# RURAL INFRASTRUCTURE, TRANSACTIONS COSTS AND MARKETED SURPLUS IN KENYA

### Mitch Renkow and Daniel G. Hallstrom

Department of Agricultural and Resource Economics North Carolina State University

## **Daniel Karanja**

Department of Agricultural Economics Michigan State University

**Key Words:** infrastructure investment, marketed surplus, price bands

#### **CONTACT AUTHOR:**

Mitch Renkow
Dept. of Agricultural and Resource Economics
Box 8109
North Carolina State University
Raleigh, NC 27695, U.S.A.
Tel: (919) 515-5179

Fax: (919) 515-6268 Email: mitch\_renkow@ncsu.edu

Selected paper to be presented at the 2001 American Agricultural Economics Association meeting, Chicago, IL, August 5-8, 2001.

# RURAL INFRASTRUCTURE, TRANSACTIONS COSTS, AND MARKETED SURPLUS IN KENYA

## **ABSTRACT**

We develop a conceptual framework for quantifying fixed transactions costs facing semisubsistence households. Using household survey data from a sample of 324 Kenyan maize farmers, we generate estimates of household supply and demand schedules, as well as the price bands that they face. Our econometric results indicate that on average the ad valorem tax equivalent of the fixed transactions costs facing the households in our sample is 28%. Additional analysis indicates that both remoteness and infrastructure quality have significant impacts on the size of the transactions costs facing farm households. To the best of our knowledge, ours are the first empirical estimates of the magnitude of transactions costs.

#### INTRODUCTION

The development and dissemination of improved agricultural technologies has long been identified by agricultural scientists, international donors and other students of economic development as an important vehicle for reducing poverty in developing countries. The majority of poor people in LDCs historically have been, and continue to be, located in rural areas (Naylor and Falcon, 1995). Agriculture is generally the primary source of income for the rural poor, both through crop production activities and via employment in agriculture and agriculture-related industries (Reardon, et al., 1998; Renkow, 1999; Haggblade, Hazell, and Brown, 1989).

There is by now little remaining doubt that the widespread adoption of improved seeds, fertilizers, and other agricultural technologies since the outset of the Green Revolution has had a profound positive impact on aggregate incomes, including the incomes of the poor (Byerlee, 1996). Considerable concern remains, however, about the spatial distribution of the benefits of new agricultural technologies. For those locations where external conditions limit a household's ability to market agricultural products or increase agricultural productivity, alternative public investments may well hold greater potential for poverty alleviation than additional agricultural research.

This view is supported by recent work by Fan and Hazell (1999) indicating significant impacts on poverty reduction of public infrastructure investments in India. Such investments can work in a number of ways to enhance the returns to resources commanded by rural households. By lowering the transactions costs of market exchange, they can boost net returns to agricultural production. They can lead to greater availability (at lower cost) of necessary agricultural inputs such as fertilizers and chemicals, and thus improve welfare by increasing agricultural productivity. Perhaps more importantly, improved transportation and communications infrastructure facilitates spatial integration of product and factor markets –both in the agricultural and nonagricultural sectors.

In this paper we develop a conceptual framework for quantifying fixed transactions costs facing semisubsistence households. Using household survey data from a sample of 324 Kenyan maize farmers, we generate estimates of household supply and demand schedules, as well as the price bands that they face. Our econometric results indicate that on average the ad valorem tax equivalent of the fixed transactions costs facing the households in our sample is 28%. Additional analysis indicates that both remoteness and infrastructure quality have significant impacts on the size of the transactions costs facing farm households. To the best of our knowledge, ours are the first empirical estimates of the magnitude of transactions costs.

The paper is organized as follows. The next section develops a conceptual framework for analyzing the size and statistical significance of fixed transactions costs in semisubsistence agriculture. We then outline an empirical strategy for estimation. Following a discussion of econometric issues and data, we present our results. Some concluding remarks are found in the paper's final section.

#### **CONCEPTUAL FRAMEWORK**

We are interested in measuring the size and statistical significance of transactions costs facing semisubsistence households that both produce and consume a staple commodity such as wheat or rice. Our starting point is the agricultural household model with missing markets analyzed by de Janvry, Fafchamps, and Sadoulet (1991). Recently, Key, Sadoulet, and de Janvry (2000) have extended that model to consider both proportional and fixed transactions costs.

In our model we explicitly consider only fixed transactions costs.<sup>1</sup> Standard examples of fixed transactions costs include costs associated with search, social barriers, and imperfections in other markets in which the household participates. Examples of these latter effects include information asymmetries and other barriers to entry into land markets (Shaban, 1987), thin agricultural labor markets in which quality differences exist between household and family labor (Benjamin, 1992), and credit and insurance market failures due to covariate production risks (Townsend, 1993; Udry, 1994).

