Dear organizers,

Please find below our submission to the CSAE 2020 conference entitled “The low quality trap: Evidence from the market for maize in Uganda”. As you can see our submission is ‘hot off the press’ and at this stage very preliminary. We have submitted it for the conference because we are both very excited about the paper and because we are confident that we can deliver a full-fledged paper in good time for the conference.

The paper deals with a hugely important question, that of low productivity and consequently low incomes for smallholder farmers in Sub-Saharan Africa. In fact, the agriculture sector in Sub-Saharan Africa may be one of the most glaring examples of the concept of misallocation highlighted by Banerjee and Duflo (2005). A number of promising, and potentially interlinked explanations, have been put forward in the recent literature to explain the low rate of technology adoption and more generally the low productivity, including missing markets for risk and credit, lack of knowledge and behavioral constraints.

In the submitted paper, we pursue a new angle, namely the question of the sub-standard quality and therefore low profitability of the crops being produced by smallholder farmers. Specifically, we present both detailed descriptive evidence of the value chain for quality crops for smallholder maize farmers in Uganda, as well as experimental evidence that the existing market structure does not reward investments in maize quality. Based on this descriptive and experimental evidence, we construct a model of the value chain that incorporates hold-up problems at many vertical layers of the value chain. We then investigate one approach to deal with issues such as hold-up problems in the supply chain, namely vertical integration (of the value chain). Specifically, we helped to set up a vertically integrated agricultural trading company that makes direct outreach to farmers and vary experimentally where the company is active. The experimental design allows us to assess whether paying for quality, with the quality premium determined by market conditions (and a essentially zero-profit condition for the start-up), can induce changes in farmer behavior that affect both quality and quantity of what is being produced.

Preliminary findings (after two seasons of operations) already suggest substantial impacts. Yields are increased, more farmers engage in quality-enhancing post-harvest practices, and the use of modern inputs such as fertilizer and modern seeds is increased. We stress that these results are preliminary at this point and that power is limited. However, we will add a new season of data to the analysis in the coming weeks and at that point have sufficient power to detect moderate effect sizes.

We think that this project has the potential to be hugely beneficial. Given the structure of markets for staples, such as maize, and specifically, the extremely low profit margins, simply increasing productivity and yield is unlikely to be transformative for small-scale farmers. Only by producing high quality maize and being able to integrate into the high-quality value chain for maize will they be able to substantially increase the mark-ups on their product and hence revenue and profits.

Kind regards, Jakob Svensson
The low quality trap: Evidence from the market for maize in Uganda*

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Very preliminary (please do not quote)

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Abstract: Agriculture remains the main source of income for the large majority of the world’s poor. Yet over the past 50 years agricultural yields have been low and slow growing in many parts of the developing world, especially in Sub-Saharan Africa. Intensity of input application, including improved seed varieties and fertilizer, has similarly been low and stagnant. While much attention has been put on explaining low productivity among smallholder farmers, the sector is not only characterized by low yield but also substandard quality of the crops produced (and sold on the market). Poor quality, in turn, is often explained by the fact that many farmers do not systematically follow recommended agricultural practices. A key prediction of the neoclassical agriculture household model is that the farmer will set the intensity of use of any particular input until its marginal value product equal its marginal cost. In such a model, prices provide a key explanation for the pattern of low yields, and low quality. This paper takes the implication of the neoclassical agriculture household model as a starting point to investigate how output prices are set on local markets. We start by provide experimental evidence on the returns to quality, showing that the market does not compensate farmers for quality improvements. Thus, farmers face weak incentives to invest in high quality and consequently invest little. We then show that the experimental findings can be rationalized as an outcome in a model of the value-added chain where sellers are subject to hold-up problems. Finally, a common strategy to deal with hold-up problems in supply relationship is vertical integration. Working with a start-up firm we investigate whether paying for quality, with the quality premium determined by market conditions, can induce changes in farmer behavior that in turn affect both quality and quantity?

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1. Introduction

The agriculture sector in many low- and middle-income countries, and especially in sub-Saharan Africa, may be the most glaring example of the concept of misallocation (Banerjee and Duflo, 2005). In the same area, we observe large productive farms using modern technologies and unproductive smallholders using obsolete technologies. Given the size of the smallholder sector, this misallocation can help explain why agricultural yields have been low and slow growing in sub-Saharan Africa for several decades.

