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Christoph Steffen
Xiaohua Yu

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Transaction Costs and Food Prices in Rural Kenya

Christoph Steffen and Xiaohua Yu
Georg-August-University of Goettingen
37073 Goettingen, Germany

Abstract

While there is rich literature covering theoretical concepts of transaction costs very few empirical strategies have been provided to estimate them. The theoretical framework proposed in this paper is based on a unit value decomposition and defines transaction costs as the difference between a unit value and a frontier value realized in a situation without transaction costs. Estimates of transaction costs are obtained by means of stochastic frontier models with the data from Kenyan maize farmers. We find a magnitude of 12-18% for maize transactions in rural Kenya and identify drive time, market distance,education and counterparts in negotiations as main determinants.

Key Words: transaction costs, stochastic frontier analysis, food prices, Kenya
JEL: D4 Q13 Q11

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1 Introduction

Throughout history transaction costs have played a major role in economic theory and a variety of theories and definitions have emerged though empirical measuring encounters many high hurdles. Coase (1937) described them as the cost of using the price mechanism while Arrow (1969) viewed them as the costs of running the economic system. However despite the development of many path breaking theories, the development of practical operational concepts has been lagging behind and remains a challenge for empirical researchers. However transactions do not occur in a frictionless environment and understanding these frictions is among the key factors of economic development. For semi-subsistence farmers in developing countries overcoming transaction costs can be a decisive factor in escaping poverty. They can substantially drain farmer's profits (Vakis, Sadoulet and Janvry, 2003) or even represent a barrier to market participation (Key, Sadoulet and Janvry, 2000). Since many of these factors are unobservable it is a challenging task to develop a reliable measure. In this paper transaction costs are defined as all costs that are related to the exchange of a good and range from information, bargaining and monitoring costs to costs related to physical transport. The analysis focuses on maize sales of Kenyan semi-subsistence farmers for whom transaction costs can play a major role to enter markets and overcome poverty. According to the Kenya Integrated Household Budget Survey 2006 which was conducted in 2005 Kenya had by then a population of 35.5 Million of which 28.36 million lived in rural areas. In total 6.45 million households were engaged in crop farming of which again 93% planted maize. About 75% of the maize production originates in small scale farms many of which are of subsistence or semi- subsistence. The current literature finds that high transaction costs, particularly the transportation costs, could impede farmers from participation of market transaction, which eventually entraps farmers in producing low-yielding food crops in Kenya and leads to subsistent life (Omamo, 1998; Alene et al. 2008; Barrett 2008; Olwande et al. 2015). Despite the undoubted importance of transaction costs in economics few models are so far concerned with the estimation of its magnitude although there is a considerable body of literature on determinants. The unobservable nature of transaction costs certainly poses one of the major challenges in achieving an appropriate measure. This issue is addressed in this paper by assuming there is a frontier value of products in the absence of transaction costs. A method is proposed to decompose unit values into spatial price factors and a quality value component following Deaton (1988) and Yu and Abler (2009). This quality value is heterogeneous across farms and not fully observed by traders, so that it incurs the transaction costs. We can derive a measure of transaction costs as the difference between the unit value and a frontier value.

A statistical method that is appropriate for the prediction of potential outcomes is the stochastic frontier model. A conditional mean model is used to determine the unit value of a good in the first stage with determinants of the value of a good and model the mean difference to the value frontier with a set of transaction costs determinants. This procedure allows to simultaneously estimating the magnitude of transaction costs and identifying the main determinants. Due the presence of a potential selection bias our empirical framework includes Greene's (2010) sample selection model as well as the Battese and Coelli(1995) model. The estimations show that the proposed concept is well operational. The estimated magnitude of transaction costs is 12.1-18.2 % of the feasible value of maize which is in line with the previous literature. Transaction costs determinants that show significant are the counterpart in negotiations, the drive time to the next market, the distance to the capital Nairobi, the existence of a market in the sub-location and years of education of the household head.

The paper is structured as follows. First the literature on the here used categorization of transaction costs is discussed and recent findings on transaction costs of smallholders summarized. The theory section explains the decomposition of unit values into spatial price factors, value and transaction costs. The data section briefly presents the RePEAT data and discusses the relevance of proxies for both value and transaction costs categories. The econometric model section is concerned with the adequate estimation of the proposed transaction costs model under the consideration of self selection. The results section provides a detailed discussion of the empirical findings and the conclusions present a summary of the results and evaluate implications for policy and further research.

2 Literature Review

It is often argued that the concept of transaction costs started with Coase (1937) "The Nature of the Firm", where he referred to the costs to using of the price mechanism. The important contribution of transaction costs economics is the recognition that transactions do not happen in a frictionless economic environment. The development of Transaction Costs Economics was further accelerated with the rise of the new institutional economic theory with Oliver Williams as a main contributor.

Meanwhile many different strands have developed in the transaction costs related literature. While there is clearly no lag of powerful and useful theories the development of operational concepts could not keep pace and remains one of the main challenges in the transaction costs literature. One of the reasons is certainly the unobservable nature of institutions that is difficult to capture with empirical models.

In the course of agricultural exchange in developing countries farmers face a variety of institutional factors affecting transaction costs. Some of them are missing markets, information asymmetry, risk and uncertainty, non-separability of consumption and production, incomplete property rights and institutional failures (Cuevas, 2014).

