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RESEARCH ARTICLE

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# Nontariff measures and production allocation decisions of cereal farmers in Ghana

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## Abstract

Using exogenous variation in trade shocks, this study examines the association between nontariff measures and cereal production allocation decisions among commercial farmers in Ghana. We study nontariff measures from both an extensive (experience of nontariff measures) and an intensive (cost of nontariff measures) perspective using a sample of 455 cereal farmers in Ghana. We employ the seemingly (un)related regression (SURE) and the inverse probability weighting with regression adjustment (IPWRA) to estimate the effect of nontariff measures on production allocation decisions. The result shows that nontariff measures are associated with lower cereal production and intensity of cereal commercialization but positively associated with the consumption of cereals. The results are robust after controlling for potential endogeneity using the Lewbel 2SLS. In addition, we find that our results are not likely to be driven by unobserved heterogeneity. We find evidence of consistent and robust estimates of nontariff measures when the IPWRA model is applied and compared to the SURE estimates. Overall, our study shows that nontariff measures can be a depressive pathway to cereal sustainable production and commercialization with associated policy implications for economic development [EconLit Citations: F1, F13, E23, Q13].

**Abbreviations:** 2SLS, two-stage least squares; FAO, Food and Agriculture Organization; FBOs, farmer-based organizations; GAP, good agricultural practices; IPW, inverse probability weighting; IPWRA, inverse probability weighting with regression adjustment; MoFA, Ministry of Food and Agriculture; NTMs, nontariff measures; OLS, ordinary least squares; RA, regression adjustment; SARI, Savanna Agricultural Research Institute; SDGs, sustainable development goals; SPS, sanitary and phytosanitary; SSA, Sub-Saharan Africa; SURE, seemingly unrelated regression.

  

KEYWORDS
cereal production, commercialization, Ghana, nontariff measures, production allocation

## 1 | INTRODUCTION

Can farmers in Sub-Saharan Africa (SSA) sustainably produce and intensify crop commercialization, maintain their food consumption and access to seed given the increasing transaction cost associated with production and agricultural commercialization? Sustainable crop production and agricultural commercialization are potential pathways to enhancing welfare outcomes and contributing toward the sustainable development goals (SDGs) one (poverty alleviation), two (enhance food security), and 10 (reduce inequality). However, population growth in SSA, characterized by high demand for food, requires strategic actions to ensure the sustainable movement of food from production to consumption centers. Enhancing the movement of agricultural commodities (inputs and outputs) is directly linked with food security, nutrition outcomes, and economic development. Notwithstanding, trade policies such as nontariff measures may restrict the movement of commodities (Beghin et al., 2012; UNCTAD United Nations Conference on Trade and Development, 2012).

Nontariff measures[1] are policy trade measures other than tariffs that generate restrictions and affect trade flows and can potentially have an economic consequence on trade in goods, quantity traded, and prices (González-Mellado et al., 2011; Multi-Agency Support Team [MAST], 2008). The nontariff measures are regulations put in place by governments to address critical societal interests when there is market inefficiency (Beghin et al., 2012). Notable among the nontariff measures are customs and police checkpoints which increase the cost of transporting goods across in-country borders (Portugal-Perez & Wilson, 2008). The high number of customs checkpoints in most African countries increases the cost of agricultural production due to rising input prices. It limits the transportation of goods in-country and across neighboring countries (World Bank, 2012). This study ascertains how nontariff measures (export licensing, customs facilities, testing and certification, sanitary and phytosanitary [SPS], packaging technical regulations and standards, quotas, global GAP standards, and fairtrade and organic standards) influence Ghanaian commercial farmers' decision to either sell their produced cereals, consume, give away as gift, or re-use as seed.