A number of promising, and potentially interlinked explanations, have been put forward in the recent literature to explain the low rate of technology adoption and more generally the low productivity, including missing markets for risk and credit (e.g. Karlan et al., 2014), lack of knowledge and behavioral constraints (e.g. Duflo et al., 2006, 2011), and uncertainty (Suri, 2011).1

While much attention has been put on the low productivity among smallholder farmers in Sub-Saharan, a possibly just as striking feature of the sector is the substandard quality, on average, of the crops produced (and sold on the market).2 Poor quality, in turn, is often explained by the fact that many farmers do not systematically follow recommended agricultural practices. Importantly, many of these agricultural tasks, including land preparation, planting, and weeding, affect both the quantity and the quality of the output, while others, like harvest and several post-harvest activities (including drying, cleaning, sorting, and storing), primarily affects the economic value of the output; i.e. they add (or potentially subtract) value to the what has been harvested. Understanding what causes farmers to produce substandard quality, therefore, can potentially help to explain both why productivity is low but also why farmers do not systematically adopt productivity and quality enhancing technologies such as fertilizer and hybrid seeds, since the returns to the adoption of such inputs depend on the farmers making complementary investments in adequate crop management.

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1 For reviews of the literature, see de Janvry, Sadoulet and Suri (2017) and Jack (2013).

2 The extent of the quality problem in countries like Uganda is difficult to measure with any precision. One (poor) quality measure that has received attention recently is the measurement of aflatoxin in maize (see e.g. Lewis et al., 2005, Mutiga et al., 2015, and Chauhan et al., 2016. Chauhan et al. (2016) test maize samples bought from local traders and in local markets in Ethiopia. They find that 50% of the samples had aflatoxin levels of at least twice the FDA threshold. A more indirect measure of quality in the market place is the share of the informal market. In Uganda, it is estimated that 70-80% of maize that is bought and sold in country are channeled through channels where it is not taxed or regulated; i.e. the informal market (Daly et al., 2016). Few smallholder sell their produce in formal markets where high-quality maize is traded.
A key prediction of the baseline neoclassical agriculture household model is that the farmer will set the intensity of use of any particular input, including effort or labor, until its marginal value product equal its marginal cost. As noted in Udry (2010), in such a model, prices of inputs, including labor, and output, thus provide a key explanation for the pattern of low yields, and low quality, in agriculture in Africa.

In this paper, we take the implication of the neoclassical agriculture household model as a starting point to investigate how output prices are set on local markets. We first provide a descriptive analysis of the behavior of the actors at the first-stage in the value-added chain for maize in Uganda; i.e. producers (smallholder farmers) and buyers (village agents).

We then provide experimental evidence on the returns to quality by randomly providing a set of farmers with best practice post-harvest services. The experimental findings suggest that the market does not compensate farmers for quality improvements. Thus, farmers face weak incentives to invest in high quality and consequently invest little.

To rationalize the low quality equilibrium we observe, we then develop a model of the value chain for maize. Unlike agricultural production in developed countries, where high quality outputs are generated in closely aligned segments of the value chain (production, aggregation, processing, distribution and marketing) by actors exploiting economies of scale, the value chain for crops like maize in (East) Africa is characterized by layers of small (informal) actors (Daly et al., 2016; Gates Foundation, 2014). While complete information of the structure of the value-added network does not exist, anecdotal evidence suggest that size of the network is vast, with maize reported to often passes through several (at least four) sets of traders before reaching mills located in urban centers.\(^3\)

We take this descriptive evidence as the starting point and develop a value chain model where a (cash-constrained) farmer sells to a (debt-financed) agent (trader) who in turn sells to an (debt-financed) agent in the next stage, until the product reaches the end producer.\(^4\) A high quality (consumer) product requires that each actor in the chain makes (non-contractible) investments (in drying, sorting, packing, storing, transporting for example). While the seller of the product, at each stage, face several potential buyers, debt-financing makes search costly. Thus, when a buyer and seller is matched, a buyer can take advantage of the fact that

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\(^3\) As described in Daly et al (2016), in a typical value chain a small-scale aggregator serves as the first link in the chain by purchasing bags from a handful of farmers. That individual most often sells the maize to someone with a truck, who then brings it to a storage facility. From there, someone else takes the bagged maize from the warehouse to a central source in Kampala, where it is then sold to processors.

