The Effect of Household Wealth on Input Market Participation in Southern Africa

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**Contributed paper prepared for presentation at the
International Association of Agricultural Economists Conference,
Gold Coast, Australia, August 12-18, 2006**

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♣ Contributed paper selected for presentation at 26th Conference of the International Association of Agricultural Economist, 12 – 18 August, 2006, Gold Coast Convention Centre, Queensland, Australia

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Abstract

Input technological change, fundamental to rural transformation, sometimes by-passes some rural populations because farmers are often reluctant to use new inputs due to production and price risks that could render their use unprofitable. The level of wealth of the household significantly relates to the household's ability to cope with such risks. Given the highly disproportionate distribution of wealth among rural households, this paper demonstrated that first stratifying households into meaningful wealth categories and estimating non-separable household improved variety adoption and seed demand models for each wealth category provides an opportunity to develop credible policy relevant recommendations on interventions that increase impact. This approach contributes significantly to the methodological challenges of assessing seed demand in developing agriculture.

JEL Classification: C12, D1, I3, Q12, Q13

Keywords: Wealth index, improved maize variety, consumption characteristics, production attributes, derived input, technological change, censored regression, Zambia

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1. Introduction

The contribution of technological change to agricultural productivity in developing countries is well documented (Arndt, et al., 1977). Though fundamental to rural transformation, input technological change sometimes by-passes some rural populations because farmers are often reluctant to use new inputs due to production and price risks that could render input use unprofitable (Kelly et al., 2003). The ability of households to cope with such risks is often related to the level of wealth of the household (Hardaker et al, 1997). Because wealth is disproportionately distributed among rural households, this paper proposes a novel-two-tier approach to the estimation of factors determining improved seed demand at the farm level in developing agriculture. Firstly, rural households must be stratified into pre-determined wealth categories, and secondly, improved variety adoption and seed demand models must be specified and estimated jointly for each wealth category. This approach affords the identification of credible policy relevant recommendations for effective targeting of interventions.

Throughout the developing world where input technology has made less dramatic changes in agricultural productivity, the incidence of rural poverty and food insecurity is pervasive. Agricultural development policy has often focused on getting the technology right but not on appropriate targeting strategies, an equally important element of agricultural growth. It is widely acknowledged that the extensive growth in Asia's green revolution created welfare effects beyond the adopting farmers and villages (Rosegrant and Hazell, 2000; Renkow, 2000). Nevertheless, large numbers of rural households across Asia for whom targeting of the "green revolution" technologies was inappropriate or less effective remain food insecure. Therefore, if improved input technology is to make a mark on the poverty of farm households in developing countries, scientists must design innovative approaches that clearly identify constraints to improved input uptake.

On the hand, input technology such as improved seed is resource intensive. Cash is needed to purchase the seed, which is normally more costly than the local ones, and complementary inputs such as fertility for optimal grain yields. This explains why "access to credit" is often observed as an important determinant of improved variety adoption (Morris et al., 1999; Gemeda et al., 2001; Adesina and Zinnah, 1993; Langyintuo, et al., 2005; Langyintuo and Mekuria, 2005). On the other hand, resource poor farmers in developing countries are usually cash-trapped and have limited access to credit for varied reasons. Consequently, they rely on productive assets to chart a route out of poverty through wealth creation (Moser, 1998; Freeman et al, 2004; Ellis and Bahiigwa, 2003). Given that assets are disproportionately distributed among households, estimating a common demand model for a heterogenous wealth group masks the real effects of any selected determinants, a recipe for misleading conclusions and policy recommendations.

This paper adopted a two step approach in estimating factors affecting farm level seed demand in Zambia. Households were stratified into meaningful wealth categories, and non-separable household improved variety adoption and seed demand models were specified and estimated jointly for each wealth category. The joint estimation was justified by the observation that a new improved seed is a derived input embodying production attributes for grain production and as a technology, which embodies consumption characteristics unfamiliar to the farmer. [In a separate paper, Langyintuo et al (2005) showed that a joint specification performed better than separate models.] When a farmer decides to adopt an improved variety, the decision on the quantity of seed required to plant a predetermined area is taken simultaneously. This approach contrasts past theoretical models and econometric methods that tended to specify seed demand and technology adoption models assuming separability (Feder, et al, 1985; Feder and Umali, 1993) and adds to the methodological exposition on input demand modeling in developing agriculture.

2 Data sources

The Katete, Sinazogwe and Mkushi districts in the Eastern, Central and Southern Provinces, respectively, in Zambia were included in a region-wide farm level survey undertaken by the International Maize and Wheat Improvement Center (CIMMYT) during the 2003/04 crop season. In each district, 10 villages and 10 households per village were randomly selected. A total of 300 farm households were interviewed by trained enumerators under the supervision of research scientists from the Soils and Crops

Research Branch of the Zambian Ministry of Agriculture and Cooperatives and CIMMYT. Structured questionnaires used were designed to capture information on household asset endowments and livelihood indicators.