To provide a theoretical framework for our empirical approach, we first specify the household's indirect utility function as

$$V_i = \psi(P_i, Y_i) = \psi(P_i, \pi(P_i, z_{2i}) + w_i T_i + \mu_i, z_{1i}),$$
(1)

where  $P_i$  is the household price of maize,  $\Box(P_i, z_{2i})$  is the household's profit from maize production,  $w_i$  is the household's wage rate,  $T_i$  is the households time endowment,  $\Box_i$  is exogenous income, and  $z_{1i}$  and  $z_{2i}$  are demand and supply shift variables.

<sup>&</sup>lt;sup>1</sup> Households in our sample report the price at which they bought and sold maize. We interpret these prices as inclusive of any proportional transactions costs incurred by the maize traders; i.e., we take them to be the incentive prices for the households that participate in the market. However, there are also a number of autarkic households in our sample, some who report identical buying and selling prices, and some who even report a higher selling price than buying price. This suggests to us that there are fixed transactions cost associated with market participation.

In (1) all prices are household specific. For households that participate in the maize market, the relevant decision price is the market price. For households that do not participate in the market  $P_i$  is endogenous. We obtain the household's shadow price in autarky by solving for the root of the total derivative of the indirect utility function with respect to price,

$$\frac{dV}{dP}(P_i^A) = \psi_P + \psi_Y \pi_P = 0.$$
 (2)

Equation (2) is a well known result in the literature on international trade, and simply says that utility will be minimized at the autarky price,  $P_i^A$  (Woodland). This, of course, is another way of saying there will be gains to trade provided the free trade price is not equal to the autarky price. A somewhat more intuitive view of equation (2) is obtained by dividing through by the marginal utility of income to obtain

$$\frac{1}{\psi_{Y}}\frac{dV}{dP}(P_{i}^{A}) = \frac{\psi_{P}}{\psi_{Y}} + \pi_{P} = 0.$$
 (2')

Applying Roy's Identity and Shepard's lemma to (2'), we can see that the shadow price for the autarkic household is the price that equates household supply to demand.

With fixed transactions costs, the household will be just indifferent between autarky and participating in the market when

$$\psi(P_i^A, \pi(P_i^A, z_{2i}) + w_i T_i + \mu_i, z_{1i}) = \psi(P_i^M, \pi(P_i^M, z_{2i}) + w_i T_i + \mu_i - FTC_i, z_{1i}).$$
(3)

The superscripts A and M on price denote the household's autarky and market prices, respectively, and  $FTC_i$  is the income equivalent of the fixed transactions costs that household i incurs to buy or sell in the market.

For a household with positive marketed surplus, utility is increasing in price so (3) implies that the market price must be above the autarky price before the household will participate in the market. Likewise, utility is decreasing in price for households with a negative marketed surplus so (3) implies that such households will not participate in the market unless the market price is below the autarky price.

Let *i* be the tax equivalent of the FTC. Using the household's indirect utility function, *i* is implicitly defined for net sellers as

$$\psi(P_i^M - \tau_i, \pi(P_i^M - \tau_i, z_{2i}) + w_i T_i + \mu_i, z_{1i}) = \psi(P_i^M, \pi(P_i^M, z_{2i}) + w_i T_i + \mu_i - FTC_i, z_{1i}), \quad (4a)$$

and for net purchasers as

$$\psi(P_i^M + \tau_i, \pi(P_i^M + \tau_i, z_{2i}) + w_i T_i + \mu_i, z_{1i}) = \psi(P_i^M, \pi(P_i^M, z_{2i}) + w_i T_i + \mu_i - FTC_i, z_{1i}).$$
 (4b)

The participation decision (but not the marginal analysis underlying how much to supply or consume) is made by comparing utility evaluated at the autarky price to utility evaluated at the purchase/selling price plus the tax equivalent of the fixed transactions costs. For example, a household will be a net seller when

$$\psi(P_i^M - \tau_i, \pi(P_i^M - \tau_i, z_i^s) + w_i T_i + \mu_i, z_i^d) > \psi(P_i^A, \pi(P_i^A, z_i^s) + w_i T_i + \mu_i, z_i^d).$$
 (5)

Since utility is increasing (decreasing) in prices for net sellers (buyers), the participation condition in (5) can be simplified to

$$P_i^A < P_i^M - \tau_i \implies \text{marketed surplus} > 0$$

$$P_i^A > P_i^M + \tau_i \implies \text{marketed surplus} < 0$$
 (6)

$$P_i^M - \tau_i < P_i^A < P_i^M + \tau_i$$
  $\implies$  marketed surplus = 0.

