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The role of (asymmetric) information in returns to Arabica coffee production in Uganda

Cansın Arslan

Research Training Group 1666 GlobalFood, University of Goettingen
Address: Heinrich-Dueker-Weg 12, 37073 Goettingen, Germany
E-mail: cansin.arslan@uni-goettingen.de

Abstract

Coffee is a major cash crop for millions of smallholder agrarian households in developing countries including Uganda. However, Arabica coffee in Uganda is persistently of low quality and thus generates low revenues for growers despite having agro-environmental conditions highly suitable to high-quality coffee production. Poor harvesting practices lead to high prevalence of home-processing of cherries into 'parchment' coffee which generates lower revenues than the alternative of selling fresh coffee cherries and is associated with quality uncertainty and information asymmetry wherein prospective buyers cannot easily ascertain quality. In this study, we conceptually identify some reasons that growers might rationally choose to engage in parchment production in lieu of selling cherries. We test the potential of these as drivers of behaviour using data from a survey of 1625 coffee producing households in the Mt Elgon region. Our results suggest that lack of information may be a barrier to realizing high value outcomes in the coffee supply chain and that some growers with higher levels of knowledge on quality and cognitive skills produce parchment to take advantage of the quality uncertainty and asymmetric information in the parchment coffee market.

Keywords*:* coffee, quality, asymmetric information, adverse selection, cognitive skills

1. Introduction

Participating in high-value markets is associated with higher agricultural income for smallholder farmers in developing countries (Wollni & Zeller 2007; Maertens & Swinnen 2009; Minten *et al*. 2009; and Wellema 2015). One such market is coffee which has the potential to generate high values across the supply chain including for primary producers. Coffee is a major cash crop and a source of income for thousands of households in African countries, such as Ethiopia, Uganda, Kenya, Rwanda, and Tanzania. Despite being the second largest coffee producer, Uganda lags drastically behind its African peers in terms of accessing high-value markets (ICO 2018). Failure to participate in high-value markets is associated with low returns to coffee for half a million smallholder Arabica[1] coffee producers and many others involved in the coffee supply chain in Uganda (UCDA 2015).

Arabica coffee growers in Uganda can either market their coffee cherries picked fresh from their garden or, alternatively, home-process the coffee cherries harvested and sell their coffee in the form of parchment, a partly-processed dried coffee bean product. Coffee cherries picked fresh from the garden are typically sold to large buyers or traders on the day of harvest due to high perishability of coffee cherries. In many cases, before being accepted by these buyers, cherries are assessed for quality which is straightforward being based simply on assessment of ripeness and the presence of defects (physical, insect or fungal damage). The alternative, dried parchment, can be produced using processing cherries at homestead by growers. Product quality is observable to a very limited extent once cherries are processed into parchment. To produce a kilogram of dried parchment, on average, five kilograms of cherries are processed (Mujawamariya *et al.* 2013). Processing cherries into parchment is also costly in terms of labour and capital and takes time (De Graaf 1986). Yet, parchment prices per kilogram are hardly ever 5 times the cherry prices per kilogram. Given the large value losses implied by parchment sales in lieu of cherry sales, why do growers continue to sell parchment instead of fresh cherries? To answer this question, we use a survey of 1625 households in the Mt Elgon region of Uganda to examine the practice of producing parchment coffee by smallholder Arabica coffee farmers. We examine why the parchment market generates lower value outcomes for growers than cherry market, why growers might still want to produce parchment instead of selling fresh cherries, and analyse if selling parchment might be a rational choice for coffee growers.

Our study contributes to the literature by providing a conceptual analysis of the limitations on improved outcomes in the coffee supply chain in Uganda. We draw attention to fundamental differences between the cherry and parchment coffee markets and their consequences on coffee revenues at the household level. In addition we extend the asymmetric information literature to value chain analysis for a major cash crop produced by smallholder agrarian households in developing countries.

This study is organized as follows: Section 2 presents background information on coffee quality and coffee markets in Uganda. Section 3 presents conceptual framework. Section 4 focuses on methodology. Section 5 presents the econometric results. Last section concludes.

