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Buyers' Response to Third-Party Quality Certification

Theory and Evidence from Ethiopian Wheat Traders

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Notices

Abstract

When quality attributes of a product are not directly observable, third-party certification (TPC) enables buyers to purchase the quality they are most interested in and reward sellers accordingly. Beyond product characteristics, buyers' use of TPC services also depends on market conditions. We study the introduction of TPC in typical smallholder-based agriculture value chains of low-income countries, where traders must aggregate products from many small-scale producers before selling in bulk to downstream processors, and where introduction of TPC services has oftentimes failed. We develop a theoretical model identifying how different market conditions affect traders' choice to purchase quality-certified output from farmers. Using a purposefully designed lab-in-the-field experiment with rural wheat traders in Ethiopia, we find mixed support for the model's prediction: traders' willingness to specialize in certified output does increase with the share of certified wheat in the market, and this effect is stronger in larger markets. It, however, does not decrease with the quality of uncertified wheat in the market. We further analyze conditions where traders deviate from the theoretically optimal behavior and discuss implications for future research and public policies seeking to promote TPC in smallholder-based food value-chains.

Keywords: Market failure, Quality, Certification, Agriculture, Smallholders.

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1. Introduction

When markets fail to reward non-observable quality attributes of products, a well-known market solution is to introduce third-party quality certification services (TPC) (Akerlof, 1970; Viscusi, 1978). TPC can emerge endogenously if some sellers are willing to have their products graded and certified, further encouraging others through "unraveling effects". TPC may however be opposed by producers or buyers concerned with the distributional consequences of more transparent markets for quality, or for lack of trust in TPC operators (Abate et al., 2021; Dranove and Jin, 2010). In this paper, we further study the emergence of TPC as a coordination issues: when both buyers and sellers can expect positive returns from quality certification but one's return to using TPC services are conditioned by others' use of these services.

We focus on food value chains in low-income countries, where markets often fail to reward quality attributes of food products that are not observable to the naked eye (e.g., flour extraction rate, moisture level, protein content, pesticides residues, aflatoxin contamination), and where TPC services are seldomly available to the mostly small-scale domestic farmers (Abate et al., 2021). In these value chains, domestic food products must increasingly compete with imports to satisfy the demand for quality crops of a growing urban middle class. This evolution can have large consequences on domestic food production, depending on whether farmers are able to satisfy quality requirements and whether they are rewarded for their investments in quality-improving inputs and practices (Bai, 2024; Barrett et al., 2022; Cockx et al., 2018; Demont and Ndour, 2015; Treurniet, 2021).

Our analysis builds on a generic description of rural food product markets where small-scale farmers sell most of their products to local traders.[1] On the supply side, farmers tend to produce lower-than-possible quality output despite costly but readily available quality-improving technologies and practices such as better seeds and fertilizers, or improved farm management, cleaning, and storage practices (Abate and Bernard, 2017; Bernard et al., 2017; Bold et al., 2022; Deutschmann et al., 2021; Magnan et al., 2021). The absence of TPC services and the resulting lack of price premiums for higher quality

[1]Rural markets remain the main outlet for small-scale producers to sell their outputs. Apart from specific export or specialty products, only a limited fraction is sold through cooperatives, contracts or a combination of both. For instance, the vast majority of Senegalese onions, Ugandan maize, Ethiopian wheat, and Senegalese groundnuts are sold to rural traders (Abate and Bernard, 2017; Bernard et al., 2017; Bold et al., 2022; Deutschmann et al., 2021)

products on these markets contribute to this situation (Abate and Bernard, 2017; Do Nascimento Miguel, 2022). As evidence shows, farmers are willing to pay fees for such services and they do increase their investments towards quality-improvements of their crops when reliable quality measurements exist and they expect traders to reward higher quality products (e.g., Anissa et al., 2021; Bernard et al., 2017; Bold et al., 2022; Magnan et al., 2021). On the demand side, a key feature of these markets is that local traders act as aggregators, purchasing products from several small-scale producers before selling in bulk to downstream wholesalers or processors who usually measure and value non-directly observable quality attributes (Do Nascimento Miguel, 2022). When TPC services are available and used by some local farmers, traders can either: ignore the certification and offer a price based on average quality; buy some certified products at a limited premium and mix it with non-certified ones to increase the average quality of the bulk; or deliberately source and reward certified product and incur a fixed cost to keep it separate (for instance through separate trucks) in order to secure significantly higher prices from their downstream buyers.

This situation lends itself to coordination issues regarding the use of TPC services, as two distinct but stable equilibriums are possible: (i) a "low-quality equilibrium" where farmers offer low-quality outputs because they expect traders to offer a price based on average quality, and traders make no effort to sort products based on certified quality because they expect most farmers to offer low-quality outputs; and (ii) a "high-quality equilibrium" where farmers expect traders to reward high-quality outputs (so they invest in producing high quality) and traders expect many farmers to offer certified high-quality outputs, so it is worthwhile to incur a fixed cost to keep flows of certified and uncertified outputs separate. Therefore, farmers' and traders' expectations about the behavior of others determine outcomes. Both equilibriums can emerge as self-fulfilling prophecies where expectations are confirmed and behavior is reproduced over time. Moving from a lower-quality/no-certification equilibrium to a higher-quality/certification one requires —possibly temporary —external interventions that simultaneously ensure traders and farmers of the others' effective reliance on TPC services.

In this paper, we do not consider the full system, but only look at trader expectations and choices —complementing earlier work that focuses on farmer decisions (e.g., Anissa et al., 2021; Bernard et al., 2017). We develop a theoretical model focusing on how traders' expectations with respect to the quantity of certified output to be supplied by farmers affect their willingness to incur the fixed cost to keep certified and uncertified crops separate, and pay a premium for certified output. The model shows that increasing the share of certified output supplied by producers (weakly) raises the probability that a trader incurs the fixed cost. This effect is however mediated by key market characteristics, such as the size of the market and the average quality level of non-certified products.[2]

The model yields clear predictions, that can be empirically tested in the field (across a large sample of markets with exogenous variations in the share of farmers selling certified output and in the quality of uncertified crops) or in an experimental setting. We rely on a purposefully designed lab-in-the-field experiment with 178 wheat traders from rural Ethiopian wheat markets.[3] The experiment mimicked traders' daily activities where they seek to purchase a certain quantity of outputs from farmers who visit their shop in sequence. Ahead of each round, we provided them with new information regarding the share of farmers selling certified higher-quality output and the share selling non-certified (i.e., non-observable) higher vs lower quality output in the market, along with the maximum number of farmers who will visit their shop that day (as a proxy for market size). Before starting their purchases, traders had to decide whether to incur a fixed cost enabling them to derive a larger price premium from the certified output that they would secure.

Our empirical results provide mixed support for the theoretical predictions. Consistent with the theory, trader expectations about the share of certified crops that they can secure shapes their intermediation decisions. For example, fewer traders are willing to incur a fixed cost to keep certified output separate if the market-level share of certified output is small, and more traders incur the fixed cost as this share increases. This effect is more pronounced in larger markets where traders can choose their purchases out of a larger set of farmers who visit them. In addition, while the theory predicts that for a given share of certified output in the market traders should not incur the fixed cost when the share of non-certified higher quality output increases, we find that it does

[2]Other market characteristics that may also condition these effects are not addressed in this paper. In particular, market-level competition can affect the pass-through of quality-related price premiums along the value chain and ultimately affect traders' willingness to invest in the sourcing of quality certified outputs (Bergquist and Dinerstein, 2020; Bulte et al., 2024; Casaburi and Reed, 2022; Dillon and Dambro, 2017).

[3]Our experiment focuses on local wheat value chain partly because wheat markets are largely segmented by location and imported wheat are often directly channeled (rationed) to millers with limited/no involvement by local traders.

not significantly affect traders decision. Last, we find that a large number of traders, regardless of their investment decisions, failed to adopt a simple rule governing which units of output to accept and which ones to reject, resulting in sub-optimal profit levels.

Our work contributes to the literature in three ways. First, the evidence in this paper supports the idea that coordination failures can be a plausible explanation for the lack of TPC services and the resulting low-quality of products supplied in local crops value chains of low-income countries. Bold et al. (2022) focus on farmers' expectations with respect to traders' demand, and we focus on traders' expectations with respect to farmers' supply. From a policy perspective, our findings support the idea that a strong-enough initial support to farmers' use of certification services may affect traders' decisions to use and sustainably rely on such services. Therefore, initiating a process of modernization and integration of smallholders in remunerative value chains need institutional solutions, in addition to technical ones.

Second, this paper contributes to an emerging body of literature on the role of local market conditions in technology adoption. While existing works suggest that several constraints restrict farmers' ability to exploit market opportunities and adopt profitable technology (e.g., Bellemare et al., 2022; de Janvry and Sadoulet, 2020; Deutschmann et al., 2021; Karlan et al., 2014; Magruder, 2018; Suri and Udry, 2022), much less is known about constraints traders may face. We show that coordination failures along the value-chain is an important constraint preventing technology adoption. Our contribution is to offer a case study of individual-level TPC services which might support coordination across actors of the value chains and foster value creation. Specifically, we document that such services are unlikely to endogenously emerge as market-mediated solutions under specific conditions (e.g., thin-markets) and that many traders are currently unable to respond optimally to opportunities provided by TPC services.

Third, this paper also speaks to a broad literature on the role of fixed costs in production (Banerjee et al., 2019; Bassi et al., 2022; Foster and Rosenzweig, 2022). Relying on a lab-in-the-field experiment allows us to document direct evidence that further encouraging technology adopting at scale may overcome fixed costs constraints local traders are facing and to engage in new trading opportunities provided by TPC systems.

The paper is organized as follows. In section 2 we briefly sketch the context of Ethiopian wheat markets and value chains. In section 3 we set up a simple model of trader behavior and show how expectations affect intermediation modalities. Section 4 outlines the lab-in-the-field experiment, the data and the empirical strategy, followed by the results in Section 5. The conclusions and discussion ensue.

2. Context: Ethiopian wheat value chain

Wheat is one of the most important crops in Ethiopia, where it is cultivated by more than 5 million small-scale farmers catering to a fast-increasing demand fueled by urban growth and changes in food habits (Minot et al., 2019; Shiferaw et al., 2014; Worku et al., 2017). Ethiopian producers have so far been unable to effectively respond to this growing demand —particularly in terms of quality —and about one-third of national consumption depends on imports. Following recent disruptions and shortages in the global wheat value supply (e.g., the COVID-19 pandemic, Ukrainian war), the Ethiopian government has intensified its efforts to reach wheat self-sufficiency.

In the Ethiopian wheat value-chain, many wheat farmers do not appear to sell any of their wheat output, and only about 10% sell more than half of their yearly production (Minot et al., 2019). Most farmers who do engage in the wheat trade supply sell in very small quantities (i.e., about 50kg per transaction), typically to local wheat traders on weekly local markets (Abate and Bernard, 2017). Local traders bulk and mix the output from several farmers, and supply mixed quality wheat onwards to larger traders, wholesalers, millers or retailers. Supply of high-quality wheat is common and represents around 25% of the total supply. Importantly, local traders typically pay a nearly uniform market-day price, and only make slight adjustments based on easily observable attributes such as grain size, color, and impurity level (Do Nascimento Miguel, 2022). Returns to important unobservable quality parameters, such as the flour extraction rate (hectoliter mass) and protein content that are in high demand by downstream actors, are typically absent in local wheat markets, as these unobservable quality attributes correlate only weakly with observable ones (Anissa et al., 2021; Do Nascimento Miguel, 2022). The lack of market institutions is a key impeding factor. In particular, TPC services have not been developed for local-level wheat markets, which increases the costs of transacting throughout the value chain (Gabre-Madhin and Goggin, 2005) and precludes a system of price premiums that incentivizes quality production.

Characteristics of local-level Ethiopian wheat markets however offer a supportive context for the existence of TPC services. Abate et al. (2021) argue that four conditions must hold for successfully implementing a TPC system. First, downstream agents (e.g., millers) must be willing to pay a premium for improved quality. This condition holds in the Ethiopian wheat value chain, where millers appear willing to pay a 6 percent price premium for high-quality wheat (Anissa et al., 2021). Second, farmers should be able to improve crop quality in response to certification. Ethiopian wheat farmers are quick to adopt practices that improve output quality if new market opportunities open up (Anissa et al., 2021; Zörb et al., 2018). Third, farmers must perceive certification services as credible and be willing to pay a fee. Abate and Bernard (2017) and Anissa et al. (2021) provide evidence of positive willingness to pay for TPC services by Ethiopian farmers. Fourth, farmers should be rewarded for quality production. This means there should be sufficient competition between traders to pass part of the quality premium through to farmers. Local Ethiopian wheat markets indeed appear fairly competitive (Bulte et al., 2024).

Field observations however suggest that for TPC to benefit traders, the latter should abstain from their current bulking and mixing of farmers' products, and instead keep high-quality certified crops separate from uncertified ones. Maintaining certified and non-certified crops separate however implies additional investments into physical capital such as trucks or storage facilities. In addition, shifting from bulk and mix to keeping output flows separate is gradual, and this transitory stage also involves extra costs for traders. In that phase, traders sell certified and uncertified crops to different buyers, yielding additional expenses at each step of the transaction process (e.g., testing, bagging) and raising transaction costs. Lastly, mental and cognitive costs are associated with keeping records of what traders should purchase. For instance, they have to work more carefully to preserve certified output labels, train their employees in new methods, and create and sustain relationships with different buyers and sellers. Thus, the price premium that most downstream value chain agents are willing to pay for quality-certified crops must be high enough to cover such costs and to reward all upstream agents.

3. Theory

In this section, we build on the Ethiopian wheat markets context described above to develop a theoretical framework showing that traders' expectations regarding the share of quality-certified output supplied on local markets determine their strategies to keep certified and uncertified output separately. The trader has to decide whether or not to incur a fixed cost to keep certified and non-certified output separate, and (conditional on the earlier decision) which units of output to accept and which ones to reject.

3.1. A model of trader behavior

Traders aggregate the output of smallholder farmers, and transport it to the next node in the value chain —typically millers —who pay a premium for high-quality crops. To receive such a price premium, traders could source quality-certified wheat, and keep it physically separate from uncertified wheat. For uncertified wheat, millers pay a price corresponding to the wheat average quality. In what follows we assume that an intermediation strategy that involves keeping certified and uncertified wheat separate involves a fixed cost F for the trader.

During a market day, traders meet up to T farmers who are willing to sell a unit quantity of their crop. We interpret T as a measure of market size. Traders can accept a maximum of $Z \leq T$ offers to fill up their truck. We assume that there are two qualities of wheat: high and low. Individual farmers can choose to grade and certify their high quality crop at some cost. Parameter $\pi \in [0;1]$ represents the share of certified wheat in the market, parameter $\theta \in [0;1]$ the share of high-quality in the uncertified wheat. The share $(1-\pi)\theta + \pi$ of wheat is thus of high quality.[4] Consistent with the situation on actual wheat markets in Ethiopia we assume that key dimensions of wheat quality are unobservable to the trader (notably the flour extraction rate). Traders struggle to distinguish between low- and high-quality crops if that crop is not certified, and therefore pay the same price for uncertified wheat, regardless of its quality. They subsequently bulk and mix the uncertified wheat.