In our empirical work, we measure the size and statistical significance of  $\Box_i$ . We interpret our results as measuring the size of a hypothetical tax the household must collect to pay for the costs of market entry. However, the tax is never actually collected by a government entity, and conditional on entry into a market the price guiding resource allocation is the market price,  $P_i^M$ .

#### **ESTIMATION**

We exploit the theoretical constraints in our structural model to estimate the size of *i*. As a by-product we also obtain consistent estimates of the supply and demand parameters, which are of considerable interest in their own right. From (6) we know that households will select into one of three regimes depending on the relationship between their shadow price in autarky and their purchase/selling price plus the tax equivalent of the fixed transaction costs. To derive the household's autarkic shadow price, we first specify the household's demand and supply functions for maize, and a reduced form full income function

$$q_{i}^{D} = \eta_{0} + \eta_{2} P_{i} + \eta_{3} Y_{i} + \sum_{k=1}^{K_{1}} z_{1ik} \phi_{k} + e_{1i}$$

$$q_{i}^{S} = f_{v} + \xi_{2} P_{i} + \sum_{k=1}^{K_{2}} z_{2ik} \gamma_{k} + e_{2i}$$

$$Y_{i} = g_{v} + \beta_{2} P_{i} + \sum_{k=1}^{K} z_{ik} \beta_{k} + e_{3i}.$$

$$(7)$$

As denoted above,  $z_{Iik}$  and  $z_{2ik}$  are demand and supply shift variables and  $P_i$  is the household's decision price. In our empirical specification, all variables are in logs, so the elasticities of demand and supply are  $z_1$  and  $z_2$  respectively. Village fixed effects are included in both the supply  $z_1$  and income  $z_2$  and  $z_3$  respectively. The fixed effects in the supply equation control for

unobserved differences among villages in agro-climatic conditions and the overall state of farming technology. In the income equation, the fixed effects control for unobservable differences affecting farm income as well as variation in village level wage rates and opportunities for off-farm employment. Finally, the  $z_{ik}$  are observable variables that will affect household income. These variables include, but are not limited to, all of the exogenous variables in the demand and supply equations.

Substituting the income function into the demand equation gives

$$q_{i}^{D} = g_{v}^{*} + \eta_{2}^{*} P_{i} + \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} + e_{1i}^{*}$$

$$q_{i}^{S} = f_{v} + \xi_{2} P_{i} + \sum_{k=1}^{K_{1}} z_{1ik} \gamma_{k} + e_{2i}$$

$$(7')$$

where the \* superscripts indicate the parameters are now linear combinations of the original demand parameters and the income parameters. All parameters of the supply equation remain identified, however, the demand parameters contain the income effects. This is not a shortcoming if the principle interest is in measuring the size of transactions costs, or in the elasticities of marketed surplus.

Equating supply to demand, the shadow price of an autarkic household is

$$P_{i}^{A} = \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( f_{v} + \sum_{k=1}^{K_{1}} z_{2ik} \gamma_{k} + e_{2i} - g_{c}^{*} - \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} - e_{1i}^{*} \right).$$
 (8)

Substituting the shadow price into the participation constraint, and rearranging yields

$$\frac{1}{\eta_{2}^{*} - \xi_{1}} \left( e_{2i} - e_{1i}^{*} \right) < P_{i}^{M} - \tau_{i} - \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( f_{v} + \sum_{k=1}^{K_{1}} z_{2ik} \gamma_{k} - g_{v}^{*} - \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} \right) \implies \text{marketed surplus} > 0$$

$$\frac{1}{\eta_{2}^{*} - \xi_{1}} \left( e_{2i} - e_{1i}^{*} \right) > P_{i}^{M} + \tau_{i} - \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( f_{v} + \sum_{k=1}^{K_{1}} z_{2ik} \gamma_{k} - g_{v}^{*} - \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} \right) \implies \text{marketed surplus} < 0$$

$$P_{i}^{M} - \tau_{i} - \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( f_{v} + \sum_{k=1}^{K_{1}} z_{2ik} \gamma_{k} - g_{v}^{*} - \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} \right) < \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( e_{2i} - e_{1i}^{*} \right)$$

$$< P_{i}^{M} + \tau_{i} - \frac{1}{\eta_{2}^{*} - \xi_{1}} \left( f_{v} + \sum_{k=1}^{K_{1}} z_{2ik} \gamma_{k} - g_{v}^{*} - \sum_{k=1}^{K} z_{ik} \phi_{k}^{*} \right) \implies \text{marketed surplus} = 0$$

$$\Rightarrow \text{marketed surplus} > 0$$

$$(9)$$

The final step in our structural model is to specify the nature of *i*. Our first specification, and the simplest, is

$$\tau_i = \overline{\tau} + e_{3i} \,, \tag{10}$$

where  $e_{3i}$  is the unobservable component of transactions costs and has mean zero and variance  $\sigma_3^2$ . This specification assumes that all households face identical transactions costs on average. Substituting this equation into the participation constraints, and moving  $e_{3i}$  over to the left hand side of the first two inequalities, and into the middle of the third, completes our initial structural model.