2. Background: Implications of Coffee Quality on Coffee Markets

Coffee quality is the most important determinant of coffee prices in the international markets. Generally, the higher the quality grade, the higher the price (Traore et al. 2018). In high-value coffee markets, quality refers to coffee cup quality which is measured systematically through an exercise called cupping. Cupping is a process through which trained experts evaluate intrinsic characteristics of coffee (flavours, aromas, and taste) and provide a quality score for each coffee (Traore *et al.* 2018). Poor harvesting (harvesting underripe, overripe, and damaged ones from mainly bacteria or fungi) and poor processing (over-fermentation, sun burns, contamination from environmental odours, such as soils, smoke) result in unpleasant flavours or aromas. Complex physical and chemical

[1] Two main species of coffee are of importance worldwide; Coffea Canephora (also referred to as robustas) and Coffea Arabica (also referred to as milds). Arabica coffee is more aromatic and flavourful than Robusta and is a higher-end product which is traded according to its intrinsic qualities, such as aroma and taste. Only Arabicas are considered high quality or specialty coffees.

transformations which occur during processing of coffee cherries largely determine coffee quality but are not visible to the naked eye (Poltronieri & Rossi 2016). For this reason, it is usually very difficult to assess product quality once coffee cherries are processed into parchment. As a result, parchment buyers in the market typically are unable to differentiate between high and poor quality parchment i.e. there exists quality uncertainty in the parchment market. Yet, producers who are usually involved in harvesting and processing cherries are well-informed about the quality of their parchment coffee.

In the coffee cherry market, on the other hand, quality uncertainty is much reduced. Assessing quality of cherries picked fresh from the garden is straightforward being based on observing the ripeness of cherries and checking if there is any pest or disease damage. Since the quality of the cherries is easily observed, selling cherries by growers are subject to passing a cherry quality threshold. Growers with heterogeneous or relatively low quality cherries can be rejected or asked to sort out the bad cherries (underripe, overripe, and damaged) from the red ripe ones. Although it is possible to observe quality and differentiate prices accordingly, cherry prices are tied to the world market. Large buyers in the area usually apply a standard price for a certain quality of cherries i.e. there is no price differentiation according to quality at the producer level. Prices for coffee cherries per kilogram in the market typically vary between 1,200 Ushs (~ 0.3 USD) and 1,500 Ushs (~ 0.4 USD) per kilogram. Assuming a processing conversion rate of 5 kilograms of cherries to produce one kilogram of parchment, parchment-equivalent price should lie at least between 6,000 Ushs and 7,500 Ushs per kilogram. Yet, parchment prices in the region typically lie in the range of 5,000 Ushs to 5,500 Ushs per kilogram. Taking into account the additional labour and capital costs incurred for processing cherries into parchment, grower-level parchment sales potentially involve a value loss compared to selling raw cherries. Parchment sales also imply a delayed payment since parchment production[2] takes from a minimum of 3 days up to 3 weeks depending on weather, resources, and the quality of parchment wished to achieve. It seems that there is potentially a large value loss implied by parchment sales in lieu of fresh cherry sales.

3. Conceptual Framework

Quality aspects of coffee likely play a key role in the decisions of production and sales. Cherry quality is relatively easy to assess by buyers (being based on visual assessment of maturity, colour, and presence of defects) and this has an important implication on coffee cherry sales: selling cherries by growers is usually subject to passing a quality threshold[3]. If growers have cherries that do not meet the required quality standards i.e. when a large share of cherries are underripe, overripe, dried up, or damaged, they may be rejected or asked to sort out the poor quality cherries. The good cherries are sold at announced prices, while the bad ones may be discarded. However, what is more common is to take bad cherries back home to process them into parchment. Once cherries are pulped, fermented, and dried, quality becomes difficult to observe. Buyers typically are unable to assess the quality of the parchment they buy and pay prices in accordance with the quality. This implies that both good and bad parchment coffee may sell at similar prices. As a result, low quality products drive out the good ones because sellers of high-quality products exit the market, leaving only poor-quality products behind (adverse selection). Similar to what is proposed by Akerlof (1970) in the used automobile market, a 'market for lemons' in which both the quality of products traded in the market and prices tend to go down appears to be generated in the parchment coffee market. Indeed, grower-level coffee production is associated with lower quality[4].

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[2] To produce dried parchment, coffee cherries picked from the garden are first pulped to remove the outer skin of the fruit using a usually-rented pulping machine. The remaining beans should then be fermented for 24 to 36 hours in proper containers and later washed to remove the remaining mucilage on the beans. Lastly, the beans are sun dried to about 12-13 percent moisture level.

[3] Cherry buyers have wet mills where they process coffee cherries in good conditions and they target high-quality coffee markets. Cherries are usually sold to big buyers in the region to be exported as high-quality coffee whereas parchment is usually sold to traders who then take the coffee to a big city and sell in the commodity coffee market.

[4] Mujawamariya *et al.* 2013 point out that farmers can process small quantities of cherries into parchment of which the quality is said to be not good in Rwanda.