\(^4\) While maize produced in Sub-Saharan Africa is mostly consumed as maize flour, animal feed and, increasingly, ethanol production are the focus in developed countries.
the economic value of the seller’s investment deteriorates after each unsuccessfully transaction by offering a lower price to capture part of the returns to the investment. Facing such a hold-up problem, in turn, may make the seller unwilling to invest ex ante. In equilibrium, farmers and traders add little value to the product, and the quality of what is being produced is low.

A common strategy to deal with hold-up problems in supply relationship is vertical integration. To investigate such an approach, we helped set up an agro trading company that makes direct outreach at the village level, and randomly assigned the villages in which the firm are active. The experimental design allow us to assess whether paying for quality, with the quality premium determined by market conditions (and a essentially zero-profit condition for the start-up), can induce changes in farmer behavior that affect both quality and quantity of what is being produced. Working close with the start-up company also provides us with case study evidence of how feasible and financially viable it is to run such a business model at scale.

2. The quality of maize and its value chain

The East African Grading Standard (EAS) classifies maize quality into five grades. The quality grade of the maize depends on the maximum amount of defects found in the grain, where ten dimensions of quality defects are examined: presence of organic matter (e.g. cobs), presence of inorganic matter (e.g. stones), impurities (e.g. insects), dirt, broken grains, pest damaged grains, rotten grains, discolored grains, immature grains, and moisture level.

Defects in maize quality can arise throughout value chain, and a quality assurance process involves different activities at different levels of the value chain, but what occurs at the farm level is absolutely crucial. At the farm level, maize quality assurance involves proper land preparation, planting and weeding. Care must also be taken not to damage the maize during harvesting and post-harvest care of the maize requires proper drying, cleaning, sorting and storage of the maize, to avoid visible mold and spoilage as well as invisible damage such as the development of aflatoxins. During these aggregation steps, proper storing and careful transport is vital. Finally, at the processing stage, the main task is to ensure that the maize being processed does not include harmful substances (i.e. microorganisms).
A cost-effective quality assurance process involves prevention of defects from the earliest stages of cultivation. This is the case because any high quality maize that comes into contact with low quality maize (as could happen if quality was only checked at the aggregation step) can become contaminated by the latter. Second, even though some defects arising at early points of production can be rectified later, such as removing stones, dirt and insects, these are often symptoms of underlying, but harder to detect, problems that are more hazardous (such as infestation, mold and development of aflatoxins).

The structure of the maize market in Uganda is not conducive to ensuring that high quality maize is produced. To see why this is the case, consider first how high quality products with large value added are produced in high income countries: Such goods tend to be produced and marketed in closely aligned segments of the value chain. That is, such sectors are characterized by production, aggregation, processing, distribution and marketing being vertically integrated. Additionally, actors tend to be large in order to be able to exploit economies of scale.

In contrast, the market for maize in Uganda consists of two ‘unconnected’ segments, a small high-end export market that functions similar to the market described above and a largely unregulated and informal market, in which the large majority of smallholder farmers operate. This market is characterized by a value chain for maize that consists of many vertical stages with many small actors operating at each stage, little integration between them, and little opportunity for reputation building. The result is a vast network of small-holder farmers and small-scale traders with maize passing through several sets of traders before reaching mills located in urban centers. Most maize bought and sold in this market is channeled through informal channels where it is not taxed or regulated. Informal trade to nearby countries is also common.

There is a large premium for accessing the formal, high quality market, and therefore a large premium if a farmer produces high quality maize and can access this kind of market. As we will see, however, most small-holder farmers are trapped in the informal market where there is little return to quality. The reason for this is that for there to be a return to quality, all maize must be of high quality. Given the vast number of actors and layers, however, this is almost impossible to ensure, and in practice maize quality varies widely in the informal market. Specifically, bulking maize from so many small actors always carries the risk of mixing high
quality and low quality maize, and, as noted above, the latter contaminates the former. For example, at the processing stage, insect infested, rotten, diseased and discolored grain may be processed with good quality maize. When flour is put up for sale, good quality flour can be mixed with low quality to create a diluted flour that could appear as a relatively high quality product to unsuspecting customers. This kind of mixing of high and low quality grain and flour can be difficult to detect initially, but the presence of low quality flour or grain can quickly contaminate the whole product, which develops off-flavors and a reduced shelf-life and may be hazardous to consume.