An empirical analysis of transaction costs requires a basic definition to establish a framework and choose adequate proxy variables. It is straightforward to choose a categorization here that has already been established in the analysis of agricultural exchange. An operational concept that has appeared frequently in the literature proposes the differentiation of information, bargaining and monitoring costs Information costs usually occur prior to the exchange and include the search for price information and potential buyers as well as the facilitation of the transactions. Bargaining, also labeled negotiation costs usually occur during an exchange and refer to all costs that are connected to the process of negotiation and reaching an agreement as well as costs related to payments. Bargaining costs can be significantly influenced by personal attributes such as education, gender and skills. Monitoring or enforcement costs are costs that occur to ensure that the agreement is fulfilled. Furubotn and Richter (2005) argue that transaction costs generally include the costs of resources utilized for the creation, maintenance, use, change, and so on of institutions and organizations. Applied to the transfer of existing property rights between individuals, transaction costs include the costs of information, negotiation, and enforcement. Hobbs (1995) is among the first empirical studies to show that this categorization is operational at the example of cattle marketing. While theorists generally describe transport costs as part of the production process empirical applications often highlight the importance of recognizing transport costs as a transaction costs category in the context of analyzing agricultural markets in developing countries (Omamo, 1998; Alene et al. 2008). Kähkönen and Leathers (1999) argue that a definition that assigns transport to the production process may be flawed if the actual costs are eventually paid by the buyer. This is a situation that can be observed in case of farmgate sales that make up for a substantial amount of transfers from semi-subsistent farmers in rural Kenya. Undoubtedly some transport costs occur in the course of the production process such as costs related to the acquisition of seeds, fertilizer or other capital goods. Kähkönen and Leathers (1999) are concerned with transaction costs in agricultural markets in Zambia and Tanzania. They provide a detailed discussion of the challenges associated with the analysis of transaction costs in agricultural exchange. They list various examples on the substitutability of information related costs and physical costs. As a consequence they conclude that a definition of transaction costs that excludes physical costs may result in misleading conclusions on the efficiency of a transaction. Another argument for the inclusion of transfer costs is that costs related to physical handling of a transaction can also be linked to institutional impediments.

Li et al. (2012) estimated the transportation costs for Chinese food traders and find that these account for 40% of trade barriers in China. Key, Sadoulet and Janvry (2000) as well as Vakis, Sadoulet and Janvry (2003) analyze transaction costs in agricultural markets while differentiating between fixed and proportional transaction costs. While fixed transaction costs are categorized as above and are independent of the quantity transferred, proportional transaction costs vary with quantity. They may originate from different per unit transportation costs or quantity related price premiums that are a result of the negotiation process.

Vakis, Sadoulet and Janvry (2003) are one of the very few studies that propose a method to estimate the magnitude of transaction costs at the example of Peruvian potato farmers. They are concerned with transaction costs as a barrier to market participation and estimate transaction costs by means of a conditional logit market choice model. The results indicate transportation costs of 10-15 percent of the price received by the farmers in integrated and 30 % in isolated areas. Special attention is here paid to market price information that has a very significant impact on transaction costs and the choice of the market channel. It can reduce fixed transaction costs by the equivalent of doubling the price received by the farmer. One of the first estimates of the magnitude of transaction costs for agricultural households comes from Renkow, Hallstrom and Karanja (2003) who estimate the magnitude by means of MLE using a sample of Kenyan maize farmers. Their results indicate fixed transaction costs of 15 % on average in their sample. The literature also shows that transaction costs vary significantly across farmers or traders.

Besides draining farmers' profits, transactions costs are the embodiment of barriers to market participation by resource-poor smallholders and as factors responsible for significant market failures in developing countries. For instance Escoba and Cavero (2004) show at the example of poor potato farmers in Peru that high transaction costs can represent an exclusion mechanism to agro industrial markets. Osebeyo and Aye (2014) confirm this pattern and find that transaction costs have a significant influence on market participation. Key, Sadoulet, and Janvry (2000) provide a household supply response model for market participation with transaction cost as decisive component. They show that the decision to participate in markets of Mexican maize farmers depends significantly on fixed as well as proportional transaction costs.

3 Theory

In order to estimate transaction costs it is necessary to first consider some determinants of the value of a good. A food group item such as maize or bananas is practically not a homogenous good and consists of many different items. The properties and hence the price of a food group item may vary depending on the variety and quality of the items. In Sub Saharan Africa many farmers use local varieties. Due to the individual selection of farmers over generations, these local seeds have a very broad gene pool in contrast to improved hybrid seeds. As a consequence quality and taste can differ significantly across regions (Fafchamps, 2004). Anticipating this heterogeneity, traders tend to inspect goods at each transaction to overcome the associated asymmetric information. Hybrid seeds tend to lead to a lower variety in quality since they are less prone to wrong treatment and climate. This might be preferred for industrial processes if a constant input quality is required for a certain output quality (Fafchamps, 2004). Such circumstances may be anticipated by traders as well in order to meet industrial demands. Other differences in quality can be attributed to soil properties, fertilizer usage, differences in climate or damages. Hence a variety of factors must be taken into account to calculate a reference price and the mere consideration of a market price would ignore some decisive factors. Since prices also differ across locations and traders take individual properties into consideration before setting a price, the magnitude of transaction costs cannot be estimated without the consideration of individual good properties and spatial variations of prices. An appropriate model for the considerations of quality and spatial variations has been introduced by Deaton (1988) and Yu and Abler (2009). For a particular food group i (e.g. maize), we assume there are M different items with different quality, and define the exogenous price vector p_{ij} of food group i in region j as

$$p_{ij} = \lambda_{ij} p_i \tag{1}$$

Where λ_{ij} is a scaler and reflects the regional price factor for food group i in region j while p_i

is a price vector capturing the price effect that arises due to differences in quality, independent of the region, such as taste, variety, moisture level, organic or not, etc. For instance, if a kg maize has 4000 items, which have different quality. The true value of this kg maize should be determined by each item's value.