3. Access to agricultural capital assets by rural households

Farm households are endowed with varying levels of different assets (Table 1), each of which can potentially contribute to the wealth status of the given household. For ease of comparison of households across space in terms of wealth, the assets were used to create wealth indices by the principal components analysis method (detailed Filmer and Pritchett, 2001; Langyintuo et al., 2005). Assets with the greatest impact on household wealth were ownership of a pair of bullocks, radio set, bicycles and access to mechanical labor with impact points of 0.575, 0.448, 0.409 and 0.383, respectively. By design, the mean of the standardized wealth index is 0. A household with a negative index is poorly endowed while one with a positive index well-off. The probability of getting a household with an index of 0 in the Katete, Sinazogwe and Mkushi districts were 0.57, 0.46 and 0.74, respectively, compared with 0.58 for the whole sample.

Two cut-off points used to classify the sample into three groups were: -0.6647 (i.e., the mean of wealth indices less than the sample mean of 0) and 0.8877 (i.e., the mean of indices greater than sample mean). Households with indices less than or equal to -0.6647 were in the wealth category termed “poor”; those between -0.6647 and 0.8877 (inclusive) “average”, and those with indices greater than 0.8877 “rich” (Figure 1). Corresponding mean (or economic) indices of the three wealth categories were, respectively, -1.00, -0.03 and 1.74. Each household was assigned to one of the categories.

The descriptive statistics of the selected farm households presented in Table 1 suggest that households in the “rich” wealth category have nearly twice the family sizes observed in the other two categories. Partly because female headed households are less endowed with assets, the proportion of them in the poor category was twice that of their male counterparts. The reverse was true in the case of the rich category.

Land distribution among households was highly disproportionate because over 50% of the total land is owned by the “rich” who form only 16% of the households. Possibly because the “rich” farmers buy relatively more inorganic fertilizers they can afford to use their lands more intensively than their colleagues judging from the estimated r-value* of 0.84 compared with 0.73 for the "poor" farmers.

Relatively more households in the "rich" than the "poor" category owned physical assets such as pairs of bullock, bicycles, radio sets and access to mechanical labor (Table 1). Households keep a total 6.4 tropical livestock units (TLU†) as a risk management strategy. The distribution of livestock kept is consistent with rural households "climbing the asset accumulation ladder". That is, as households move from a lower wealth index to a higher one, the number of cattle and small ruminants owned increases.

Access to cash and credit are limited so governments and NGOs provide input support to some farmers. Although NGOs complement government's efforts to provide agricultural extension services to farmers, coverage is still poor and skewed towards the rich (Table 1). For instance, about a third of the farmers interviewed in Katete, 89% in Sinanzogwe and 95% in Mkushi never had any contact with extension staff at all during the 2003/04 cropping season. Proportionately more farmers in the "rich" than "poor" wealth category are members of various farmers' associations partly due to the demands on members to pay registration and annual membership fees.

Households generate income for their livelihoods from agriculture, and employment in the formal and informal sectors. Agricultural activities include crop and livestock production, which account for over 50% of household income of ZK10.56‡ mil, ZK1.27 mil and ZK1.87 mil for the "poor", the "average" and "rich" wealth categories. Major food crops grown for the market and home consumption are maize, sorghum, groundnuts, millets while minor ones include cowpeas and vegetables (such as tomatoes, cabbages and onions). Cash crops are cotton and tobacco. On aggregate, maize constitutes the single largest cultivated crop, occupying 65%, 56% and 43% of the cultivated areas of "poor", "average" and "rich" households. To spread maize yield risk, farmers plant more than one variety on about three different plots scattered about their homesteads. The "rich" households purchased about 11 kg of seed compared with 4 kg

* R-value is an index of the land use intensity given by: R-value = cropped years/(cropped years + fallow years) (Ruthenberg, 1983)

† A TLU (Tropical Livestock Unit) is an animal unit that represents an animal of 250 kg liveweight, and used to aggregate different species and classes of livestock as follows: Bullock :1.25; cattle: 1.0; goat, sheep and pig: 0.1; guinea fowl, chicken and duck: 0.04 and turkey: 0.05 (compiled after Janke 1982).

‡ The Zambian currency is called the Zambian Kwacha (ZK). The exchange rate in October 2005 was: 1US$ = ZK 4450

and 6 kg for the "poor" and "average" households. Respective quantities of fertilizer purchased were 6 kg, 2 kg and 4 kg. Given the relatively smaller quantities of seed purchased during the 2003/04 crop season, estimated adoption rates for improved maize varieties for the "poor", the "average" and the "rich" households were, respectively, 22%, 24% and 31% in terms of area and 51%, 68% and 86% in terms of number of farmers. Although no significant differences were observed in the estimated household incomes per capita, expenditure on farm inputs and food differed dramatically between the "poor" and the "rich": the "poor" spent a larger proportion of their income on food than the "rich" (Figure 2). The reverse is true for farm inputs.