Given this context, there is little incentive to ensure that maize quality is high. And while traders inspect bags for foreign matter and moist, no rigorous quality assessment of maize takes place at the farm gate. In addition, it is also the case that maize quality cannot be perfectly measured through careful visual inspection, i.e. moisture and aflatoxin presence requires specialized equipment, which may not be profitable for a small-scale trader. Nevertheless, we think it is more likely that market structure and the low return to quality explains why quality is not more systematically assessed. We do not think that the difficulty to observe maize quality explains why there is no return to maize quality, since clearly there is a parallel formal market in which both these things, high maize quality and high returns to quality, are easily achieved.

3. Farmers: the first link in the value chain for maize

In this section, we describe the how maize is produced and marketed at the first level of the maize value chain. Specifically, we describe what investments and activities farmers undertake to produce maize and how much maize output this yields. We then describe the market for maize as faced by farmers and the resulting revenues and profits farmers gain from selling their maize. We also describe the environment, specifically its riskiness, in which farmers operate, by documenting aggregate and idiosyncratic fluctuations in price, yield and revenue across five seasons.

TBC

4. Does the market reward quality?

Summarizing the main points in bullet points:
• **Field experiment:** maize farmers in Kakumiro (western Uganda)

• **In treatment group:** provide best-practice post-harvest process (harvest, drying, sorting); i.e. provide an exogenous improvement in quality

• In both *Treatment* and *Control* before selling:
  - measured weight of maize and inspected all bags: organic matter (e.g. cobs); inorganic matter (e.g. stones); impurities (e.g. insects); broken, pest damaged, rotten, discolored, immature grains, dirt and moisture level
  - Use the data to create a *poor quality index*: average share of low quality markers in bags

• In both *Treatment* and *Control* after selling:
  - collect information on sales volume and prices

• In total 120 sales

**Results**

Figure illustrates the main results:

(i) Almost perfect “compliance”; i.e., in the treatment group almost farmers sold maize of good quality.
(ii) In control, a large majority do not sell good quality maize
(iii) No relationship between price and quality as evident from the ATE depicted in the figure.

Possible that buyers respond to lower quality not by lowering prices but by deductions.

Figure 2 reports CDFs of deductions in treatment and control.

**Take away:**

(i) Deductions (or biased measurement) are common (4-5% of the weight is deducted for most farmers), but these deductions are not different across the two groups
In Figure 3 we use net-price instead of price, with net-price defined \( p^* = p(y - z)/y \), where \( p \) is the market price, \( y \) is true (measured) weight, and \( z \) is the amount of maize deducted.

As evident, the pattern reported in Figure 1 holds.

Interpretation:

(i) Little evidence that the market compensate farmers for quality improvements

(ii) Deductions (or biased measurement) common (4-5%) but not systematically related to quality (although quality as we use it here is essentially observable)

Implication: farmers face weak incentives to invest in high quality, and consequently invest little in quality enhancing processes.

5. Low return to quality: why?

*In progress: model of the value chain for maize*

Starting point: in sub-Saharan Africa: segmented market with layers of small (debt-financed) actors

Two possible channels:

(i) Hold-up problems
   a. A high quality end product requires that each actor in the chain makes (non-contractible) investments (in drying, sorting, packing, storing, transporting)
   b. At each transaction stage: buyer has incentives to capture seller’s returns to investment
   c. expecting that to happen, sellers don’t invest

(ii) Fixed cost to ensure/verify quality
   a. investments which small debt-financed actors cannot afford

6. Policy: experimental evidence

The experimental findings suggest that the market does not compensate farmers for quality improvements. That is, farmers face weak incentives to invest in high quality. We also document that most farmers sell maize with questionable quality.
In this section, we investigate the impact of integrating farmers into a value chain for quality maize. Specifically, we assess whether paying for quality, with the quality premium determined by market conditions, can induce changes in farmer behavior affecting both quality and quantity of maize?