Rothschild and Stiglitz (1976), on the other hand, find that in the presence of asymmetric information and quality uncertainty, a separating equilibrium may also occur in which low-risk and high-risk individuals have transactions in different markets. In our context, such separating equilibrium implies that high-quality parchment producers and low-quality parchment producers sell at different prices in different markets. In our study area, a very small share of growers trade at the high-quality parchment market at higher prices which are outside the normal price range. Most of the growers, however, seem to sell parchment at relatively lower prices to traders or larger buyers. Miyazaki (1977) and Wilson (1977) further demonstrate that in the insurance market, when it is impossible or highly expensive to distinguish between high- and low-risk individuals, market prices tend to stabilise at average rates for all individuals which results in low-risk individuals subsidizing high-risk individuals. This appears to be the case in our context. Average prices result in underpaying for the high-quality and overpaying for the low-quality parchment in the market. Higher-quality parchment producers tend to be underpaid and the lower-quality parchment producers are overpaid for their parchment and this holds even in the presence of two different parchment markets since there is continuum of parchment quality. Then, the question is why does the market not collapse due to adverse selection? In other words, why do some growers continue to produce and sell parchment while they are underpaid for the parchment they sell?

One explanation is that parchment sales still generate positive revenues and better than exiting the market with no transactions. Asymmetric information and quality uncertainty in the parchment market give farmers the opportunity to process bad cherries which are rejected or likely to be rejected in the cherry market and sell them as parchment nonetheless[5]. Given the quality requirements in the cherry market, some growers may be increasing their coffee revenues through selling parchment using the poor quality cherries which would otherwise fail to be sold and thus yield no revenue.

Factors that affect cherry quality can be broadly grouped in two: agronomic aspects and harvesting practices. Altitude is correlated with coffee tree health and thus cherry quality to a large extent (Decazy *et al*. 2003; Leroy *et al*. 2006; Wollni & Zeller, 2007). For this reason, households from lower altitudes are likely to produce lower quality cherries on average and more of their cherries are likely to fall below the quality threshold which may imply that they are more likely to engage in parchment production. Controlling for agronomic aspects, harvesting maturity is the most important determinant of cherry quality. To achieve highest quality, ripe cherries should be hand-picked selectively from the trees (Ameyu 2017). Cherries which are unripe, overripe, dried up, and damaged are of lowest quality and should not be harvested (Goto & Fukunaga 1986; Kuit *et al.* 2004; and Wasserman 2012). Such low quality cherries tend to be rejected by buyers[6]. Poor quality cherries which cannot be sold in the cherry market are usually home-processed into parchment coffee by growers. In other words, harvesting determines the quality of cherries and the quality of cherries determines the extent to which growers sell their cherries and potentially home-process the poor quality ones into parchment. Poor harvesting of coffee cherries is likely to increase the share of poor quality cherries and parchment production.

One potential reason why coffee growers fail to harvest optimally and sell all of their cherries is lack of information and knowledge. Lack of knowledge is considered a barrier to adoption of new agricultural practices and techniques (McNairn & Mitchell 1992; Foster & Rosenzweig 1995; Knowler & Bradshaw 2007; Aker 2011). Farmers may not be aware of new practices and techniques and their benefits. If growers have limited knowledge on how to selectively harvest high quality cherries, it may explain why their cherries are not harvested of high quality, fall below the quality threshold, fail to be sold in the cherry market, and, thus, are processed into parchment despite yielding lower values.

[5] Poor quality coffee is usually bought at low prices by traders later to be used in blends or instant coffee. It is commonly said in the study area that there is always a buyer for each quality.

[6] Mujawamariya *et al.* 2013 point out that the cooperatives which are the main buyers of cherries reject poor quality cherries in the case of Rwanda.

Harvesting quality is determined by how selectively and frequently cherries are picked to large extent (Leroy *et al*. 2006). Growers usually hire pickers and do not harvest coffee alone. Hiring relatively more pickers and paying more can be considered an effort to pick better since selective picking requires time and effort. In addition, if cherries are left in the garden for long time it is difficult to pick cherries of red ripe. Picking coffee often facilitates picking cherries of ideal maturity and implies hiring pickers more often. For this reason, we use seasonal hired labour expenditure for picking to proxy harvesting quality.

Below, we first shed light on the role of quality requirements in parchment production decisions. Secondly, we examine the factors underlying the decision of selling parchment produced using lower quality cherries i.e. adverse selection. For instance, does knowledge on quality play a role? Are growers who know better about coffee quality more likely to sell parchment produced using lower quality cherries? In addition, cognitive ability is associated with socioeconomic success (Heckman 1995; Murnane *et al.* 1995; Almund *et al*. 2011; and Gertler *et al.* 2014). Is it the case that growers with higher cognitive skills are likely to better observe, process, and make sense of the available information and characteristics of different markets? Are growers with higher cognitive skills more likely to produce parchment using lower quality cherries? Below, we attempt to answer those questions using the data collected from 1625 Arabica coffee growing households in Eastern Uganda.