We assume that local markets are fairly competitive (Bulte et al., 2024; Casaburi and Reed, 2022; Dillon and Dambro, 2017), hence traders take prices as given. Let p^u (p^c) be the price paid for uncertified (certified) wheat by the trader to the farmer (with $p^c > p^u$). The next node in the value chain are millers, who are able to verify the quality of the crop supplied to them. Millers are willing to pay a premium for high-quality wheat in general, including for certified wheat. Let P^C be the price paid for certified wheat by the miller to the trader (where $P^C > p^c$), and P^U the price paid for uncertified wheat

[4]Conversely, the share $(1-\pi)(1-\theta)$ of supplied wheat is uncertified and of low qulaity.

(with $P^U > p^u$). P^U is increasing in average quality. Define $P^U = a + bh$, where a is the price traders receive for uncertified low-quality output, b is the quality premium, and h is the share of high-quality output (certified or uncertified) in this mix. Hence, the price per unit a trader expects to receive is $E(P^u) = a + b\theta$ if she only buys and sells uncertified wheat, where E is the expectations operator.[5]

We make two additional assumptions. First, $(P^C - p^c) > a + b\theta - p^u$, after paying the (sunk) fixed cost, traders prefer to trade certified wheat rather than uncertified wheat. Observe that if this assumption would not hold, no trader would ever incur the fixed cost F.[6] Second, traders who did not pay the fixed cost F and cannot keep certified and uncertified flows separate prefer to purchase uncertified crop: $(p^c - p^u) > b(1-\theta)$. These traders can however, still buy certified wheat to mix in with their other crop and "fill their truck" if there is no uncertified wheat for them to buy: $(P^U - p^c) > 0$.

The trader's problem involves two steps: (i) whether or not to incur the fixed cost F to maintain a separate flow of certified output, and (ii) which units of crop supply to accept and which ones to reject on a trading day. This problem is solved through backward induction. Using an optimal accept-reject strategy, traders compute the expected profits with and without separate flows. Given these outcomes, she decides to incur the fixed cost or not. If expected profits with separate flows are greater than expected profits of a bulking and mixing strategy, then the trader pays F.

3.2. Purchasing crops after paying the fixed cost

Consider first the case when the trader has paid the fixed cost that allows her to keep certified and uncertified wheat separate. The decision rule applied by the trader follows immediately from the assumption that the marginal return from buying certified wheat is higher than uncertified wheat. Traders should thus accept all certified wheat and reject all uncertified wheat, until they encounter farmer number N. Farmer N is the farmer after which the number of remaining encounters $(T - N)$ with farmers on that

[5] Millers may pay a premium for high quality produce because they seek to incentivize traders to prioritize high quality output (which rests on the assumption that the correlation between observable and unobservable attributes of high-quality wheat is not zero), or because there is competition between millers for traders who "shop around" for a good offer.

[6] For example, assume that millers can verify crop quality at cost v, and offer the same price for uniform high-quality uncertified output (if θ=1) as for certified output but deduct the verification cost: $a + b = P^C - v$. Then the assumption is satisfied if $v > p^c - p^u$.

day is equal to the remaining space available on the truck. From farmer N onwards, the trader should buy all wheat offered (but keep the certified and uncertified separate). Observe that after N encounters, the trader expects to have obtained πN units of certified output, leaving $Z - \pi N$ slots to fill on the truck while there are $T - N$ encounters left. Critical farmer N is thus defined by $T - N = Z - \pi N$, or:

$$N = \frac{T-Z}{1-\pi} \tag{1}$$

Define $E(C)$ as the expected number of certified units that a trader can obtain and $E(U) = Z - E(C)$ as the expected number of uncertified units. If the share of certified output offered on the market is sufficiently high, $\pi > \frac{Z}{T}$, then the trader expects to only accept certified units, so that $E(C) = Z$ and $E(U) = 0$. Trader profits amount to:

$$\Pi^{fc} = Z(P^C - p^c) - F \tag{2}$$

Instead, if $\pi < \frac{Z}{T}$, then the trader expects to buy both certified and uncertified units (which are to be sold separately):

$$E(C) = \pi N + (T-N)\pi = \pi T \tag{3a}$$

$$E(U) = (T-N)(1-\pi) = Z - \pi T \tag{3b}$$

For traders managing two flows of output, with different quality levels, expected profits are:

$$\Pi^{fc} = \pi T(P^c - p^c) + (Z - \pi T)(a + b\theta - p^u) - F \tag{4}$$

3.3. Purchasing crops without paying the fixed cost

Consider now the case when the trader has not paid the fixed cost. Since the extra cost of purchasing certified wheat is greater than the benefit brought by its contribution to increasing the quality of mixed wheat, traders who did not pay the fixed cost (and must mix the crops they buy) should accept all uncertified wheat, and reject all certified wheat until they encounter farmer M. Farmer M is the farmer after which the number of remaining encounters, $T - M$, equals the number of remaining empty units on the (rented) truck. After farmer M, the trader should buy all crops offered by the farmers that they meet that trading day. After M encounters, the number of remaining slots on the truck is equal to $Z - M(1-\pi)$ and the remaining number of encounters equals

$T - M$. Equating these two expressions yields an expression for critical farmer M:

$$M = \frac{T - Z}{\pi} \tag{5}$$

If $\pi \leq 1 - \frac{Z}{T}$ then the trader expects to purchase only uncertified wheat: $E(C) = 0$ and $E(U) = Z$. Trader profits are

$$\Pi^{nfc} = Z(a + b\theta - p^u) \tag{6}$$

If $\pi > 1 - \frac{Z}{T}$, the trader expects to buy both certified and uncertified wheat, and mix them, with certified wheat increasing the quality of the mix:

$$E(U) = T(1 - \pi) \tag{7a}$$

$$E(C) = (T - M)\pi = Z - (1 - \pi)T \tag{7b}$$

Expected profits are then:

$$\Pi^{nfc} = T(1 - \pi)(a + b\theta - p^u) + \{Z - (1 - \pi)T\}(a + b - p^c) \tag{8}$$

3.4. Paying the fixed cost, or not?

To decide whether it is profitable to pay the fixed cost and keep certified and uncertified crops separate, the trader compares expected profits Π^{fc} and Π^{nfc} of the two trading strategies, as defined above. This comparison gives rise to four cases, depending on the size of the local market (whether T is larger or smaller than $2Z$) and the share of the certified wheat π relative to $\frac{Z}{T}$ and $1 - \frac{Z}{T}$.

First consider large local markets, where $T > 2Z$, i.e., $\frac{Z}{T} < 1 - \frac{Z}{T}$. The comparison of Π^{fc} and Π^{nfc} define three cases depending on the value of π. The solution is represented in Figure 1. To ease notation, we define $\Delta = P^C - p^c - (a + b\theta - p^u)$, which is the differential marginal return from buying and selling certified rather than uncertified wheat. This margin Δ is decreasing in θ, the proportion of high-quality wheat among non-certified crops offered by farmers.

Case 1. $\pi < \dfrac{Z}{T}$.

Traders expected profits are given by equation (4) if they pay the fixed cost and by equation (6) if they don't. Subtracting these two equations yields the following differential profit from buying and selling certified wheat:

$$\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = \pi T \Delta - F \tag{9}$$

This net profit is increasing in π and decreasing in θ. Incurring the fixed cost F and keeping certified and uncertified crop separate is a profitable strategy for traders, $\Delta^{fc} > 0$, if $\theta < \theta^* = \frac{1}{b}(P^c - p^c - a + p^u - \frac{F}{\pi T})$. The function $\theta^*(\pi)$ is the segment AB on Figure 1.

Case 2. $\frac{Z}{T} < \pi < 1 - \frac{Z}{T}$.

Traders expected profits are given by equations (2) and (6). Subtracting these yields:

$$\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = Z\Delta - F \tag{10}$$

Hence $\Delta^{fc} > 0$ if $\theta < \theta^* = \frac{1}{b}(P^c - p^c - a + p^u - \frac{F}{Z})$. This term is independent of π and represented by the horizontal segment BC on Figure 1. This net profit is decreasing in θ.

Case 3. $\pi > 1 - \frac{Z}{T}$.

Traders expected profits are given by equations (2) and (8). Subtracting these yields:

$$\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = Z(P^c - (a+b)) - (1-\pi)T(p^c - p^u - b(1-\theta)) - F \tag{11}$$

Hence $\Delta^{fc} > 0$, if $\theta < \theta^* = 1 + \frac{Z(P^C - a - b) - F}{b(1-\pi)T} - \frac{p^c - p^u}{b}$. This is the segment CD in Figure 1. This net profit is increasing in π and decreasing in θ.

Taking these cases together shows that the net benefit from keeping certified and non certified wheat separately is (weakly) increasing in the share of certified supply, π, and decreasing in the share of high-quality in uncertified supply, θ. It is positive and traders will incur the fixed cost for values of θ and π that are below and to the right of the line $\theta^*(\pi)$ on Figure 1. It is negative and traders do not incur the fixed costs for values above and to the left of the line.

Recall that once traders have decided to pay the fixed cost, their objective is to maximize the quantity of certified crops purchased. In the case where the share of certified output offered on the market is sufficiently high, $\pi > \frac{Z}{T}$, we can thus expect them to never reach farmer N of section 3.2 and fully specialize in certified crops (area below and to the right of EBCD in Figure 1). In contrast, if $\pi < \frac{Z}{T}$ they are expected to have to buy both certified and non certified crops to fill in their load, albeit keeping them separate (area ABE). Symmetrically, when traders have not payed the fixed cost (in the area above the $\theta^*(\pi)$ line in figure 1, their objective is to maximize the quantity of uncertified crops purchased. Traders are expected to specialized in non-certified crops where the share of certified output offered on the market is sufficiently low, $\pi < 1 - \frac{Z}{T}$ (area to the right and above ABCG), but they would buy both certified and uncertified if the share π is very high (area GCD).

The larger the market the further apart are $\frac{Z}{T}$ and $1 - \frac{Z}{T}$. Hence the areas of specialized intermediation in a unique type of output increase. The intuition is that in large markets traders can expect to interact with many farmers, so they can more easily decide *not* to trade with specific farmers (to save space in their truck for more profitable output).

Next, we turn to the case of a "small market" where $T < 2Z$, i.e., $1 - \frac{Z}{T} < \frac{Z}{T}$. The comparisons of Π^{fc} and Π^{nfc} for $\pi < 1 - \frac{Z}{T}$ and $\pi > \frac{Z}{T}$ are the same as under case 1 and case 3 above. We encounter a new situation for $1 - \frac{Z}{T} < \pi < \frac{Z}{T}$.

Case 4. $1 - \dfrac{Z}{T} < \pi < \dfrac{Z}{T}$

Traders expected profits are given by equations (4) and (8). Subtracting these yields:

$$\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = \pi T \Delta + (Z - (1-\pi)T)(p^c - p^u - b(1-\theta)) - F \tag{12}$$

Hence $\Delta^{fc} > 0$, if $\theta < \theta^*(\pi) = 1 + \frac{\pi T(P^C - a - b) - F}{b(T-Z)} - \frac{p^c - p^u}{b}$, an increasing function of π. This is the segment AB in Figure 2.[7] This net profit is increasing in π and decreasing in θ.

Like in the large market, the traders will incur the fixed cost for values of θ and π below the line $\theta^*(\pi)$, and don't incur the fixed costs for values above and to the left of the line. A major difference with case 2 of the large market is that they can't expect to be specializing in that middle range values of π. As their purchase objective Z is larger than either the expected quantity of certified crop (πT) and of non-certified crop ($(1-\pi)T$)

[7] With the values we use in the experimental game and to draw Figure 1, $\theta^*(1 - \frac{Z}{T}) < 0$ and $\theta^*(\frac{Z}{T}) > 1$

they will encounter, traders have to accept both certified and non certified crops to fill their truck, keeping them separate if $\theta < \theta^*(\pi)$, and mixing them if $\theta > \theta^*(\pi)$.

While we defined the frontier between incurring or not the fixed cost as the function $\theta^*(\pi)$, this function is monotonic and hence one can just as well define it as $\pi^*(\theta)$. This gives a fairly intuitive proposition that summarizes the results of the model as follows.

Proposition 1. Traders should invest in intermediation modalities that keep certified and uncertified output separate if $\pi > \pi^*(\theta)$, but not if $\pi < \pi^*(\theta)$.

The intuition is simple: to re-coup their fixed costs, traders need a minimum supply of certified output. Since they earn an extra margin per unit of certified crop bought and sold (compared to trading high quality output), traders will keep certified and uncertified output separate if they expect to encounter a sufficiently large number of farmers supplying certified output.

Corollary 1. In production areas where a sufficient number of farmers produce high-quality crop output, $\theta > \theta^*(\pi)$, traders should not invest in intermediation modalities that keep certified and uncertified output separate —they should bulk and mix output to maximize their profits.

Next, we examine how traders' decisions very with the market size (see Appendix A.1 for a detailed demonstration). Consider two markets of size T^L and T^S, with $T^L > T^S$. If both are 'large' markets, as defined above, $2Z < T^S < T^L$, using equations 9-11, one can show that Δ^{fc} is weakly larger in the larger market for $\pi < 1 - \frac{Z}{T^S}$, but lower beyond that value. If both are small markets, the comparison shows that if $\Delta > (a + b\theta - p^u) - (a + b - p^c)$, meaning that the marginal benefit of specializing in the trading of only certified output exceeds that of specializing in the trading of only uncertified output, Δ^{fc} increases with market size for all $\pi \leq 0.5$. Finally, if $T^S < 2Z < T^L$, corresponding to one small and one large market, one can show that Δ^{fc} is larger in the larger market for $\pi < \max(\frac{Z}{T^L}, 1 - \frac{Z}{T^S})$, but not beyond $\max(\frac{Z}{T^S}, 1 - \frac{Z}{T^L})$. Taken together these results can be summarized as follows:

Proposition 2. Returns to investing in intermediation modalities that keep certified and certified output separate increase with market size as long as the share of certified output $\pi \leq 0.5$, and $\Delta > (a + b\theta - p^u) - (a + b - p^c)$.

The intuition is as follows: When the supply of certified output is low, it is easier for traders to re-coup their fixed cost in larger markets.

The model generates three important predictions that can be empirically tested in the field (across a large sample of markets with variation in the share of farmers selling certified output and in the quality of uncertified crops) or in an experimental setting. In this paper, we use a lab-in-the-field experiment with Ethiopian wheat traders to test the following three predictions:

1. All else equal, increasing the share of certified output (weakly) increases the probability that a trader incurs a fixed cost to keep certified and uncertified output separate.
2. All else equal, increasing the share of high-quality crop in uncertified output increases the probability that a trader bulk and mix uncertified and certified output
3. Under conditions that the net benefit of specializing in trading only certified output exceeds that of specializing in trading only uncertified output, the probability that a trader incurs a fixed cost to keep certified and uncertified output separate increases with market size for $\pi \leq 0.5$.

We have developed and solved a "partial equilibrium" model of trader behavior that takes the quality of crop supply and certification status as given and does not capture the reverse direction of causality —how farmer expectations with respect to intermediation strategies chosen by traders affect production and certification decisions of farmers. Obviously, this relation is important in any "full model" of rural intermediation. Only when "taken together" the story about farmers, traders, and expectations takes its full shape.

4. An experimental test of trader behavior

4.1. Sample

We implemented an experiment to test the model's predictions with wheat traders in Ethiopia's main wheat-producing areas: Amhara, Oromia, and Southern Nation

Nationalities and Peoples' Region. During the 2018-2019 marketing season we did a census of all wheat markets in these regions to collect market-level information (e.g., number of farmers and traders, volume traded, market facilities).[8] We selected 25 high-potential wheat *woreda*s (i.e., districts) and the main wheat market in each *woreda*. We randomly selected 15 markets from this list and obtained a list of active traders from the *woreda* trade office. Using this list, we randomly selected a sample of 12 traders per *woreda*. If a trader was unable to participate, we randomly selected another one. We conducted the survey in April 2022, and collected information from 12 traders per market, except in Mishaworeda where fewer traders were present during our visit. Our final experimental sample consists of 178 traders.

