# Revision memo (manuscript reference: AER-2023-1277)

# **“The (perceived) quality of agricultural technology and its adoption: Experimental evidence from Uganda”**

This revision memo provides a detailed response to the concerns from two reviewers regarding our manuscript “The (perceived) quality of agricultural technology and its adoption: Experimental evidence from Uganda,” initially submitted to the American Economic Review with manuscript reference AER-2023-1277. Text in regular font is the original text from the editor and the two reviewers. Our response is in italic. Indented paragraphs present texts that were inserted into the manuscript.

## **Editor**

Dear Dr. Van Campenhout:

I am writing to you about your AER submission above. I thought that your paper was very promising and so I sent the paper to three very knowledgeable referees, whose reports are below.

I am afraid that I do not have great news to share, as both referees recommend rejection. Both note that it is a well-done experiment, but they both have concerns about the contribution to the literature given what the paper is able to measure. Having read the paper, I agree with the referees, and I will have to pass on the paper. Both referees provide really thoughtful and constructive reports that I hope can be useful to you as you decide on the next steps on the paper. My own read is that the paper may make a very nice fit for a journal such as Review of Economics and Statistics or AEJ: Policy if you are able to address some of the comments of the referees.

Again, I am very very sorry to convey this disappointing news. I thank you for giving us the opportunity to consider your work, and hope that the outcome of this specific submission will not discourage you from the submission of future manuscripts. Good luck with the project!

Sincerely,

Prof. Rema Hanna

Coeditor, American Economic Review

## **Reviewer 1**

This paper is concerned about the low adoption of improved maize seeds sold by agro-dealers. The authors argue that low adoption could be due to agro-dealers not knowing how to store or handle the seeds, or to misperceptions by farmers, thinking that the seeds are of lower quality than in reality. The authors design two interventions to test these two hypotheses: a training of agro-dealers and a rating system about the quality of each agro-dealer disseminated to participating farmers. They find that the training had no effect but that the rating system led to higher take-up of seeds, especially among farmers that were not using improved seeds at baseline.

The paper covers an important topic, but I feel like the treatments could be better motivated, and that sharper tests should be provided for the various mechanisms that could drive the results. In what follows I try to provide suggestions of issues that should be clarified to rule out some pathways.

*We would like to thank the reviewer for the valuable comments and for considering the importance and potential of this study. Our detailed response can be found below.*

### Reviewer 1, major comment 1: Agro-dealer handling and storing of seeds

The paper suggests that agro-dealers are unable to properly store or handle the seeds due to a combination of lack of knowledge and/or poor storage facilities. This claim should be backed by clear evidence. While 65% of agro-dealers had pests and 16% had opened bags in the storage facility, the paper also reports that the amount of maize seed lost/wasted is only a small share of the amount of maize seed sold. There might be under-reporting but agro-dealers, but wastage does not seem to be an issue, prima facie.

*Our hypothesis is indeed that agro-dealers lack knowledge, leading to incorrect seed storage and handling, leading to lower seed quality, leading to lower adoption by farmers. To test this hypothesis, we train random agro-dealers, here the theory of change for this intervention:*

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*And indeed, wastage does not seem to be a major issue, but we do not necessarily agree that a larger reported amount of maize seed lost/wasted is a symptom of incorrect seed storage and handling. Instead, agro-dealers that lack knowledge might not be able to identify seed that should be disposed, might not pay attention to shelf-life, packaging/expiry dates, etc., and sell spoiled seed to farmers, leading to low average wastage.*

*To back our claim that agro-dealer knowledge is lacking by clear evidence and to further motivate our hypothesis as the reviewer requested, we provide baseline information on knowledge in Table A6, which we add to the appendix of the manuscript and here:*

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*We also add the following paragraph:*

*“As these knowledge indices generally mask how much agro-dealers knew at baseline, we provide baseline means and effects on all individual knowledge variables in Appendix A.5. Baseline knowledge is low with only 5% of agro-dealers knowing which variety to recommend if a farmer complains about little rain. They perform best when asked about repackaging seed: 64% of agro-dealers know that this practice should be avoided.*

*We also mention that this lack of agro-dealer knowledge leads to sub-optimal seed storage and handling in two descriptive paragraphs:*