In practice, a farmer could also produce many different items for food group i with different qualities, and his output quantity vector is q_{ij}. Thus the total revenue from the food group i is E_{ij} and $E_{ij} = p'_{ij}q_{ij}$, and the total quantity sold in the market is $Q_{ij} = \Theta'_i q_{ij}$, where Θ_i denotes a vector of ones. The unit value for the food group i can now be derived as follows:

$$V_{ij} = \frac{E_{ij}}{Q_{ij}} = \frac{p'_{ij}q_{ij}}{\Theta_i q_{ij}} = \lambda_{ij}(\frac{p'_i q_{ij}}{\Theta'_i q_{ij}}) = \lambda_{ij} v_{ij}(p_i, q_{ij}) \tag{2}$$

The unit value is obtained by dividing the total revenue E_{ij} by the total quantity Q_{ij} . Price differences across regions can be removed by factoring them out in λ_{ij}. Then v_{ij} denotes the average price of different food items for food group i in region j while λ_{ij} represents the price differences across regions. v_{ij} can be regarded as the quality value of food group i , which is determined by the composition of different items q_{ij} with different qualities. Due to transaction costs, the quality information cannot be fully observed, measured , monitored or realized by the traders or even the farmers . When taking logs the unit values can be expressed in an additive relation of spatial price factors and the value of quality:

$$lnV_{ij} = ln\lambda_{ij} + lnv_{ij}(p_i, q_{ij}) \tag{3}$$

Equation (3) shows that the unit value or the receive price of a farm is determined by a regional effect λ_{ij} and a quality factor $lnv_{ij}(p_i, q_{ij})$which is asymmetry between farmers and buyers due to transaction costs. In order to find a measure for transaction costs by means of a hedonic price model a situation needs to be modeled in which zero transaction costs occur so that the deviation from the observed unit value can be derived. Hence define V^*_{ij} as the maximum unit value paid for good i that may be obtained by farmers (or traded in the market between farmers and traders) in the absence of transaction costs. This implies that observed unit value can never exceed the feasible one so that $V^*_{ij} \geq V_{ij}$. As the regional factor λ_{ij} is often fixed and known to both trade partners, we can assume

$$lnV_{ij}^* = ln\lambda_{ij} + lnv_{ij}^*(p_i, q_{ij}) - t_{ij} \tag{4}$$

Where $lnv_{ij}^*(p_i, q_{ij})$ can be defined as the frontier quality. Then the transaction cost can be defined as the distance between the frontier and the realized values. Consequently its share as a fraction of the frontier can be calculated as follows:

$$t_{ij} = lnV_{ij}^* - lnV_{ij} = ln(\frac{v_{ij}^*(p_i, q_{ij})}{v_{ij}(p_i, q_{ij})}) \tag{5}$$

Combining Equation (3), (4) and (5), yields,

$$lnV_{ij} = ln\lambda_{ij} + lnv_{ij}^*(p_i, q_{ij}) - t_{ij} \tag{6}$$

In this representation of unit values we can explain the value of a good in terms of a value frontier and its difference to the realized unit value. This model now consists of three components: firstly a spatial price factor for each product that varies over regions and secondly the frontier quality and thirdly a component t_{ij} which represents the transaction costs. As the frontier quality is unknown, the given structure in Equation (6) can be estimated by a stochastic frontier approach.

Note that the difference between the frontier price and the actual price is defined as the transaction costs in our study, but we do not explicitly indicate who pays the transaction costs. Let's take an example for transportation cost here. If the realized prices are the farmgate prices as most cases occur in the maize market of Kenya in this study, the transportation costs are actually paid by the buyers. If farmers deliver maize and pay the transportation costs, the transportation costs will be added to the farmgate price, but the "actual" farmgate price does not change. Empirically, the trade places will be controlled for the transportation costs.

4 Econometric Model

4.1 Stochastic Frontier Model

With the aim to estimate transaction costs, we are interested in the deviation of an observed price (or unit value) from a frontier price that is achievable under optimal conditions rather than a deviation from the average which would be given by a common regression model. We hence require a model that allows us to estimate the distance between an observed and a maximum feasible price as illustrated in figure 1. Although it has never been used in this context, a stochastic frontier model fulfills these criteria. The stochastic frontier model is used to estimate equation (6) which has been derived in the theory section while keeping in mind that the value frontier consists of a regional base price and the feasible price effect that is in nature hedonic. This equation can be estimated by a standard stochastic frontier model as suggested by Aigner, Lovell and Schmidt (1977).

$$lnV_i = x_i\beta + (v_i - u_i) \tag{7}$$

V_i refers to the to the unit value of a good that was observed in a transaction for farmer i. x_i is a kx1 vector containing the determinants of quality and spatial variations and β is the vector of parameters to be estimated. $v_i - u_i$ is the decomposed random error term. The symmetric disturbance $v_i \sim N(0, \sigma_v^2)$ captures unobserved heterogeneities and measurement errors and is assumed to be independently and identically distributed. The term u_i presents a measure of transaction costs which is in the theoretical model referred to as $ln(\frac{v_{ij}^*(p_i,q_{ij})}{v_{ij}(p_i,q_{ij})}) > 0$. It is non-negative, follows a one-sided distribution and is assumed to be distributed independently of v_i . In the context of the underlying analysis it is desirable to model transaction cost with a set of exogenous variables to identify determinants. This feature is available from conditional mean models. The first conditional mean models to parameterize the mean of the transaction costs in order to study exogenous effects on transaction costs which originates from of Kumbhakar, Ghosh, and McGuckin (1991) and Huang and Liu (1994), The model was extended to the case of panel data by Battese and Coelli (1993, 1995).

