.

Key words: Smallholder, stochastic frontier, technical efficiency, land tenure reform.

INTRODUCTION

The overwhelming population of Ethiopia are residing in rural area and eke out a living from farming. Arable land is becoming scarce and precious and the per capita landholding showing a consistent and declining trend. Over the last four decades the per capita land holding has shown a half cut (Jayne et al., 2002). Ethiopia is the only country in Sub Sahara Africa where its land policy remains static after the radical 1975 land reform which nationalized all rural land and made a state property. The 1975 land reform has brought mixed outcomes in the country. On the one hand, it abolished the exploitative tenant-landlord relationship and provided tenants'

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usufruct (non-free hold) right to land. In this regard, the reform was applauded for its egalitarian distribution of land and social justice.

However, its long term significance in improving the agricultural sector growth had fell short of the expectation mainly due to tenure insecurity and misguided socialist policy. Following the down fall of the Derg regime in 1991 a contested debate was opened on land policy among scholars, policy makers and donors. The debate has largely been carried out along two antagonistic arguments concerning property rights to land which include; privatization versus public land ownership (Samuel, 2006).

The Federal Democratic Republic of Ethiopia (FDRE) government has maintained the status quo of state landownership and overruled the privatization of land. The constitution which was erected in 1995 reaffirms the state ownership of land in Ethiopia (FDRE, 1995). It continues its predecessor regime land policy whereby only usufruct rights are bestowed upon landholders while the state enjoys eminent domain. The usufruct rights exclude the right to sell or mortgage the land. The government justifies its decision from the point of view of protecting farmers from losing their holding by distress selling and to avoid the possibility of resurgence of tenancy through land concentration on the hands of the wealthy.

Although the government position has attracted some support it has been attacked by advocates of a privatization of land. The latter argued that, state ownership of land prevents the development of a land market that facilitates the transfer of land to most efficient users, discourages farmers to invest on land, and thereby holds down land productivity as well as encourages unsustainable land use practices. At the heart of the land policy debate the government of Ethiopia introduces land proclamation at federal and regional level (FRLAUP, 2005; OR, 2007; SNNPR, 2007). The major departure in the new land proclamation ranges from decentralization of land administration to regional level to the introduction of land certificate to improve tenure security. It also allows land rental market and share cropping which is outlawed in the previous regime. The present study proposed to fill two gaps. First, it investigates the technical efficiency among the different landownership arrangements[1]. Secondly, it provides policy feedback for further refinment of the existing land policy.

METHODOLOGY OF THE STUDY

Background of the study area

The study was conducted in two regional states of Ethiopia which are; Southern Nation Nationalities and Peoples Region (SNNPR) and Oromiya Regional State (ORS). Three districts, one from the former and two from the later state were selected for the study. Shashemene and Arisi Negele districts were selected from Oromiya region for their importance as active trading centers along the main road to the capital city, Addis Ababa. The land pressure and conversion of land into non-agricultural purposes is likely to be higher and the land market is also assumed to be dynamic. The third district, Meskan, was selected from the southern region for comparison purpose, the area is also being known for land scarcity and land market was expected to be active in this woreda, and which may facilitate collection of valid and authentic information from the sample farmers.

Sample and sampling design

A multi stage random sampling techniques were employed in selecting the samples. In the first stage districts were selected purposefully. In the second stage eleven Peasant Associations[2] (PAs) were selected purposefully from the three districts. In the third stage a sampling frame was prepared comprising all households resides and cultivating farm land that is, own land or leased-in or share cropped-in land. A total of 394 households were selected using simple random sampling techniques.

Well structured and pre-tested questionnaires were used to elicit information from the selected sample households and their operational farm plots pertain 2007 to 2008 production year (mainly main season following June to August monsoon and whenever appropriate the small season which follow after the shower of March to April rain). A structured questionnaire which had three actions was used for the purpose. The first section was designed for collecting basic household socioeconomic information such as demographic, consumption, expenditure and marketing activities. The second section covered all the relevant information from individual farm plot such as input use and output levels, investment, land rental activity etc.