Table 1 reports summary statistics of traders and their trading behavior. Almost all traders are men with some formal education, and half of them are members of a traders association. Few traders own much physical capital to support their wheat trading activities (e.g., trucks and grain storage facilities), and transport cost and storage rental costs represent almost half of their total trading costs. Panel C shows how traders deal with wheat quality. Many traders pay a quality premium to their sellers, although this premium is small in magnitude: less than 1 birr per kilogram. While most traders assess observable quality attributes (i.e., color, impurity, kernel size), a minority also report checking the flour extraction rate although proper testing of this attributes requires specific and costly equipment that very few (if any) traders use. Almost three quarters of the traders' report to separate quality levels, but again sorting is rough and only based on observable quality attributes.

4.2. Protocol

Each trader received a participation fee of 300 Birr (6 USD in 2022). We used a survey to collect information on traders' background characteristics, marketing activities, attitudes, and behaviors characteristics. After the survey, traders were invited to participate in a lab-in-the-field marketing experiment, where they would be asked to invest some of the money they had earned from showing up and answering our survey. While these investments could yield positive returns, traders were informed that they could also loose (part of) what they had just earned. Traders were free to leave without playing, al-

[8] At that time, the census was also conducted in Tigray but was not included in our study because of the ongoing conflict in this region.

though all decided to participate. We visited all traders at their warehouses and played a single-person decision game in full privacy. We explained the game orally with support materials. The game started after the traders fully understood the rules of the game. Details of the protocols and support materials are in Appendix B.

The experiment involved traders buying and selling units of output ("wheat"). They could draw chips from a non-transparent urn containing 36 chips, one after another, without replacement. They could purchase a maximum of 12 chips (Z), and after drawing a chip traders had to decide whether to buy or reject it. Chips were either blue or red—each representing a unit of wheat. Blue chips represented certified (high-quality) wheat, and red chips represented uncertified wheat, of either high or low quality. Participants could not observe the quality of red chips. Traders had to pay more to acquire blue chips (p^c=220 Birr) than red chips (p^u= 200 Birr). Importantly, traders had the option to keep certified and uncertified output separate, but then they had to pay a fixed cost (F=330 Birr). Traders offering certified wheat (blue chips) kept separately received a price P^C of 280 Birr per chip. Traders who did not incur the fixed cost had to mix and bulk their chips, and received a price based on the average quality of their private stock, as determined by the experimenter after the round. The selling price for these chips P^U ranged from 220 to 240 Birr. A price of 220 Birr (240 Birr) corresponded with the extreme case of selling only low-quality (high-quality) wheat.

Each trader in our experiment participated in multiple rounds of play, so we have a within-subject design. First, we varied the market size (T) and distinguish between "large market sessions" and "small market sessions". Traders could draw 30 chips in large market sessions and only 16 chips in the small market ones. Second, across different market sizes we varied the share of certified wheat, π, and the share of uncertified wheat that is of high-quality, θ.[9] We selected three values for π (10%, 30%, and 50%) and two values for θ (20% and 80%) to construct 4 different treatments (i.e., not a factorial design) representing our 4 theoretical cases outlined in section 3. The objective was to compare traders' behavior (i) across the four treatments within a session; and (ii) between sessions for a given treatment. After the experiment, we randomly selected the earnings of one of the game rounds to determine payouts for traders. We summarize our treatment games and map them onto their corresponding theoretical case and expected traders' optimal decisions in Figures 1 and 2 representing the case of large

[9]Wheat markets in Ethiopia differ in terms of the quality of supply, reflecting differences in agroecological endowments (e.g., soil quality). Areas with a reputation for supplying high-quality wheat are Bale, Arsi, and North Shewa.

and small markets, respectively.

Excluding two test trials per trader, our data is based on 1,424 games (178 traders × 8 rounds). Charness et al. (2013) discuss potential issues arising from within-subject designs. Participating in multiple treatments can introduce biases (e.g., anchoring, demand and order effects). Treatment order is a concern, so we randomly varied the order of treatments presented to each trader. We find no substantial correlation between treatment order and trader decisions (i.e., between decisions whether to buy a cup and the number of chips drawn), which suggests that order effects are unimportant.[10] Communication spillovers are another threat to the internal validity of experiments (Coutts, 2022). Communication spillovers may occur when participants talk about the game with future participants—affecting behavior of the latter group. We minimize within-market spillovers by conducting all sessions on the same day. We are also not concerned about between-markets spillovers because the average distance between markets is large. Last, we sought to avoid windfall effects by engaging traders to play with their own money: the money that had effectively earned from showing up to answer our survey.

4.3. Empirical Strategy

Figure 3 shows actual trader profits distributions across all rounds by decision to incur a fixed cost. The range in earnings is wider for traders paying the fixed cost. Separating certified and uncertified flows allows some traders to earn high profits, but causes other traders to make near-zero profits or even a loss. Investing to keep high and low-quality output flows separate can therefore be profitable, but this depends on market conditions and the accept-reject strategy adopted by traders. Our key choice variable is the trader decision to incur a fixed cost.

We explore the model's predictions through the following estimation:

$$\begin{aligned} F_{ij} = &\beta^2 T_{ij}^2 + \beta^3 T_{ij}^3 + \beta^4 T_{ij}^4 \\ &+ \delta^1 T_{ij}^1 \times L_{ij} + \delta^2 T_{ij}^2 \times L_{ij} + \delta^3 T_{ij}^3 \times L_{ij} + \delta^4 T_{ij}^4 \times L_{ij} \\ &+ \alpha_i + \lambda_j + \epsilon_{ij} \end{aligned} \tag{13}$$

[10]For example, the Pearson correlation coefficient is equal to -0.025 for buying a cup and the round's number, suggesting no correlation – or at most a very weak one – between cup purchase and round order. See Figure C.1

where the dependent variable F_{ij} is a dummy equal to one when trader i pays the fixed cost in round j, T^k are dummy variables equal to one when trader i was exposed to treatment arm $k = \{1, 2, 3, 4\}$ in round j, and L_{ij} identifies whether the round was played in large market condition or not. The excluded category consists of treatment 1 ($\pi = 0.1, \theta = 0.3$) in small markets. We also include round order fixed effects λ_j and trader fixed effects α_i to control for carryover effects and traders' unobservable characteristics. We use robust standard errors.

Equation 13 enables us to test the three main predictions of the model as follows:

Prediction 1. All else equal, the share of traders incurring a fixed cost (weakly) increases with the share of certified output (π) available for their purchase in the market. Recalling that the share of high-quality in uncertified supply (θ) equals 0.3 across $T = \{1, 2, 3\}$, parameters β^2 and β^3 only capture variations in π in small markets, while δ^1, δ^2 and δ^3 capture variations in π in large markets. The model therefore predicts that $\beta^3 \geq \beta^2 \geq 0$ (in small markets), and $\beta^3 + \delta^3 \geq \beta^2 + \delta^2 \geq \delta^1$ (in large markets).

Prediction 2. All else equal, trader decisions to incur a fixed cost decreases with the share of uncertified wheat that is of "high-quality". We rely here on the variation of θ between $T^3(\theta = 0.3)$ and $T^4(\theta = 0.8)$, where the share of certified product is constant at $\pi = 0.5$. The model therefore predicts $\beta^4 \leq \beta^3$ in small markets and $\beta^4 + \delta^4 \leq \beta^3 + \delta^3$ in large markets. Note however that given the game parameters we used, the model predicts that in small markets traders should neither incur the fixed cost in T^4 nor in T^3, despite the differential in net profit (Figure 2). In contrast, in larger markets traders are expected to incur the fixed cost (and specialize in the trade of certified output) in T^3 and to not incur the fixed cost (and specialize in uncertified output) in T^4. So while the relative profitability of incuring a fixed cost is higher in T^3 than in T^4 in both cases, the contrast in the optimal decision is weaker in a small market.

Prediction 3. All else equal, the probability that a trader incurs a fixed cost to keep certified and uncertified output separate increases with market size for $\pi \leq 0.5$. The prediction thus implies a steeper slope in large markets for the first three treatment conditions: $\delta^1 \geq 0, \delta^2 \geq 0, \delta^3 \geq 0$.

Next, we leverage traders' acceptance or rejection of chip drawn from the urn to assess their degree of alignment with the optimal strategy. Our model produces simple predictions with respect to the types of chips that should be accepted and rejected.

If the trader keeps certified and uncertified chips separate, she should accept only certified chips until encountering threshold chip N. After that she should accept every chip. Conversely, traders who mix and bulk should accept only uncertified chips until encountering threshold chip M, after which she should accept every chip. We will visually examine the patterns in the time series of purchasing decisions to probe whether traders indeed behave optimally.

5. Experimental Results

5.1. Fixed costs: separating flows versus mixing and bulking

We summarize regression results from the estimation of Equation 13 explaining variation in fixed costs investments to keep certified and uncertified output (blue and red chips) separate in Figure 4 (the corresponding value of each parameter estimates are provided in Appendix Table C.1). For each Treatment arm $T = \{1, 2, 3, 4\}$ we separately report the coefficients for small and large markets where the former correspond to the β parameters in Equation 13, and the latter to the sum of the corresponding β and δ parameters. The estimation further controls for individual trader (α_i) and round order (λ_j) fixed effects (not reported).

Overall, the results provide mixed support to the model's main predictions. To begin with, we find that a handful of traders (i.e., 34% regardless of market size) incurred the fixed cost in situations where the share of certified output is low ($\pi = 0.1$), despite its unambiguously lower expected profit than the strategy of not paying the fixed cost.

Next, and in line with the first prediction, we find a positive gradient in the probability that traders do incur the fixed cost, as we move from a lower share of certified output in the market (T_1: $\pi = 0.1$) to a medium (T_2: $\pi = 0.3$) and a higher one (T_3: $\pi = 0.5$). Focusing on the large markets only (reported in orange), an increase from 10% to 30% and from 30% to 50% in the share of certified output (π) increases the probability of paying the fixed cost by 25 and 41 percentage points, respectively.

We also find support for the third prediction, according to which traders' response to an increase in the share of certified output is somewhat steeper in larger market conditions (reported in orange) than in smaller ones (reported in blue). While a similar proportion of traders incur the fixed cost when the share of certified output is low (T_1: $\pi = 0.1$), we find a five percentage points higher (albeit non-significant; p=0.30) proportion in large markets when the share of certified output is increased to $\pi = 0.3$ (T_2), and a significant (p=0.03) 11 percentage points difference when the share is increased to $\pi = 0.5$ (T_3).

However, our results do not support the model's second prediction. Accordingly, and specifically for larger markets, the larger the share of high-quality uncertified products available in the market, the lower the probability that traders should incur the fixed cost. Our results suggest that traders in large markets are unresponsive to a large increase in the share uncertified higher quality output (from $\theta = 0.3$ to $\theta = 0.8$). Reversely, and at odds with the model's prediction, traders in smaller markets respond positively to the higher share in uncertified higher quality output, with a 13 percentage point increase in the probability to invest in the fixed cost (p=0.00).

These last results possibly point to traders' difficulty to keep-up with optimal behavior given the somewhat complex nature of our experiment where traders were asked to combine values of three different parameters (π, θ, and L) to make their decisions. We further explore these issues below.[11]

5.2. Purchasing decisions: accepting and rejecting wheat

We use traders' accept/reject decision of each chip drawn to evaluate if they follow an optimal strategy to maximize their expected profits—conditional on whether they incurred a fixed cost. For every treatment, we computed the theoretical threshold level of supply *before* which the trader should specialize and only buy her preferred output: the certified wheat (blue chip), for traders with a separating technology and the uncertified wheat (red chip), for traders without it. After this threshold, the trader should purchase all outputs because moving any unit of output is profitable, so failing to trade at full capacity reduces profits. We first examine if traders who incurred the fixed cost accepted only certified output until they reach critical farmer N. We distinguish between small and large markets. Results are provided in Figure 5.

Results provide mixed support for the theory. It is encouraging that, across markets, the majority of traders who invested in the separating technology only purchased certified wheat if the share of certified wheat is high (the specialization rate is between

[11]Note that the results hold when we use market rather than trader fixed-effects.

62%–74% for high π=0.5). When the share of certified wheat is at a medium level (π=0.3), approximately half the traders adopted the correct acquisition strategy, showing that not all traders behave optimally. Our data further suggest that sub-optimal behavior is concentrated amongst specific traders whose decision to incur the fixed and following purchase behavior is consistently at odd with the profit maximizing behavior.[12] Accordingly, 34% of the traders, regardless of market size) incurred the fixed cost even in situations where the share of certified wheat was at its lowest (= 10%) —reducing their expected profits. The majority of them traders subsequently adopted the wrong acquisition strategy : only 12% (31%) of the traders accepted only certified outputs in small (large) markets.

The sub-optimality of the behavior of some traders is also evident from the acquisition strategies adopted by the farmers who chose to mix and bulk. A small share of 1 to 11% only accept uncertified wheat before farmer M. In fact 1% and 12% of these traders accepted only certified wheat—exactly the wrong behavior, as these traders should reject all certified wheat and accept only uncertified wheat.

In Figure 6, we unpack the acquisition strategies a bit further for the subsample of "small markets" treatments (qualitatively similar results emerge for the case of large markets—see Figure C.3 provided in the Appendix). Each panel presents the share of certified and uncertified output accepted by traders for a specific treatment (different combinations of π and θ) before and after the critical farmer, distinguishing between traders who did and did not incur the fixed cost.

For the small market case, we expect the share of uncertified output accepted to be positive. Traders who incurred the fixed cost should accept uncertified output to exploit their full capacity after threshold farmer N. Traders who did not incur the fixed cost should consistently accept all the uncertified output they are offered until M. However, the patterns in the data summarized in Figure 6 are at odds with such an interpretation. For instance, panel A shows the result for treatment 1 (low π - low θ combination). Acceptance rates for uncertified (red bar) and certified (blue bar) output equal roughly 80 and 95% before the farmer M when traders do not pay the fixed cost. When paying the fixed cost, treatment combination yields a threshold value higher than the number of draws available to traders. Moving to cases where traders pay the fixed cost, the acceptance rate for uncertified output drops to 50% but remains constant for certified

[12]While adopting different decisions, these traders are on average similar to the others.

output before the critical farmer (N). After the threshold, acceptance rate increase by 30 ppt for uncertified output and equals 100% for certified output. Examining results across the 4 panels reveals more deviations from the optimal acquisition strategy. First, we see that nearly all traders accept all the certified wheat they are offered. The overall acceptance rates across treatments hovers between 95% and 100%. For the traders who mix and bulk (did not incur the fixed cost) this is clearly sub-optimal. While trading certified output is still profitable for these traders—they buy at 220 Birr and sell at a price strictly greater than 220 Birr—they could have done better by purchasing uncertified output instead. The lure of the premium product proves almost irresistible to many of our traders. Traders who mix and bulk are keen to upgrade their product mix with certified premium quality output—even at a cost to themselves. Second, traders without the separating technology do not accept all uncertified output they are offered. Third, traders with the technology start accepting uncertified wheat "too soon".