Our second specification allows transactions costs to vary by time of transport available and proximity to market:

$$\tau_{i} = \theta_{1} T_{1i} + \theta_{2} T_{2i} + \sum_{k=1}^{2} \alpha_{k} D_{i} * T_{ki} + e_{3i},$$
(11)

where  $T_1$  is an indicator variable equal to one if the primary mode of transportation within a village is by truck,  $T_2$  is an indicator variable equal to one if the primary mode of transportation within a village is by bike or animal, and D is the distance from the village to the nearest

permanent market. Here, the interactive terms are included to test whether the effect of distance differs depending on the dominant mode of transportation available to the household.

An examination of the switching conditions quickly shows why standard regression analysis leads to biased estimates. Conditional on being a net seller or buyer, transactions costs truncate the distribution for the error terms in the demand and supply equations. A standard fix to obtain consistent estimates for the demand and supply parameters is Heckman's two stage procedure where the probability of a household being a net buyer, seller, or in autarky is first estimated, and the selectivity terms are then included in a second stage regression to obtain estimates of the remaining structural parameters (Goetz).

This procedure yields consistent estimates of the demand and supply parameters, but without further restrictions will not identify the factors affecting transactions costs separately from the factors determining supply and demand. One possible restriction is to assume that the variables influencing transactions costs are separate from the variables affecting a household's production and consumption decision. However, we anticipate a households transactions costs to depend partly on its wealth, education, and demographics, the very set of variables that should be included in an analysis of household production or consumption. Since *i* enters linearly in the switching condition a Probit analysis cannot separately identify the effect of variables entering into both *i* and the demand and supply equations.

To identify *i* we jointly estimate it along with the demand and supply equations.

Intuitively, the demand and supply parameters are identified using the observed responses of households that do participate in the market, and the switching conditions are used to identify transactions cost parameters. In order for this approach to work, we must assume that household demand and marginal cost schedules are identical for autarkic and non-autarkic households alike.

This is a big assumption, but perhaps not more objectionable than assuming constant elasticities across villages.

## The Likelihood Function

Let  $n(e_1,e_2,e_3)$  be the multivariate density function for the demand, supply, and transaction cost error terms. We assume the error terms are normally distributed, and allow for correlation between  $e_1$  and  $e_2$ . The unobservable component of transactions costs,  $e_3$ , is assumed to be independently distributed from the other errors.<sup>2</sup>

To obtain the contribution to the likelihood function for a household with positive marketed surplus, let  $J_S$  be the Jacobian corresponding to the transformation

$$u_{1} = e_{1}$$

$$u_{2} = e_{2}$$

$$u_{3} = \left(\frac{1}{\eta_{2}^{*} - \xi_{1}}\right) \cdot (e_{2} - e_{1}) + e_{3}.$$
(12)

Note that  $u_3$  is the term on the left hand side of the first two participation conditions in (9), and the middle term in the last condition, after (10) or (11) is substituted in for i.

Integrating over the area of positive marketed surplus, the contribution to the likelihood function from a selling household is

$$l_{Si} = \int_{-\infty}^{P_i^M - E[\tau_i] - \Lambda_i} |\det(J_S)| n(J_S \times \boldsymbol{u}) du_3,$$
(13)

where  $\mathbf{u} = (u_1, u_2, u_3)'$ ,  $\Lambda_i = \frac{1}{\eta_2^* - \xi_1} \left( f_v + \sum_{k=1}^{K_1} z_{2ik} \gamma_k - g_v^* - \sum_{k=1}^{K} z_{ik} \phi_k^* \right)$ , and E[i] is the expected value of transactions costs.

<sup>&</sup>lt;sup>2</sup> At this point, this is an assumption made solely for simplicity, and will be relaxed in further work.