*“Information was also collected to provide an initial assessment of the quality of maize seed sold at the sampled agro-dealers. This included specific questions on seed storage and handling. Furthermore, with the shop manager's permission, enumerators—drawing on training provided to them at the outset of the study—inspected the area where seed was stored and noted the conditions. Baseline data reveals various signs that seed storage and handling are sub-optimal and may affect seed quality in line with the first hypothesis. For example, we find that 65% of agro-dealers had problems with pests such as rats or insects, while 16% store maize seed in open containers, thus exposing the seed to a range of pests and contaminants. Not surprisingly two thirds of the agro-dealers sampled reported that they had received at least one complaint about seed they sold from a customer during the prior season.*

*Turning to the seed samples obtained from the agro-dealers, our measurements of moisture content in the bag indicated an average of 13.6%, with a minimum of 10.3% and a maximum of 17.4%. On average, these moisture rates were above the recommended rate of 13%, suggesting potential for the growth of molds and pests that can negatively affect seed quality and performance. In terms of labeling for quality, 68% of the purchased seed bags contained a printed packaging date, only 18% had an expiry date, and only 8% displayed a quality indication label issued by the National Seed Certification Services (NSCS).”*

Of course, farmers could still be purchasing damaged seeds that will not germinate. To their credit, the authors proceed to purchase one bag of seeds from each agro-dealer and check for its moisture content, finding that the average moisture was higher than the recommended one. We do not know, however, the share of bags above the moisture threshold nor the probability that a bag of seeds with excess moisture will not germinate properly if planted.

*The share of bags above the moisture threshold is 49% at baseline, 35% at midline, and 44% at endline. To address this comment, we added footnote 11:*

*“The life of seed doubles with every 1% reduction in its moisture content.”*

*and the binary variable “Moisture exceeds recommended level (13%)” to Table A1:*

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Related, moisture should presumably be more of an issue for repackaged seeds, that is, seeds sold in smaller bags repackaged by the agro-dealer from the original one manufactured by the seed provider. The paper should be clear about the share of agro-dealers that repackage seeds, whether the seeds purchased at random came from a repackaged bag, and finally, the share of farmers that actually purchase repackaged seeds.

*While we agree with this statement about repackaging, the random bag of seed was never a repackaged one, implying that moisture is also an issue for seeds that have not been repackaged. To clarify this for the reader and to report the share of agro-dealers that repackage seeds, we add footnote 10:*

“*Even though repackaging seed from original larger bags from seed companies into smaller bags to offer quantities that are convenient and affordable to their clients is common (around half of the agro-dealers in our sample report to do so) and dangerous (as important information may be lost and the material used for re-packaging may affect aeration, moisture, and seed viability), enumerators purchased only unopened, i.e., not repackaged bags of seed, to have a comparable sample.”*

Finally, and perhaps more importantly, one reason why the agro-dealer training was ineffective is that agro-dealers were already knowledgeable about how to store and handle seeds. To check that, Table 11 should report the raw score for the different questions that make up the index, since in the current version, both indexes are standardized, and one cannot assess actual knowledge.

*We can confidently eliminate the reviewer’s concern, as the new Table A6 (also above) now reports the raw scores for the different questions in the knowledge indices, showing that agro-dealers were not already knowledgeable about seed storage and handling at baseline.*

### Reviewer 1, major comment 2: Mechanisms

The paper correctly outlines the multiple pathways through which the ratings system could have an effect on purchases of improved seeds. First, the treatment may correct (mis)perceptions about seed quality that farmers have at baseline. Second, the treatment provides information about who the high- quality agro-dealers are, and so treated farmers switch to these agro-dealers after receiving the ratings. Finally, the ratings may increase the average quality by fostering competition across agro-dealers.

The paper tries to provide evidence to distinguish between these different mechanisms, but it should provide additional context and information.

#### Farmer mis-perceptions

To assess if initial mis-perceptions are driving the results, the paper should clarify if, given differences in clime, soil and cultivation practices of the farmer, there is an “optimal” seed variety. (As an aside, in a footnote or appendix the paper should also provide details about the pros and cons of hybrid seeds relative to OPV seeds, and between different varieties of hybrid seeds -Longe7H vs Longe 10H- and OPV seeds -Longe 4vs Longe 5).

If an optimal variety does exists for each farmer, are they aware of it? To address this, the paper should provide farmers’ baseline knowledge about the quality of different seed varieties and the suitability of each to their plots. Do they know, for example, the average yield of each seed variety in their plots given normal weather conditions?