4. Methodology

4.1. Estimation Strategy

We first analyse the decision of producing dried parchment production at all versus selling only fresh cherries. The dependent variable is an indicator variable i.e. to engage in dried parchment production. The error term is assumed to have a standard normal distribution and we use a probit model. Probit estimation equation is as follows:

$$DP_i = \alpha + \beta T_i + \delta X_i + e_i \quad (1)$$

Where DP_i represents the outcome of interest of household and is an indicator variable that takes a value of 1 for those who engage in dried parchment production. T_is are the explanatory variables, such as knowledge on coffee cherry quality and resources spent on harvesting. Vector X_i includes covariates, such as distance to tarmac road, coffee garden size, and household characteristics. βs are the parameters to be estimated.

Secondly, we focus on the variation in share of cherries processed into parchment in all cherries harvested (sum of cherries processed and cherries sold fresh). We attempt to explore if certain factors explain the variation in share of cherries processed into parchment among parchment producers. Note that 60 percent of the growers in our sample sell only cherries and the share of cherries processed into parchment takes the value of zero for them. OLS regression will not adjust the estimates of the coefficients to take into account the effect of truncating the sample at zero and the coefficients may be severely biased. To account for the bias, we use truncated regression. With truncated regression, the variance of the outcome variable is reduced compared to the distribution that is not truncated i.e. all growers in the sample. Truncated estimation equation is as follows:

$$ShDP_i = \theta + \gamma T_i + \lambda X_i + \nu_i \quad (2)$$

Where $ShDP_i$ represents the outcome of interest of household i.e. share of processed cherries into dried parchment in all cherries harvested. T_is are the explanatory variables, such as knowledge on coffee cherry quality and resources spent on harvesting. Vector X_i includes covariates, such as distance to tarmac road, coffee garden size, and household characteristics. γs are the parameters to be estimated.

4.2. Data

Coffee has traditionally been the main cash crop in the Mt. Elgon area of Eastern Uganda which is particularly well-suited for Arabica coffee production due to its fertile volcanic soils, elevation, and climate. In this study we focus on a particular district of the Mt Elgon area, Kapchorwa, which is the highest Arabica-coffee-producing district in Uganda. Our sample consists of about 1625 coffee growers in a total of 192 villages in 19 parishes of the district of Kapchorwa. Each grower is a member of a farmer group[7]. We randomly selected and interviewed 15-25 growers from each of the 88 farmer groups in the district. We varied the number of interviews per group depending on the size of the farmer group. We obtained the list of farmer groups and registered farmers from Kawacom[8] which is the most established and largest coffee processor and exporter company working with about 4000 coffee growers in the district. Kawacom has several coffee buying centres (collection points) in different parishes of the district and a centrally-located modern washing station (wet mill) to process all the coffee collected from thousands of growers in the district.

Data collection took place in the months of March and April 2018. Since we attempt to explore the drivers of the decision to sell parchment which is of low value, our main outcome variables are engaging in parchment production and share of processed cherries into parchment in all cherries harvested. For our outcome variable, the share of processed cherries, the nominator is the quantity of cherries processed to produce parchment (in kgs) multiplied by 100 and the denominator is the nominator plus the total quantity of fresh cherries sold (in kgs). When we say cherries harvested, we technically mean the cherries harvested and either sold fresh or processed into parchment. In other words, all harvested cherries are assumed to be either sold as fresh cherries or processed into parchment and we mainly are interested in their ratio. We measure revenues using the stated quantities of coffee sold to and prices received from each buyer and sum them up. Our explanatory variables include knowledge on coffee quality which is constructed using 17 questions on cherry quality which include pictures of cherries and coffee growers were asked to classify them into quality levels, such as unacceptable, acceptable, good, and excellent. We also have data on socioeconomic characteristics of the households and cognitive skills[9].

4.3. Summary Statistics

We have a total of 1625 coffee farming households in our sample. 963 of the households sell cherries exclusively. 662 of the households sell dried parchment of which 204 sell solely dried parchment. When we focus on determinants of parchment production, we mainly work with the sub-sample of 662 households who are involved in parchment coffee production to varying degrees.

Table 1 below presents summary statistics. Average coffee farm size is 1.5 acres. About 14 percent of the households are female-headed. Average household size is 6.3 of whom 2.3 members are engaged in off-farm labour activities. Average household head age is 52 years. On average household heads have about 9 years of education (primary school completion corresponds to 8 years of education). On average, coffee growing households harvest around 885 kilograms of coffee cherries and earn about 1170 UShs per kilograms of cherries harvested. Annual coffee revenue is close to one million Ushs (~270 USD).

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[7] In our context farmer groups do not act as cooperatives. They have no buying or marketing roles. Trading of parchment coffee was performed by the cooperatives prior to the liberalisation reforms in 1990s, but current cooperative structure has become weak as a result of the liberalisation of the coffee sector (Baffes, 2006). In particular in our study area, exporters or middlemen directly purchase coffee from growers instead of cooperatives.