Additional detail can be gleaned from distinguishing between trading rounds within treatment. We summarize acceptance rates for uncertified and certified outputs, per round, for the small market case in Figure 7 (large market results are qualitatively similar, see Figure C.4). Again, we find that nearly all traders accept all the certified output offered—regardless of whether they aim to keep flows separate or "mix and bulk". An additional insight now also stands out. The acceptance rate for uncertified wheat starts relatively low, but consistent with expectations this rate increases to (nearly) 100% in the final rounds. The overall and surprising insight that emanates from Figure 7 is that the acquisition strategy employed by traders is not *entirely conditional* on their investment in separating technology. Traders clearly distinguish between uncertified and certified output, but there is no difference in accepting or rejecting behavior between traders who incurred the fixed cost and traders who did not.

5.3. The (limited) role of risk and confusion in decision making

Building on the above results, we further investigate traders' deviation from the optimal behavior defined by our model. While our theoretical model outlined in section 3 relies on the assumption that traders only maximize expected earnings, this may not be the case. Leveraging variation in game risk and Monte Carlo simulation, we provide a formal test to assess whether parameters beyond expected earnings can explain traders' investment decisions.[13] In particular, we identify three plausible parameters other than expected earnings. First, the spread of the earnings difference after paying or not the fixed cost, which captures the earnings risk. The second is the overlap in earning distribution with and without paying the fixed cost, which captures trader's confusion [14]. A higher overlap makes choices harder. The last is earnings salience, which relies on nonlinear responses along the earnings difference spectrum: weak (or no) response for small differences and large response after a certain threshold. We start with a model containing only the expected earnings parameter, add the three others successively, and estimate the additional variation explained by moving from one model to the next.[15]

We find that the added value of risk, confusion, and salience compared to an expected earnings framework is very limited in explaining trader behavior (reported in Figure C.5). This result suggests that the assumption that traders maximize expected earnings seems credible in our setting and that complexifying their decision process does not substantially increase the share of the variation explained.

5.4. Who separates flows, and who "mixes and bulks"

As a final question we explore how trader characteristics are associated with investment behavior (in particular the choice to pay a fixed cost to separate certified and uncertified output). We employ a machine learning approach, the eXtreme Gradient Boosting (XGB) algorithm, and explain traders' decisions to follow the optimal fixed cost decision. We calculate Shapley (SHAP) values for each variable to measure the magnitude and size of its relationship with traders' investment decisions. SHAP values are the unexplained part

[13] Appendix D provides further details about Monte Carlo simulation and Table D.1 shows simulated parameters of interest.

[14] We measure overlap as the proportion of the earning distribution with and without the fixed cost which overlaps.

[15] We estimate the following equation:

$$F_{ij} = \alpha_i + \beta_1 \mathbb{E}[\mathrm{E}_1 - \mathrm{E}_0]_j + \beta_2 SD[\mathrm{E}_1 - \mathrm{E}_0]_j + \beta_3 \text{overlap}_j + \beta_4 \text{salience}_j + \lambda_j + \epsilon_{ij} \quad (14)$$

where F_{ij} is a dummy equal to one when trader i pays the fixed cost in round j, $\mathbb{E}[\mathrm{E}_1 - \mathrm{E}_0]_j$ is returns to incur the fixed cost, the standard deviation of this return $SD[\mathrm{E}_1 - \mathrm{E}_0]_j$, overlap$_j$ is the overlap in earnings after incurring the fixed cost or not, and salience$_j$ is the tangent of the returns to incur the fixed cost. We also include round order fixed effects λ_j and trader fixed effects α_i to control for carryover effects and trader unobservables. We used robust standard errors.

of the model for each observation, and the feature sign is associated with the outcome.[16] The higher the absolute SHAP value, the more meaningful the corresponding variable is for the model.

Figure 8 shows the relationship between trader characteristics and optimal predicted investment decisions. We plot average Shapley (SHAP) values with colors corresponding to the correlation degree between the variable and its SHAP values. Trader's social network is significantly associated with the fixed-cost investment, although its orientations (i.e., within or outside the district) have opposite signs. Traders with an extensive network out of the district are less likely to follow the optimal fixed cost decision. Conversely, within district-oriented traders are more likely to incur the fixed cost. Results further indicate that behavioral factors appear to be strong predictors of trader decisions. While impatience and being more welcoming to change are positively correlated with trader probability to make the optimal choice, higher aspirations and risk aversion are negatively correlated with trader optimal choices but have a limited explanation power.

6. Conclusion

In a context where formal contracting is expensive, expectations about the behavior of other value chain actors may govern actors' business strategies and trap them in sub-optimal equilibria. In this paper we study Ethiopian wheat traders' willingness to invest in a technology that enables them to keep high- and low-value output separate (and, thus, to start paying premium prices to farmers supplying higher quality crops) in the context of an emerging third-party certification of farmers output.

We develop a model identifying how different market conditions (i.e., market size, supply of certified output, and the share of high-quality uncertified output) affect traders' decision to purchase quality-certified output from farmers. Then, we implement a lab-in-the-field experiment with Ethiopian wheat traders to test model predictions. We document that trader expectations regarding the flow of certified output they can acquire does affect their investments in technologies to keep certified and uncertified output separate, and that market size further mediate their decisions. All of this is

[16] A positive (negative) SHAP value means an increase (decrease) in the overall average predicted outcome resulting from this variable inclusion. A null SHAP values signifies no deviation from the average mean prediction.

consistent with our theoretical predictions. We however find that traders are either non-responsive or significantly at odds with our predictions regarding the share of uncertified high-quality output that is available for their purchase. We also document that the acquisition strategy that traders adopt when purchasing crops is not entirely conditional on their earlier investment, reducing trader profits. We do not find systematic behavioral reasons for these discrepancies and tentatively attribute them to the complexity of our design, the novelty of the lab-in-the-field experience, and the limited consequences of their errors in a non real-life setting.

Our work call for additional studies, and in particular to test whether our results carry over to the context of real rural markets. Follow-up study may for instance rely on the allocation of temporary subsidies for farmers use of TPC services, with the share of farmers receiving subsidies being randomly varied across markets, and traders made aware of the share that concerns the market(s) where they operate. In turn, such study would assess whether the induced changes in trader behavior will incentivize farmers to make additional investments in the production of high-quality crops and the use of TPC services in the following seasons, setting a virtuous cycle in motion. In addition, market competition for different quality standards (including imported crop) may need to be considered in further research.

Traders in agricultural value chains are a vitally important yet under-researched group of actors. Inducing traders to adopt business practices that start rewarding the production of high-quality crops by smallholders would be a major step forward in enhancing agricultural development in low-income countries, and notably in sub-Saharan Africa where this study takes place.

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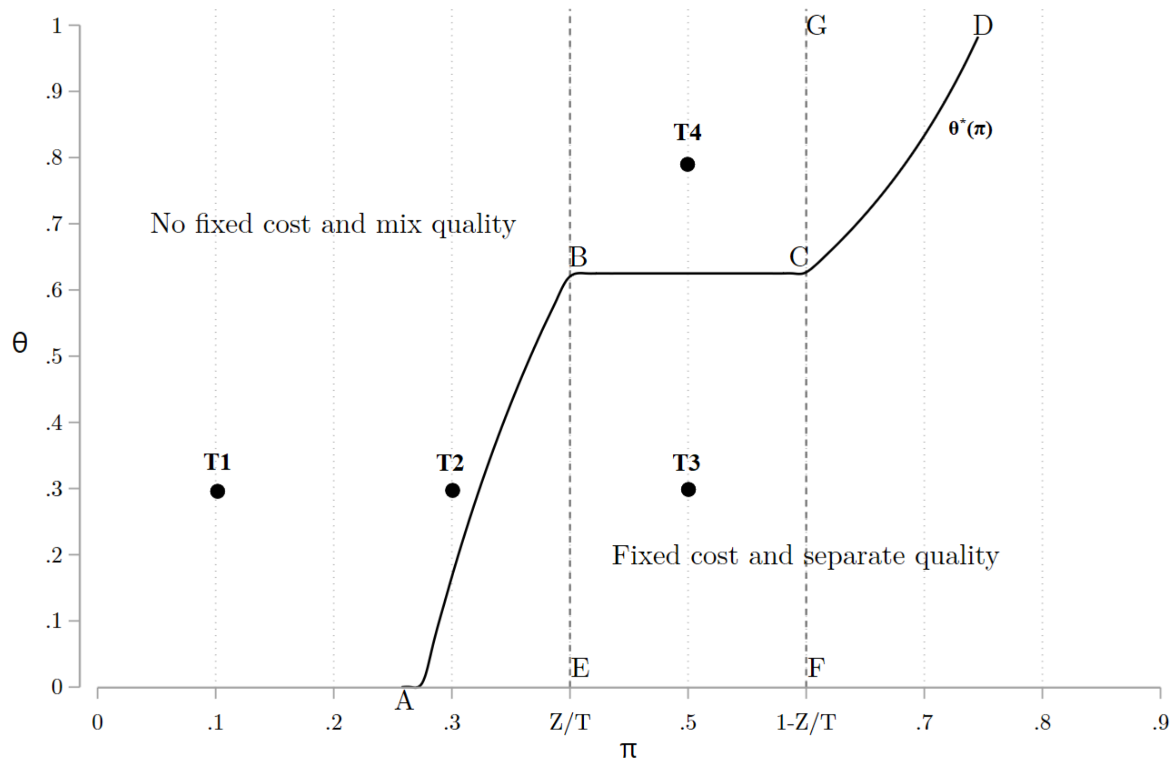
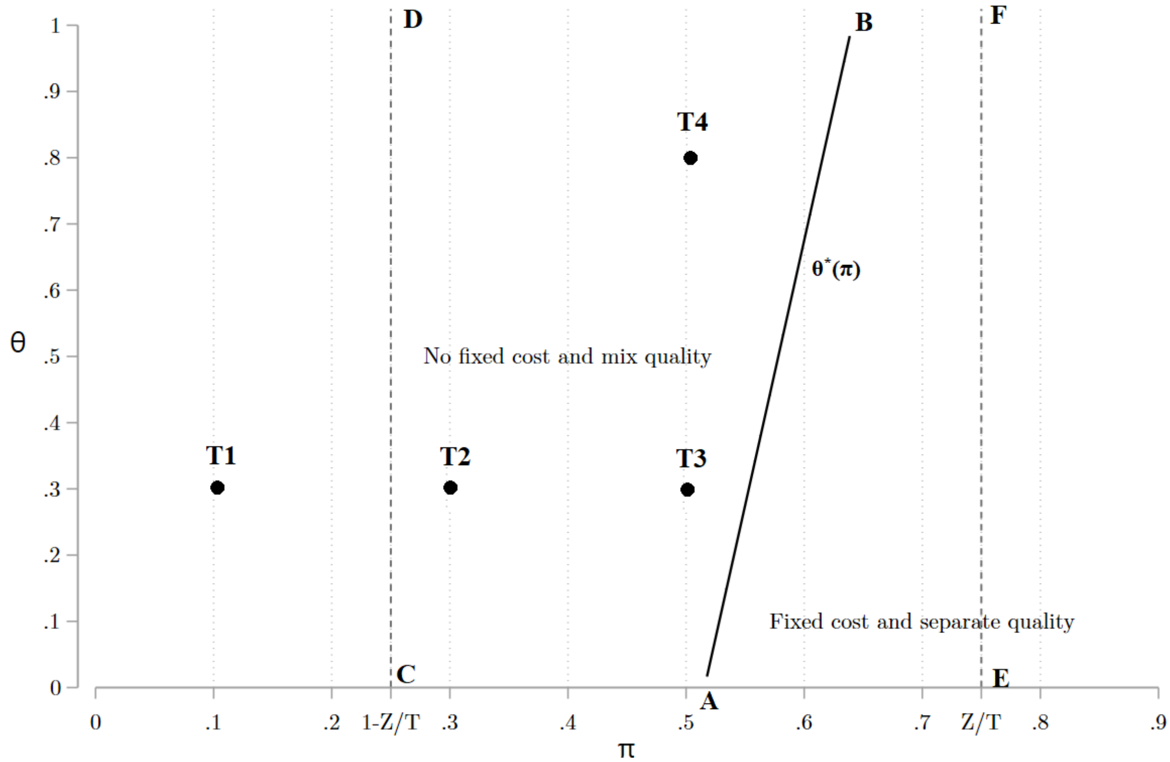
Figure 1. Model's prediction and treatment parameters in large markets



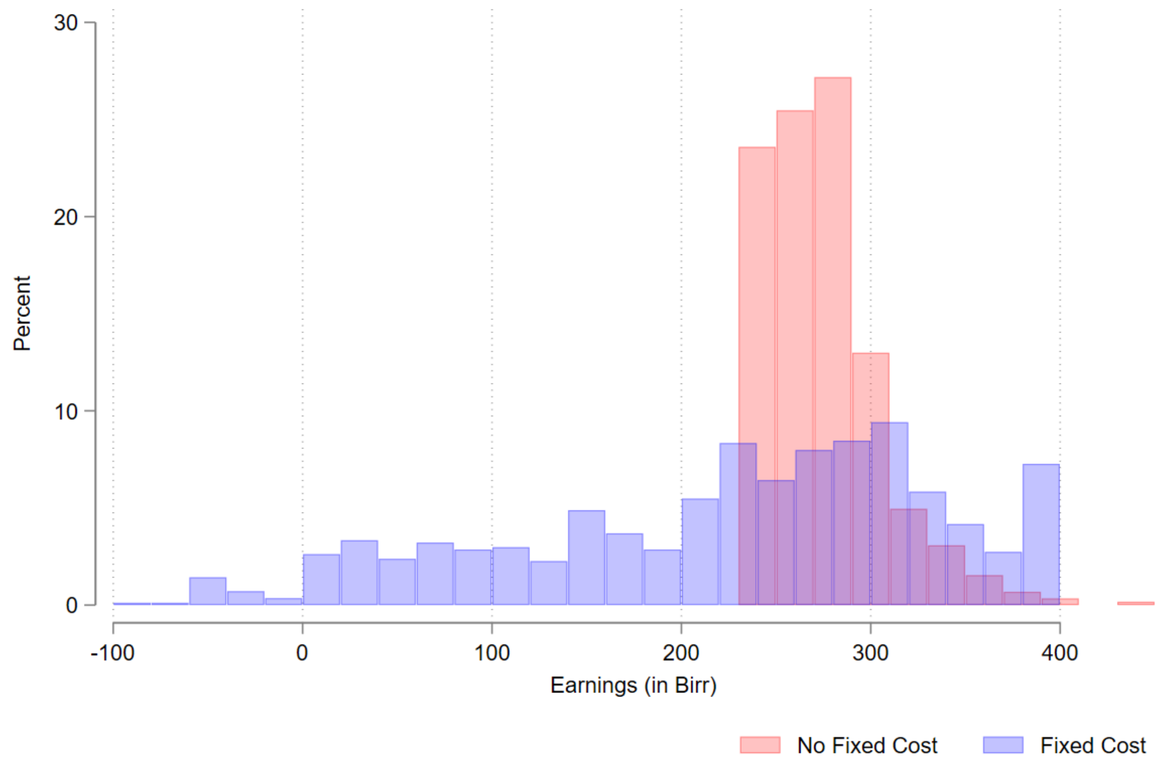
Notes. This figure presents the optimal theoretical choice to incur the fixed cost as function of the share of certified and high-quality uncertified output supply, in large markets. θ is the share of high-quality among uncertified wheat. π is the share of certified-wheat. The ABCD curve represents π-θ combinations for which traders are indifferent between incurring the fixed cost or not. The optimal choice for π-θ combinations located above the curve is to not incur the fixed cost and mix certified and uncertified output. The optimal choice for π-θ combinations located below the curve is to incur the fixed cost and separate certified and uncertified output. One expects traders to buy both certified and uncertified crops in the area ABE and CGD, but to specialized in the other areas, in certified crops below ABDC, in uncertified crops above. Black dots indicate the empirical values used in the experimental game. T1, T2, T3, and T4 correspond to different treatments (i.e., games).

