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Smallholder marketed surplus and input use under transactions costs: maize supply and fertilizer demand in Kenya

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Abstract

This paper assessed the effects of transactions costs—relative to price and non-price factors—on smallholder marketed surplus and input use in Kenya. A selectivity model was used that accounts not only for the effects of fixed and variable transactions costs but also for the role of assets, technology, and support services in promoting input use and generating a marketable surplus. Output supply and input demand responses to changes in transactions costs and price and non-price factors were estimated and decomposed into market entry and intensity. The results showed that while transactions costs indeed have significant negative effects on market participation, cost-mitigating innovations—such as group marketing—are also emerging to mitigate the costs of accessing markets. Output price has no effect on output market entry and only provides incentives for increased supply by sellers. On the other hand, both price and non-price factors have significant influence on adoption and intensity of input use. Overall, the findings suggest that policy options are available other than price policies to promote input use and agricultural surplus.

Keywords: Commercialization, Marketed surplus, Fertilizer use, Transactions cost, Kenya

Introduction

Subsistence agricultural producers in sub-Saharan Africa (SSA) face several barriers that make it difficult for them to gain access to markets and productive assets. The single most important barriers to smallholder market participation in SSA are transactions costs—the pecuniary and non-pecuniary costs associated with arranging and carrying out a transaction (Goetz, 1992; Staal et al., 1997; Holloway et al., 2000). In the presence of transactions costs, traditional analyses of output supply and input demand responses to changes in prices and other factors may fail to identify the right mix of policy and institutional reforms to promote market-oriented smallholder agricultural production. The main objective of this paper is thus to assess the effects of transactions costs and cost-mitigating institutional innovations—relative to prices and non-price factors—on marketed surplus and input use among maize producers in Kenya..

Empirical methodology

Most empirical studies on output marketed supply or input demand have used the famous Heckman's (1976) sample selection model (e.g. Minot et al., 2000; Winter-Nelson and Temu, 2005) or its variants of double hurdle (e.g. Coady, 1995) and switching regression models (e.g., Goetz, 1992) while some used the more restrictive tobit model to analyze output marketed supply (e.g., Holloway et al., 2000). Because fixed transactions costs are expected to affect the decision to participate in a market, but not the intensity of participation, the sample selection model has been considered more appropriate than the restrictive tobit model. The sample selection model has an advantage over the tobit model in that the tobit model assumes that "zero" values associated with non-participation are outcomes of a rational choice (i.e., corner solutions). The sample selection models were implemented by first estimating a probit model of participation in the respective markets. The inverse Mills' ratios were then generated and used in a second-stage regression to explain maize supply and fertilizer demand (See Heckman (1976) for details of the sample selection model). (Due to space limitations, the theoretical framework and variable hypotheses are not presented and can be obtained from the authors upon request). There are four different responses of marketing behavior to changes in the explanatory variables. These are the change in probability of market participation, the change in desired quantities transacted, the change in actual quantities transacted conditional on market participation, and the total change in quantities transacted unconditional on

market participation. First, the change in probability in market participation per unit change in the *i*-th explanatory variable ($\mathbf{Z}_{ki}$) can be calculated as:

$$\left(\frac{\partial\Phi(\alpha_k'\mathbf{Z}_k)}{\partial\mathbf{Z}_{ki}}\right)=\alpha_{ki}\,\phi(\alpha_k'\mathbf{Z}_k),\qquad k=m,f.$$

Second, the change in desired (or potential) quantities transacted is simply the coefficient associated with the variable in the output marketed supply or input demand equation. The parameters β_m and β_f thus represent the marginal effects on potential maize supply and fertilizer demand, respectively. Third, the conditional and unconditional marginal effects on actual quantities transacted (Q_t) per unit change in the *i*-th variable ($\mathbf{X}_{ki}$) can be calculated as: Eq. (1) shows that the total unconditional marginal effect on quantities transacted equals the sum of (1) the marginal effect on quantities transacted by participants weighted by the probability of participation, and (2) the marginal effect on the probability of participation weighted by the expected quantities transacted by participants. While the changes in the quantities transacted by participants weighted by probability of participation represent the *total effects due to current participants*, the changes in probability of participation weighted by expected quantities transacted by participants represent *total effects due to new participants*.