[8] Kawacom is a subsidiary of the large global commodity trading and processing company, ECOM Agroindustrial, based in Switzerland. Kawacom has been operating in the Mt Elgon region since early 2000s.

[9] We use Raven's matrices to measure cognitive skills following Laalaj & Macours (2018) that find cognitive tests to be consistent in developing countries.

Table 1: Summary Statistics

Panel A: all coffee producers				
	mean	std dev	min	max
harvest kg	885	1337	3	16,090
share of processed cherries	31	40	0	100
coffee revenues (UShs)	997,749	1,416,758	2800	18,000,000
revenue per kg (UShs)	1170	250	200	8000
coffee farm size	1.55	1.51	0	29
household size	6.34	2.44	1	18
female household head	0.14	0.35	0	1
number of observations	1625			
Panel B: only cherry doers				
	mean	std dev	min	max
harvest kg	526	668	3	9500
share of processed cherries	0	0	0	0
coffee revenues (UShs)	663,887	882,211	2800	12,400,000
revenue per kg (UShs)	1232	281	533	8000
coffee farm size	1.36	1.40	0	29
household size	6.19	2.48	1	18
female household head	0.14	0.35	0	1
number of observations	963			
Panel C: only parchment doers				
	mean	std dev	min	max
harvest kg	1492	1884	15	15,000
share of processed cherries	100	0	100	100
coffee revenues (UShs)	1,535,762	2,114,396	15,600	18,000,000
revenue per kg (UShs)	1012	175	200	1400
coffee farm size	1.67	1.40	0	9
household size	6.22	2.25	1	14
female household head	0.13	0.33	0	1
number of observations	204			
Panel D: both cherry and parchment doers				
	mean	std dev	min	max
harvest kg	1370	1781	80	16,090
share of processed cherries	65	22	7	100
coffee revenues (UShs)	1,460,094	1,711,807	90,999	17,100,000
revenue per kg (UShs)	1112	144	344	1852
coffee farm size	1.88	1.71	0	23
household size	6.71	2.42	1	16
female household head	0.16	0.37	0	1
number of observations	458			

When we look at the sample separately, households who sell both cherries and parchment seem to have more members. Dried parchment producers seem to have larger coffee farms, harvest more coffee, and earn higher coffee revenues than only those who sell only cherries. However, when

we consider revenue per kilogram of cherries harvested, it is the opposite. Households who sell only cherries receive about 1232 Ushs per kilogram of cherries harvested, whereas those who produce only parchment earn 1012 Ushs per kilogram. Dried parchment sales seem to be associated with lower revenues per kilogram of cherries harvested compared to selling fresh cherries.

5. Econometric Results

In this section, we explore the reasons why growers might continue to sell parchment although it is associated with lower revenues compared to selling fresh cherries. We assume that growers ideally prefer to sell cherries over parchment since cherries are of higher value, yet some factors constrain cherry sales. One such constraint is hypothesised to be market quality requirements of the coffee cherry market. Cherry quality which is observable to a large extent is assessed by buyers prior to each transaction. If, on average, cherries are of lower quality than what the market requires, growers are asked to sort out the bad cherries so that the remaining ones meet the quality standards. Since altitude is a major determinant of cherry quality, it is highly likely that growers of low-altitudes may produce lower quality coffee and, hence, more of their cherries may be likely to fall below the quality threshold compared with high-altitude growers[10]. Our results show that altitude is not correlated with the probability of selling parchment but is negatively correlated with the share of processed cherries into parchment (Table 2).

Apart from agronomic aspects, how cherries are harvested is the most important factor that affects cherry quality. We test if harvesting quality explains parchment production. Our results show that it is the case. Harvesting expenditure is negatively associated with the probability of producing parchment (Table 2 Column 1). We then see if resources spent on harvesting explains the variation in the share of cherries processed for those who engage in parchment production. We estimate a truncated regression in which the variance of the outcome variable is adjusted to truncated distribution. Similarly, harvesting expenditure per kilogram is decreasing in the share of processed cherries into parchment (Table 2 Column 2).

A potential reason why coffee growers fail to harvest optimally to sell all of their cherries is lack of knowledge. To test the hypothesis, we see if knowledge on coffee cherry quality is associated with lower probability of selling parchment. Our results show that the probability of engaging in parchment production is increasing in knowledge on cherry quality. One point increase in quality knowledge score is associated with 0.5 percentage point higher probability to engage in parchment production (Table 2 Column 1). To interpret it simply, those who know better about cherry quality have higher probability of doing parchment versus the alternative of selling only cherries. It might sound counter-intuitive at first but it is only one side of the story.