The plot level data also complemented with the information obtained from land certificate. The last one is partner schedule which was meant to collect information from land market partner to the main sample households. All information concerning the farm plots which were rented out by the main sample household to the land market during the 2007 to 2008 production year was collected by using partner questionnaire. A total of 1786 plots[2] (owned and rented in/share cropped in plots) were covered in the analysis. While rented in/share cropped in plots information were obtained from the main household, information regarding rented out/share cropped out plats were obtained from partner households (tenants). Hence, the partner households are identified after information was obtained on the status of the plot from the main household.

Analytical procedure

In this study, stochastic prduction function (SPF) was employed. The most important advantage of SPF approach is that, it allows for

[1]The federal land proclamation of 2005 states that, land redistribution may be used in relation to irrigation investment to ensure equitable distribution of irrigable land and land of deceased without hire will be distributed to landless. OR and SNNPR also adapted the two federal land proclamation cases of land redistribution in their 2007 land proclamations.

[2]Peasant Association refers to the smallest administration unit in Ethiopia. It was formed during the former socialist regime for the mobilization of rural community and to facilitate the trickle down of socialist ideology. Basically, peasant association has similar size. However, the population size is different from one peasant association to another as historically more people settled in fertile areas. Peasant association continued as the smallest administrative unit in the current regime too. [4]The price of agricultural commodity this year affects the supply (production) on the same commodity in the following year. Market guilt occurs when food aid or import coincides with harvest time affect pricing wrongly.

the introduction of statistical noise resulting from natural events which are outside the control of economic agents' such as the incidence of drought which is common in Ethiopia and other factors including market guilt[3] and luck. The SPF treats the disturbance term (ε) as being comprised of two components which are; standard independent statistical noise term (υ) and one sided non-negative random disturbance (μ), that is, ε = υ- μ. The white noise component, υ, that accounts for non idiosyncratic random effects, stands for a systematic error term assumed to be indenpendently and identically distributed (iid) as N[0, σ^2_{υ}). The second error term, μ, represents systematic effects that are not explained by the production fucntion and therefore are attributed to the agents' technical inefficiency. The inefficncy term μ is one sided since if μ = 0, the agents would be lying on the production frontier, obtaining maximum production given the level of inputs. Where as, if u_i >0, then, the agents would be operating at some level of technical inefficiency. The inefficiency effect term assumed to follow 'half normal[4]' being identically and independently distributed as N|(0, σ^2_{μ})|.

Following Farrell's (1957) techncial efficiency (TE) notation, a measure of TE for any given economic agent i would be given by the following ratio:

$$TE_i = \frac{E(Q_i \mid \mu_i, x_i)}{E(Q_i \mid \mu_i = 0, x_i)} \quad (1)$$

Where, Q_i, x_i and μ_i are the vectors of output, input and ifnefficiency effect terms, respectively. Intern, the general stochstic frontier production function is usually defined by:

$$Q_i = F(x_i; \beta)\, \varepsilon^{(\nu_i - \mu_i)} \quad (2)$$

Despite its well known limitation, a Cobb Douglas type of production function is used in the present study. Taylor et al. (1986) argued that, as long as interest rests on efficiency measurement and not on the analysis of the general structure of the production technology, the Cobb-Douglas production function provides an adequate representation of the production function. Moreover, in one of the very few studies examining the impact of functional form on efficiency, Kopp and Smith (1980) concluded that, "the functional specification has a discernible but rather small impact on estimated efficienc" (pp. 1058). That is why the Cobb-Douglas functional form has been widely used in farm efficiency analyses both for developing and developed countries (Battese, 1992; Coelli et al., 1998).