Data

The data used in this study come from a sample survey of 691 maize producers in 8 districts in western

Kenya, where maize is an important food as well as cash crop and fertilizer is critical for sustaining maize production. The data were collected between September and December 2005 both for 2004 and 2005 agricultural years. The sample households were selected randomly from a total of 32 villages in 8 major maize growing districts in Nyanza and Western provinces.

Empirical results

The selectivity model estimates of maize market participation and supply are presented in Table 1. The first striking result is that female-headed households have a greater likelihood of participation in maize markets than male-headed households. However, male-headed households who already participate in the market tend to supply more maize than female-headed households. Maize price, transactions costs, and the factors that mitigate transactions costs have the expected significant effects on market participation and supply. Maize price has the expected positive and significant effect on marketed supply, but its effect on market participation is not significant. A 1% increase in maize prices increases maize supply by 1.7% among sellers.

As fixed transactions costs are expected to influence only market participation, information variables were excluded from the second-stage marketed supply

$$\begin{aligned}
\left(\frac{\partial E(Q_t|Q_t>0)}{\partial\mathbf{X}_{ki}}\right) &= \beta_{ki}+\alpha_{ki}\gamma_k[(\alpha_k'\mathbf{Z}_k)\lambda_k+\lambda_k^2],\\
\left(\frac{\partial E(Q_t)}{\partial\mathbf{X}_{ki}}\right) &= \beta_{ki}\Phi(\alpha_k'\mathbf{Z}_k)+\alpha_{ki}\phi(\alpha_k'\mathbf{Z}_k)[(\beta_k'\mathbf{X}_k)+\gamma_k(\alpha_k'\mathbf{Z}_k)],\\
&= \left(\frac{\partial E(Q_t|Q_t>0)}{\partial\mathbf{X}_{ki}}\right)\Phi(\alpha_k'\mathbf{Z}_k)+\left(\frac{\partial\Phi(\alpha_k'\mathbf{Z}_k)}{\partial\mathbf{Z}_{ki}}\right)E(Q_t|Q_t>0)\\
&\qquad k=m,f.
\end{aligned}\tag{1}$$

Table 1. Selectivity model estimates of maize marketed supply under transactions costs in Kenya

Variable	Market participation (*MMP*)		Marketed supply (*MZSOLD*)	
	Coefficient	Change in probability	Coefficient	Elasticity of observed supply
Gender of the head (male=1)	-0.343** (-2.22)	-0.103**	0.287(1.25)	0.144
Age of the head (years)	-0.591**(-2.46)	-0.166**	-0.513(-1.12)	-0.764
Education of the head (6 years=1)	0.022 (0.12)	0.006	0.042 (0.18)	0.051
Extension (% farmers/district)	0.235*** (3.16)	0.066***	0.941***(3.83)	1.041***
Credit access (unconstrained=1)	0.617*** (4.81)	0.188***	-0.120 (-0.35)	0.137
Land per capita (ha)	0.380*** (5.20)	0.107***	0.341 (1.57)	0.502*
Adults in the household (number)	0.387*** (2.91)	0.109***	0.534* (1.90)	0.699*
Livestock ownership (TLU)	-0.044 (-1.10)	-0.012	0.113* (1.83)	0.095*
Off-farm incomes (Ksh)	-0.137*** (-2.74)	-0.038***	0.105 (1.20)	0.047
Modern variety (% adopters/district)	-0.054 (-0.96)	-0.015	0.440***4.47)	0.417***
Price of maize (Ksh/kg)	0.316 (1.43)	0.089	1.531*** (4.20)	1.665***
Distant maize market (>10km=1)	-0.172 (-1.31)	-0.048	-0.542** (-2.29)	-0.615**
Distant fertilizer market (>15km=1)	-0.220* (-1.61)	-0.061*	-0.633*** (-2.52)	-0.727***
Group marketing (member=1)	-0.022 (-0.10)	-0.006	0.569* (1.76)	0.560*
Pack animals (number)	0.079 (0.30)	0.023	0.488 (1.29)	0.521
Communication facilities (yes=1)	0.021 (0.14)	0.006		
Transport equipment (yes=1)	0.419*** (2.94)	0.114***		
Zone (Western Province=1)	0.110 (0.71)	0.031	0.066(0.27)	0.112
λ_m (Mills' ratio)			-0.544*(-1.73)	
Constant	1.417(1.12)		-2.055(-1.02)	