We then see if knowledge on coffee quality explains the variation in the share of cherries processed for those who engage in parchment production. We estimate a truncated regression in which the variance of the outcome variable is adjusted to truncated distribution. We find that higher levels of knowledge on cherry quality are associated with lower share of cherries processed into parchment. One point increase in the cherry quality knowledge score is associated with 1.3 percentage point decrease in share of processed cherries (Table 2 Column 2). Among the growers who sell parchment, those who know better on cherry quality are associated with lower shares of parchment cherries. Combining the results, we find evidence that growers who know well about coffee cherry quality are more likely to engage in parchment production (rather than selling only cherries), but tend to process smaller shares of their cherries into parchment.

Table 2: Probit regression: selling parchment. Truncated regression: share of processed cherries into parchment

[10] We use the altitude data of the homestead captured during the interviews. Most smallholder farmers have their coffee gardens around their homestead. Some have coffee gardens farther away from their home but altitude change can be considered minor. It is uncommon to have coffee gardens outside the parish.

	Probit regression: selling parchment (1)	Truncated regression: share of processed cherries (2)
harvesting expenditure per kg	-0.000511** -0.000242	-0.0245** -0.0113
quality knowledge	0.0386** -0.0186	-1.399** -0.595
altitude	-0.000155 -0.00014	-0.0135** -0.00528
coffee farm size	0.105** -0.0481	-0.385 -0.595
distance to road	-0.0445*** -0.0125	-0.651* -0.384
assets owned 2018	0.141 -0.0996	2.292*** -0.815
household size	0.00372 -0.00256	-1.712*** -0.433
female household head	0.00128 -0.00698	-3.872 -2.841
household head age	0.00413 -0.00255	-0.0819 -0.0737
household head education in years	0.000492 -0.00697	-0.316 -0.203
Observations	1625	662

*** p<0.01, ** p<0.05, * p<0.1 Intercepts included but not reported.

One explanation for that result is that growers who know well about quality tend to process the cherries which are likely to fall below the quality threshold and thus be not sold. Ideally, growers may prefer to sell their cherries fresh than process them, but when they are likely to fail to sell all of their cherries, lower quality cherries are home-processed and sold as parchment. It is the unobservable nature of parchment coffee quality which enables farmers to sell parchment made from the cherries which may be rejected. Hence, knowing well about cherry quality and being able to identify poor quality cherries i.e. cherries which are likely to fall below the quality threshold may lead farmers to some parchment production.

In search for evidence, farmers are asked why they produce parchment rather than sell only fresh cherries. We use multinomial logistics regression to examine the predictors of the reasons why growers produce parchment. Multinomial logistic regression is a classification method that generalizes logistic regression to multiclass problems i.e. with more than two possible discrete outcomes (Greene 2012). Simply, the model is used to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable (reasons for producing parchment) given independent variables. In our analysis, we use knowledge on cherry quality as a predictor to explain the reasons why growers produce parchment (choice variable). Among the five options[11] listed only "I only do parchment with lower quality cherries" is significantly associated with the knowledge on cherry quality (results not reported).

Informed by this insight, we estimate a probit regression to explore the determinants of producing parchment using lower quality cherries. We see if those with better knowledge on quality have higher probabilities of producing parchment with only lower quality cherries. Our results

[11] Other options are: It is what I have always done, It is hard or costly to deliver cherries on the same day, I make more money from parchment, and I like to receive (lumpsum) money at once.

indicate that knowledge on cherry quality increases the probability of producing parchment using lower quality cherries significantly. Scoring one point higher on knowledge index is associated with 0.3 percentage points higher probability of producing parchment using lower quality cherries (Table 3). Putting results together, we find evidence that knowledge on cherry quality matters for parchment production decision. Specifically, growers who know better about cherry quality have higher probability to process lower quality cherries into parchment. Our results are in line with what is suggested in the literature that lack of knowledge may be a barrier to adoption of better practices.

Table 3: Probit estimation: producing parchment using lower quality cherries

	Probit estimation: parchment production using lower quality cherries
quality knowledge	0.283***
	-0.0564
Raven's score	0.220***
	-0.0565
picking expenditure per kg	0.00193**
	-0.000776
altitude	-0.000279
	-0.000379
distance to road	0.0157
	-0.0271
coffee farm size	-0.177***
	-0.0673
household size	0.120***
	-0.0337
female household head	0.0142
	-0.234
household head age	-0.000102
	-0.00575
household head education in years	-0.00661
	-0.0157
Observations	662