*Farmers in the study area are likely to know that different varieties perform differently in terms of yield and other traits. They are also likely to know that hybrid maize seed is likely to out-perform seed saved from a prior harvest of hybrid maize, and open pollinated varieties of maize.[[1]](#footnote-1) On the other hand, they may not know exactly which hybrid or OPV is most optimal for their specific climatic, farm, or economic conditions. That is because there are important interaction effects between clime, soil, technologies, inputs, and cultivation practices, so that it is difficult for farmers to try out all possible combinations and learn about their optimal seed variety, at least within a reasonable time frame. Furthermore, the optimal choice is a dynamic problem since all these conditions—temperature and precipitation, soil health, input and commodity prices, and household income—change from season to season. If there is little rain in one season, the optimal seed variety might be Wema, if the farmer is late for planting in the next, Myezi mitatu (mm3) might be the better choice. Moreover, farmers may face certain behavioral constraints that inhibit their ability to learn if, for example, they pay attention to minor or tangential attributes and miss the more important ones.[[2]](#footnote-2)*

Related, the paper reports that 2/3 of farmers think that seeds from the agro-dealer are counterfeit or adulterated and use it as evidence of mis-perceptions about seed quality, particularly among farmers that did not purchase improved seeds. It is unclear, however, whether this question asked about seeds in general sold by the agro-dealer or about arguably the more relevant seed variety that the farmer purchased (or would likely purchase if they did not purchase improved seeds). To be clear, perceptions of seed quality should depend on the seed variety used, how they are packaged, the reputation of the seed provider (manufacturer brand) and the reputation of the agro-dealer. For example, if repackaged seeds are of lower quality because of agro-dealer mishandling, a farmer that never purchased repackaged seeds would have different perceptions about seed quality used than a farmer that only purchases repackages seeds.

*While we agree that all this determines farmers’ perceptions of seed quality, this question (“Do you think that maize seed that you can buy at agro-input dealers is counterfeit/adulterated?”) was asked to obtain a general picture of farmers’ perceptions, while the next variable (farmer’s maize seed ratings of agro-dealers within area) is conditional on specific shops. To address this comment, we add the following to the text:*

*“We intentionally asked this question in a general manner, about maize seed that you can buy at any agro-dealer, without specifying the seed variety or agro-dealer, to obtain an overall idea about farmers’ sentiments regarding maize seed at agro-dealers.*

Since agro-dealers appear to stock up different seed varieties (according to Table 6, the mean is 2.8), and presumably some have better protection against droughts, pests and diseases, but are likely more expensive, the single rating given per agro-dealer, will likely mask differences in the type of seeds sold by the agrodealer with differences in the quality of the storage facilities.

In addition, some farmers might be willing to trade-off lower quality for a lower price, and yet pricing is not reflected in the ratings. Finally, ratings are also silent about how seeds were actually sold, whether in the original packages as sold by the manufacturer, or in smaller bags repackaged by the agro-dealer.

*To address this comment, we added footnote 9:*

*“We also asked farmers to rate agro-dealers on general quality, location, price, stock, and reputation, but these dimensions do not contribute to our ratings. Even though some farmers might trade-off lower quality for a lower price, the ratings are supposed to provide indications of quality, not indications of quality relative to price or other dimensions. Other farmers might be willing to trade-off lower quality for a convenient location, but our objective is not to provide a rating that captures every aspect why a farmer might (not) prefer a specific dealer but to make seed quality better observable at the time of purchase.”*

In short, the authors should explain why they decided to use a “generic” ratings system (one rating per agro-dealer), instead of an alternative one that was explicit about the seed variety and how it was sold (i.e. Longe 10H manufactured by X sold by agro-dealer Y in the original package).

*We agree that it would have been ideal to ask farmers to rate agro-dealers conditional on variety (and even on other features like packaging). However, when enumerators asked farmers at baseline to mention all improved maize varieties they knew, the average farmer was aware of 3. At the same time, agro-dealers had 3 varieties in stock on average. These varieties do not necessarily overlap, and even if a farmer has heard of a variety, they are not necessarily able to judge its quality (as they need to have experienced it or know someone who did). Hence, many farmers in our sample are probably unable to rate more than one variety and we would often have none or only 1 observation for “Longe 10H manufactured by X sold by agro-dealer Y in the original package.”*