Table 2. Unconditional total elasticities of maize marketed supply and decompositions

Variable	Total expected change in sales (%)	Total change through new participants (%)	Total change through current participants (%)
Extension	0.488	0.278	0.210
Modern variety	0.084	NS	0.084
Land per capita	0.551	0.449	0.101
Adults in the household	0.599	0.457	0.141
Price of maize	0.336	NS	0.336
Group marketing	0.113	NS	0.113
Distant maize market	-0.124	NS	-0.124
Distant fertilizer market	-0.403	-0.256	-0.147
Transport equipment	0.026	0.024	0.002

Note: Only significant total elasticities and decompositions are reported. NS=not significant.

Table 3. Selectivity model estimates of fertilizer demand under transactions costs in Kenya

Variable	Adoption		Fertilizer demand	
	Coefficient	Change in probability	Coefficient	Elasticity of observed demand
Gender of the head (male=1)	0.062 (0.27)	0.002	-0.375* (-1.77)	-0.384*
Age of the head (years)	-0.605* (-1.80)	-0.017*	0.222 (0.49)	0.307
Education of the head (6 years=1)	0.269 (0.88)	0.006	0.001 (0.01)	-0.037
Extension (% farmers/district)	1.148*** (4.60)	0.033***	0.825* (1.66)	0.664*
Credit access (unconstrained=1)	-0.155 (-0.86)	-0.004	0.042 (0.27)	0.064
Land per capita (ha)	-0.155 (-1.53)	-0.004	-0.325***-2.60)	-0.303***
Adults in the household (number)	0.192 (1.06)	0.005	-0.278 (-1.37)	-0.305
Livestock ownership (TLU)	-0.071 (-1.25)	-0.002	0.178*** (2.94)	0.188***
Off-farm incomes (Ksh)	0.132** (2.14)	0.004**	0.238***(3.39)	0.220***
Modern variety (% adopters/district)	0.070 (1.01)	0.002	0.132** (2.03)	0.122**
Price of maize (Ksh/kg)	1.881*** (6.02)	0.054***	1.304* (1.64)	1.041*
Distant fertilizer market (>15km=1)	-0.789*** (-3.98)	-0.022***	-0.526 (-1.39)	-0.415
Group marketing (member=1)	0.275 (0.84)	0.010	0.515*(1.79)	0.477*
Pack animals (number)	0.530(1.37)	0.026	0.683*(1.89)	0.610*
Communication facilities (yes=1)	0.129 (0.70)	0.008		
Transport equipment (yes=1)	0.312* (1.67)	0.003*		
Zone (Western Province=1)	1.571*** (6.70)	0.071***	0.626 (0.84)	0.407
λ_f (Mills ratio)			0.155* (1.68)	
Constant	-11.748*** (-5.75)		-7.086 (-1.37)	
% correct prediction	89			

equation. Ownership of transport equipment has turned out to have a positive and highly significant effect on market participation. Another important result is that while distance to the maize market has a negative and significant impact on maize supply, distance to the fertilizer market has a negative and significant impact both on maize market participation and marketed supply.

The significant effect of distance to the fertilizer market both on participation and supply confirms that fertilizer markets are less accessible and hence fertilizer use is too low to meet production thresholds for market participation and to increase marketed supply. Consistent with the expectation that group marketing mitigates proportional transactions costs, the results show that group marketing membership has a positive and significant impact on marketed supply. Market participants who belong to the maize marketing group supply 56% more maize than participants who do not belong to the group. The relationship between the exogenous variables and output marketed supply can be assessed either conditional on selling maize at the time of the survey, or unconditionally for the entire sample. Table 2 reports the unconditional marginal effects. One of the issues of interest in studies of elasticity of supply is price elasticity under transactions costs. The estimated price elasticity of maize marketed supply of 0.34 is only slightly lower than Key et al.'s (2000) estimate of 0.49 for maize in Mexico. There is thus evidence of a small but positive and significant supply response. The advantage of the selection model used in this study is that a distinction is made between the total elasticity estimate of 0.34 and the conditional elasticity of 1.67. The substantial difference between the estimate for all farmers and that for sellers confirms the low level of market participation among smallholders. The high conditional elasticity suggests that output price is indeed an effective policy instrument to increase marketed surplus among sellers. However, given that the majority do not sell output, interventions that raise