4. Estimating farm level seed demand

4.1 Conceptual framework

The conceptual basis for consumption and production goods demand is based on goods characteristics in the utility function and input attributes in the production function pioneered by (Lancaster 1966a, b) and subsequently modified by (Ladd and Suvannunt, 1976). The household is assumed to derive utility from the set of intrinsic attributes of the food goods it consumes, the consumption of other goods, and leisure. On the basis of this theory, a household model is specified to explicitly incorporate variety attributes and used to derive seed demand equations. Let the household utility function U be defined as:

$$U[X^g(F, a^c), Z^r, V \mid \Omega_h \Omega_l] \qquad \ldots(1)$$

where X^g is a K-dimensional vector of consumption attributes, $\boldsymbol{F}$ an M-dimensional vector of food products consumed from each plant variety harvested, a^i an M x K matrix of input-output coefficients in which each element a^c_{ik} maps consumption of a unit of variety i to a unit of attribute k, Z^r the consumption level of other goods, V household leisure, Ω_h household characteristics and Ω_l the local market characteristics faced by the household. It is assumed that the input-output coefficients associated with the different plant varieties are exogenous to the decision process. That is, the variety-specific intrinsic consumption attributes are fixed from the perspective of an individual household.

The household engages in the cultivation of food crops on a given piece of land using labor and seed. The variety mix (local versus improved) is dependent on the farmer's perceptions of the intrinsic characteristics or attributes of the variety.

Define the production function Y as:

$$Y[Q, G^{d}(V, d^{p}), L \mid \Omega_{f}\Omega_{l}] = 0 \qquad \ldots (2)$$

where Q is an M-dimensional vector of crop products from each variety, G^d a J-dimensional function defining the relationship between the M-dimensional vector V of production scales for each crop variety grown and the relative P proportions of production attributes they yield, d^P is an $M \times J$ matrix with fixed elements d_{ik} defining this mapping, L is household labor input, and Ω_f the exogenous farm characteristics.

de Janvry et al (1991) noted that households in semi-subsistence economies often face high transactions costs of market participation, which influence their production decisions rather than exogenous market prices. Furthermore, the thinness of local grain markets suggests that quality differentials between crop varieties may be inadequately reflected in market prices (Edmeades et al., 2004). The above justifies explicitly modelling household production and consumption decisions as non-separable. Formally, the household maximizes utility by choosing the level of crop products consumed from each available variety, spending on other goods, the scale of each crop variety produced, and labor hours spent in crop production subject to the production technology, income, time, seed, land and non-negativity constraints. This may be stated as follows:

$$\max_{F, Z, v, L} U[X^{g}(F, a^{c}), Z^{r}, V \mid \Omega_{h}\Omega_{l}] \qquad \ldots (2)$$

Subject to

$$Y[Q, G^{d}(V, d^{p}), L \mid \Omega_{f}\Omega_{l}] \leq 0 \qquad \ldots (3)$$

$$(P - F^{g})' P - P^{y} Z^{y} + I \leq 0 \qquad \ldots (4)$$

$$\bar{S} \leq \sum_{i=1}^{g} S_{i} \qquad \ldots (5)$$

$$S_{i} = 0 \ \forall i \notin \tilde{S} \qquad \ldots (6)$$

$$T - L - V = 0 \qquad \ldots (7)$$

$$X_{i}, Q_{i}, S_{i}, all \geq 0 \ \forall i \in \tilde{S} \qquad \ldots (8)$$

where T is total household time available, P is a vector of crop product output prices, P^y is the price of other goods, I is exogenous income, $\tilde{S}$ is the set of crop varieties for which seed is available at the village level, and S denotes the total scale of production for the crop of interest, measured in the same units as S_i. Constraint (3), the production technology, establishes the crop production margins while the full income constraint limiting households' cash transactions is stated in constraint (4). The land constraint specified in equation (5) also captures the physical limitations of available land to households for crop production. Constraint (6) captures the effect of the magnitude of available seed (improved versus traditional) in terms of crop varieties at the village level. The time constraint (7) captures the total time available to production and home activities.

The partial Kuhn-Tucker necessary conditions for optimality for derived demand relationship, which determines the optimal production scale for each crop variety potentially grown by the household, is given as:

$$S_i = S_i(a^c, d^p, P^y, P^q, I, T, \bar{S}, \tilde{S} \mid \Omega_h \Omega_l \Omega_f)\ \forall S_i \geq 0 \qquad \ldots (9)$$

The non-separable agricultural household model implies that seed demand is functionally dependent on all the exogenous variables in the problem, including variety-specific consumption and production attributes, exogenous prices and income, household characteristics, production technology and market-related variables. Based on this reduced form derivation, the empirical model is derived below.