In the present study, technical efficieny analysis was computed at plot level. Since the status of the plot pricesely defined whether it was cultivated by owner operators or tenants, it enabled us to examine perfomence of technical efficency across various tenacy arrangements. The emperical model for plot level production function is specified as follows:

$$\ln Q_i = \beta_0 + \sum_{i=1}^{7} \beta_i \ln X_i + \nu_i - \mu_i \quad i=1,2,\ldots 7 \quad (3)$$

Where, Q_i is the dependent variable in the production function showing total output value for the i[th] plot. In represents the natural logarithm. Both the output value in ETB and inputs quantity are expressed in logarithms. Six input categories are defined as explantory vaiables in the production function. X_i is a vector of k inputs used in the production of i[th] crop and it is defined as follows:

x_1 = quantity of manure applied (kg/M^2), x_2 = draft animal power used in pair (oxen days), x_3 = fertilized applied (kg/M^2), x_4 = family labour (person day), x_5 = size of plot in ha, x_6 = value of seed (ETB[5]).

β_is'are unknown parameters to be estimated and V_i and U_i are random error term and non-negative random variables associated with technical inefficiency respectively. U_i is assumed to be independetly distributed such that, the technical inefficiency effect for the i[th] plot is obtained by truncation (at zero) of the normal distribution with mean μ_i and σ^2 such that:

$$u_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + w_i \quad (4)$$

Where, Z_1 = represent a dummy variable for plots registration in land certificate (1 = if it is registered in the land certificate, 0 otherwise), Z_2 = represent the soil type (1 = black, 2 = Dark brown, 3 = red, 4 = white, 5 = sandy), Z_3 = soil depth (1= shallow, 2 = medium 3 = deep), Z_4 = slope (1 = plain, 2 = foothill 3 = midhill 4 = steephill), Z_5 = plot qulaity (1 = poor 2 = medium 3 = good 4 = very good) Z_6 = dummy variable showing the presence or absence of soil conservation parcatice (1 if soil conservation structure is constructed, other wise 0).

The δ's are unknown parameters to be estimated. w_i is composed of υ_i and u_i as defined earlier. It is assumed that, some farmers produce on the frontier and others do not. For this study the parameters of Equations 1 and 3 were estimated using the Maximum Likelihood (ML) method, following the likelihood function estimation by Battese and Corra (1977). Where, $\sigma^2_s = \sigma 2 + \sigma^2_v$ and $\gamma = \sigma^2 / \sigma^2_s$, and σ^2_u is the variance of u_i and σ^2_v is variance of υ_i. And γ is defined as, the total variation of output from frontier which can be attributed to technical (in) efficiency.

RESULTS AND DISCUSSION

The prevailing tenancy structure

The sample households were found operating in eight types of tenancy structures. The majority (66%) was pure owner operator who cultivates their own farm holdings while the rest of 34% of households participated in the land rental market as a tenant or lessee or both. About 46% of the household participated in the share cropped type of tenancy while 40% of households took part in fixed rental land market. The remaining 14% was participated in both fixed and share cropped rental market. Examination of the tenancy structure shows that, of all the households that participated in the land rental market, 50% of the respondent household were situated at the demand side whereas, 46% participated as

er, the population size is different from one peasant association to another as historically more people settled in fertile areas. Peasant association continued as the smallest administrative unit in the current regime too. [4]The price of agricultural commodity this year affects the supply (production) on the same commodity in the following year. Market guilt occurs when food aid or import coincides with harvest time affect pricing wrongly.

[4]The price of agricultural commodity this year affects the supply (production) on the same commodity in the following year. Market guilt occurs when food aid or import coincides with harvest time affect pricing wrongly.

[5]Plot in this study refers to a specific parcel of land allocated for the production of one type of crop or intercepting. In the latter case most inputs are commonly used as the result the figures are divided equally for the two crops while yield data is collected separately.

[6] ETB refers to Ethiopian Birr. Birr is the name of Ethiopia currency.

Table 1. Type and structures of tenancy (%).

Tenancy type	Household level (N = 394)	Plot levels (N = 1786)
Pure owner operator	65.99	83.76
Fixed rent tenants	5.84	4.03
Fixed rent lessors (land lord)	7.87	3.70
Share tenants	8.88	4.70
Share lessors	6.60	3.81
Fixed and share tenants	2.28	-
Mixed (lessors and tenant)	1.27	-
Fixed and share lessors	1.27	-
Total	100	100

supplier of land. Only 4% of the household were participated at both supply and demand side simultaneously. The plot level data reveals that out of the total 1786 plots, 290 plots (16%) were supplied to the land rental market. For the details of input-output information at plot level and the major crops grown in the study area refer Table 1A and 2A of the appendix (Table 1).