Figure 2. Model's predictions and treatment parameters in small markets



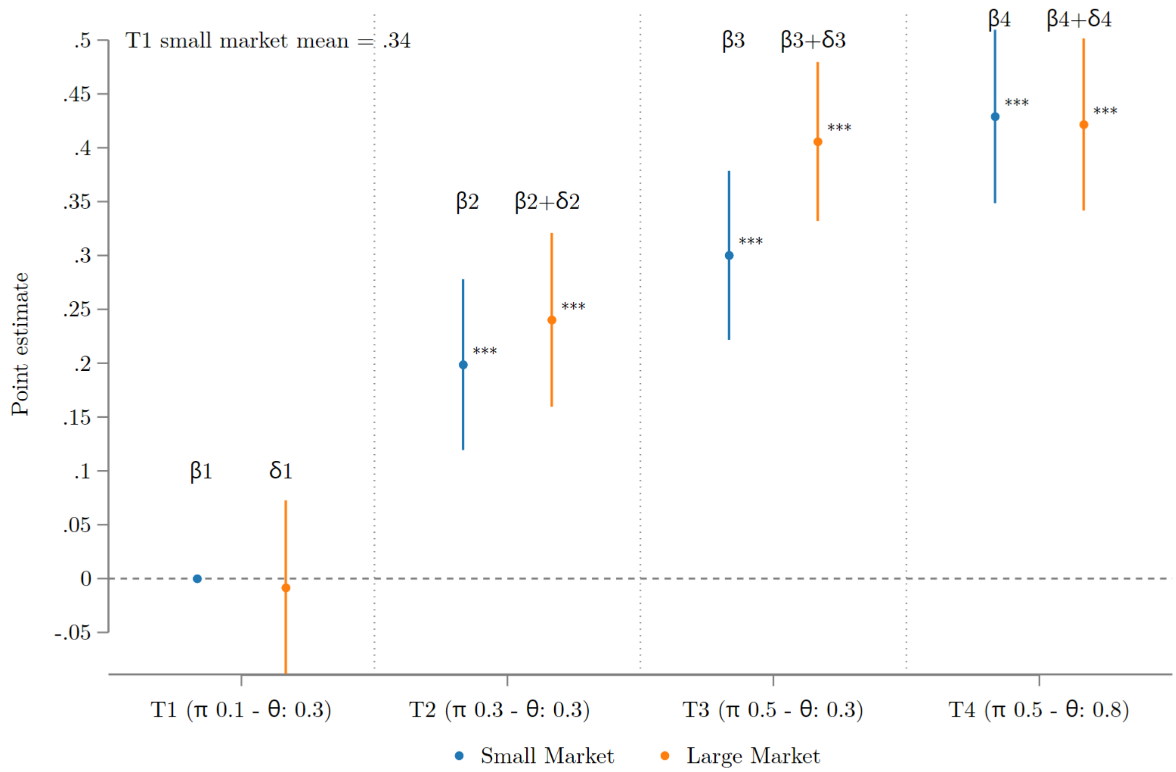
Notes. This figure presents the optimal theoretical choice to incur the fixed cost as function of the share of certified and high-quality uncertified output supply. θ is the share of high-quality among uncertified wheat. π is the share of certified-wheat. The AB curve represents π-θ combinations for which traders are indifferent between incurring the fixed cost or not. The optimal choice for π-θ combinations located above the curve is to not incur the fixed cost and mix certified and uncertified output. The optimal choice for π-θ combinations located below the curve is to incur the fixed cost and separate certified and uncertified output. One expects traders to buy both certified and uncertified crops in the area ABCD and ABFE, but to specialized in the other areas, in certified crops to the right of EF, in uncertified crops to the left of CD. Black dots indicate the empirical values used in the experimental game. T1, T2, T3, and T4 correspond to different treatments (i.e., games).

Figure 3. Traders' profits, by investment decision



Notes. This figure shows the distribution of traders' profit across all games by investment decision. The profits are expressed in Birr. Profits for traders paying the fixed cost are in blue. Profits for traders not paying the fixed cost are in red.

Figure 4. Traders investment decisions across market conditions and market sizes

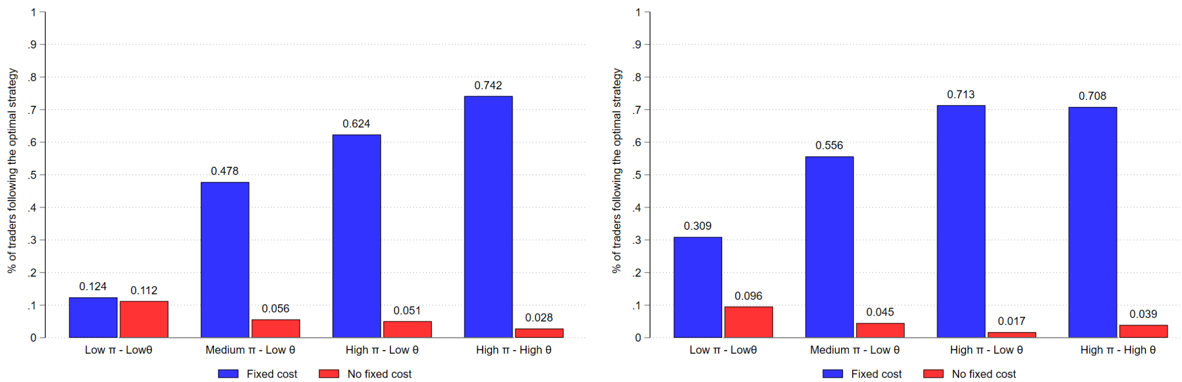


Notes. This figure shows the probability of paying the fixed cost in a given game, relative to the probability of paying it in the T1 small market game. Each dot corresponds to the estimated coefficient associated with a given a treatment arm (specific combination of π and θ), along with its interaction with market size, as per equation 13. π is the share of certified wheat. θ is the share of high-quality wheat among uncertified wheat. Coefficient estimates are in blue for small market games and orange for large market games. T1 small market is the omitted category. 95% confidence intervals are base on robust standard errors. Controls include game order and trader fixed effects. *** p<0.01, ** p<0.05, * p<0.1. Unit of observation is participant × game level.

Differences across parameter estimates: statistical significance

$\beta^2 = 0 : p - value = 0.00$; $\beta^2 = \beta^3 : p - value = 0.00$; $\beta^3 = \beta^4 : p - value = 0.00$; $\delta^1 = 0 : p - value = 0.84$; $\beta^2 = \beta^2 + \delta^2 : p - value = 0.30$; $\beta^3 = \beta^3 + \delta^3 : p - value = 0.03$; $\beta^4 = \beta^4 + \delta^4 : p - value = 0.85$; $\delta^1 = \beta^2 + \delta^2 : p - value = 0.0$;$\beta^2 + \delta^2 = \beta^3 + \delta^3 : p - value = 0.00$;$\beta^3 + \delta^3 = \beta^4 + \delta^4 : p - value = 0.66$.

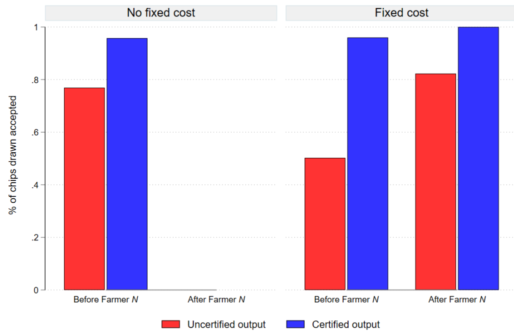
Figure 5. Proportion of traders following the optimal decision strategy



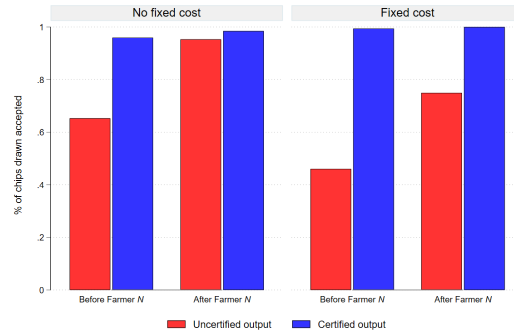
A. Small market B. Large market

Notes. This figure shows the proportion of traders accepting only (uncertified) certified output before the Farmer N (M) threshold if they (do not) pay the fixed cost. Farmer N (M) is the farmer after which the number of remaining encounters with farmers on that day is equal to the number of remaining empty slots on the rented truck. Panel (a) shows results for the small market case. Panel (b) shows results for the large market case. Blue bars are the proportion of traders incurring a fixed cost accepting only certified output before the Farmer N. Red bars are the proportion of traders not incurring a fixed cost accepting only uncertified output before the Farmer M.

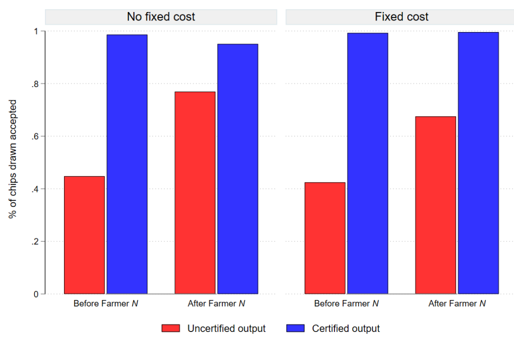
Figure 6. Proportion of chips drawn accepted according to fixed costs decision in small market



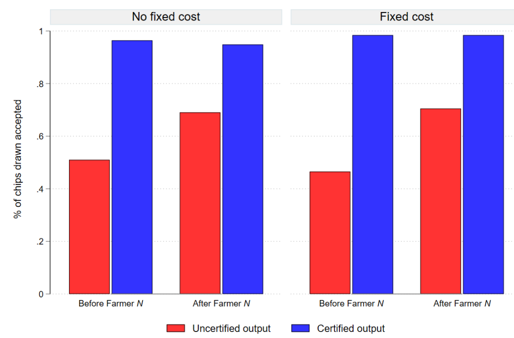
A. Low π - Low θ



B. Medium π - Low θ



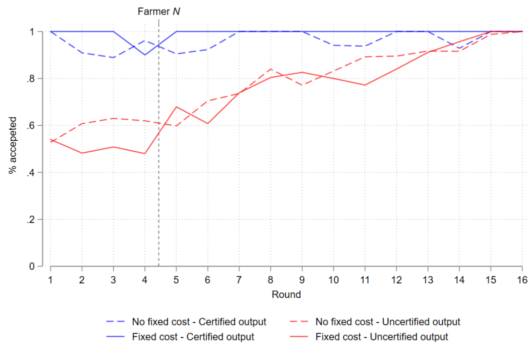
C. High π - Low θ



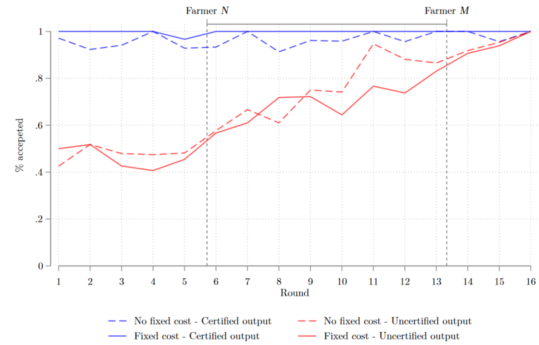
D. High π - High θ

Notes. This figure shows the proportion of traders accepting only (uncertified) certified output before the Farmer N (M) threshold if they (do not) pay the fixed cost. Farmer N (M) is the farmer after which the number of remaining encounters with farmers on that day is equal to the number of remaining empty slots on the rented truck. Red bars represent the proportion of uncertified wheat accepted. Blue bars represent the proportion of certified wheat accepted. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

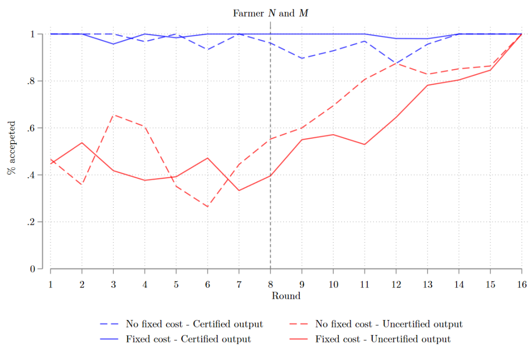
Figure 7. Acceptance rate per round in small market



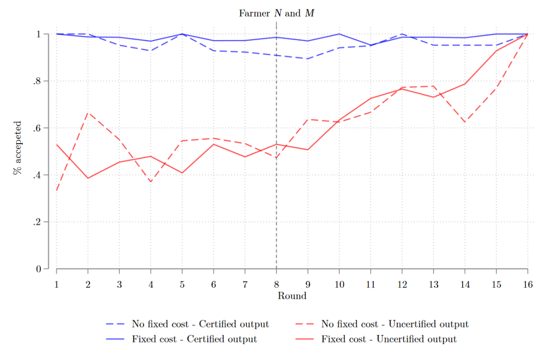
A. Low π - Low θ



B. Medium π - Low θ



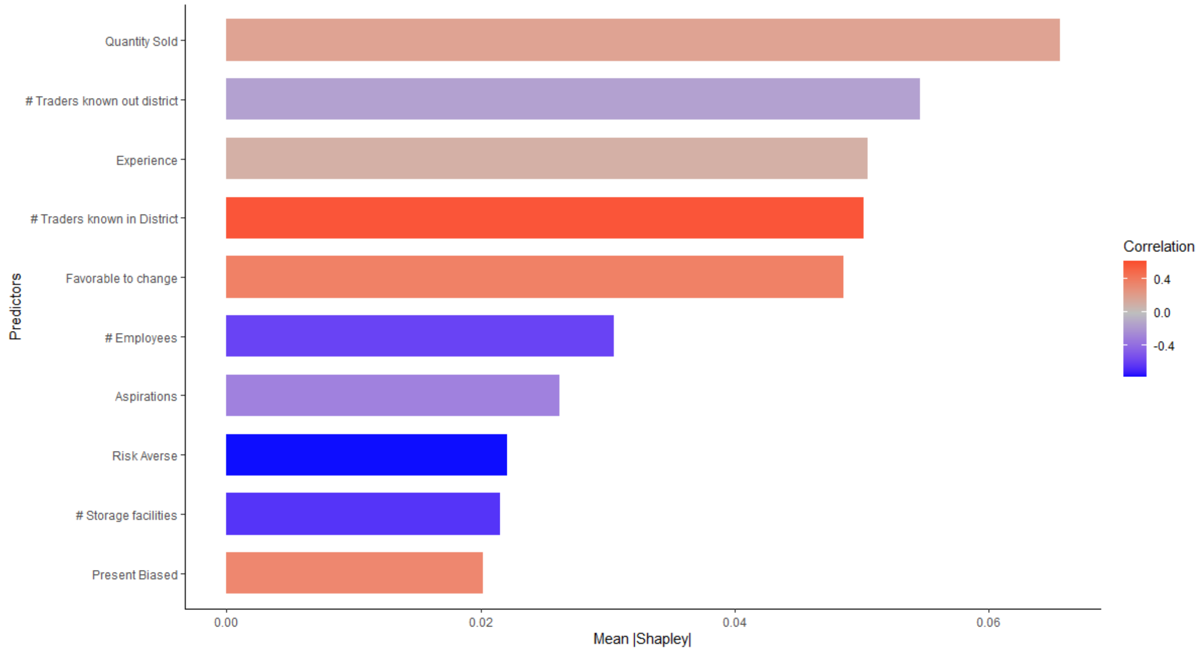
C. High π - Low θ



D. High π - High θ

Notes. This figure shows for each treatment the proportion of chips drawn accepted at a given round before and after the Farmer N (M) threshold if they (do not) pay the fixed cost. Farmer N (M) is the farmer after which the number of remaining encounters with farmers on that day is equal to the number of remaining empty slots on the rented truck. Farmer N (M) is not displayed when its value is larger than the maximum number of rounds. Red lines represent the proportion of uncertified wheat output accepted at a given round. Blue lines represent the proportion of certified wheat accepted at a given round. Plain lines represent cases for which the trader incurs a fixed cost. Dashed lines represent cases for which the trader does not incur a fixed cost. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

Figure 8. Correlation between predictive variables and optimal investment decision: eXtreme gradient boosting model



Notes. This figure shows the tent most predictive features explaining trader's probability to make the optimal fixed cost decision using an eXtreme gradient boosting algorithm. It provides the direction of the association (red for positive and blue for negative), and the predictor's marginal contribution in prediction based on the mean Shapley (SHAP) value. SHAP values are the unexplained part of the model for each observation, and the sign of predictors are the association with the outcome.