*This implies that we would have needed a much larger farmer sample to obtain representative variety-specific ratings. We feel that visiting 3470 farmers six times (for 3 rounds of rating collection and dissemination) was already quite challenging, and doubling or tripling our sample size was not feasible in terms of costs and logistics. That is why we assume that the ratings of different varieties at one agro-dealer are correlated instead. To address this comment, we added footnote 10:*

*“We acknowledge that it would have been ideal to ask farmers to rate agro-dealers conditional on variety, but we would have needed a much larger farmer sample to obtain representative variety-specific ratings, which was not feasible in terms of costs and logistics. That is why we assume that the ratings of different varieties at one agro-dealer are correlated instead.”*

*As we were aware of this shortcoming when we designed the experiment and agree that maize varieties differ in seed quality characteristics, we asked many of the rating questions relative to how a particular quality attribute was advertised, see Table 1:*

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#### Agro-dealer quality

To assess if the ratings system identified the agro-dealers of high quality, the paper should clarify the relationship between farmers and agro-dealers. We are told that there are between one and three agro- dealers in each of the study’s catchment areas. With multiple agro-dealers, do farmers purchase seeds from the same agro-dealer every year? Since farmers could tell their peers that the seeds sold by their agro-dealer were of poor quality, it seems like reputational effects could play a role in this context. And if so, is it the reputation of the agro-dealer that matters, or that of the manufacturer of the seeds?

*There are actually between 1 and 18 agro-dealers in a catchment area (with 3 on average). To address this comment, we add descriptive statistics about the relationship between rating farmers and rated agro-dealers:*

*“For the rating system, clearinghouse treated farmers were asked about all (up to 18) agro-dealers in their proximity, leading to a dyadic data set of 12,003 farmer-dealer links at baseline. In 36% of the cases, farmers knew the agro-dealer. Considering only these instances, 19% had bought seed there, 5% knew someone who did, and the remaining 76% were not allowed to rate. This implies that reputational effects could play a role but should not drive the results. Farmers who bought seed at an agro-shop report to have been customers for 4.6 years on average (with a minimum of 0 and a maximum of 35 years), and 44% bought seed there in the previous season.”*

Related, seed characteristics such as germination time, yield, resistance against droughts, pests and diseases and duration relate to the quality of the product made by the manufacturer, so long as the maize is properly stored. In this sense, knowing that a given agro-dealer carries seeds from a particular manufacturer, and that seeds have not been repackaged should be enough to convince farmers of the quality of the seeds.

*We agree that seed quality is not the agro-dealer’s responsibility alone. If the manufacturer provides seed of low quality and the dealer sells it without being aware, our clearinghouse could solve another information asymmetry by informing the dealer about this surprisingly low quality.*

*On the other hand, we suspect that seeds being a) from a manufacturer with a good reputation and b) in the original package are insufficient signals for quality. Otherwise, farmers would simply need to pay attention to these two dimensions (and there is only a limited number of seed manufactures), seed quality would be better observable, the lemon’s problem would be less significant, and our clearinghouse would indeed have less use. Instead, in our sample of random* ***not repackaged*** *seed bags, the average moisture is above 13%. This result is in line with the literature showing that deterioration in maize seed quality is consistent with mishandling and poor storage, instead of with repacking as a bad practice alone.[[3]](#footnote-3)*

*Robert: If it is the reputation of the dealer and not the manufacturer, then we would expect some variation in ratings within catchment areas. Can we assess this?*

More broadly, the paper should report how well farmers knew the number of agro-dealers operating in their catchment area and their quality at baseline. Since knowledgeable treated farmers should not switch agro-dealers, the degree to which farmers are knowledgeable at baseline, can inform the likelihood of switching. In addition, it should make the result that the increase in the number of clients and in the usage of improved seeds is the result of the ratings (and not of the dissemination telling farmers about the existence of agro-dealers) more credible.

*As reported above, farmers knew an agro-dealer in their proximity in 36% of the cases. However, we are confident that farmers switch due to the ratings, not because the clearinghouse treatment informed them about the existence of agro-dealers, as we address in the manuscript:*

*“A potential concern arises from asking treated farmers to rate agro-dealers because it may increase awareness among farmers of the existence of all agro-dealers in the area, so that this awareness effect could confound the clearinghouse effect. To address this concern, we also iterated through the agro-dealers in the catchment areas with farmers in the control group to make them similarly aware of the existence of agro-dealers in their vicinity.*

*[…]*

*To isolate the effect of the ratings from more general effects that may arise from sending SMS messages, we also use a placebo for the control group that consisted of an "empty" SMS that only pointed out the existence of the agro-dealers in the control farmer's catchment area. This also makes it more difficult for farmers to identify if they are being treated or not, thus reducing the likelihood of reactivity effects and experimenter bias.”*

As an aside, I’d be curious to learn whether treated farmers were more accurate about the quality of agro-dealers over time and in general whether there was a lot of intra-market differences in quality.