*** p<0.01, ** p<0.05, * p<0.1 Intercepts included but not reported.

In addition, since cognitive ability is associated with socioeconomic success, it may play a role in adverse selection decision. Growers with higher cognitive skills likely better observe, process, and make sense of the available information and understand characteristics of different markets. When bad cherries are likely to be sorted out and cannot be sold in the cherry market, they are processed into parchment by some growers. Unobservable nature of parchment quality allows farmers to nonetheless sell the parchment produced using poor quality cherries. We think that some growers may be taking advantage of the information asymmetry in the parchment market to earn higher revenues. Those who do, may have not only higher levels of knowledge but also cognitive abilities. We then see if cognitive ability increases the probability of producing parchment using lower quality cherries. In line with the literature, our results suggest that it is the case. To put it simply, those with higher cognitive skills are associated with higher probability of producing parchment using only

lower quality cherries. Household size seems to play a role possibly through availability of household labour to both sell cherries and process some more into parchment which is a labour-intensive activity.

Table 4: OLS estimation: coffee revenue per kg of cherries harvested. OLS estimation: coffee revenue per kg

	OLS regression: coffee revenue per kg of cherries harvested (1)		OLS regression: coffee revenue per kg of cherries harvested (2)
indicator: only cherry doer	121.6***	share of processed cherries into parchment	-2.876***
	-12.23		-0.3
indicator: only parchment doer	-96.96***		
	-13.99		
distance to tarmac road	0.0104	distance to tarmac road	4.84
	-2.271		-4.645
household size	1.592	household size	-1.712
	-1.746		-2.419
coffee farm size	0.172	coffee farm size	1.356
	-3.392		-3.68
female household head	25.77	female household head	-5.644
	-30.53		-17.74
household head age	-0.238	household head age	-0.00247
	-0.427		-0.483
household head education in years	0.642	household head education in years	1.058
	-0.9		-1.302
Observations	1625	Observations	458
R-squared	0.103	R-squared	0.206

*** p<0.01, ** p<0.05, * p<0.1 Intercepts included but not reported.

Lastly, we look at the coffee revenues for those who sell only cherries, only parchment, and both cherries and parchment. Our OLS regression results show that households who sell only cherries are associated with (122 UShs) higher coffee revenues per kg of cherries harvested and those who sell only parchment are associated with (97 UShs) lower coffee revenues per kg of cherries harvested than those who do both (Table 4 Column 1). In addition, when we focus on coffee revenues of households who sell both cherries and parchment, share of processed cherries is decreasing in coffee revenues per kilogram (Table 4 Column 2).

These results corroborate with our idea that selling cherries is associated with higher revenues and that selling some parchment may be the best alternative to maximize revenues for growers who cannot sell solely cherries due to quality requirements in the cherry market. Hence, assuming constant cherry quality, under quality uncertainty and asymmetric information some growers may rationally be engaging in parchment production to maximize revenues. As we discussed above, those who know better about cherry quality and with higher cognitive skills seem to do so.

6. Conclusion

At first glance, it seems irrational for coffee growers to engage in partially-processed parchment coffee production rather than selling fresh coffee cherries which is associated with higher profits. Using data from 1625 Arabica coffee farmers in the Mt Elgon region of Uganda, we explore

the reason that growers might rationally choose to engage in parchment production in lieu of selling cherries. Coffee cherry buyers in the area apply a standard price per kilogram of cherries of a certain level of quality. Lower quality cherries that fall below the quality threshold may be rejected by cherry buyers. However, coffee quality becomes difficult to assess in the next stages of production. Quality uncertainty and asymmetric information in the parchment market seem to play a major role in decisions to produce parchment. We find that those who know better about coffee quality have higher probabilities of engaging in some parchment production versus selling only cherries but process relatively lower shares of their coffee cherries into parchment. Knowing better about cherry quality is associated with selling parchment which is produced using lower quality cherries. Some coffee growers with good knowledge about coffee quality home-process low quality cherries which are (likely to be) rejected in the cherry market and still sell them in the form of parchment taking advantage of the asymmetric information in the parchment market. These growers seem to have higher levels of cognitive ability as well. Our results are in line with what is suggested in the adoption literature that lack of knowledge is a barrier to and cognitive skills are positively associated with better economic outcomes.

This research leaves some important research and policy questions unanswered. Producing some parchment with low quality cherries which cannot be sold in the cherry market may be a rational behaviour given the quality constraints. However, selling only cherries is still of higher values than selling some parchment. Is it then logical to improve quality in the region so that farmers sell all of their cherries and earn higher revenues? In a qualitative study, Vicol *et al*. (2018) suggest that coffee growers are likely to benefit more if they sell their coffee in the form of cherries so that central processors or cooperatives can access higher quality coffee markets and pass on higher prices to growers. By adopting a larger scale strategy to produce high-quality coffee, can high values be achieved across the whole value chain as in the case of Costa Rica (Wollni & Fischer 2015)? More research is needed to address these questions.