Table 1. Traders characteristics

	Mean	SD	N
Panel A. Trader characteristics			
Age	41.944	11.28	178
Male(0/1)	.949	.22	178
Formal Education (0/1)	.921	.27	178
Wheat Trading Exp. (years)	8.764	6.74	178
Panel B. Trading characteristics			
Traders Association (0/1)	.47	.5	178
Number of Trucks	.12	.38	178
Number of Grain Storage	1.05	.58	178
Family Members in Agr Trade	1.66	3.42	178
Traders Known in the Woreda	55.37	80.69	178
Number of Selling Markets	2.34	3.47	178
Volume Bought last season (Qt)	1925.57	8157.56	178
Average Selling Price (Birr/Qt)	2734.71	375.1	175
Panel C. Quality Practices			
Pay a Premium (0/1)	.76	.43	178
Price Premium (Birr/Qt)	78.26	47.08	135
Assess Quality (0/1)	.98	.15	178
Color(0/1)	.9	.3	174
Impurity(0/1)	.99	.08	174
Grain Size (0/1)	.94	.24	174
Moisture(0/1)	.85	.36	174
Extraction Rate (0/1)	.48	.5	174
Separate Quality (0/1)	.72	.45	178
Panel D. Behavioral Attributes			
Risk Aversion (0/1)	.81	.39	178
Loss Aversion (0/1)	.44	.5	178
Present Biased (0/1)	.66	.48	178

Notes. This table shows summary statistics for traders in our sample. Age is trader's age in years. Male is a dummy equal 1 if the trader is a male. Formal education equals 1 if the trader has formal education. Wheat trading exp. is the number of years of experience in wheat trading. Trader association equals 1 if she is member of a trader association. Number of trucks is the number of trucks a trader owns. Number of grain storage is the number of grain storage a trader owns. Family members in agr trade is the number of family members in agricultural trade. Traders known in the *woreda* is the number of traders one knows in the *woreda*. Number of selling markets is the number of markets where the trader is active. Volume bought last season is the wheat quantity (in Qt) a trader bought the previous season. Average selling price is the average price a trader is obtaining (in Birr per Qt). Pay a premium equals 1 if a the trader pays a quality premium. Price premium is the amount she pays for rewarding quality (in Birr per Qt). Assess quality equals 1 if the trader measures any quality characteristics. Color equals 1 if the trader measures color. Impurity equals 1 if the trader measures impurity. Grain size equals 1 if the trader measures grain size. Moisture equals 1 if the trader measures moisture. Extraction rate equals 1 if the trader measures extraction rate. Separate quality equals 1 if the trader separate wheat based on quality. Risk aversion equals 1 if the trader is risk averse. Loss aversion equals 1 if the trader is loss averse. Present biased equals 1 if the trader is impatient.

Appendix

A. Theory

A.1. Net benefit of paying fixed cost as function of market size, at given θ

Consider two markets of size T^L and T^S, with $T^L > T^S$.

1. If both are 'large' markets, as defined above, $2Z < T^S < T^L$.
   $\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = \pi T \Delta - F$ increases linearly in π, with slope $T\Delta$ until it reaches $Z\Delta - F$ for $\pi = \frac{Z}{T}$ and then remains constant for $\frac{Z}{T} < \pi < 1 - \frac{Z}{T}$. Beyond $\pi = 1 - \frac{Z}{T}$, Δ^{fc} increase linearly in π, with slope $T(p^c - p^u - b(1-\theta))$, to reach $Z(P^C - a - b) - F$ at $\pi = 1$.

   This shows that Δ^{fc} is weakly larger in the larger market for $\pi < 1 - \frac{Z}{T^S}$, but lower beyond that value.

2. If both are 'small' markets, as defined above, $T^S < T^L < 2Z$.
   $\Delta^{fc} = \Pi^{fc} - \Pi^{nfc} = \pi T \Delta - F$ increases linearly in π, with slope $T\Delta$ until it reaches $(T-Z)\Delta - F$ for $\pi = 1 - \frac{Z}{T}$. Then increases linearly in π with slope $T(P^C - a - b) > T\Delta$ until it reaches $Z\Delta + (2Z - T)(p^c - p^u - b(1-\theta)) - F$ for $\pi = \frac{Z}{T}$. Beyond $\pi = \frac{Z}{T}$, Δ^{fc} increase linearly in π, with slope $T(p^c - p^u - b(1-\theta) < T(P^C - a - b)$, to reach $Z(P^C - a - b) - F$ at $\pi = 1$.

   For $\pi < 1 - \frac{Z}{T^S}$, $\Delta^{fc} = \pi T \Delta - F$ for both markets is an increasing function of market size. Beyond that value for π, the smaller market falls under case 4 with a steeper slope in T, meaning that Δ^{fc} in the smaller market may overpass Δ^{fc} in the larger of the two markets. We can show that this overpassing only happens beyond $\pi = 0.5$ under certain conditions.

   Consider $\pi = 0.5$, which is the largest of the values $1 - \frac{Z}{T}$ among the small markets. In both markets $1 - \frac{Z}{T} \le \pi \le \frac{Z}{T}$. Therefore:

   $$\Delta^{fc} = \pi T \Delta + (Z - (1-\pi)T(p^c - p^u - b + b\theta) - F = K + 0.5T[\Delta - (p^c - p^u - b + b\theta)]$$

   Hence, if $\Delta > p^c - p^u - b(1-\theta)$, Δ^{fc} increases with market size at $\pi = 0.5$. Since all functions $\Delta^{fc}(\pi)$ are linear in π, with slope function of T, their can't be any crossing of two lines before $\pi = 0.5$. This shows that Δ^{fc} increases with market size for all $\pi \le 0.5$. This condition can also be written $\Delta > (a + b\theta - p^u) - (a + b - p^c)$, meaning that the marginal benefit of specializing in the trading of only certified output exceeds that of specializing in the trading of only uncertified output.

3. If $T^S < 2Z < T^L$, corresponding to one small and one large market.
   The evolution of Δ^{fc} on each of the markets is similar to that described above. This shows that Δ^{fc} is larger in the larger market for $\pi < \max(\frac{Z}{T^L}, 1 - \frac{Z}{T^S})$, but not beyond $\max(\frac{Z}{T^S}, 1 - \frac{Z}{T^L})$.

Taken together, one can affirm that Δ^{fc} is larger in the larger market for $\pi \leq 0.5$, whatever categories those two markets belong to.

B. Experiment: protocol

B.1. Script

We presented the following script to traders in their native language (Amharic or Oromo) after the survey.

Enumerator: *please inform the trader that he/she will now play (marketing) games that involve buying and selling bags of 10kg of wheat (chips). Please also inform the trader that he/she will play the game as a wheat trader, and you (the enumerator) will represent the miller. Now, clearly explain the below "rules of the game".*

Jars and chips. Let's consider that you are on a market, and farmers supply wheat of different quality. As usual, you are buying wheat and selling it to millers. Farmers can certify their wheat before selling it on the market and signal it using a specific bag. Hence, you know the quality of the certified wheat with **certainty**. However, some farmers don't certify their wheat, use their bag, and you cannot distinguish between bad and high-quality wheat. According to the market, the average quality supply can be highly variable. We have some jars here with chips that represent 10 kg of wheat. These jars contain blue and red chips. The blue chips correspond to high quality-certified wheat, while the red chips are uncertified wheat. Thus, the red chips (the uncertified wheat) can be either low- or high-quality wheat. The proportion of blue and red chips within each jar is varying. Let's draw a few chips so that we can see.

Enumerator: *please show chips in front of each jar and show the trader that all the jars will have blue and red chips (with and without dot) but different proportions. Then, fill the jar with the appropriate chips.*

Sessions and rounds. When traders visit markets, they use trucks and aim to fill them to recover their fixed costs. However, according to the market size they may have a leeway to select wheat among what farmers supply. You will play 8 games corresponding to different market settings. Each game will lead to a potential earning, and you be paid from one at the end. You will draw some chips from the jar to select and buy **exactly 12 chips** – as if you wanted to fill up your truck, you will later sell to the experimenter (who represents a miller). Remember that you must select and buy 12 chips, which you will later sell to the experimenter (miller). You will draw the chips one by one, and each time you decide whether you want to buy the chip, you draw or reject it (***Enumerator:*** *you MUST record the choice made by the trader*).

Buying chips and its prices. As indicated before, the blue chips represent high-quality certified wheat, and the red chips represent uncertified wheat. Thus, the buying price for blue chips is always higher than red ones. **A blue chip costs 220 birr** to buy, and a **red chip costs 200 birr**. At that time, you do not know whether the red chip represents a high or low-quality wheat

Selling chips to a miller and its prices. After buying wheat on the market, traders usually sell it to millers, and the price varies according to the average quality bought. Millers pay a premium for high-quality certified wheat and rely on certification grade because it provides all information about unobservable quality. Certified wheat is valued only if it is kept separate from uncertified wheat. However, traders must make up-front investments in capital such as trucks or storage facilities to keep certified wheat separated.

As indicated before, you will have the opportunity to sell the chips directly to a miller (represented by me, the experimenter). Before beginning each game, you must decide whether you want to sell blue chips (high-quality certified wheat) separately. If you choose to sell the blue chips separately, you **MUST** buy a specific **cup to store blue chips at 330 birr before drawing any chips. In that case, you will be sure to obtain 280 birr per blue chip** when you sell it to the miller. For the red chips, the miller will assess the average quality of these chips and pay you accordingly (on average **220 birr per chip if you have only low-quality chips, 240 birr if you have only high-quality chips and something between for intermediate cases**). A red chip is high-quality wheat if a mark is drawn under the opaque adhesive tape.

If you decide not to sell the blue chips separately, you can mix them with the red chips and sell them to the miller. In that case, the blue chips have the same value as the high-quality red chips. The miller will assess the average quality of the mixed chips and pay you accordingly (on average **220 birr per chip if you have only low-quality chips, 240 birr if you have only high-quality chips, and something between for intermediate cases**).

Return (profit). At the end of each game, I will assess the average quality of your wheat and determine your potential earnings. After you play the eight games, we will randomly select one of the games using the tablet, and you will be paid the amount you earned in the corresponding game.

Enumerator: *Ask the trader the following questions to make sure that he/she understand the game.*

B.2. Support documents

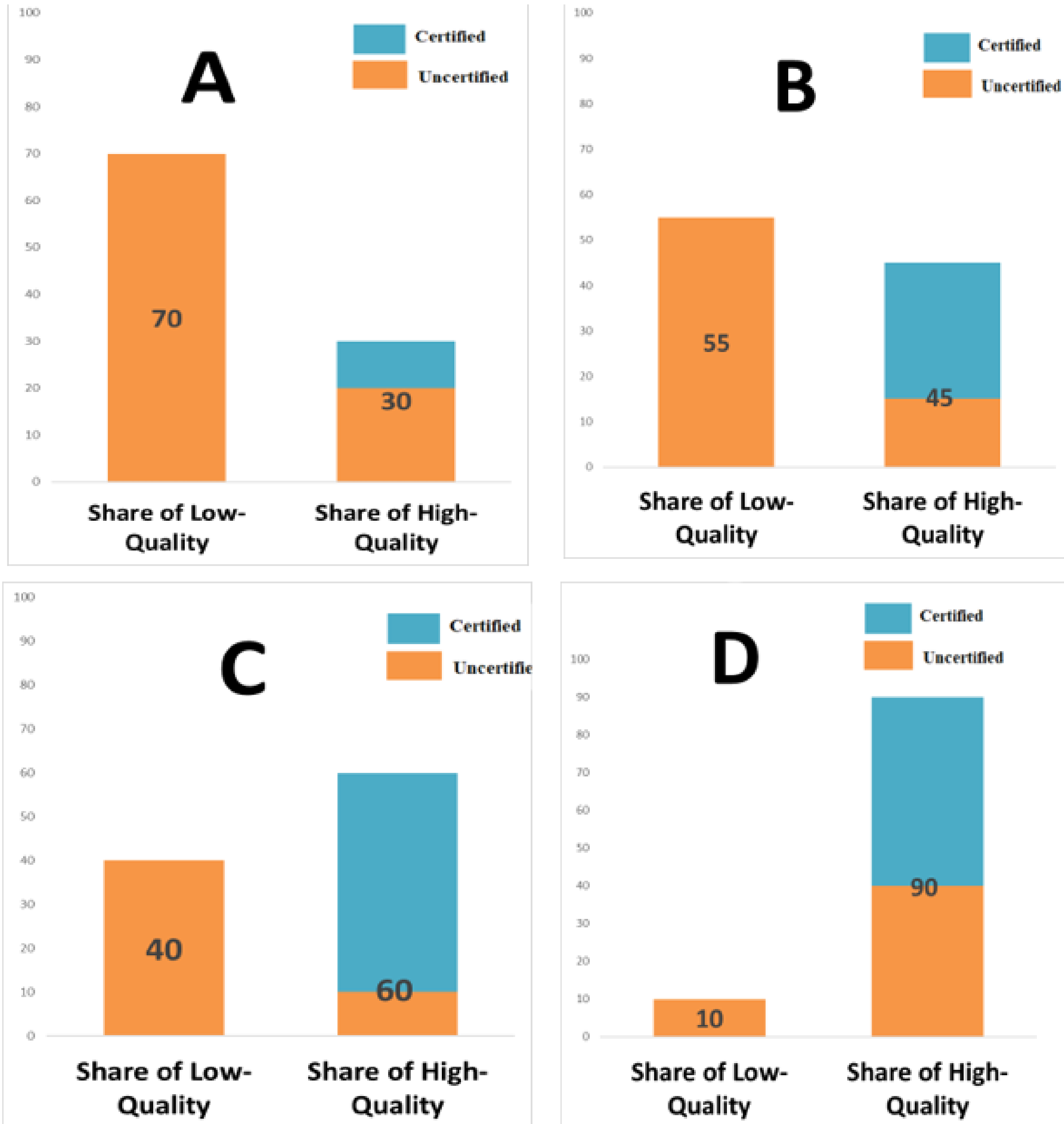
Figure B.1. Summary sheets

A. Rules of the game

B. Market Size

Notes. This figure shows the summary sheets provided to the traders. The sheets summarize the rules of the game and different settings in which traders have to take their decisions.