For net purchasing households, the transformation is the same as (12) with the exception that the sign on  $e_3$  is switched. Let  $J_P$  be the Jacobian for this transformation. The contribution to the likelihood function from a purchasing household is

$$l_{p_i} = \int_{P_i^M + E[\tau_i] - \Lambda_i}^{\infty} \left| \det(J_P) \right| \cdot n(J_P \times \boldsymbol{u}) du_3.$$
 (14)

Finally, let  $n_{U_3}(u_3)$  be the marginal distribution for  $u_3$ . The contribution to the likelihood function by an autarkic household is

$$l_{Ai} = \int_{P_i^M - E[\tau_i] - \Lambda_i}^{P_i^M + E[\tau_i] - \Lambda_i} n_{U_3}(u_3) du_3.$$
 (15)

The total likelihood function can be compactly written by defining  $d_i(r)$  to be an indicator function equal to 1 if household i is in regime r,  $r ext{ } ext{$ 

The variance-covariance matrix for the parameter estimates is obtained using the sandwich estimator

$$V = \Gamma^{-1} \times \Omega \times \Gamma^{-1}, \tag{16}$$

where  $\Box$  is the Hessian of the log-likelihood function, and  $\Box$  is the outer-product matrix, both evaluated at the maximum likelihood estimates.

#### DATA

To test our model, we used data collected as part of the Kenya Maize Impact Study (KMIS). The study collected household level information from a sample of 426 farmers located in six maize agro-climatic zones in Kenya, as well as village level information for the 30 villages in which respondents dwelled (Karanja, forthcoming). The household and village surveys were conducted concurrently between June and October 1999.<sup>3</sup>

Table 1 provides the summary statistics. Of the 426 original observations, 69 households had missing data on maize production or consumption and were dropped from the analysis. 33 households reported both purchasing and selling maize, and were also dropped leaving 324 observations. Out of the 324 remaining households 127 households had a positive marketed surplus, 113 had a negative marketed surplus, and 84 remained in autarky. Typically, households of each type coexist in the same village. However, all households in four villages had a positive marketed surplus. Three of these villages are located in the Western highlands, a region of large commercial farms.

Regardless of their market position, each household reported a selling and purchase price for maize. In our econometric analysis we used the selling price in both the demand and supply equations for households with a positive marketed surplus, the purchase price for households with a negative marketed surplus, and the average of reported buying and selling price for the autarkic households. Since the autarkic households were not involved in any market transactions, it is not clear whether the price they reported is that observed in the local village markets, or the price they would receive inclusive of any marketing costs. Finally, for all non-

-

<sup>&</sup>lt;sup>3</sup> The sampling frame of the KMIS was a subset of a much larger household survey conducted as part of the 1994 Kenya Maize Data Base project. That project used GIS techniques to design a spatial sampling frame for a national survey of 1300 Kenyan maize farmers (see Hassan, Lynam, and Okoth, 1998 for details). For the KMIS, the

autarkic households, prices varied over villages, and over households within the same village, indicating that the incentive price is truly household specific.

Besides the village fixed effects and maize prices, an education dummy, farm size, and household size are included in the both the demand and supply equations. The education dummy is one if the head of household has a secondary education or higher. In the supply equation, it is included as a measure of human capital that may increase maize productivity. Education is included the demand equation as a possible determinant of total household income, presumably originating from higher on-farm labor productivity or higher wages in off-farm employment. Farm size is a measure of household wealth on the demand side, and an input into maize production on the supply side. Household size measures aggregate household demand for maize. We have made no adjustments at this stage for household composition. In the supply equation, household size is included to control for on-farm labor availability.<sup>4</sup>

## **RESULTS**

Table 2 provides the maximum likelihood estimates for our first model. Both equations are estimated with a full set of village fixed effects, which are not reported in order to save space. The price elasticities are reasonable in magnitude and precisely estimated. Both farm size and household size have a positive, and statistically significant, impact on maize consumption. Having an education level at the secondary level or better also increases maize consumption although the coefficient is not significantly different than zero. An increase in farm size increases maize supply; however, neither household size or education having a significant effect.

proportional distribution of the farmers between different zones was determined by the relative importance of maize in each zone, logistical considerations and available research funds.

<sup>&</sup>lt;sup>4</sup> Agricultural labor markets are typically quite thin in Kenya, hence family labor availability is an important determinant of maize production (Karanja, forthcoming).

Before turning to the transactions costs estimates, it is informative to compare the results in Table 2 to the results from a standard SUR model that ignores the selectivity in the sample.

Table 3 provides the SUR results, once again not reporting the fixed effects. The greatest difference is in the price elasticities. Without accounting for transactions costs, both are biased towards zero and insignificant. This result corresponds to the finding in Key, Sadoulet, and de Janvry who find the price elasticity of marketed surplus becomes smaller in absolute value and statistically insignificant when transactions costs are not taken into account.