The land tenure structure most often indicates the level of land rental market participation and the direction of tenancy. Swamy (1988) and Chattopadhyay and Ghosh (1983) has shown that, the term and structures of tenancy prevailing in a given area influence the condition of demand and supply in the land lease market. The demand for land is a function of labour endowment that is, the extent of unemployed or underemployed family labour within the tenant household in relation to landholding size. The terms of tenancy such as arrangements of inputs allocation and output sharing in share cropping and also obligation of tenants and the duration of contract in the fixed rental market influence the demand for land.

The supply of land on the other hand depends upon the state of the art or methods of cultivation and the ground rent in relation to the marginal product of investment through direct cultivation. Under perfect condition tenancy equilibrium is attained, when the marginal product of capital equal to rent and when wage rate is equal to the excess of marginal product of land over rent while the former make the landlord indifference between self cultivation and renting out the latter makes the tenant indifference between renting in and working as labourers.

However, in most of the cases the land and labour market are less than been perfect and it prevents these conditions to be happened. The actual scenario is that, there are too many aspirant tenants at the demand side and few landlords are at the supply side. Hence, the land rental market is characterized by near monopoly at the supply side and near perfect competition at the demand side. However, when the landlord is poorly endowed with resources and rent out land under distress situation to respite this situation or due to lack of labour employment as in the case of the study areas, the supply and demand of land governed by not as such due to surplus or deficit of land at household level but due to the prevailing interlocked (such as social capital, resource transfer) and imperfect factors market (credit and labour).

Estimates of parameters for SFP function and inefficiency determinants

In the present study prior to proceeding to the analyses of technical efficiency and its determinants (Table 2); the presence of technical inefficiency was detected. The test was carried out by estimating stochastic frontier production function and conducting a likelihood ratio test assuming the null hypothesis of no technical inefficiency. The test statistics confirmed that the inefficiency component of the disturbance term (u) is significantly different from zero at 5% level suggesting that the null hypothesis of the technical inefficiency is rejected. Hence in the production input-output data for plot level inefficiency exist and it is indeed stochastic. The value of gamma (γ) (Table 2) further indicates that, there is 38% of variation in output is due to technical inefficiency. This means that, technical inefficiency is likely to have an important effect on in explaining output among the plots in the sample[6].

Following a one step approach of Coelli (1996), a stochastic frontier production function was estimated using Cobb-Douglas formulation where, the natural logarithm of output value per hectare is considered as dependent variable. In plot level crop production, technical efficiency is likely to be affected by a wide range of plot level characteristics, plot ownership (tenancy), tenure security and plot level investment in conservation measures.

The result as presented in Table 3 indicates that, the coefficients which denote the output elasticity of inputs

[7]Therefore, Maximum Likelihood Estimate (MLE) gives appropriate results rather than ordinary least square estimator (OLS).

Table 2. Detecting the presence of inefficiency.

Explanatory variable	Coefficients	Std. Err.	Z
Manure	0.006	0.009	0.66
Seed	0.114**	0.054	2.08
Fertilizer	0.050***	0.009	5.58
Draftanimal	0.425***	0.050	8.46
Plotsize	0.496***	0.047	10.54
Tlabout	-0.033***	0.013	-2.67
_constant	1.432***	0.203	7.06
Number of observation	1786		
Wald chi-square (χ^2) (6)	2196.13		
Prob.>chi2(6)	0.000		
σ^2_v	0.328	0.028	
σ^2_u	0.203	0.095	
$\sigma^2 = (\sigma^2_u + \sigma^2_v)$	0.532	0.058	
$\lambda = (\sigma^2_u / \sigma^2_v)$	0.787	0.121	
$\gamma = \frac{\lambda^2}{(1+\lambda^2)}$	0.382		
Likelihood-ratio test of sigma _u = 0: chibar2(01)	2.65**		

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 1. Plots level estimate of stochastic frontier for C-D type production function.