In the empirical model the feasible value V_i^* can be estimated by means of $x_i\beta$ The estimation of the frontier model yields estimates of u_i that in turn allow for a calculation of transaction costs. Note that u_i denotes the difference between the logs of expected feasible and observed values. Here u_i is modeled as a function of z_i, and assumes u_i following a truncated normal distribution:

$$u_i \sim N^+(\mu_i, \sigma_u^2), \tag{8}$$
$$\mu_i = z_i\delta + \omega_i$$

N^+ refers to a truncated normal distribution. z_i represents a vector of transaction cost determinants and δ the respective parameter to be estimated. In this way u_i can be modeled as a function of transaction costs determinants z_i with parameters $\delta.\omega_i$ is a random error following a truncated normal distribution. Relative transaction costs (t) as the share of the feasible values can then be calculated with

$$t = 1 - exp(-u_i) \tag{9}$$

The total transaction costs (T) can be calculated as a share of the predicted frontier values:

$$T = exp(x_i\beta) * (1 - exp(-u_i)) = exp(x_i\beta * t \tag{10}$$

4.2 Selection Bias

In our sample only a fraction of the maize producers decide to participate in the market. Despite transaction costs being constituted through a market transaction, each producer has to face them prior to the decision whether to participate in a market. Transaction costs may be a decisive determinant of this decision and many households fail to participate in a market due to transaction costs. Thus market participants cannot be considered representative for all producers and are a biased represent. Since unit values can only be observed when farmers participate, the data used in the transaction cost model is subject to truncation. According to Heckman (1979) a selection bias can occur if the dependent variable can only be observed when passing a certain threshold. The threshold that needs to be passed in order to observe a price and hence conclude on transaction costs is the participation in the market. If there are unobserved costs related to market participation ignoring this problem will yield biased estimates.

Accounting for selection bias adequately in a conditional mean model is however challenging as all existing solutions have different weaknesses. The empirical approach in this paper largely leans on Wollni and Brümmer (2012) who analyzed the productive efficiency of specialty and conventional coffee farmers in Costa Rica under self selection and provide a detailed discussion on the dilemma situation. Their self selection framework includes the Greene (2010) selection model as well as the Battese and Coelli (1995) model.Following Heckman we apply a two step procedure. In the first step the probability of market participation is estimated by means of a probit model. The model predictions are then used to calculate the inverse Mills ratio and include it in the stochastic frontier model as an additional regressor.

The two-step Heckman approach in combination with a stochastic frontier model has however been criticized as biased by Greene (2009) since the Heckman model is not an adequate solution for non-linear models. It has grown increasingly popular to solve selection biases in stochastic frontier analysis by means of propensity score matching in order to achieve unbiased estimates of differences in technology. However since we can only observe transaction costs after a farmer's decision to participate in the market, matching procedures are not an option. Greene (2009) proposed a selection corrected stochastic frontier based on a maximum simulated likelihood estimator that can consistently account for a selection bias, assuming that the unobserved factors of the selection equation are correlated with the error term of the stochastic frontier model. Greene's solution represents a special case of the Heckman 2-step estimator. The model does, however, not allow for conditional mean modeling. This is a potential shortcoming for our analysis since we are especially interested in the determinants of transaction costs. Hence we regress the transaction costs on related variables and predict transaction costs of the Greene's selection model. Such a procedure will yield biased results since the first step is misspecified. Schmidt and Wang (2002) as well as Schmidt (2011) discuss the shortcomings of a 2-step procedure versus possible 1-step procedures. Schmidt and Wang (2002) perform a Monte Carlo simulation and find a substantial bias in two-step procedures while examining several model parameters. The effects of z on u are biased downwards even if x and z are uncorrelated. An 1-step solution in which the transaction costs distribution can be directly affected by z is hence superior but cannot correctly account for self selection.

In contrast to the Battese and Coellie Model that follows a truncated normal distribution Greenes self-selection model assumes a half normal distribution of transaction costs so that $u_i \sim N^+(0, \sigma_u^2)$,. With μ the Battese and Coellie model has one additional parameter to be estimated which makes it more flexible. As transaction costs in the Greene's method follow a half-normal distribution this implies that increasing transaction costs become increasingly less likely (Kumbhakar and Lovell, 2000). Note that, compared with other distribution assumption (e.g. truncated normal distribution), the half normal model might generate lower transaction costs since it forces the model value of transaction costs to be 0 and is therefore more restrictive.

5 Data

We use the survey data collected by the Tegemeo Institute in cooperation with the National Graduate Institute for Policy Studies (GRIPS). The data was collected as part of the Research on Poverty and Environment and Agricultural Technology Project (RePEAT). The objective of the survey was the identification of agricultural technologies and farming systems that contribute to increased agricultural productivity, the sustainable use of resources and reduced poverty in Kenya (Yamano et. al (2004)). The surveys in Kenya were conducted in 2006-2007 following a randomized design. It covered 725 households located in 93 sub-locations. The survey contains detailed information on the farm activities and household characteristics as well as information on the villages. The choice in favor of this rather dated survey was made since it provides the information required to test our model adequately. This includes sufficient details on each transaction to find proxies for capture several categories of transaction costs as well as sufficient specifics on the cultivation of maize for the hedonic value model. Since the data contains details on the plots where the maize that was sold was planted it even allows the value of a transacted good to vary in value even if it has been produced by the same household. This level of detail makes this data set particularly interesting for this study despite the uncertainties that arise from the use of different weight measures.

