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Market Channel and Heterogeneous Storage Behavior in Response to Multiple Risks: The Case of Nigerian Maize Traders

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Introduction

As maize value chains expand and lengthen, they become increasingly vulnerable to various risks. In this study, we focus on Nigerian maize wholesale traders, who serve as representative midstream actors in the maize value chain, and analyze their storage behaviors in response to multiple risks induced by climate change, armed conflicts, and maize spoilage. We also assess how their storage behaviors vary depending on their market channel choices, specifically between selling to "modern buyers" (industrial food and feed mills) versus "traditional buyers" (consumers, other wholesalers, and retailers). While understanding traders' behaviors by their market channel is important as different traders would have heterogeneous incentives, previous studies have not taken into account the varying effects of risks across traders. We use data from a unique, large sample survey of Nigerian maize traders and apply a triple-hurdle model with probit and bivariate probit estimation approaches. Our findings provide consistent evidence of heterogenous trader responses to risks depending on their primary market channel, highlighting the importance of considering traders' market channel choice when developing policies aimed at mitigating the impact of risks and building resilient maize value chains.

Key Findings

- Nigerian maize wholesale traders' decisions to store maize and apply chemicals and/or non-chemicals to stored maize are influenced by their choice of primary market channel.
- Temperature fluctuation affects the probability of storage in opposite ways. For traders mainly selling to the modern channel, higher temperature variability increases the likelihood of storing maize, whereas for those selling to the traditional channel, it reduces the likelihood of storing maize.
- Previous experience with climate-induced shocks has no effect on the storage practices of traders selling to modern buyers, but is positively associated with the use of chemicals among traders selling to traditional buyers.
- Taking into account the differential effects of risks on traders selling to different market channels is crucial to implement policies aimed at mitigating the impact of risks and building a more resilient maize value chain in Nigeria.

Data

We use a survey of maize wholesale traders conducted in 2021, which covers the major grain markets in Nigeria. The states covered include Kano, Kaduna, Katsina, and Plateau, which are the primary maize producing states in northern Nigeria, and Oyo in southern Nigeria, which is a major maize consuming area where some maize production occurs. In each state, the main city was selected, and all traders in maize markets within that city were listed and interviewed. In addition, all regional markets in the four northern states that serve other states in Nigeria or other countries were listed. The top five regional markets with high volume of maize traded were selected in each of the northern states, and 30 traders were randomly selected from each of the chosen regional markets: 15 from the large trader stratum (with maize sales above 32 tons during a typical month in the high maize trading season) and 15 from the small trader stratum (with maize sales below 32 tons during the same period). As a result, our study sample included 1,109 traders, with 584 traders from Kano, 136 traders from Kaduna, 170 traders from Katsina, 137 traders from Plateau, and 80 traders from Oyo.

The survey collected detailed information on maize traders' demographic characteristics, assets, maize purchases and sales, value-adding activities such as storing and drying maize, as well as their experiences of business environment shocks and their responses to them. Table 1 presents the variables used in the analysis along with their

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average values. Among the traders in our study sample, 64% stored maize. Among those who stored maize, 20% applied chemicals and 5% applied non-chemicals on stored maize to prevent damage. Traders sell maize to various market channels, and we classified them into two main categories: modern and traditional. The modern market channel includes processors (feed mills, flour mills or the food industry) and governmental and non-governmental organizations, which have emerged more recently as formal market channels. In contrast, the traditional market channel comprises consumers, other wholesalers, and retailers. As traders usually sell to multiple market channels, we determined their primary channel based on the share of maize sold to each individual channel and constructed a binary market channel variable accordingly.

Table 1. Definition of Variables and Summary Statistics

Variable	Definition	Mean	(Std. Dev.)
Dependent variables			
Storage	1 if trader stored maize during the last transaction, 0 else	0.64	(0.48)
Chemical	1 if applied chemical on stored maize to prevent damage, 0 else	0.20	(0.40)
Non-chemical	1 if applied non-chemical on stored maize to prevent damage, 0 else	0.05	(0.22)
Main market channel	1 if mainly sold to modern channel, 0 if mainly sold to traditional channel	0.23	(0.42)
Risks and Shocks			
CV of rainfall	Coefficient of variation of monthly rainfall (mm) between 4/2021-7/2021	0.94	(0.34)
CV of temperature	Coefficient of variation of monthly temperature (°C) between 4/2021-7/2021	0.11	(0.02)
Past climate shock	1 if experienced climate-induced shocks between 8/2020-7/2021, 0 else	0.13	(0.34)
Past spoilage shock	1 if experienced spoilage shocks between 8/2020-7/2021, 0 else	0.03	(0.17)
Past conflict shock	1 if experienced conflict-induced shocks between 8/2020-7/2021, 0 else	0.49	(0.5)
Explanatory variables			
Male	1 if male, 0 else	0.88	(0.33)
Education	1 if formally educated, 0 else	0.71	(0.45)
Years of trading	Number of years trader has been a maize wholesaler	20.00	(8.74)
Storage training	1 if has ever received storage technique training, 0 else	0.02	(0.13)
Scale	1 if has large monthly sales over 32 tons in the high season, 0 else	0.64	(0.48)
Distance to highway	Km distance from trader's business to the nearest highway	4.84	(9.01)
Trader association	1 if a member an organization/group associated with maize business, 0 else	0.56	(0.50)
Other job	1 if engaged in other income-generating jobs between 8/2020-7/2021, 0 else	0.14	(0.35)