Variable	Coefficients	Standard error	t-ratio
Constant (β_0)	2.72	0.153	17.75***
ln manure (β_1)	0.001	0.009	0.038
ln draft animal (β_2)	0.514	0.039	13.18***
ln fertilizer (β_3)	0.598	0.009	4.89***
ln family labour (β_4)	0.044	0.049	12.27***
ln seed (β_5)	-0.010	0.012	-0.877
ln plot size (β_6)	0.277	0.027	2.84***
Technical inefficiency			
Constant (δ_0)	-5.260	3.526	-1.92**
ln land certificate (δ_1)	-1.736	0.752	-2.31**
ln soil type (δ_2)	-1.796	0.911	-1.97**
ln soil depth (δ_3)	0.533	0.251	2.13**
ln slope (δ_4)	-0.092	0.254	-0.364
ln plot quality (δ_5)	2.632	1.120	2.35**
Lnadoption conservation (δ_6)	-0.850	0.402	-2.12**
$\sigma_u/\sigma_v = \lambda$	0.590		
$(\sigma^2_u+\sigma^2_v)=\sigma^2$	0.532	0.401	3.56***
σ^2_u	0.203		
σ^2_v	0.329		
Gamma (γ)	0.382	0.071	10.47***
Log likelihood	-1756.1		
N	1786		

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

included stochastic frontier estimation were all positive except for seed. The negative sign for value of seed has indicated that farmers have over expended for seed. This is quite often the case as in mixed farming areas of

Table 4. Technical efficiency of plots under different tenancy arrangements (N %).

Technical efficiency	Technical efficiency				
	Owner operated plots	**Rented in plots**	**Rented out plots**	**Share in plots**	**Share out plots**
Below 75	238 (16)	2 (2.78)	7 (10.6)	10 (11.9)	5 (7.35)
75.1 to 90	1242 (83)	69 (95.83)	59 (89.4)	72 (85.7)	61(89.71)
Above 90	16 (1)	1 (1.34)	0	2 (2.4)	2 (2.94)
Mean	0.8071	0.8362	0.8063	0.8152	0.8238
Loss of output value due to inefficiency (ETB)	19.31	16.38	19.37	18.48	17.62
N	1496	72	66	84	68
F statistics			4.05***		

*** Significant at 1% level.

Ethiopia farmers exceed the normal seed rate for some cereals to thin out later to feed their animals as green fodder. The positive and significant value for other inputs implies that there is scope for increasing plot level productivity of crops in the districts under study. Fertilizer, draft animal and land come as the most important factors of production with elasticity of 0.598, 0.514, and 2.77, respectively. This implies that, ceteris paribus, an increase in the extent of fertilizer application, increase in oxen days and cultivable plots under crop production would significantly lead to increased output of crops. Similar results are reported by Barnes (2008) and Basnayake and Gunaratne (2002) among Scottish cereal producers and Sri Lanka tea smallholders respectively. The returns to scale (RTS) value, 1.424[7] obtained from the summation of the coefficients of the estimated coefficients of elasticity confirm that, plot level production in the study area is in Stage I of the production frontier. This stage is characterised by increasing return to variable inputs (Table 3).

Plot level technical efficiency

The model overall explanatory powers are good with significant log likelihood ratio test ($\chi^2 = 21.51$, $p < 0.05$). The null hypothesis which specifies the technical inefficiency effect is not present ($H_{o:}\ \gamma=0$) can be rejected as the gamma value 0.38 is significant at 1% level implying that inefficiency exist and is indeed stochastic. The estimated value of σ^2_u and σ^2_v were 0.204 and 0.329, respectively. The estimate of the total error variance sigma square (σ^2) value of 0.532 implying that, 53% of the difference between the observed and the maximum possible production for the plots considered are due to existing differences in the technical efficiency levels or management practice among the producers.