One reason why our structural model including transaction costs results in a higher degree of price responsiveness than the SUR model is that the price elasticities are estimated using those households who are actually responding to market prices (while properly accounting for the effect of the selectivity on the error distribution). A second reason is that the price elasticities affect the probability of a household being in autarky. The participation equations in (9) show that the probability of being a net purchaser or seller depends on the difference between the demand and supply price elasticities. Intuitively, the response of a households autarkic shadow price to exogenous shocks increases as demand and supply become more price inelastic. All else the same, this will decrease the probability of a household remaining in autarky. For reasonable estimates of transactions costs, then, extremely inelastic demand and supply elasticities are incompatible with a sample such as ours where 26% of the households surveyed do not buy or sell maize.

The primary benefit in estimating the transactions costs jointly with the remaining structural parameters is we can measure their size relative to market price. This is not possible with the two-stage Heckman procedure, and does not appear to be possible using the approach of Key, Sadoulet, and de Janvry, who work with a somewhat different selectivity equation. Table 2

reports our estimate of  $\bar{\tau}$  to be .25 with a standard error of .03. This estimate is measured relative to the logarithm of prices, so the ad valorem tax equivalent of the fixed transactions costs is equal to the exponent of .25, or 1.28. On average, then, transactions costs cause a price band equal to 28% of the market price. The mean selling and purchase price for maize are 11.45 and 15.21 Ksh/kg, respectively, so in levels transactions costs vary from 3.21 Ksh to 4.26 Ksh. To us, this seems like a reasonable number. Transactions costs are a significant, but not insurmountable, barrier to market participation.

We turn now to our estimation of model 2, in which we allow transactions costs to vary by primary mode of transportation and the distance to a permanent market. Both of these variables are obtained from the village-level portion of the survey. *A priori*, we expect that the distance from a permanent market will not have a major impact in villages where maize is primarily hauled by bicycle or animals, on the assumption that maximum feasible distance for hauling by these modes of transport is relatively short. For example, we expect that there is little difference, say, between 15 kilometers and 20 kilometers: in both cases, the distance is too great to move large amounts of commodity using only human or animal power. Conversely, where trucks are the major means of transportation, the effects of an increase in distance are more likely to be important.

The estimates provided in table 4 show that including the additional transactions cost variables has a very minor impact on the supply and demand parameters. More interesting, the results confirm our intuitive notion on how transportation infrastructure and distance should interact. Transactions costs in villages with truck transport begin at a lower level than transaction costs in villages with bicycle/animal transport and then increase with distance.

Villages with primarily bicycle or animal transport have higher transactions costs, and they do not change with the distance from a permanent market.

A sense for the quantitative importance of transactions costs can be obtained from Figure 1. In this figure transactions costs are graphed against the distance from a permanent market. Once again, since the transactions costs are estimated as additive to the log of market price, we have taken their exponent to find the ad valorem make tax equivalent. For villages with bicycle/animal the ad valorem equivalent of the transactions costs is estimated to be 1.23, or 23% of market price, and are shown by the horizontal line in the figure. For villages that transport maize by truck, transactions costs range from a low of 19% of market price when a permanent market is one kilometer away, to a high of 58% in the village located 48 kilometers from a permanent market.

We interpret these results as measuring the effect of market integration on fixed transaction costs. These costs are measured relative to the household specific market prices, which should include the marketing margins charged by traders. To the extent that transportation type and distance proxy for the degree of market integration, the results indicate that transactions costs increase as villages become more isolated. While the exact source of the cost increase has not been identified, there are several stylized facts that may provide some insight. First, we would expect that the more isolated villages will have the highest degree of covariation between price and household supply. General equilibrium linkages will cause household supply shocks to be correlated with market price, increasing the probability of households remaining in autarky. Second, we might also expect less opportunity for off-farm employment in isolated villages, although this is a hypothesis we have not yet verified. Finally, search costs and the effort required to obtain market information may be higher in the more isolated villages.

## **CONCLUDING REMARKS**

For those locations where external conditions limit a household's ability to market agricultural products or increase agricultural productivity, alternative public investments may well hold greater potential for poverty alleviation than additional agricultural research. In this paper, we have generated what we believe to be the first quantitative measures of the fixed transactions costs facing semisubsistence households. The magnitude of those transactions costs, estimated here to be equivalent to an ad valorem tax of 28%, indicates that public infrastructure investment represent a potentially fruitful avenue for improving welfare of semisubsistence households in Kenya.