Various Risks in Traders' Activities

The risks that traders face in maize trading consist of climate-induced risks, as well as climate-, conflict-, and maize spoilage-induced shocks experienced in the past (Table 1). Monthly rainfall and temperature data are obtained at the local government level from the Climate Hazards Group InfraRed Precipitation with Station and Climate Data Store, respectively. The coefficients of variations are included as indicators of variability in rainfall and temperature in traders' business area during the maize growing season, which was just before most traders stored maize (if they stored). The experience of climate-induced shocks was constructed based on traders' response to whether they had encountered any of the following problems: maize shortage due to production disruptions caused by floods or droughts; significant delay in receiving maize due to roads washout; and washout or flood in the market destination area. The experience of spoilage shocks was constructed based on traders' response to whether they had encountered any of the following issues: aflatoxin outbreaks; pests or rodents affecting stored maize; and serious spoilage of maize, for example, due to mold. Finally, the experience of conflict-induced shocks was constructed based on traders' response to whether they had encountered any of the following challenges: Boko Haram conflict in the North that directly affected their ability to sell maize or buy maize from farmers or other traders; farmer-herder conflict affecting their ability to buy maize from farmers; and other insecurity problems such as banditry or kidnapping that impacted their ability to trade maize.

Following the approach of Liverpool-Tasie and Parkhi (2021), we consider Nigerian maize traders as small and medium-scale enterprises whose objective is to maximize

expected profit by purchasing maize, adding value to it (through storing maize and/or applying chemicals or non-chemicals to control damage on stored maize), and selling it. Maize with certain qualities, such as having less damage from pests or meeting some food safety standards, is likely to be more strictly required by modern buyers and entails a quality premium reflected in higher prices (Hoffmann and Moser, 2017). Adding value to maize through adopting storage and/or damage control practices is thus an important way to maximize profit. However, such activities entail costs and risks. For example, extreme variability in rainfall in traders' business operation area can influence their ability to store and control the quality of stored maize. This is because such variability could raise the incidence of pest and disease in storage, which then affects the quantity, quality, and price of maize when traders sell to buyers. The experience of climate-induced shocks that disrupt the ability to source maize also affects storage decisions. Traders who experienced such a disruption in the past may tend to store more to secure maize. However, it is also plausible that such traders store less because they were not able to source enough to store after selling to buyers.

Effects of Various Risks on Traders' Primary Market Channel Choice and Storage Behaviors

We employ a triple-hurdle approach (Burke, Myers, and Jayne, 2015) in which traders first decide whether to sell primarily to modern or traditional market channels. We then examine the extent to which different risks affect the decision to store and particular storage behaviors for traders who store. In the second and third sets of decisions, we explore how the impact of risks varies by traders' main market channel choice determined in the first stage. The results of the first stage analysis on the determinants of the primary market channel choice using probit regression indicate that rainfall and temperature variability do not influence traders' decision. However, male and large-scale traders are more inclined to sell to the modern market channel, while traders with longer trading experience and membership in trader associations are less likely to do so.

The probit regression results of the second stage reveal that temperature variability affects the probability of storing maize in opposite ways for traders selling to traditional buyers versus those selling to modern buyers. Traders who primarily sell to the modern channel tend to store maize in the face of higher temperature variability, while traders who mainly sell to the traditional channel tend not to store maize under similar conditions. This may be because traders selling to the modern channel are more likely to be under contract with their buyers, hence striving to secure their maize by storing it to fulfill their contract, even when faced with adverse conditions. However, traders whose main buyers are in the traditional channel may choose not to store maize under high weather variability since storage under such conditions can easily result in maize damage. Therefore, they would opt to sell their maize immediately to buyers in demand. Additionally, for traders selling to the modern channel, our results indicate that the experience of conflict-induced shocks has a negative impact on their storage decisions. One possible explanation for this finding is that conflicts caused disruptions in sourcing sufficient maize, which may have made traders unable to spare maize for storage after delivering the designated amount to their modern buyers.

The third stage analysis on maize-storing traders' application of damage control practices using bivariate probit regression suggests that traders who had experienced spoilage shocks are more likely to apply chemical and non-chemical treatments, regardless of their main market channel type. This would be because they are more cautious in preventing damage to stored maize compared to those who had not experienced such shocks. In addition, previous experience with climate-induced shocks has no effect on the storage practices of traders selling to modern buyers but is positively associated with chemical use among traders selling to traditional buyers. Given that those selling to the traditional channel account for the majority of traders (77%), this finding raises concerns about the safety of maize as chemical residues in maize can be harmful when consumed.

Policy Implications

Maize traders play a crucial role in Nigeria's economy, as the production and consumption of maize serve as a fundamental aspect of the country's food system. The storage behaviors of maize traders, including their use of chemicals and non-chemicals, have a direct impact on the quantity and quality of maize that reaches consumers, making it critical to address issues of food security and safety. The decisions of traders to store maize and apply damage control practices are likely to be influenced by their choice of market channel. Traders who mainly sell to modern buyers would prioritize meeting quality requirements and maintaining the quality of their maize as specified by their buyers. Consequently, they may have different incentives when it comes to facing risks and making decisions about storage and damage control compared to traders who primarily sell to traditional buyers. As such, it is essential to consider traders' varying incentives and behaviors based on their market channel

choice, as this leads to different responses to risks and policies addressing such risks.

We recommend that policies aimed at mitigating the impact of risks and building a more resilient maize value chain in Nigeria need to account for the differential effects of risks on traders selling to different market channels. For example, climate-induced shocks are particularly linked to the use of chemicals by traders mainly selling to tradition buyers. Therefore, a policy addressing climate-induced shocks would be more effective if it focuses on this group of traders to reduce their exposure to such shocks and mitigate the impact of such shocks on the maize value chain, which can deliver safe and nutritious maize.

Key References

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