References

Akerlof GA, 1970. The Market for Lemons: Quality Uncertainty and the Market Mechanism. Quarterly Journal of Economics 84(3): 488-500.

Almund M, Duckworth A, Heckman J & Kautz T, 2011. Personality Psychology and Economics, Handbook of the Economics of Education. Amsterdam, Elsevier.

Ameyu MA, 2017. Influence of harvesting and postharvest processing methods on the quality of Arabica coffee (Coffea arabica L.) in Eastern Ethiopia. ISABB Journal of Food And Agriculture Science 7(1): 1-9

Baffes J, 2006. Restructuring Uganda's coffee industry: Why going back to basic matters. Development policy review 244: 413-436.

De Graaff J, 1986. The Economics of Coffee. Economics of Crops in Developing Countries, 1. Pudoc. Wageningen, the Netherlands.

Decazy F, Avelino J, Guyot B, Perriot JI, Pineda C, and Cilas C, 2003. Quality of different Honduran coffees in relation to several environments. Journal of Food Science 68:2356-2361.

Gertler P, Heckman J, Pinto R, Zanolini A, Vermeersch C, Walker S, Chang SM & Grantham-McGregor S, 2014. Labor market returns to an early childhood stimulation intervention in Jamaica, Science 344(6187): 998-1001

Goto YB & Fukunaga ET, 1986. Harvesting and Processing for High Quality Coffee, University of Hawaii.

Greene WH, 2012. Econometric analysis. Seventh edition. New Jersey, Prentice Hall.

Heckman JJ, 1995. Lessons from The Bell Curve. Journal of Political Economy 103(5): 1091-1120.

International Coffee Organisation ICO 2018. Trade Statistics. Available at http://www.ico.org/prices/po-production.pdf.

Knowler D & Bradshaw B, 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy 32: 25-48.

Kuit M, Jansen DM, & Thiet NV, 2004. Coffee handbook: Manual for Arabica cultivation. Vietnam.

Laalaj R & Macours K, 2018. Measuring Skills in Developing Countries. CEPR Discussion Papers 13271, C.E.P.R. Discussion Papers.

Leroy T, Ribeyre F, Bertrand B, Charmetant P, Dufour M, Montagnon C, Marraccini P & Pot D, 2006. Genetics of coffee quality. Brazilian Journal Plant Physiology 18(1):229-242

Maertens M & Swinnen J, 2009. Trade, Standards, and Poverty: Evidence from Senegal. World Development 37(1): 161-178.

McNairn HE & Mitchell B, 1992. Locus of control and farmer orientation: Effects on conservation adoption. Journal of Agricultural and Environmental Ethics 5(1): 87-101.

Minten B, Randrianarison L & Swinnen J, 2009. Global Retail Chains and Poor Farmers: Evidence from Madagascar. World Development 37(11): 1728-1741.

Miyazaki H, 1977. The Rat Race and Internal Market. Bell Journal of Economics 8(2): 394-418

Murnane RJ, Willett JB & Levy F, 1995. The growing importance of cognitive skills in wage determination. Review of Economics and Statistics 77(2): 251-266.

Mujawamariya G, D'Haese M & Speelman S, 2013. Exploring double side-selling in cooperatives, case study of four coffee cooperatives in Rwanda. Food Policy 39: 72–83

Poltronieri P & Rossi F, 2016. Challenges in Specialty Coffee Processing and Quality Assurance. Challenges 7(2): 19

Rothschild M & Stiglitz J, 1976. Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information. Quarterly Journal of Economics 90(4): 629-649

Traore TM & Wilson NLW, 2018. What explains specialty coffee quality scores and prices: A case study from the cup of excellence program. Journal of Agricultural and Applied Economics 503: 1-20.

Uganda Coffee Development Authority UCDA, 2011. Annual Reports, Kampala, Uganda. Available at http://www.ugandacoffee.org.

Vicol M, Neilsona J, Faila D, Hartatrib S & Cooper P, 2018. Upgrading for whom? Relationship coffee, value chain interventions and rural development in Indonesia World development 110: 26-37.

Wasserman GS, Bradbury A, Cruz T & Penson S, 2012. Coffee. Wiley Online Library, John Wiley & Sons, Inc.

Wilson C, 1977. A model of Insurance Markets with Incomplete Information. Journal of Economic Theory 16: 167-207.

Wollni M & Fischer E, 2015. Member deliveries in collective marketing relationships: evidence from coffee cooperatives in Costa Rica. European Review of Agricultural Economics, 42(2): 287-314.

Wollni M & Zeller M, 2007. Do farmers benefit from participating in specialty markets and cooperatives? The case of coffee marketing in Costa Rica, Agricultural Economics 37(2): 243–248.