The value of gamma (γ) further indicates the presence of inefficiencies in the production of crops. In other words, about 38% of the difference between the observed and the frontier output was mainly due to the inefficient use of resources, which are under the control of farmers. The result corroborates with the findings of Rama Rao et al. (2003), Bhende and Kalirajan (2007) from India, Kariuki et al. (2008) from Kenya; Getu (1997), Ahmed et al. (2002), Gavian and Ehui (1999); Tesfaye et al. (2005); Kassie and Holden (2007); and Bamlaku et al. (2009) from Ethiopia, they reported the prescience of inefficiency in smallholder farming. Table 4 shows the frequency distribution of estimated technical efficiency and mean plots efficiency by tenancy types.

The results of technical inefficiency model shows that, except slope all plot level characteristics and other explanatory variables included in the model have significant effect on technical efficiency. Receiving land certificate, soil type and adoption of soil conservations have a significant positive effect on technical efficiency. On the other hand, shallow soil depth and poor soil quality have a significant negative effect on technical efficiency. Taking each of these technical inefficiency variables in turn we find that, receiving land certificate is significant (t-ratio = - 2.31), showing thatfarmers who received land certificate for their plots are more efficient than those who did not receive certificate. Soil type of the plot is also found to be significant (t =-1.970) which suggest that, black and dark brown soils contributes more efficient production than white and sandy soils. Soil depth is significant at 5% level (t = 2.13), supporting the argument that, shallow depth soil reduce technical efficiency (Tchale and Sauer, 2007). Likewise poor quality plot found to have a significant negative effect on technical efficiency in that owning poor quality plot lead to technical inefficiency.

As mentioned earlier, the technical inefficiency effect is significant; thus, the technical efficiencies of the sample

[8]The calculated value of return to scale (1.424) is tested for its statistical difference from constant return to scale using t-test approach. The result indicates that the calculated t value 2.92 is greater than the tabulated t value 2.447 at 5% level and 6 degree of freedom. Hence implying the hypothesis of constant return to scale is rejected at 5% level.

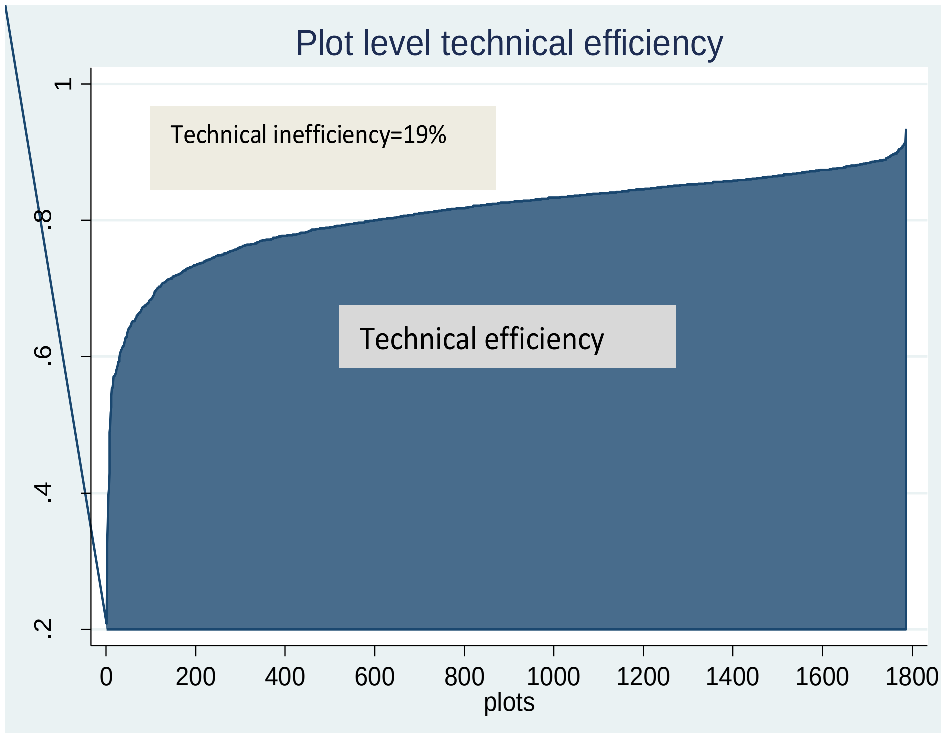

Figure 1. The cost of technical inefficiency.

households are equal to 1 when the plot level production was on the frontier or less than one. The cost accrued to the farmers due to the existence of technical inefficiencies is considerable, ranging from 7 to 79% in terms of loss of outputs value. The area bounded below the concave curve in Figure 1 indicates the technical efficiency, while the upper area represents technical inefficiency. The technical inefficiency area amounts about 19% in the output value on average due to technical inefficiency that can be bridged by efficient use of the existing resources under the prevailing.