*Here some descriptive statistics regarding moisture (as our quality proxy) and quality perceptions:*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Moisture in bag of maize seed in %** | | | | | | |
| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |  |
| Baseline: | | | | | | |
| 10.30 | 12.50 | 13.10 | 13.58 | 14.50 | 17.40 | A graph of a function  Description automatically generated |
| Midline: | | | | | | |
| 10.80 | 12.40 | 12.80 | 12.97 | 13.30 | 17.20 | A graph of a number of objects  Description automatically generated with medium confidence |
| Endline: | | | | | | |
| 11.00 | 12.40 | 12.80 | 13.26 | 13.70 | 18.20 | A graph of a line  Description automatically generated |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Agro-dealer ratings** | | | | | | |
| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |  |
| Baseline: | | | | | | |
| 2.000 | 3.238 | 3.440 | 3.428 | 3.643 | 5.000 | A graph of a graph  Description automatically generated |
| Midline: | | | | | | |
| 2.000 | 3.357 | 3.595 | 3.581 | 3.789 | 4.667 | A graph of a function  Description automatically generated |
| Endline: | | | | | | |
| 2.429 | 3.443 | 3.629 | 3.634 | 3.841 | 4.714 | A graph of a function  Description automatically generated |

#### Competition

The authors see an increase in registrations of treated agro-dealers with UNADA (the association of agro-dealers, as well as a significant increase in inspections. Do farmers value that agro-dealers are registered with UNADA? Do they know which agro-dealer is registered and who is not? Do they rate agro-dealers that are registered higher? Finally, did the ratings system lead to the opening of new agro- dealers in the catchment area?

### Differential attrition

The authors report differential attrition, perhaps due to a larger share of control agro-dealers going out of business and then go on to conjecture that the unadjusted estimates likely provide lower bounds because the attritors are likely the ones that would have benefited the most from the treatment. I have two comments on this issue. First, the authors should check this claim using existing data. How do the characteristics of attritors in the control group compare to treated agro-dealers that benefit the most from treatment? And to those of treated agro-dealers that benefit the least?

Second, the literature suggests different methods to deal with differential attrition. One is to construct bounds following Lee (2009).

### Other Comments

1. Table 4 should also report the number of maize varieties in stock, since this outcome variable appears in Table 6.
2. A rough back of the envelope calculation from Tables 6-8 suggests that 56% of revenues come from sales of Longe 10H while 41% from Longe 5 leaving the remaining 3% of revenues from the sale of the other two varieties… Is this true?
3. Table 6-8 could be run as a pooled regression, adding a dummy for whether data was collected at endline, as well as interactions with the treatment dummies. The midline and endline coefficients from this pooled regression could still be reported separately, but standard errors should be smaller given the larger number of observations in the pooled regression.
4. Related, when reporting the treatment effects on individual variables, the authors should also include the standard errors computed using multiple hypothesis testing corrections (see for example List et al. 2019).
5. Table 12 suggests that agro-dealers put more effort as they become more aware of the rating system. However, the ratings system only increases agro-dealer effort and services at midline and not at endline. Why? Should not the impacts be amplified over time? Or are agro-dealers able to make all the improvements by midline?
6. The paper states that rating system led to an increase in the number of customers. Is this increase fully accounted for by study participants or did it come from other individuals outside the experiment? Put differently, were ratings shared among farmers in treated catchment areas?
7. It would be interesting to check if treated farmers were less likely to buy repackaged bags, (ie smaller quantities of seeds from opened bags)
8. Feel free to ignore this comment, but I’m not a fan of the label clearinghouse for the ratings treatment, in part because clearinghouse refers to an institution that collects and disseminates information. The paper collects ratings and sends SMS with those ratings to participating farmers, but it does not create an institution or mechanism that can continue beyond the duration of the study. I would simply refer to the treatment as “ratings”.
9. There are several typos throughout the paper so it would benefit from a review by a copy editor.

### References

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