After removing all households from the data that did produce maize and dropping observations with missing values, the data set used in the analysis contains 510 households of which 328 did not participate in the market. For the remaining 182 households there are 258 observed transaction for the stochastic frontier model. Descriptive statistics for transactions and sold maize are listed in Table 1 of Appendix A and Table 2 provides an overview on household characteristics.

The stochastic frontier model contains Kenyan Shillings per kilogram of maize as dependent variable. The weight measures for maize trade price, represented by Shillings per kilogram had to be calculated from a range of different weight measures. Along with the survey data on different weight measures was collected to construct conversion tables. These were used here as well to convert all measures to kilogram. Since only very few attributes of the product are directly observable, like for instance the variety, factors are included that can influence the hedonic value of the maize due to its influence on the production process. In order to find a proxy for quality we used the amount of chemical fertilizer in kg per acre to account for the influence of chemical fertilizer on the price. We also tried further differentiations of chemical fertilizers such as the separate consideration of NPK fertilizer, which is often mentioned to be of special importance for maize as for instance stated by Matsumoto and Yamato (2009). Niaz et. al.(2015) find that the application of nitrogen can enhance the yield as well as the quality of maize grains. Although they also show that the application pattern of fertilizer matters it is here only possible to account of the quantity that was applied per hectare. In the estimations the type of the chemical fertilizer did not seem to matter. Additionally we added kg of organic fertilizer per acre, which can be manure, ash or compost. The total amount of land in acres available for a household has been added to test the hypothesis that quality is more difficult to control when managing a larger land mass. We further added a dummy that indicated if the household owns the parcel from where the sold goods originated as a household might be willing to invest more into a parcel that it owns than into a rented parcel. Yamano et. al (2005) find that farmers for instance apply more fertilizer to plots for which they possess a land title. They do generally suspect that farmers are less willing to invest into plots that could be taken away from them in the near future. The willingness to invest may positively influence the quality of the products. On the other hands more than half of the parcels were inherited. It is hence likely that they have been cultivated over a long time and may suffer from the depletion. Hence the sign of this dummy could go either way. A damage dummy signals if the harvests experienced any damage in this sub-location. The information on damage includes damage caused by rain, floods, insects, animals and disease in the area. While this information is only available for the sub-location there is some probability that the harvest involved in the transaction was affected as well. In our sample such damages occurred in the surrounding of 17.5 % of the households. We assume that there is a lower price for damaged goods as the damage could lead to low quality. The educational level of the household head measured in years of education is supposed to capture the ability to process agricultural information and hence introduce innovations. For the same reason the mean education in years of all household members was added as they are likely to be involved in the production process as well. The size of the household is related to the number of people from the household that help out on the field. Since the sample covers semi subsistence and subsistence farmers household members basically grow their own food and hence are expected to do this with a different motivation than hired labor. Concerning the age of the household head we do not have specific expectation on the sign of its impact on prices. It can reflect experience but there can also be decreasing productivity with increasing age. Further a dummy was included indicating if the household head is female as the gender of the household head might influence production technologies. Information on the variety used was included with a dummy indicating whether improved hybrid seeds have been used (=1) or local varieties. In 74 % of the transactions maize from hybrid seeds were transferred while the remaining 26 % were traditional varieties. A delivery of the goods might increase its value for a buyer a dummy indicates whether the maize was sold at the farmgate. 77 % of all transactions were farmgate sales. The remaining 23 % of the transactions took place at local markets, trading centers, and schools. The spatial variation is covered by 4 province dummies. These were the Western Province (12%), Nyanza (28%) and Rift Valley (20%). The Central Province which accounts for 40% of the observations was attributed to the base category.

As explanatory variables 11 variables were selected as proxies for search and information costs, bargaining costs and transport related costs. In some cases it is possible to reason that one variable may serve as a proxy for more than one type of costs. Table 3 gives an overview which proxy variables can be assigned to which transaction costs category. There are however no suitable proxies in the sample that can be related to monitoring and enforcement. All observed transactions in our sample are spot market transactions that usually involve an instant exchange of goods and cash. However the absence of other channels may indicate that enforcement costs are too high to use other markets than spot markets.

Firstly we add a dummy that indicates whether the household possesses a mobile phone given that a mobile phone network has been available. This is the case for 45 % of the households in the sample. Phones are essential to gain market information, search for buyers and establish business connections. Next a dummy is added that takes the value 1 if the household used a phone to obtain market information. The substantial influence of price information on transaction costs has been discussed by Vakis, Sadoulet and Janvry (2003).

Personal attributes can influence the course of negotiations and its outcome. So we added the information whether the household head is female and the education of the household head in years. It is very likely that the household head is involved in price negotiations. The gender of the household head was included as a dummy that takes the value 1 if the gender of the household head is female. Depenbusch (2017) analyzes data from Kenya and finds that the gender of vegetable traders can influence price negotiations. The years of education can be related to several cost categories. On the one hand it will be easier for a more educated person to process market information on the other the ability to acquire and process information can influence the outcome of negotiations as well.

In general the place of the exchange as well as the trading partner will influence the distribution of the transaction costs. Associated variables may affect bargaining as well as transportation costs. A dummy was added that indicates whether the exchange took place at the farmgate. All off farm locations are attributed to the base. The counterpart in negotiations and their experience will influence the outcome of negotiations. The major counterparts involved were traders, consumers and institutions such as schools. Since traders are the only group that negotiates food prices by profession a dummy is added that takes the value 1 if the counterpart was a trader. This allows inference on how a professional food trader fares compared to non professional one. In 75 % of all transactions the farmer negotiated with a trader.