Tenancy and plot level technical efficiency

In theory, technical efficiency level ranges between zero and one. The higher the technical efficiency value (close to one) the higher the efficiency of the farm (Coelli, 1994). The efficiency levels in this study ranged from 0.208 to 0.932[8] with a mean of 0.809. This implies that, if an average plot of land to achieve the efficiency of the most efficient counterpart, then the average operator would realize up to 13.2% more output from the same resources[9]. In terms of tenure structure the technical efficiency of the five types of tenancy were examined. The finding indicates that, rented in plots was found to have the highest technical efficiency level with a mean of 0.84. Contrary to the Marshalian conception of share tenancy as inefficient institutional arrangement we found both share in and share out plots were more efficient than pure owner operated with mean technical efficiency of 0.815 and 0.824, respectively. The possible explanation for the share tenant managed plots technical efficiency superiority over pure owner operated and rent out plots might be due to the tenancy arrangement was mostly done between blood relatives and in-laws and this might reduce moral hazard and associated disincentives. For instance Sadoulet et al. (1997), using data from a 1992 survey of three Philippine villages, test for efficiency differences across sharecrop contracts made among kin and impersonal sharecrop contracts and concluded that the technical efficiency of tenancy with kin was superior to that of non-kin. The absence of noticeable difference between share cropping and other tenancy arrangements was also reported by Ashok Rudra (1973) from India.

The observed technical efficiency difference among

[10]Getu (1997) measured the technical efficiency of farmer as well as plot level in Babile area of Ethiopia for 1993 and 1994 production seasons and he reported a technical efficiency ranged from 0.20 to 0.91 in 1993 and 0.30 to 1 in 1994 which is similar to the findings of this study.

[11] $\left(1-\frac{0.809}{0.932}\right)$

various tenancy structures was significant at 1% level indicating positive potential role of land rental market for efficiency (Table 4). It allocates land from less efficient owner operator to efficient tenants which are commendable policy implication from both equity and efficiency point of view. First, since both study regions dissociate from future land redistribution except for irrigated areas and with the community consent, the available best alternative is market oriented allocation of land and should be encouraged through appropriate policy intervention. Second, the existing land ownership inequality between the generation who benefited from last redistribution and the current generation who are near landless was overcome by land rental market. Despite the efficiency and equity merit of land rental market both Oromiyia and SNNP regions put some restrictions on the land market operation. In both regions landholder is allowed to lease out up to half of the land under his or her holding with the justification of protecting household food production. This means under the prevailing average land holding a farmer after leasing out is left out with 0.5 ha or less for self cultivation which is not viable and economical to use modern technologies on the face of chronic production risk (drought, infestation, market etc) and the prevailing methods of production.

In addition this restriction tied up farmers to a tiny parcel rather than contemplating alternative non-farm and migration livelihood options. This mainly because of the land policy is narrowly viewed food security from production perspective and this critically undermines the possibility of acquiring food security from non-agricultural livelihood options. In terms of duration of lease Oromiya region specified three years if the renter use traditional technology and 15 years if the renter uses modern technology. SNNP region relax the duration of lease out up to five years for users of traditional technology and up to 10 years if renter uses modern technology. From the point of view, crop production which enables to reap short term, benefit the lease period can be considered adequate but it can hampers long term investments in agriculture which normally requires longer gestation period.

Conclusion

The findings of this study showed that, there is efficiency gain as a result of land allocation through land rental market (both fixed and share cropping contracts). Contrary to the Marshalian conception of share tenancy as inefficient institutional arrangement, we found that, both share cropped in and out plots were more efficient than pure owner operated plots. However, the restriction imposed on the size and duration of land lease through the land proclamations in the study regions has constrained households from tapping the full potential benefit of land rental market.