6.1 Trial design
Key concerns influencing the trial design:

- within market spillovers, leading us to use a clustered design
- complex intervention (integrate the value-chain), leading us to limit the number of clusters
- short and long-run impacts may differ dramatically, leading us to follow the trial groups over a longer horizon

Design choices: clustered repeated measurement design

- restrict the number of clusters (20) but expand on number of waves

Empirical model: $y_{ijt} = \beta \times TREAT_j + \sum_{t=1}^{T} \theta_t + \epsilon_{ijt}$

Comments:

(i) Interpretation of $\beta$: average treatment effect over the $T$ post-treatment rounds (cf. “state of nature” concern of Rosenzweig and Udry, 2016)

(ii) Well-powered design: adjust for correlation within cluster and across households over time yields a $MDE \approx 0.2 \, STD$ after 3 post-treatment rounds

(iii) To check balance with a small number of clusters, use not one but data from three pre-post season rounds. This enables us to check balance both across space and over time.

6.2 Descriptive data
Currently: 5 rounds of data for 20 + 20 villages, $\approx 10$/hhs/village

Patterns with respect to:

- selling (and buying) behavior
- prices over time (micro and macro level)
- risk and economic shocks
- technology (use over time)
Market for maize
Most interactions are repeated, with a large majority of farmer knowing the buyer they sold to and most also having to sold to the same buyer before.

The market is essentially a spot market where parties agree agree on the amount to sell and the price and buyer pay when the maize is sold. Almost all transactions take place at the farm-gate.

Sales decisions
Mainly driven by liquidity constraints: to cover debts, to buy inputs for the next season, and foremost because farmers needed to cover expenses (school expenditures for example).

No constraint on selling because cannot find a buyer

Prices
Large variations in average price between seasons, in average price within season, and between farmers at a given point in time (see Figure 4 and Figure 5)

Risks and shocks
Large variation of yields for a given farmer across time
  • Raw autocorrelation coefficient of 0.26 in yields
  • Falls to 0.21 when controlling for village and time fixed effects
    • For comparison autocorrelation coefficient for acreage planted with maize is over 0.6 across seasons

6.3 Intervention
The sample consist of 20 villages (clusters), randomly assigned into a control group or a treatment group. In each cluster, around 10 households (and an additional 5 replacement households) were identified.

In the treatment group, the agro trading company (using the abbreviation ATC) makes direct outreach to the preselected household. It offers to buy quality maize at a small premium (compared to local prices). In the first season of buying, the company was active for a relatively short period in the local markets, while in the second (and ongoing season), the
The company has been present for about two months. Potential sellers (farmers) are given mobile phone numbers to representatives of the company, enabling them to contact ATC in case they are willing to sell. The ATC’s representatives also conduct outreach (in person or mostly by phone) to inform farmers about the company’s willingness to buy quality maize (and the price).

For a farmer willing to sell, the ATC’s representative conducts a visual inspection of seller’s maize (often stored in bags) as well as measuring moisture using handheld moisture meter. ATC only buys maize that are deemed as high quality; i.e. maize without defects or waste (e.g. cobs, stones, insects, dirt, broken grains, pest damaged grains, rotten grains, discolored grains, and immature grains) and with a moisture level of at the most 13.5%. If the quality is sufficiently high, the maize is weighted and the farmer is paid in cash.

6.4 Preliminary results

Figure 6 illustrate that the sample is balanced, both across villages and over time. Figures 7 and 8 illustrate some preliminary findings, or effect sizes, mid-way through the experiment.

The preliminary results show and increase in price received and yield, in treatment versus control.

We also document changes in post-harvest activities, such as proper drying and sorting.

And finally an increase in input use.
References


Jack, B. Kelsey. 2013. “Constraints on the adoption of agricultural technologies in developing countries.” Literature review, Agricultural Technology Adoption Initiative, J-PAL (MIT) and CEGA (UC Berkeley).


Figure 1. Returns to quality: prices
Figure 2. Adjustment through deductions rather than price

Kolmogorov–Smirnov test \( H_0: \) Distributions are equal (p-value=0.39)
Figure 3. Quality vs net price $p^* = \frac{p(y-z)}{y}$
Figure 4: Large variations in prices

Self-Reported weekly weighted average
Market price Kampala
Figure 5: Distribution of prices between farmers in a season

Graphs by season
Figure 6: Balance at baseline (with repeated measurement); %-change in T vs C
Figure 7: Effect sizes after 2 seasons

Price

Yield
Figure 8: Effect sizes after 2 seasons

Proper drying (tarpaulin)

Inputs (fertilizer, hybrid seeds)