The quantity involved in a transaction can influence the bargaining position of buyers and sellers. Typically the price per unit decreases in quantity. Quantity is hence related to bargaining as well as transport. However we may assume as well that traders try to exploit their transport capacities in which case the single sales quantity does not matter anymore while the trader relates the cost of transportation to its capacity and not the single sales quantity. On the other hand his bargaining power will increase with growing distance to a market since for the farmer alternatives to sell his goods decrease especially when missing adequate transport possibilities to a market. The sample provides drive time and distance to the next market. As these variables are highly correlated only drive time was considered in the model as it might better reflect the effort to reach a market which accounts for other factors like road condition beyond the mere distance. The road condition and the accessibility of a location can vary with the harvest season due to changing weather conditions. Consequently a dummy indicates the harvest season. Beyond that it can influence the risk of damage during transport for instance due to road flooding. The importance of the road infrastructure for agricultural production and markets has for instance been highlighted by Dorosh, Wang and Schmidt (2010). Further the distance to Nairobi is added, which is the capital of Kenya. Transport related variables do of course not only affect transport costs. They can also increase costs related to the search for buyers or market information. Kähkönen and Leathers (1999) additionally provide some examples on how factors that can affect physical handling of a good can be linked to institutional impediments.

The selection model contains characteristics of households that planted maize to estimate the probability of a household to participate in the market.

6 Empirical Results

Table 4 contains the results of the first stage probit that was estimated for the Greene selection model and the Battese and Coelli model. The model shows that the probability to participate in the market decreases in the household size. Since semi-subsistence farmers are subject to the analysis we can assume that larger households are more likely to rely on subsistence and consume their produced crops. On the other hand it increases in the size of the land of a household. More land allows the household to produce food beyond subsistence needs which enables it to generate additional income. The age of the household head is negatively related to market participation. Older household heads are often less likely to adapt innovations. The existence of a market in the sub location has a significant positive effect. The existence of such a channel can be expected to reduce the costs related to the search for buyers significantly. The distance to the capital Nairobi has a negative effect. The distance is especially important for traders who want to sell to export firms or the industry since a larger distance increases their costs. The Greene selection model as well as the Battese and Coelli model show clear evidence of self selection. The selection parameter rho that indicates that unobservable factors from the selection equation are correlated with the error term of the stochastic frontier model is highly significant. The same is true for the inverse mills ratio in the Battese and Coelli model so that the selection parameters in both models confirm that controlling for selection is required to avoid a selection bias.

From the estimation results for the Battese and Coelli model that are reported in Table 5, we can see that two of three province dummies are highly significant. We can thus infer that the location has a significant influence on the price, consistent with our theoretical framework. As expected damages in the area have a significant negative effect on the unit value which probably originates in loss of quality due to the damage. The amount of land has indeed a significant negative impact on the price, which supports the hypothesis that quality control becomes more difficult with increasing farm land size. For instance Yamano et al (2005) find that semi-subsistence farmers in Kenya apply fertilizers more frequently to smaller plots. Owning a legal land title has a negative effect that probably originates from soil depletion due to long time cultivation. Surprisingly the years of education of the household head show a negative effect. One possible explanation is that better educated farmers face more alternatives to generate income and are therefore neglecting the cultivation.

The second stage models the mean of the transaction costs term μ. The presence of a market in the sub-location significantly increases transaction costs. A natural explanation for this effect is that this channel increases the competition among farmers. Price negotiations with a trader lead to significantly higher transaction costs. Hence there is significant positive difference in transaction costs when negotiating with a professional food trader as compared to a non professional one. The drive time to the next market as well as the distance Nairobi increase costs. Both enhance the bargaining position of buyers. The years of education of the household head lead to a reduction transaction costs. Table 6 contains the results of the Greene's selection model. Only the dummy indicating that that household owns the land title has a significant effect as well as the province dummies. In the second stage of the model which was estimated by OLS only the trader dummy is significant. However according to the F-statistic the overall model relation is insignificant. It implies that Greene's selection model does not perform well in this study. Table 7 report the estimated relative and absolute transaction costs, respectively. Figure 2 shows the corresponding Kernel density estimates.

The estimates from the Battese and Coelli model are with 18.2 % substantially larger than the estimates from the Greene model with 12.1 %. The difference can occur due to the choice of the distribution as the Battese and Coelli model uses a truncated normal and the Greene model a half normal distribution. Our results on the magnitude of transaction costs can only be vaguely compared with other findings in the literature since they are calculated using a different base in the stochastic frontier approach as percentages relate to feasible values. However we can infer from a comparison on whether the results are reasonable. The estimate of 15% from Renkow, Hallstrom and Karanja (2003) is right in between ours. Since they concentrated on estimating fixed transaction that impose a market entry barrier it can be inferred that total transaction costs might be underestimated by this measure. Yamano and Arai(2010) calculated within part the same data as we used a price spread of 15% in the Kenyan maize market which is pretty close as well. Although pursuing a different aim than we did they also identified drive time as one of the major determinants of price spreads. Taking into consideration similar or in part comparable approaches to estimate transaction costs our estimates appear to be of a reasonable magnitude and comparable with the findings of other researchers.