Our empirical results support a generally held belief that transactions costs are a significant deterrent to market participation by rural agricultural households. This, by itself, is not surprising, and can be inferred by simply noting a significant number of households in the survey neither purchase nor sell maize. However, we have also provided some empirical estimates on how market integration affects the size of the price bands facing rural households. With cross sectional data the more standard cointegration techniques for testing the degree of market integration are not available to us. Instead, we used data on primary modes of transportation and the distance to the nearest permanent market as indirect measures of the degree a village is integrated into broader markets.

Our results indicate a considerable degree of heterogeneity. Everything else the same, fixed transactions costs are generally higher in villages with primarily bicycle or animal transportation, but the distance to a permanent market has no significant effect. In villages where maize is transported mainly by truck, fixed transactions costs are initially lower, but then increase with

the distance to a permanent market. Depending on transportation type and distance, we find the tax equivalent of fixed transactions costs range from 19% to 58% of market price.

Transactions costs of this magnitude have numerous implications for development and poverty alleviation policies. In future research we intend to further investigate empirical regularities in the size of transactions costs, both across agro-ecological zones and across the socio-economic spectrum. If transactions costs are higher for poor households – as is commonly supposed – then public investments that lower unit transactions costs equally for all households are likely to increase the welfare of (richer) households already participating in agricultural commodity and input markets by more than they will benefit poorer households, many of whom initially will be autarkic. The success of infrastructure investment as a mechanism for enhancing the agricultural incomes of the poor therefore may well depend on the degree to which such investment can be targeted toward autarkic households (for whom transactions costs are highest).

#### **REFERENCES**

- Benjamin, Dwayne. 1992. "Household Composition, Labor Markets, and Labor Demand: Testing for Separability in Agricultural Household Models." <u>Econometrica</u> 60(2): 287-322.7
- Byerlee, D. 1996. "Modern Varieties, Productivity, and Sustainability: Recent Experience and Emerging Challenges." World Development 24(4), 697-718.
- Coxhead, I. and P. Warr. 1991. "Technical Change, Land Quality, and Income Distribution: A General Equilibrium Analysis." <u>American Journal of Agricultural Economics</u> 73(2), 345-360.
- David, C. and K. Otsuka (eds.). 1994. <u>Modern Rice Technology and Income Distribution in Asia</u>. Boulder, CO: Lynne Rienner Publishers.
- de Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. "Peasant Households with Missing Markets: Some Paradoxes Explained." <u>Economic Journal</u> 101(409), 1400-1417.
- Fan, S. and P.B.R. Hazell. 1999. "Are Returns to Public Investment Lower in Less-favored Rural Areas? An Empirical Analysis of India." EPTD Discussion Paper No. 43, International Food Policy Research Institute, Washington, DC.
- Goetz, S.J. 1992. "A Selectivity Model of Household Food Marketing Behavior in Sub-Saharan Africa." <u>American Journal of Agricultural Economics</u> 74(x): 444-452.

- Haggblade, S., P.B.R. Hazell, and J. Brown. 1989. "Farm-nonfarm Linkages in Rural Sub-Saharan Africa. World Development 17(8), 1173-1201.
- Hassan, R., J. Lynam, and P. Okoth. 1998. "The Spatial Sampling Frame and Design for Farmer and Village Surveys," in R. Hassan (ed.), *Maize Technology Development and Transfer: A GIS Application for Research Planning in Kenya*. Wallingford, UK: CAB International, pp. 27-43.
- Key, N., E. Sadoulet, and A. de Janvry. 2000. "Transactions Costs and Agricultural Household Supply Response." American Journal of Agricultural Economics 82(2): 245-259.
- Leonard, H. J. and contributors. 1989. "Environment and the Poor: Development Strategies for a Common Agenda." U.S.-Third World Policy Perspectives No. 11, Overseas Development Council, New Brunswick, NJ: Transactions Books.
- Lipton, M. with Longhurst, R.. 1989. New Seeds and Poor People. Baltimore, MD: Johns Hopkins University Press.
- Naylor, R. and W. Falcon. 1995. "Is the Locus of Poverty Changing?" <u>Food Policy</u> 20(6), 501-518.
- Pinstrup-Anderson, P. and R. Pandya-Lorch. 1994. "Alleviating Poverty, Intensifying Agriculture, and Effectively Managing Natural Resources." IFPRI Food Agriculture, and the Environment Discussion Paper No. 1. Washington, DC: International Food Policy Research Institute.
- Reardon, T., K. Stamoulis, A. Balisacan, M.E. Cruz, J. Berdegue, and B. Banks. 1998. "Rural Nonfarm Income in Developing Countries: Importance and Policy Implications, in FAO, <u>The State of Food and Agriculture</u>. Rome: Food and Agriculture Organization of the United Nations.
- Renkow, M. 1993. "Differential Technology Adoption and Income Distribution in Pakistan: Implications for Research Resource Allocation." <u>American Journal of Agricultural Economics</u> 75(1), 33-43.
- Renkow, M. 1999. Poverty, Productivity, and Production Environment: A Review of The Evidence." Invited paper presented at the CIAT Workshop on Assessing the Impact of Agricultural Research on Poverty Alleviation, San Jose, Costa Rica.
- Scobie, G. and R. Posada T. 1978. "The Impact of Technical Change on Income Distribution: The Case of Rice in Colombia." American Journal of Agricultural Economics 60(1), 85-92.
- Shaban, R.A. 1987. "Testing between Competing Models of Sharecropping." <u>Journal of Political Economy</u> 95(5): 893-920.
- Townsend, R.M. 1994. "Risk and Insurance in Village India." Econometrica 62: 539-591.