4.2 Empirical seed demand model framework

Using improved maize variety as target agricultural commodity, the model jointly estimates the probability of a farm household in Zambia adopting an improved maize variety and the quantity of seed purchased for a predetermined portion of the cropped area. For a given improved maize variety, some farmers would adopt conditioned by farm and farmer specific characteristics as well attributes of the variety while others would choose not to adopt. Even those who adopt may not allocate the whole farm to the improved variety. Therefore, the proportion of area under the improved variety is censored at zero. As a result, a censored regression model was specified using the Tobit[§] procedure derived from utility maximization underlying farmers' decision to adopt the improved technology, which may be stated as:

$$Y_i = M_i\alpha + A\psi \ \text{ if } i^* = M_i\alpha + A\psi + \mu_i > T \ \text{(Adoption)}$$

$$= 0 \text{ if } i^* = M_i\alpha + A\psi + \mu_i \leq T \ \text{(Non-Adoption)} \qquad \ldots (10)$$

where Y_i is probability of adoption (and intensity of use) of the improved variety, *M*, a vector of farm- and farmer- specific attributes as well as information access variables of the adopter, *A*, a vector of the supply-side production and processing attributes associated with the technology, α and ψ are parameters to be estimated, i* = non-observed latent variable, μ_i is a stochastic error term, and T = non-observed threshold level.

As noted earlier, once a household has agreed to plant an improved variety, it simultaneously decides on the quantity of seed to purchase. Assuming that the variety is made available, the household seed purchase decision is conditioned by the traditional input market factors, income and some household specific attributes that may form part of the adoption decision model. The demand model may be specified as follows:

$$D_i = \varphi_k Z_{ik} + \gamma_j E_{ij} + \varepsilon_i \qquad \ldots (11)$$

where D_i is the quantity of seed demanded by the *i*th household (taken to mean strictly seed purchased from the seed market), ***Z*** a matrix of designed household socioeconomic factors influencing seed demand, ***E*** a matrix of exogenous input market factors, φ and γ are parameters to be estimated while ε is a stochastic error term. Variables contained in ***A*** and ***Z*** could overlap. The correlation coefficient between the errors of the two models measures the extent of correlation between the two equations. To account for any cross-equation correlation, the two models were estimated simultaneously. Note that only farmers adopting the improved varieties were included in the demand model.

5. Empirical results and discussions

[§] A full mathematical treatment of the Tobit model is not included in this paper as its usage is common in applied economics research. Thorough treatments of the model may be found in Greene (2000), chapter 20, pp. 896-951.

The choice of variables for the adoption model in Table 2 was based on literature (See for example Adesina and Zinnah, 1993; Smale et al., 1994; Morris et al., 1999; Gemeda et al., 2001; Langyintuo et al., 2003). Variables used in the demand model requiring some discussion are FDIFICIT, IMPROPN, and AGPROG. In the literature, non-market factors influencing farmers' decision on seed choice and quantities are: (1) emergency situations when environmental calamities or civil conflict result in insufficient harvest to provide seed stock, (2) poverty situation when shortage of labor or illness, etc result in poor harvest compelling farmers to consume their seed stock, and (3) demand for seed quality arising from the farmer's desire to replace old seed stock due to poor performance or when a new variety or germplasm is introduced into the community (Tripp and Rohrbach, 2001). In a rather static analytical situation, the first two conditions could be condensed into "lack or depletion of seed stock". To capture this scenario, a variable called FDEFICIT was created[**] and used. A farmer desirous of replacing his/her existing seed stock with another can be regarded as an adopter and captured by including the adoption rate (IMPROPN). The larger the area under improved maize variety the more seed would be required and vice versa. Because farmers who receive seed hand-outs are unlikely to patronize the commercial seed market, AGPROG used to capture the scenario was hypothesized to have a negative impact on seed demand.

Two separate models were specified and estimated, one for those households with wealth indices below the sample mean of 0 termed "poor" and the other for those with indices above the mean termed "rich". The results were compared with those of a third model estimated for the whole sample as traditionally done.

To facilitate targeting, ownership of a pair of bullocks, radio set, bicycle and access to mechanical labor (with impact points of 0.575, 0.448, 0.409 and 0.383, respectively), which have the greatest impact on household wealth were used to develop a simple criterion that could be used to classify households within the given communities into either wealth group without constructing wealth indices (Langyintuo et al., 2005). A

[**] To calculate the minimum energy requirement per household, each household member was converted to a consumer equivalent unit (CEU) after Runge-Metzger (1988) as follows: less than 9 years: 0.4; 9 to 15 years: 0.7; males 16 to 49: 1; females 16 to 49: 0.9; over 49 years: 0.8, and the aggregated CEU normalized by the minimum energy requirement per CEU per year assumed to be 10.9 MJ (ibid). Energy equivalents of the various crop outputs were estimated based on the following Kcal per g of crop: maize, 36.2; sorghum, 35.3; millet, 33.2; rice, 35.4; cassava, 15.3; cowpea, 34.0; and groundnuts, 58.0.

household with all the four items is in the rich wealth category as one with any two of them. Access to only of them or none classifies a household among the "poor". A physical examination of the households showed that only 30 out of 300 households were wrongly classified. This gives some confidence in using the procedure as a "rule of thumb" in targeting interventions.