7 Conclusions

This paper presents a theoretical framework and an empirical method to derive transaction costs within the frame work of stochastic frontier. This method can help to infer on transaction costs when dealing with heterogeneous goods as it is typically the case of agricultural products. It could be demonstrated that despite the unobservable nature of transaction costs the concept is well operational at the example of Kenyan semi-subsistent farmers. The presented price decomposition techniques and estimation approaches in this paper can aid policy makers to assess transaction cost and set priorities among policies that aim to support semi-subsistence farmers. Such policies have substantial meaning for poverty reduction programs in developing countries.

The presented method can be used to estimate and simultaneously explain transaction costs by means of econometric models. Although the current state of development does not offer solutions to all econometric problems that are related to the presence of a selection bias while modeling a transaction costs term. In the proposed stochastic frontier approach we find transaction costs of 12.1-18.2 % in the Kenyan maize market. A comparison with other recent findings shows that the estimated magnitudes are of a reasonable level. Further information on the main determinants of transaction costs could be obtained. One hurdle to overcome appears to be the drive time to the next market and the distance to Nairobi. The corresponding conditions can change with improving road infrastructure which would allow farmers to receive better prices or gain access to markets in case the magnitude of the transaction costs still has a critical level that prevents market participation. Evidently negotiations with professional traders raise transaction costs significantly. The study also shows the importance of education. This has important implications for small hold farmers since better educated farmers do not only have more alternatives to generate income but can improve existing income sources. Although it was not possible to find adequate proxies for monitoring costs the persistent reliance of farmers on spot markets may be seen as an indicator in its own right. If monitoring and enforcement costs are too high to use other sales channels then the reasons may originate from the institutional setting.

It remains a challenge for empirical researchers to find adequate data for a transaction costs analysis. Institutions are difficult to assess and require plenty of proxy variables for a holistic assessment that covers the whole range of transaction costs. Currently very few data sources are available that allow an adequate analysis of the transaction costs that small hold farmers face in developing countries.

Further research in this area should be concerned with elicitation of data and the identification of proper proxy variables for transaction cost analysis.

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Table 1: Characteristics of transactions and products

Variable	Mean	Standard Deviation
Maize Price per kg	12.548	2.818
Chemical fertilizer per acre in kg	20.456	30.871
Organic fertilizer per acre in kg	72.206	317.819
Household owns parcel (dummy)	0.779	0.416
Improved hybrid seeds	0.74	0.439
Other sales party was a trader(dummy)	0.748	0.435
Quantity sold in kg	560.539	730.809
Sale took place at the farmgate	0.771	0.421
Observations: 258		

Table 2: Household characteristics

Variable	Mean	Standard Deviation
Market participation	0.357	0.480
Household size	8.218	3.490
Damage (dummy)	0.175	0.380
Acres of land (owned and rented)	5.194	7.968
Education of household head in years	6.723	4.613
Age of household head	58.757	13.391
Hh posses mobile phone given a network(dummy)	0.449	0.498
Household head is female (dummy)	0.245	0.431
Drive time to next market in minutes	30.765	22.071
Distance to Nairobi in km	206.657	113.165
Hh obtained market information via phone (dummy)	0.045	0.201
Province 1(Nyanza)	0.284	0.452
Province 2(Western Province)	0.118	0.323
Province 3 (Rift Valley)	0.198	0.399
Province 4 (Central Province)	0.400	0.491
Observations: 510		

Table 3: Proxies for different types of transaction costs

Proxy/Type	**Transport**	**Information**	**Bargaining**
hh posses mobile phone given a network(dummy)		**X**	
hh obtained market information via phone (dummy)		**X**	
drive time to next market in minutes	**X**	**X**	
distance to Nairobi in km	**X**	**X**	
other sales party was a trader(dummy)			**X**
sale took place at the farmgate	**X**		**X**
quantity sold in kg	**X**		**X**
education of hh head (Years)		**X**	**X**
household head is female (dummy)			**X**
Season	**X**		
There is market in the area	**X**	**X**	

Table 4: Probit model on market participation

Variable	Coefficient	Standard Error	$P > \|z\|$
P(Market Participation)			
Ln Household size	-0.3881***	0.123	0.002
ln acres of land (owned and rented)	0.4835***	0.070	0.000
ln education of household head in years	0.0066	0.079	0.933
household head is female	-0.2087	0.147	0.155
ln age of household head	-0.7306***	0.266	0.006
there is a market in the area(dummy)	0.2504*	0.139	0.071
ln distance to Nairobi	-0.2727*	0.142	0.055
ln drivetime to next market	0.0749	0.076	0.324
Province 1 (Nyanza)	0.2339	0.280	0.404
Province 2 (Western Province)	-0.122	0.310	0.694
Province 3 (Rift Valley)	0.2473	0.196	0.208
Constant	3.9416***	1.380	0.004
Number of obs = 586			
Prob > χ^2 = .00000			
Log likelihood = -359.921			
Pseudo R^2 = .1046598			

Table 5: Stochastic frontier model for transaction costs (BC 1995)