The area of land that can be leased and the length of time the rental agreement lasts impede not only the land rental market efficiency but also labour mobility which consequently tied up households on farming sub-economic plots. Lifting the ceiling on the land area to be leased and relaxing the time limit on rental contract is an important step and can serve as a natural experiment to study the responses of households to such changes in terms of land transfer, its direction and the possible negative consequences before embarking to fundamental reforms like land privatisation. In addition removing the restriction on duration of lease will motivate tenants to invest on the land that can improve land management and overall efficiency.

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Appendix

Table 1A. Input and output level at plot level.

Variable	Districts			
	Shashamene	Arsi Negele	Meskan	All
Landholding size (ha)	1.12 (0.070)	1.33 (0.075)	0.78 (0.045)	1.11(0.41)
Output per ha (kg)	1397 (126)	1361 (70.4)	1024 (70)	1286 (58)
Weighted index output value (ETB/ha)	3373.93 (250.83)	3726.40 (98.35)	4013.94 (149.37)	3692.70(102.36)
Seed Value (ETB)	533.64(35.86)	543.87(27.48)	185.67(13.89)	448.84(18.92)
Manure (kg /ha)	875.4 (186.4)	217.4(43.4)	440.2(363)	988.2(312.7)
Draft animal (oxen days per ha)	107.00(2.12)	101.38(1.63)	130.69 (5.02)	111.99(1.784)
Fertilizer (DAP+UREA) (kg/ha)	72.83(4.64)	92.67(8.06)	41.70(4.13)	45.78(0.95)
Male labour allocated (person days per ha)	44.25(1.80)	43.78(0.85)	49.96(2.20)	45.78(0.95)
Female labour allocated (person days per ha)	33.69(2.12)	21.10(0.66)	30.62(1.82)	28.19(0.94)
Hired labour used (person days per ha)	5.63(0.38)	8.30(0.52)	6.80(1.12)	6.95(0.41)
Number of plots (fragmentation)	3.02(0.09)	3.68(0.12)	5.54(0.26)	3.91(0.10)
Total gross income (ETB)	7497.53(801.21)	9283.70(805.05)	6531.64(337.86)	7904.79(433.82)
Per capita income (ETB)	1245.23(114.62)	1397.71(109.91)	1226.66(103.92)	1296.60(64.83)

Figures in the table are mean followed by standard error (SE).

Table 2A. Plots allocation for crop production by districts.

Crop type	Districts			
	Shashamene	Arsi Negele	Meskan	All
Total plot numbers	600 (33.60)	654 (36.62)	532 (29.79)	1786 (100)
Wheat	68 (11.33)	168 (25.70)	24 (4.51)	260 (14.56)
Barely	13 (2.15)	28 (4.30)	12 (2.26)	53 (2.97)
Tef[12]	98 (16.32)	84 (12.90)	144 (27.12)	326 (18.25)
Sorghum	13 (2.15)	15 (2.30)	68 (12.81)	96 (5.38)
Maize	147 (24.50)	208 (31.80)	201 (37.78)	566 (31.13)
Haricot bean	16 (2.65)	13 (2.00)	68 (12.81)	97 (5.43)
Horse bean	1 (0.17)	13 (2.00)	5 (0.94)	19 (1.06)
Chickpea	3 (0.5)	-	-	3 (0.17)
Sweet potato	4 (0.67)	1 (0.15)	-	5 (0.28)
Chilli pepper	-	-	7 (1.32)	7 (0.39)
Potato	220 (36.67)	100 (15.30)	-	320 (17.92)
Kale	12 (1.99)	10 (1.54)	1 (0.19)	23 (1.29)
Cabbage	5 (0.83)	2 (0.31)	-	7 (0.39)
Onion	-	12 (1.84)	2 (0.38)	14 (0.78)
Enset	73 (48.32) †	31 (21.38) †	-	104 (5.82) †
Chat	-	-	17(17) †	17(0.95) †

Figures in the table are number of plots allocated for each crop followed by percentage. † indicate number of households.

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