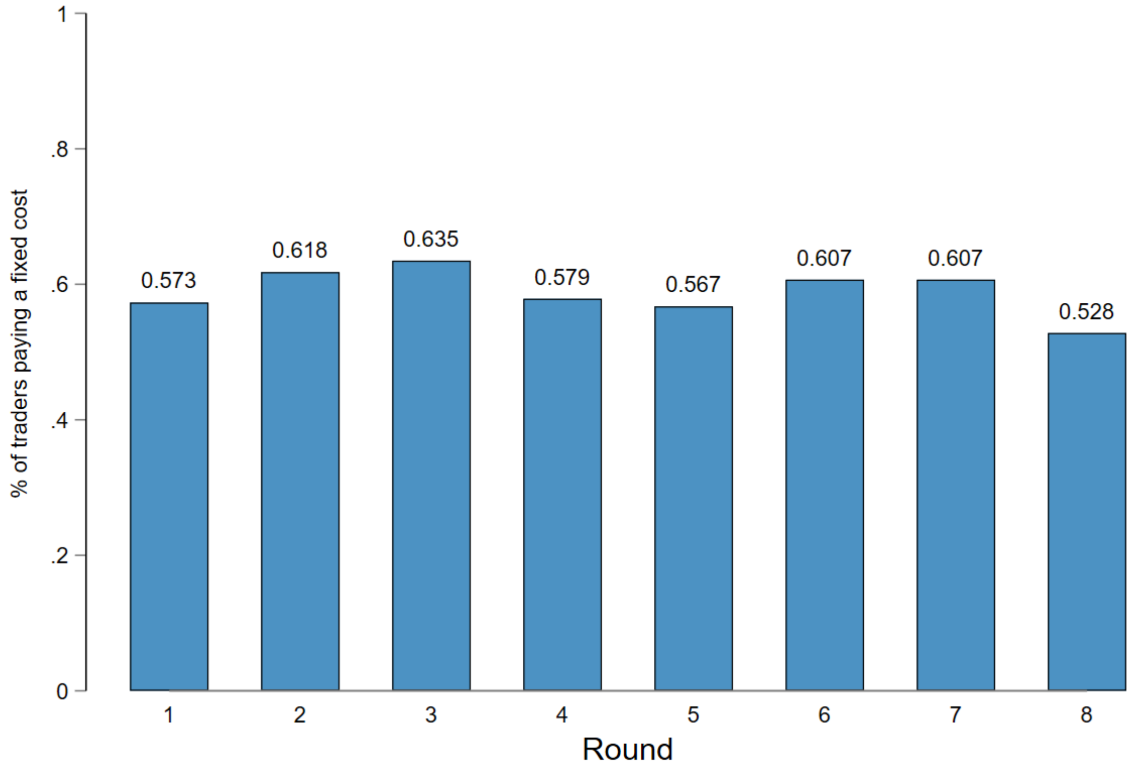
Figure B.2. Treatment game support materials



Notes. This figure shows the support materials provided to the traders. It shows the different cases under which traders have to take their decisions.

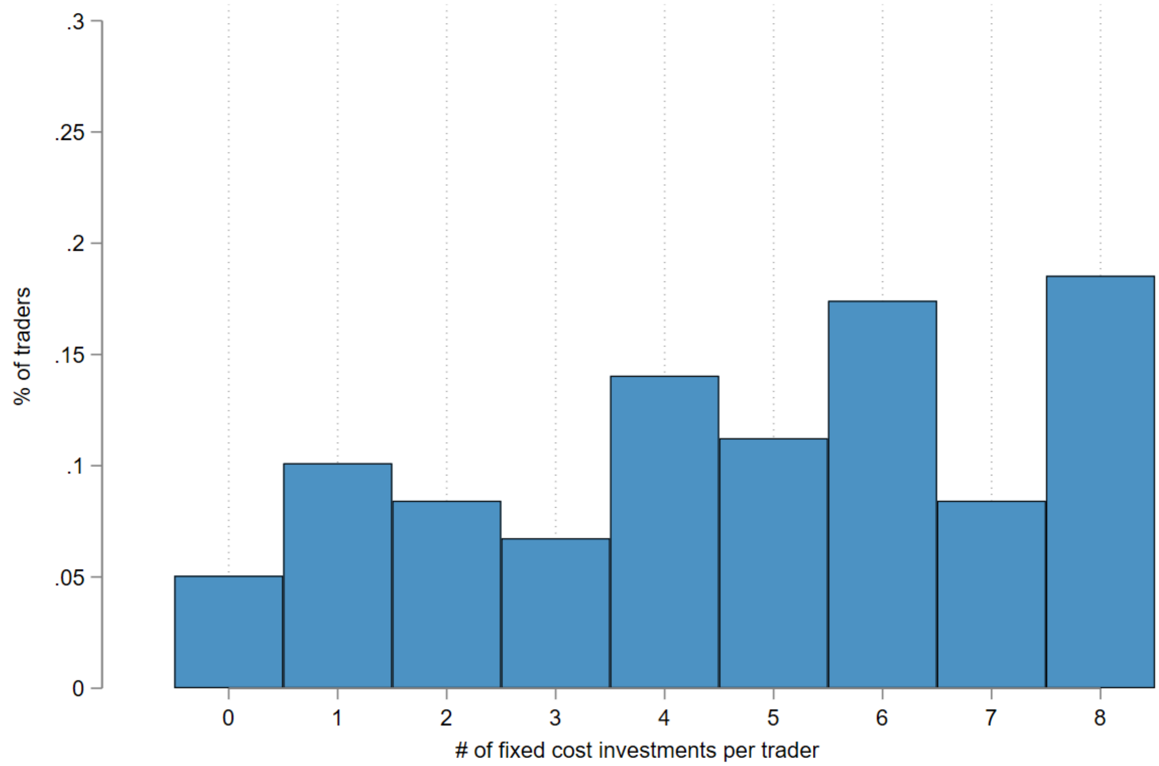
C. Additional results

Figure C.1. Proportion of traders incurring a fixed cost, by round



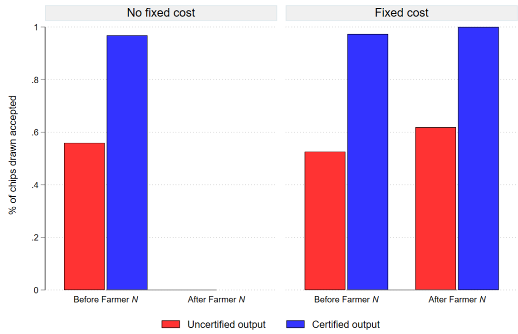
Notes. This figure shows the proportion of traders incurring a fixed cost across the different game round.

Figure C.2. Number of fixed-cost investments per trader during the game

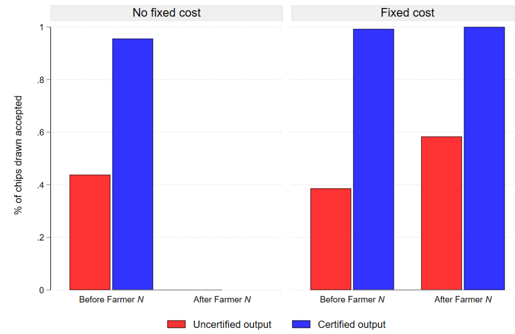


Notes. This figure shows the distribution of the total number of fixed-cost investments traders incurred across all games.

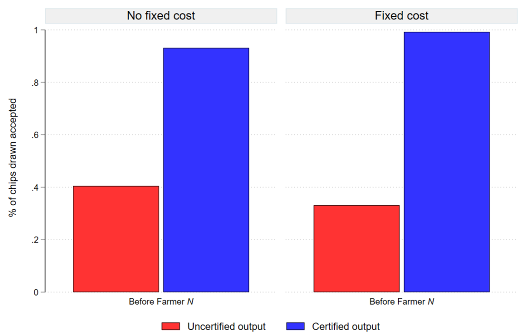
Figure C.3. Proportion of chips drawn accepted according to fixed cost decisions in large market



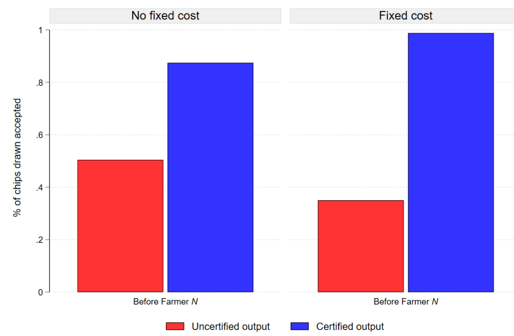
A. Low π - Low θ



B. Medium π - Low θ



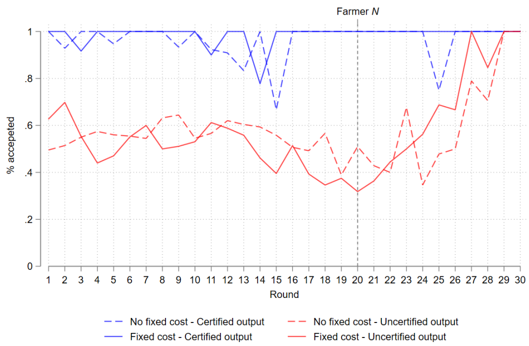
C. High π - Low θ



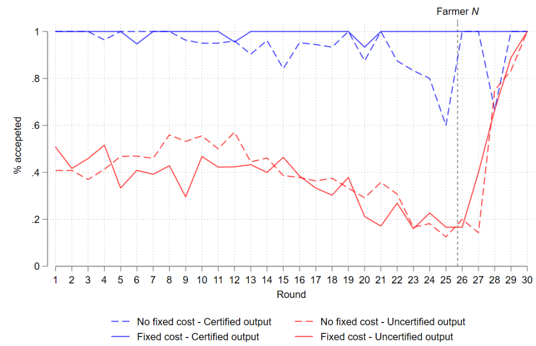
D. High π - High θ

Notes. This figure shows for each wheat type the proportion of chips drawn accepted before and after the threshold Farmer N if the farmer incurred the fixed cost, and M if she did not. Farmer N (M) is the farmer after which the number of remaining encounters with farmers on that day is equal to the number of remaining empty slots on the rented truck. Red bars represent the proportion of uncertified wheat accepted. Blue bars represent the proportion of certified wheat accepted. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

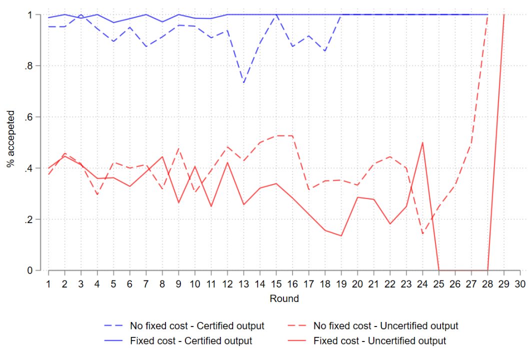
Figure C.4. Acceptance rate per round in large market



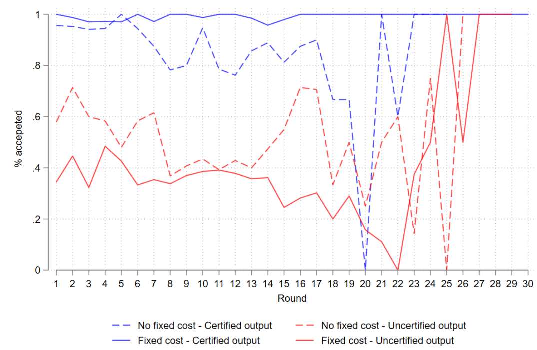
A. Low π - Low θ



B. Medium π - Low θ



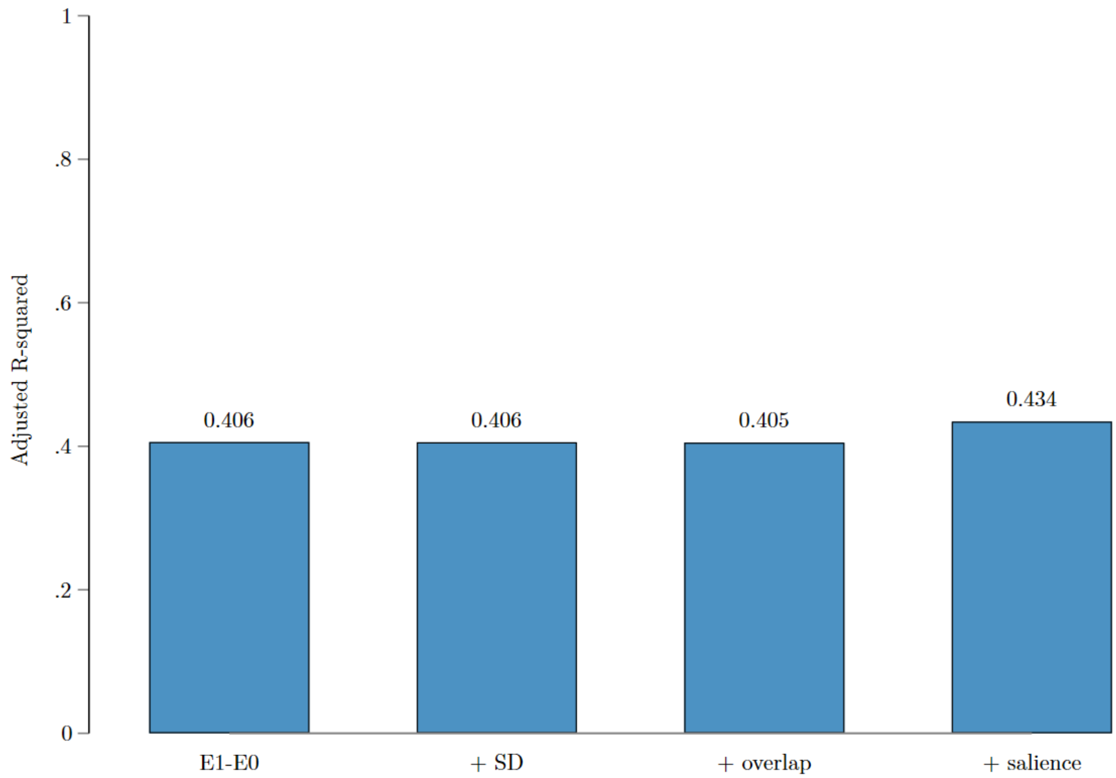
C. High π - Low θ



D. High π - High θ

Notes. This figure shows for each treatment the proportion of chips drawn accepted at a given round before and after the Farmer N (M) threshold if they (do not) pay the fixed cost. Farmer N (M) is the farmer after which the number of remaining encounters with farmers on that day is equal to the number of remaining empty slots on the rented truck. Farmer N (M) is not displayed when its value is larger than the maximum number of rounds. Red lines represent the proportion of uncertified wheat output accepted at a given round. Blue lines represent the proportion of certified wheat accepted at a given round. Plain lines represent cases for which the trader incurs a fixed cost. Dashed lines represent cases for which the trader does not incur a fixed cost. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

Figure C.5. Sources of variation explained in fixed cost decisions



Notes. This figure shows the fixed cost decision variation sources. It reports the share of total fixed cost decision dispersion explained when estimated using a series of decision function specifications, including additional controls beyond expected utility. Bar on the far left was estimated from a model including only expected earnings returns to paying the fixed cost. Left-to-right, subsequent specifications add (i) the standard deviation of the earning difference after paying or not the fixed cost, (ii) the overlap in earnings distribution with and without paying the fixed cost, and (iii) the tangent function of the expected returns to paying the fixed cost.