The estimated results of the three models are presented in Table 3. The adoption results (from Equation 10) are at the upper portion and the demand (from Equation 11) the lower. Clearly, the whole sample model results could adequately predict the relative impacts of Membership of farmers associations (ASOCN), farmer's perceptions on grain yield (RYIELD) and maize farm size (MAIAREA) on households improved variety adoption decisions but not gender of household head (GENDER), access to credit (CREDIT), seed cost (RCOST), consumer acceptability of the grains (RSALE), and perceived resistance of the improved varieties to field pests (RPEST).

Membership of farmers associations significantly improve technology adoption decisions among farmers and should be encouraged. Moving a farmer from non-membership to membership of an association could potentially increase adoption rate by more than 10% in each group. Convincing farmers that a given improved variety is superior to the best local ones in terms of yield would increase the adoption and use intensity by 40% and 73%, among the poor and the rich farmers, respectively. This implies that field demonstration to show the yield advantage of improved varieties over the local ones would have nearly twice the impact on the "rich" as on the "poor" households. Contrary to a priori expectations, farm size has a negative impact on variety adoption decisions by farmers. Farmers with relatively smaller farms are willing to intensify maize production by adopting improved, high yielding varieties while those with larger farms prefer area expansion for increased production.

As noted earlier, extension services are skewed toward the rich where proportionately fewer females are represented. It is therefore not surprising that the results seem to suggest that any extension activities targeting female farmers could potentially have significant pay-off among the "poor" group of farmers.

In general, improved seeds are more expensive than the local ones and often beyond the means of most poor farmers. Therefore, increasing improved seed price by a unit over the local ones would inevitably result in a 41% dis-adoption rate among the poor. To maximize the benefits from adopting an improved variety, farmers need money to invest in the improved seed and complementary inputs such as fertilizer. This supports the findings that moving a farmer from a situation of no access to credit to access would significantly improve adoption decisions by as much as 25% among the poor. Only the rich farmers are concerned about the resistance of improved varieties to field pests (RPEST), and are willing to increase adoption rate by 13% once they are convinced of such superiority. Poor farmers in Katate are less willing to adopt improved varieties compared with their counterparts in the Mkushi district.

Looking at the seed demand models results, estimates from the whole sample showed that AGPROG, IMPROPN, and MAIAREA significantly influence seed demand at the 1% level while FDEFICIT and WEALTH at the 5% level. Specifying separate models for the poor and the rich, however, show some disparity in the relative significance of these variables in influencing seed demand decisions suggesting different recommendations for the two wealth groups.

Both models rightly point out that the quantity of seed a farmer is willing to purchase is positively influenced by the total maize area and adoption rate. That is, increasing the proportion of land on improved seed (IMPROPN) by a percentage point would increase the quantity of seed purchased by over 50% for both wealth groups, while increasing the area under maize by a unit would significantly increases the quantity of seed purchased by 70% and 68%, respectively the poor and rich households.

Only the rich farmers would be willing to buy seed once they loose their seed stock for some reason. However, a percentage increase in their level of grain self-insufficiency (FDEFICIT) would result in a 7% decrease in seed demanded. This seems to suggest that households in deficit may quickly become cashed trapped and unable to afford improved seed and hence less willing to increase quantities purchased.

Beneficiary of agricultural input support programs or emergency seed relief has significantly negative impact on seed demand among poor farmers who are more likely to benefit from such support. Once a farmer becomes a beneficiary of a government or NGO inputs program, his/her investment in seed would decrease by as much as 53%, negatively affecting input market development. The results confirm the generally held view that input-led efforts to deal with food insecurity often hamper input market development. Large-scale subsidized inputs often used as a vehicle to increase food security and reduce poverty following drought or civil unrest increase risk and uncertainty for emerging commercial input sector (Tripp and Rohrbach, 2000; Kelly et al., 2003). It is sometimes argued that input programs increase aggregate demand for inputs under conditions of credit failures, which cannot be ascertained in the complex input market environment found in Zambia (Jayne et al., 2003).

Once disaggregated, household wealth ranking significantly influences quantities of seed purchased only among the poor farmers: the higher the ranking within the group, the more seeds are purchased. Moving a household from a lower wealth ranking to a higher one through wealth accumulation would increase the quantity of seed purchased by as much as 63%.