Variable	Coefficient	Std. Error	$P > \|z\|$
Ln Price per kg (Frontier Model)			
Any Damage (dummy)	-0.0596*	0.0353	0.0908
ln Chemical fertilizer per acre in kg	0.0010	0.0097	0.9162
ln Organic fertilizer per acre in kg	-0.0099	0.0061	0.1034
household owns parcel (dummy)	-0.0590*	0.0339	0.0818
ln acres of land (owned and rented)	-0.1244***	0.0409	0.0024
ln education of household head in years	-0.0924**	0.0456	0.0428
ln mean education of hh members in years	0.0304	0.0410	0.4581
Ln Household size	0.0347	0.0424	0.4124
ln age of household head	0.1337	0.0907	0.1404
household head is female	0.3353	0.2993	0.2626
sold at farmgate(dummy)	-0.0123	0.0547	0.8216
improved hybrid seeds	-0.0073	0.0353	0.8371
Province 1(Nyanza)	0.2683***	0.0560	0.0000
Province 2(Western Province)	0.3197***	0.0747	0.0000
Province 3 (Rift Valley)	-0.0387	0.0419	0.3557
Inverse Mills Ratio	-0.4801***	0.1456	0.0010
constant	2.7158***	0.3145	0.0000
μ***(Transaction Costs Function)***			
hh posses mobile phone given a network(dummy)	-0.0419	0.0533	0.4313
hh obtained market information via phone (dummy)	0.0839	0.0918	0.3605
there is a market in the area(dummy)	0.1416**	0.0696	0.0418
drive time to next market in minutes	0.0028**	0.0012	0.0233
distance to Nairobi in km	0.0010**	0.0004	0.0126
other sales party was a trader(dummy)	0.2432***	0.0865	0.0049
sale took place at the farmgate	0.0148	0.0876	0.8659
quantity sold in kg	0.0000	0.0004	0.9392
education of hh head (Years)	-0.0290**	0.0131	0.0270
household head is female (dummy)	0.4010	0.3017	0.1838
Season(dummy)	-0.0427	0.0822	0.6033
Constant	-0.3388	0.2567	0.1870
σ^2	0.0394***	0.2125	0.0489
γ	0.4185**	0.0091	0.0000
Log likelihood	85.0905		
N	258		

Table 6: Stochastic frontier model for transaction costs (Green, 2010)

Variable	Coefficient	Std. Error	$P > \|z\|$
Ln Price per kg (Frontier Model)			
Any Damage (dummy)	-0.0543	0.0391	0.1645
ln Chemical fertilizer per acre in kg	-0.0074	0.0115	0.5207
ln Organic fertilizer per acre in kg	-0.0046	0.0061	0.4461
household owns parcel (dummy)	-0.0739**	0.0373	0.0476
ln acres of land (owned and rented)	-0.0495	0.0302	0.1011
ln education of household head in years	-0.0238	0.0272	0.3818
ln mean education of hh members in years	0.0365	0.0441	0.4082
Ln Household size	0.0162	0.0409	0.6923
ln age of household head	0.0190	0.0902	0.8276
household head is female	0.0177	0.0408	0.6719
sold at farmgate(dummy)	-0.0018	0.0357	0.9589
improved hybrid seeds	-0.0168	0.0349	0.6295
Province 1(Nyanza)	0.1439***	0.0438	0.0010
Province 2 (Western Province)	0.0592	0.0561	0.2915
Province 3 (Rift Valley)	-0.1382***	0.0400	0.0005
Constant	2.8083***	0.3769	0.0000
$\rho(w, v)$	-0.7919***	0.1949	0.0000
σ_u	0.1515	0.1370	0.2685
σ_v	0.2181***-	0.0669	0.0011
Log likelihood	127.5835		
OLS			
hh posses mobile phone given a network(dummy)	-0.0072	0.0060	0.2343
hh obtained market information via phone (dummy)	0.0037	0.0106	0.7283
there is a market in the area(dummy)	0.0007	0.0060	0.9015
drive time to next market in minutes	0.0001	0.0001	0.2754
distance to Nairobi in km	0.0003	0.0003	0.2805
other sales party was a trader(dummy)	0.0190***	0.0064	0.0034
sale took place at the farmgate	0.0005	0.0067	0.9433
quantity sold in kg	0.0000	0.0000	0.7358
education of hh head (Years)	-0.0006	0.0007	0.3942
household head is female (dummy)	0.0022	0.0076	0.7719
Season(dummy)	-0.0076	0.0073	0.2979
constant	0.1049***	0.0130	0.0000
R^2	0.0605		
Prob F>F*	0.156		
N	258		

Table 7: Relative and absolute transaction costs

Total/Relative Tcs	Model	Mean	Standard error	Min	Max
Relative TCs	BC95	0.182	0.171	0.02	0.588
Total TCs	BC95	3.089	3.484	0.255	14.391
Relative TCs	Greene	0.121	0.043	0.045	0.27
Total TCs	Greene	1.93	0.759	0.706	5.141

Figure 1: Illustration of transaction costs as distance between observed and feasible price

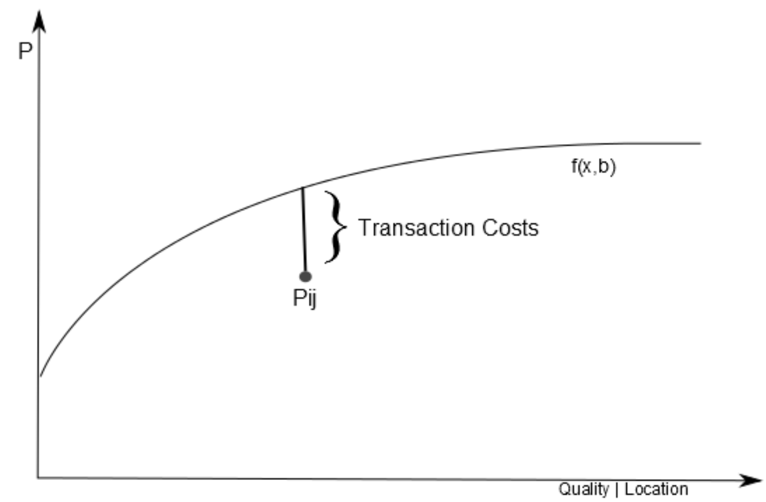

Figure 2: Kernel density estimates of transaction costs