prices are likely to benefit sellers only, bypassing the majority and imposing costs on buying households. Maize supply also responds to increased access to land, labor, and extension. Remoteness of the maize market reduces supply by 12%. Because fertilizer markets are much further than output markets, remoteness of the fertilizer market reduces total marketed supply by over 40% and this comes about through both reduced participation (25%) and reduced supply (15%). The result that the effects of all variables except output price on marketed supply are through market entry, relative to that through increased supply among participants, brings out an interesting implication that a successful commercialization policy is one that brings a large proportion of the peasant population into the realm of markets—through, for example, improved technology, support services, and infrastructure.

Fertilizer demand

The selectivity model estimates of fertilizer demand are presented in Table 3. An interesting result is that although male-headed and female-headed households have equal likelihood of adoption of fertilizer, female-headed adopter households used fertilizer more intensively than male-headed adopter households.

Maize price has the expected positive and significant effect on adoption of fertilizer, with a 1% increase in maize price increasing the probability of fertilizer adoption by 5% and fertilizer demand among adopters by over 1%. Because fixed transactions costs are expected to influence only the fertilizer adoption decision, information and information-transport interaction variables—communication and ownership of transport equipment—were excluded from the second-stage fertilizer demand equation. Ownership of transport equipment has a positive and significant effect on adoption. Distance to the fertilizer market has a negative and significant impact on adoption, but has no significant effect on intensity of fertilizer use. The significant effect of distance to the fertilizer market on fertilizer adoption confirms that input market distance affects technology adoption by increasing the fixed cost of acquiring modern inputs. On the other hand, group marketing of maize has a positive and significant effect on intensity of fertilizer use, with adopters who are members of the marketing group using 48% more fertilizer per ha than adopters who are non-members. Ownership of pack animals also has a positive and significant impact on intensity of fertilizer use, with adopters who own pack animals using 61% more fertilizer per ha than adopters without pack animals.

Unconditional total elasticities of fertilizer demand with respect to significant variables are presented in Table 4. The output price elasticity of fertilizer demand is 0.19, indicating that fertilizer use is inelastic with respect to output price.

Conclusions and policy implications

This paper estimated output supply and input demand responses to changes in transactions costs and price and non-price factors and decomposed the estimates into market entry and intensity. Results revealed that output price has no effect on output market entry and only provides incentives for increased supply by sellers. On the other hand, both price and non-price factors have significant influence on adoption and intensity of input use. While transactions costs indeed have significant negative effects on market participation, cost-mitigating innovations—such as group marketing—are also emerging to mitigate the costs of accessing markets. Rising information and transportation costs in the input and output markets may therefore explain the low use of purchased inputs and limited output response following market reforms. The transactions costs of acquiring inputs and selling farm output could thus be reduced through improved information and transportation infrastructure, deeper penetration of reputable input distributors, and promotion of institutional innovations, such as production and marketing cooperatives. Indeed, the results provide evidence that institutions, such as the Maize Marketing Movement, are emerging to mitigate transactions costs and to promote market transactions. However, this social capital has yet to be strengthened to induce greater market participation.

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Table 4. Unconditional total elasticities of fertilizer demand and decompositions

Variable	Total expected change in fertilizer use (%)	Total change through new adopters (%)	Total change through current adopters (%)
Extension	0.114	0.107*	0.007*
Off-farm income	0.015	0.012	0.002
Price of maize	0.186	0.175	0.011
Distant fertilizer market	-0.077	-0.072	-0.004
Transport equipment	0.011	0.010	0.001

Note: Only significant total elasticities and decompositions are reported