6. Synthesis and policy inferences

Though fundamental to rural transformation, input technological change sometimes by-passes some rural populations because farmers are often reluctant to use new inputs due to production and price risks that could render input use unprofitable. The level of wealth of the household significantly relates to its ability to cope with such risks. In developing countries, wealth is disproportionately distributed among rural households to the extent that any effort to assess the relative impacts of factors determining farm level input demand without first disaggregating households could result in misleading conclusions and policy recommendations. This paper demonstrated a novel-two-tier approach that first stratified households into two distinct wealth groups before specifying and estimating non-separable household improved variety adoption and seed demand models for each wealth category. The joint estimation was justified by the observation that a new improved seed is a derived input embodying production attributes for grain production and as a technology, which embodies consumption characteristics unfamiliar to the farmer.

The results supported the hypothesis that whole sample models disregarding wealth groups is unlikely to correctly predict the effects of selected exogenous variables on seed demand resulting in misleading conclusions and policy recommendations. For instance, although, the whole sample model results could have adequately represented the relative impacts of membership of farmers associations, farmer's perceptions on grain yield and maize farm size on households improved variety adoption decisions, it would have poorly predicted those related to gender, access to credit, seed cost, consumer acceptability of the grains, and perceived resistance of improved varieties to field pests. Model results from the poor households suggested that extension activities targeting females has the potential of improving adoption rates, which was not captured in the whole sample model. Whereas access to credit and seed cost significantly influence the poor in their decisions to adopt or not to adopt improved varieties, rich household who are market oriented worry about consumer acceptability of the grains and the resistance of such varieties to field pests. Similar observations were made with the seed demand model. Whereas the impacts of adoption rate and area on demand are similar for both wealth groups, grain self-sufficiency was an issue among only the "rich" while access to free seed issues and household wealth are important among poor households.

In conclusion, it may be stressed that stratifying households into meaningful wealth categories and estimating demand models for each group is a significant step in improving targeting of interventions to increase impact. Furthermore the method contributes to the methodological challenges of assessing seed demand at the farm level in developing agriculture.

Acknowledgement

This publication was made possible through financial support provided by the Rockefeller Foundation. The ideas expressed here are those of the authors' and do not necessarily reflect those of the Rockefeller Foundation. Many thanks to M. Mwanza, L. Chama and J. Jere for collecting the data and P. Hamazakaza, E. Nawale and I. Jere for supervising the data collection.

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Table 1: Selected households wealth indicators by wealth category in Zambia

	Wealth category			Whole sample
	Poor (n=79)	Average (n=173)	Rich (n=48)	(n=300)
Access to human capital				
Household size	6.37	7.69	12.42	8.10
	(3.03)	(4.96)	(7.16)	(5.34)
Male headed households (%)	21.78	60.00	18.22	21.78
Female headed households (%)	40.00	50.67	9.33	40.00
Ownership of natural capital (ha)				
Total farm land	3.64	5.24	8.19	5.29
	(3.58)	(6.52)	(9.16)	(6.56)
Cultivated land	1.52	2.97	5.68	3.02
	(0.89)	(1.82)	(4.23)	(2.58)
Maize area as a proportion of cultivated land	0.65	0.57	0.46	0.56
Ownership of selected physical assets				
A bicycle (proportion)	0.18	0.61	0.88	0.54
A television set (proportion)	0.03	0.03	0.04	0.03
A radio set (proportion)	0.15	0.59	0.83	0.51
Mechanical labor (proportion)	0.14	0.55	0.85	0.49
Pair of bullocks (proportion)	0.00	0.03	0.77	0.26
Cattle (number)	0.13	1.21	6.10	1.71
	(0.72)	(2.63)	(7.09)	(3.99)
Small ruminants (number)	0.52	1.99	7.68	2.51
	(1.70)	(4.44)	(8.12)	(5.29)
Fowls (number)	6.18	11.82	46.35	15.86
	(12.89)	(41.29)	146.68)	(67.75)
Tropical livestock units (number)	0.85	3.88	16.25	5.06
	(1.45)	(5.03)	(12.02)	(7.96)
Access to financial and social capital				
Access to cash credit (proportion)	0.48	0.78	0.88	0.72
Membership of farmers association (proportion)	0.37	0.41	0.46	0.41
Beneficiary of input support programs (proportion)	0.43	0.60	0.73	0.57
Extension visits (number per year)	1.38	1.64	1.85	1.61
	(1.25)	(1.22)	(1.17)	(1.23)