Table C.1. Treatment effects on trader decisions to pay a fixed cost

	Small Market	Large Market	Full Sample
	(1)	(2)	(3)
T2	0.19***	0.25***	0.20***
	(0.04)	(0.04)	(0.04)
T3	0.30***	0.42***	0.30***
	(0.04)	(0.04)	(0.04)
T4	0.42***	0.44***	0.43***
	(0.04)	(0.04)	(0.04)
T1 × Large Market			-0.01
			(0.04)
T2 × Large Market			0.05
			(0.06)
T3 × Large Market			0.11**
			(0.05)
T4 × Large Market			0.00
			(0.06)
T2=T3 *p*-value	.00	.00	.00
T3=T4 *p*-value	.00	.62	.00
T3 + T3 × Large Market = T4 + T4 × Large Market *p*-value			.66
Trader FE	Yes	Yes	Yes
Order FE	Yes	Yes	Yes
N	712	712	1424
Outcome mean, T1	.34	.33	.33

Notes. Dependent variable is a dummy equals 1 if the trader incurs a fixed cost before the game. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat. Small market corresponds to small market game (16 draws) Large market corresponds to large market game (30 draws). Results are based on small market games in column 1, large market games in column 2, and full sample in column 3. The value of reference is the low share of certified wheat case ($\pi = 0.1$). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

D. Monte Carlo analysis

Relying on our theoretical model outlined in Section 3, we employ a Monte Carlo approach to estimate the first and second-moment conditions of earning distribution for each market case (8 in total) conditional on the initial decision to incur the fixed cost. The objective is to estimate the coefficient variation of earnings for each game, which captures the riskiness of a market case to some extent.

Following each case mentioned in Section 3, we define earnings functions after incurring or not the fixed cost according to the model's parameters: market size, the share of uncertified high-quality wheat (θ), and the share of certified wheat (π). This replicates the earnings functions derived from our theoretical model to each game traders face in real life. In other words, we have two earnings functions per game: one after incurring the fixed cost and one without incurring it.

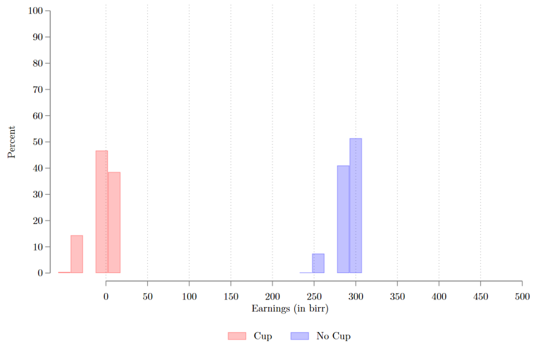
In each game, a trader's earnings function depends on her choice to incur the fixed cost or not. We generate 1,000 rounds played for each game. Each round involves up to 16 or 30 repeated draws, according to the market size, from the sample containing 36 certified and noncertified wheat units without replacement. We assign a uniformly distributed random number to each chip over the interval [0,1] and rank them accordingly. After each draw, we apply the optimal decision rule to accept or not a given unit (see Section 3.2 and 3.3) until 12 units are accepted. We compute the earning gap between the two fixed-cost cases for each simulation. Next, we calculate the average difference in earnings, the standard deviation of earnings difference over the 1,000 draws, and the overlap in earnings for each game. We measure overlap as the proportion of the earning distribution with and without the fixed cost which overlaps (similar to common support). Figure D.1 and Figure D.2 show the earnings distribution for small and large market cases. Table D.1 shows simulation results.

Table D.1. Simulated games characteristics

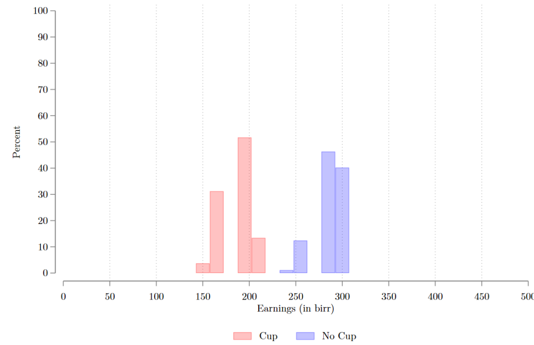
Market size	Small Market				Large Market			
Treatment Combinations	Low π Low θ	Medium π Low θ	High π Low θ	High π High θ	Low π Low θ	Medium π Low θ	High π Low θ	High π High θ
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
E_1	-5.34	184.96	249.68	290.32	100.48	317.14	390.00	390.00
SD $[\mathbb{E}_1]$	14.02	14.57	13.30	13.09	19.23	16.47	0.00	0.00
E_0	288.72	285.12	269.98	330.92	280.50	274.02	264.46	338.24
SD $[\mathbb{E}_0]$	12.75	14.21	11.77	16.52	20.55	18.47	16.42	26.47
$\mathbb{E}[\mathrm{E}_1 - \mathrm{E}_0]$	-294.06	-100.16	-20.30	-40.60	-180.02	43.12	125.54	51.76
SD $[\mathrm{E}_1 - \mathrm{E}_0]$	8.05	12.37	12.07	17.11	13.33	21.62	16.42	26.47
Overlap	0.00	0.00	0.68	0.62	0.00	0.98	0.00	0.00
Salience	-0.84	0.95	2.24	2.35	-5.40	-1.83	0.86	-1.45

Notes. This table reports summary statistics results from 1,000 Monte Carlo simulations by game (treatment combination) and market size. Columns (1-4) show results for small market cases. Columns (5-8) show results for large market cases. E_1 measures average expected earnings (in Birr) after incurring the fixed cost. SD$[\mathbb{E}_1]$ is the earnings spread after paying the fixed cost. E_0 measures average expected earnings (in Birr) without incurring the fixed cost. SD$[E_1]$ is the earnings spread when not paying the fixed cost. $\mathbb{E}[E_1 - E_0]$ is the expected earnings difference between cases with and without paying the fixed cost. $SD[E_1 - E_0]$ is the spread of the earnings difference after paying or not the fixed cost. Overlap is the proportion of the earnings distribution in common between cases with and without paying the fixed cost. Salience is the tangent of the difference in expected earnings.

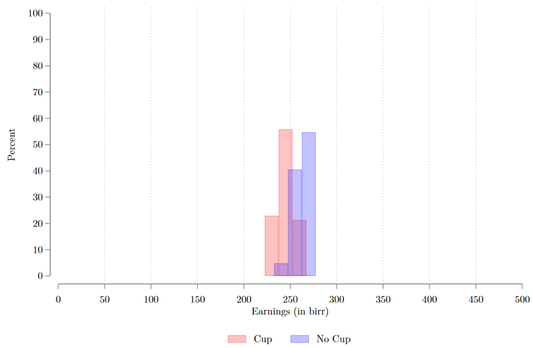
Figure D.1. Simulated earnings distribution in small market, by game



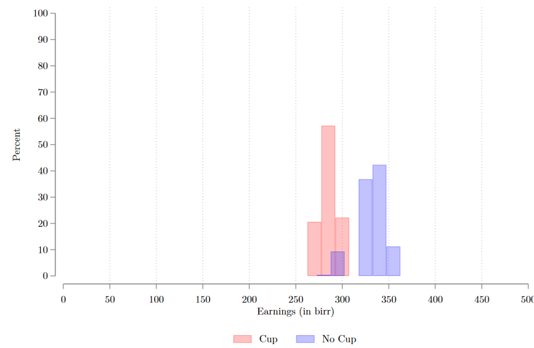
A. Low π - Low θ



B. Medium π - Low θ



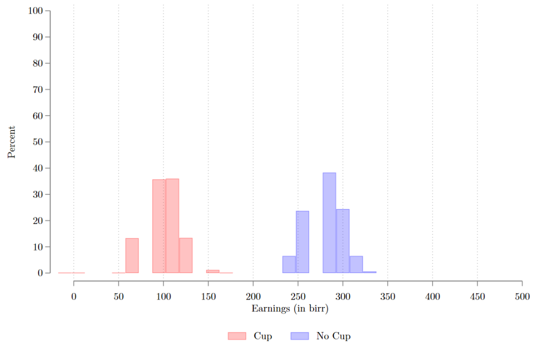
C. High π - Low θ



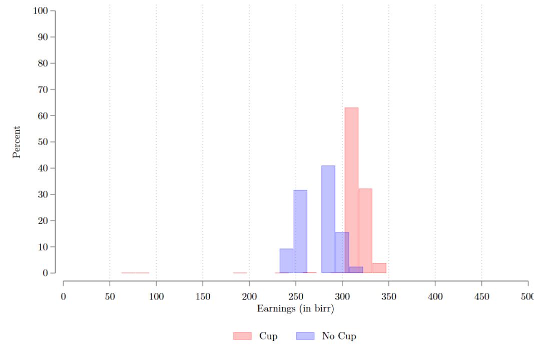
D. High π - High θ

Notes. This figure shows simulated earnings distributions (in Birr) from 1,000 Montecarlo simulation by fixed cost decision and game. Red bars show earnings after incurring the fixed cost. Blue bars show earnings after incurring the fixed cost. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

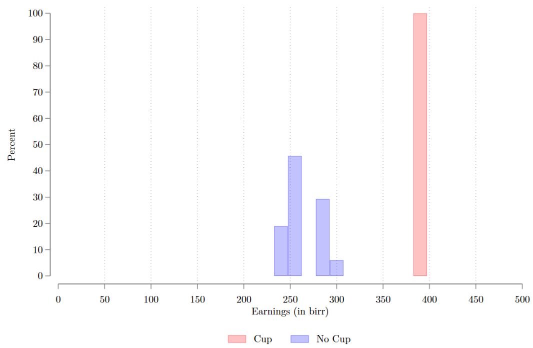
Figure D.2. Simulated earnings distribution in large market, by game



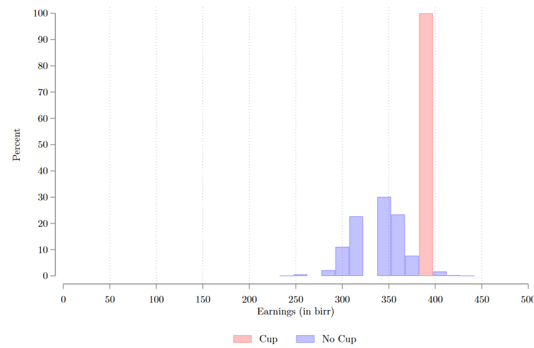
A. Low π - Low θ



B. Medium π - Low θ



C. High π - Low θ



D. High π - High θ

Notes. This figure shows simulated earnings distributions (in Birr) from 1,000 Montecarlo simulation by fixed cost decision and game. Red bars show earnings after incurring the fixed cost. Blue bars show earnings after incurring the fixed cost. π is the share of certified-wheat. θ is the share of uncertified high-quality wheat.

E. Data and Measures

This section provides further details on the construction of the behavioral variables used in the paper.

E.1. Present Bias Elicitation

We elicit intertemporal choices using the Convex Time Budget method (Andreoni et al., 2015). This approach allows us to measure to whether and to what extent individuals smooth time-dated monetary rewards. We can elicit all the parameter of the quasi-hyperbolic discounted model using only one experimental instrument: the discount factor δ, present bias β, and instataneous utility function u. We asked traders to select a reward schedule from a set of 3 options delivered at two points in time given an inter-temporal budget constraint with a k-period gross interest rate, $1+r$. We are varying the time horizons and gross interest rate to identify the three parameters mentioned.

We asked traders to consider how much they would like to received for sure today and in 4 weeks from a set of 3 options over 5 reward schedules, then they do the same task over a different time horizon (4 weeks vs 8 weeks). Figure E.1 shows the survey materials used.

Figure E.1. Survey materials for time preferences elicitation

#	Question	Response options	CAPI notes
For each decision number below, decide the AMOUNTS you would like for sure **today** AND in **4 weeks** by checking the corresponding answer. *Example: In Decision 1, if you wanted 250 birr today and 0 birr in four weeks you would check the first answer. Remember to check only one answer per decision*			
D1a.	Would you like to receive X payment TODAY **and** Y payment in 4 weeks	1. 250 and 0 birr 2. 125 and 125 birr 3. 0 and 250 birr	Only 1 answer
D1b	Would you like to receive X payment TODAY **and** Y payment in 4 weeks	1. 225 and 0 birr 2. 113 and 125 birr 3. 0 and 250	Only 1 answer
D1c	Would you like to receive X payment TODAY **and** Y payment in 4 weeks	1. 200 and 0 birr 2. 100 and 125 birr 3. 0 and 250 birr	Only 1 answer
D1d	Would you like to receive X payment TODAY **and** Y payment in 4 weeks	1. 175 and 0 birr 2. 88 and 125 birr 3. 0 and 250 birr	Only 1 answer
D1e	Would you like to receive X payment TODAY **and** Y payment in 4 weeks	1. 150 and 0 birr 2. 75 and 125 birr 3. 0 and 250 birr	Only 1 answer

A. Task over short time period

For each decision number below, decide the AMOUNTS you would like for sure in **4 weeks** AND in **8 weeks** by checking the corresponding answer. *Example: In Decision 1, if you wanted 250 birr in four weeks and 0 birr in eight weeks you would check the first answer. Remember to check only one answer per decision*			
D2a.	Would you like to receive X payment in 4 weeks **and** Y payment in 8 weeks	1. 250 and 0 birr 2. 125 and 125 birr 3. 0 and 250 birr	Only 1 answer
D2b	Would you like to receive X payment in 4 weeks **and** Y payment in 8 weeks	1. 225 and 0 birr 2. 113 and 125 birr 3. 0 and 250	Only 1 answer
D2c	Would you like to receive X payment in 4 weeks **and** Y payment in 8 weeks	1. 200 and 0 birr 2. 100 and 125 birr 3. 0 and 250 birr	Only 1 answer
D2d	Would you like to receive X payment in 4 weeks **and** Y payment in 8 weeks	1. 175 and 0 birr 2. 88 and 125 birr 3. 0 and 250 birr	Only 1 answer
D2e	Would you like to receive X payment in 4 weeks **and** Y payment in 8 weeks	1. 150 and 0 birr 2. 75 and 125 birr 3. 0 and 250 birr	Only 1 answer

B. Task over long time period

We then follow Andreoni et al. (2015) to estimate time preferences parameters in the the optimal demand for sooner payment using Nonlinear Least Squares. Then, we create an indicator variable equals 1 when a trader is present biased (i.e., $\beta < 1$). A present-biased ($\beta < 1$) trader allocates more to the sooner payment date when the sooner payment date is the current period than when both payment dates are in the future.

E.2. Risk Preferences

We used a survey-based measure of risk preferences based on Binswanger (1980) and Cole et al. (2013). We asked traders about a hypothetical wheat sale. We asked them to select which of the six hypothetical options they would prefer for this transaction. In the first payout they would be certain to receive 280 Birr for 10kg of wheat. In the second, they would have an equal chance of receiving 210 or 330 Birr. The subsequent four payouts are increasing in both mean and variance. We construct a risk aversion indicator variable equals 1 for traders who choose the safest lottery.

E.3. Loss Aversion

We used a survey-based measure of loss aversion from lotteries choice as in Binswanger (1980) and Cole et al. (2013). We asked traders about a hypothetical 250 Birr earnings they can increase by playing a coin tossing game. However, there are both a chance of increasing and a risk of losing some of this earning. We asked them to select which of the five hypothetical option they would prefer. In the first payout they would be certain to earn 250 Birr. In the second, they would have an equal chance of losing 50 Birr or winning 400 Birr. After that, there are three more payouts, which increase in both mean and variance. We use two variables capturing loss aversion. First, a dummy variable equals 1 if a trader chose the safest lottery (i.e., earning 250 Birr with certainty). Second, a continuous measure increasing with loss aversion equals to $\frac{\Delta\mathbb{E}[\text{Earning}]}{\Delta\text{Risk}}$.

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