- Udry, C. 1994. "Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria." <u>Review of Economic Studies</u>, 61(3): 495-526.
- Woodland, A.D. 1980. "Direct and Indirect Trade Utility Functions." Review of Economic Studies 47(5):907-926.

TABLE 1. SUMMARY STATISTICS

Variable Variable	N	Mean	C.V.	Min.	Max.
Area planted to maize (ha)	324	4.2	2.83	0.1	138
Maize production (kg)	324	4674.7	5.54	10	405,000
Maize consumption (kg)	324	998.1	1.34	24	10,530
Maize sales (kg)	324	3787.1	6.62	0	396,000
Maize purchases (kg)	324	110.5	2.26	0	2,340
Maize sale price (Ksh/kg)	324	11.5	0.48	4.5	25
Maize purchase price (Ksh/kg)	324	15.2	4.95	5.0	50
Farm size (ha)	324	15.6	0.98	0.3	1,200
Age of household head (yrs)	324	44.7	0.34	17	89
Household size	324	7.9	0.51	1	35
Distance to nearest market (km)	30	17.5	0.86	1	64
Education of household head:					
No education	94				
Primary school	143				
Secondary school	74				
Post-secondary school	13				
Distance to: <sup>a</sup>					
Nearest permanent market (km)	30	17.5	0.86	1	64
Nearest tarmac road (km)	30	9.6	11.1	0.0	47
Nearest seed dealer (km)	30	10.3	10.4	0.1	45

a. Distance data are village level.

Source: Kenya Maize Impact Study

TABLE 2. MAXIMUM LIKELIHOOD ESTIMATES OF MODEL 1

Variable	Supply Equation	Demand Equation	Transactions Cost Equation	
Maize sale price	0.63 *** (0.15)	_	_	
Maize purchase price	_	-0.25 *** (0.11)	_	
Education	0.12 (0.13)	0.06 (0.11)	_	
Farm size	0.45 *** (0.08)	0.23 *** (0.05)	<del>_</del>	
Household size	-0.07 (0.14)	0.34 *** (0.09)		
$\overline{ au}$	_	_	0.25 *** (0.03)	
$e_3$			0.14 *** (0.03)	
N	324	324	324	

TABLE 3. SEEMINGLY UNRELATED REGRESSION EQUATION ESTIMATES

Variable	Supply Equation	Demand Equation
Maize sale price	0.13 (0.17)	_
Maize purchase price	_	-0.09 (0.12)
Education	0.16 (0.13)	0.12 (0.10)
Farm size	0.45 *** (0.06)	0.25 *** (0.05)
Household size	-0.04 (0.12)	0.38 *** (0.09)
N	324	324

TABLE 4. MAXIMUM LIKELIHOOD ESTIMATES OF MODEL 2

Variable	Supply Equation	Demand Equation	Transactions Cost Equation	
Maize sale price	0.62 *** (0.15)	_	_	
Maize purchase price	_	-0.25 *** (0.11)	_	
Education	0.13 (0.13)	0.06 (0.11)	_	
Farm size	0.46 **** (0.08)	0.23 *** (0.05)	_	
Household size	-0.07 (0.14)	0.34 *** (0.09)	_	
Truck transport dummy	_	_	0.25 *** (0.03)	
Bicycle/animal transport dummy	_	_	0.21 *** (0.05)	
Truck $\times$ distance	_	_	0.006 **** (0.002)	
Bicycle/animal × distance	_	_	0.0006 (0.0018)	
$e_3$	_	_	0.15 *** (0.03)	
N	324	324	324	

Figure 1: Transactions Costs versus Distance