Table 2: Descriptive statistics of selected variables in empirical models

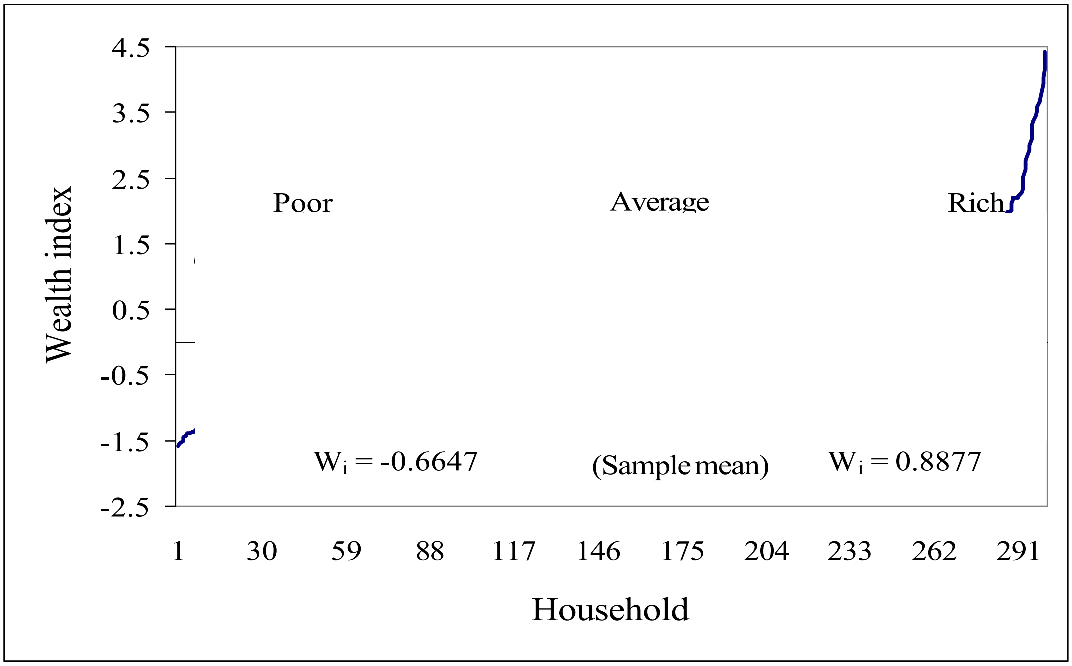
Variable	Definition	Wealth category	
		Poor (n=172)	Rich (n=128)
GENDER	Value of 1 if household head is a male and zero otherwise	0.73 (0.44)	0.78 (0.41)
AGEHH	Age of household head	43.7 (14.6)	40.3 (12.4)
EDUCN	Years of formal education of household head	1.96 (0.67)	2.02 (0.52)
ASOCN	1 if household head belongs to a farmers' association and 0 otherwise	0.42 (0.49)	0.38 (0.49)
LABFORC	Household labor force	5.38 (3.29)	6.26 (4.51)
FIELDAY	1 if household head has attended a field day in 2003/04 and 0 otherwise	0.15 (0.36)	0.15 (0.36)
CREDIT	Value of 1 if household have had access to cash credit and 0 otherwise	0.65 (0.48)	0.87 (0.34)
RCOST	1 if farmer perceives the improved seed to be more costly than the local one and 0 otherwise	0.84 (0.37)	0.88 (0.33)
RAVAIL	1 if the improved seed is more readily available than local one and 0 otherwise	0.15 (0.36)	0.12 (0.33)
RSALE	1 if it is easier to sell grain from improved seed compared with the local one and 0 otherwise	0.58 (0.49)	0.67 (0.47)
RYIELD	Value of 1 if the improved variety to yield more than the local one and 0 otherwise	0.56 (0.50)	0.74 (0.44)
RPESTS	1 if the improved variety to be more resistant to field pests than the local one and 0 otherwise	0.44 (0.50)	0.35 (0.48)
RSTPEST	1 if the improved variety is more resistant to storage pests than the local one and 0 otherwise	0.36 (0.48)	0.26 (0.44)
RPALATA	1 if the improved variety to be more palatable than the local one and 0 otherwise.	0.12 (0.33)	0.05 (0.22)
SEEDPUR	Quantity of seed purchased	5.69 (10.3)	8.07 (14.1)
DISTANCE	Distance to output markets in physical units	31.0 (37.2)	18.7 (23.3)
FDEFICIT	1 if household was food self-insufficient and 0 otherwise	-32.5 (55.5)	-10.0(102.9)
AGPROG	1 if household is a beneficiary of any input support program and 0 otherwise	0.53 (0.50)	0.66 (0.48)
IMPROPN	Maize price (x1000 ZKW)	0.22 (0.27)	0.30 (0.30)
MAIAREA	Proportion of cropped area under maize	1.48 (1.45)	1.80 (1.49)
MAIPRICE*	Maize price (x1000 ZKW)	39.7 (34.7)	38.5 (28.9)
WEALTH	Household wealth index	-0.44 (0.70)	0.91 (0.93)

Note: *Figures in thousands

Table 3: Joint estimation of factors influencing improved maize variety adoption and seed demand in selected districts in Zambia

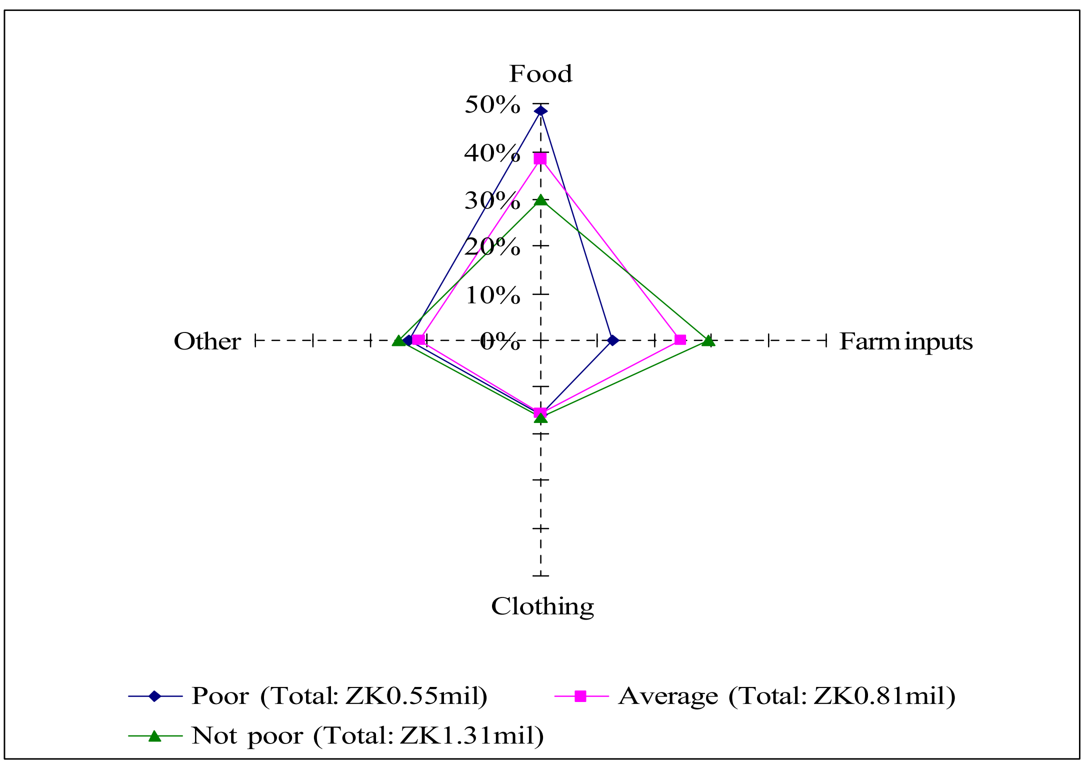
	whole sample (n=300)	Poor (n=172)		Rich (n=128)	
	Coefficient	Coefficient	Elasticity at the mean	Coefficient	Elasticity at the mean
Equation 1: Adoption model					
GENDER	-0.027	-0.078*	-0.252	0.020	
AGEHH	-0.001	-0.002		-0.001	
EDUCN	0.026	0.038		0.021	
ASOCN	0.079**	0.065*	0.127	0.104*	0.141
LABFORC	0.002	-0.003		0.003	
FIELDAY	0.004	0.007		-0.016	
CREDIT	0.076**	0.092*	0.253	-0.013	
RCOST	-0.099**	-0.105*	-0.415	-0.085	
RAVAIL	0.035	0.017		0.016	
RSALE	-0.049	-0.009		-0.086*	-0.216
RYIELD	0.203**	0.164**	0.398	0.276**	0.728
RPESTS	0.060*	0.060		0.088*	0.130
RSTPEST	-0.048	-0.049		-0.079	
RPALATA	0.067	0.047		0.106	
MAIAREA	-0.043**	-0.044**	-0.263	-0.059**	-0.410
KATETE	-0.107**	-0.138**	-0.196	-0.111	
SINAZONG	-0.064	-0.085		-0.104	
CONSTANT	0.260**	0.312**		0.329*	
Equation 2: Seed demand model					
DISTANCE	-0.024	-0.029		-0.008	
FDEFICIT	0.018*	-0.006		0.027**	-0.070
AGPROG	-3.749**	-5.720**	-0.530	-1.976	
IMPROPN	14.168**	12.984**	0.538	15.655**	0.541
WEALTH	1.027*	4.288*	-0.535	0.595	
MAIAREA	2.756**	2.779**	0.695	2.772**	0.668
MAIPRICE	-0.001	-0.001		-0.001	
KATETE	-6.405**	-7.459**	-0.439	-5.086*	-0.229
SINAZONG	-1.915	-3.045		-1.110	
CONSTANT	5.706	6.174		11.056	
R^2 (Equation 2)	0.346	0.360		0.370	

Note: ** Significant at 1%; * Significant at 5%



Note: W_i = -0.6647 is the mean index of households falling below the sample mean of 0; W_i = 0.8877 is the mean index of households with indices above the sample mean

Figure 1: Distribution of households according to wealth groups



Note: The Zambian currency is called Zambian Kwacha (KW). The exchange rate in May 2005 was: 1US$ = ZKW 4850.

Figure 1: Expenditure profile of households by wealth category