Farmers' motivation to consume, commercialize, give away part of the produce as gift or re-use as seed depends on several factors. Agricultural households rely on their food production as their primary food source while selling the surplus to generate income (Rapsomanikis, 2015). Commercial farmers produce to sell to generate income while semicommercialized farmers produce for consumption and sale. Commercialization enables households to substitute their produce with consumption of market commodities as they convert their in-kind income to cash income (van Asselt & Useche, 2022). According to Gray (2021), the farmer-saved seeds are derived from grain conditioning from the previous harvest. Factors, such as information asymmetry, access, preferred varietal preservation, and costs, influence farmers to save seed. Farmer-saved seeds require less cost in terms of transportation and asymmetric information in the transaction, given that the farmer is fully aware of the nature of the seeds. Larger farms are more likely to use saved seeds than certified seeds due to the lower per unit storage costs, seed cleaning costs, seed testing costs, and seed treatment costs (Gray, 2021). It is a common practice among rural households to give away some of their produce to relatives, friends, neighbors, and those in need depending on the quantity of harvested produce for the season and the ability to maintain household consumption. Nevertheless, the

[1]NTMs have a corrective role, by reducing asymmetric information, mitigating risks in consumption, improving the sustainability of eco-systems, and influencing the competition and the decision to import or export (United Nations Conference on Trade and Development [UNCTAD], 2012).

extent to which farmers allocate their farm produce in terms of consumption, commercialization, gift, and seed largely depends on production and transaction costs they face. In this study, we test the hypothesis that transaction cost such as nontariff measures is more likely to reduce the quantity of cereal production and commercialization but increase consumption to maintain household food needs.

Nontariff measures impose both fixed (certification) and variable (testing and inspection at customs checkpoints) costs to producers (Crivelli & Groeschl, 2016; Xiong & Beghin, 2012) and reduce profits and supply. According to Swinnen (2016), the reduction in supply creates an increase in price effect which determines the size of producers' profit depending on the magnitude of the revenue gain and the cost of nontariff measures. Maziku and Mashenene (2020) assess the effect of nontariff barriers on the production and commercialization of maize in Tanzania and find that nontariff barriers reduce the quantity of maize produced and supplied. They recommend reducing or removing the nontariff barriers to facilitate production and trade. Several studies from Indonesia have shown that farmers do not necessarily benefit from nontariff measures. For example, Respati et al. (2017) show that about 91% of the farmers in Indonesia are net consumers who do not benefit from nontariff measures, given that the positive price effects on their income do not match their expenditures. A study by Yusuf and Warr (2018) in Indonesia indicates that an increase in farmers' income resulting from implementing nontariff measures led to an increase in price but did not commensurate with the high food expenditure incurred by the farmers. Neilson (2018) argues that farmers do not necessarily benefit from nontariff measures (protection against food imports). A more recent study in Indonesia by Amanta and Wibisono (2021) show an upward price adjustment due to nontariff measures rather than increased inequality among farmers.

Although there are several studies on nontariff measures regarding farmers' welfare and market participation, none address how nontariff measures influence production and allocation decisions, given that farmers are both producers and consumers. Our study focuses on Ghanaian commercial farmers who cultivate large land areas and participate intensively in input and output markets. Farmers are producers and consumers who make sole or joint decisions on land allocation and production decisions. Ghana serves as a unique case study, given that several complaints by producers and private firms have consistently featured in the local newspapers regarding the cost of nontariff measures. The country has observed a rising cost of living in the last 3 years, and it is estimated that the current rise in food prices will continue if drastic measures are not implemented. Although nontariff measures affect several crops, our study is centered on cereal production since a large share of the population depends on cereals (e.g., maize, rice, and millet) as a source of calories, thus increasing their demand.

Our study contributes to the agricultural production and commercialization literature in two folds. First, our study precedes all others in Ghana in ascertaining the relationship between nontariff measures and the quantity of cereal allocated to household consumption, gift, seed, and sold in exchange for cash. Consistent with the literature, we first find that nontariff measures are negatively associated with cereal production in Ghana. Regarding production allocation decisions, we find that nontariff measures are positively associated with consumption but negatively associated with the intensity of commercialization. Second, most studies cited concentrate on cross-border trade, but our study focuses on internal trade across administrative regions. The findings from our study will inform policymakers on the potential mechanisms that can be employed to boost cereal production. Ghana cannot meet its domestic cereal demand with the current supply; thus, imports are used to supplement the rest of the demand. Therefore, the recommendation from our study can contribute immensely to improving production through the relaxation of retrogressive nontariff measures that derail economic development.

The rest of the paper is organized as follows: Sections 2 and 3 describe the data and present the empirical strategy, respectively. Section 4 presents and discusses the study's empirical results while Section 5 provides the conclusion and recommendations for policy considerations.

## 2 | DATA AND DESCRIPTIVE STATISTICS

### 2.1 | Data and measurement of key variables

Our study relies on primary data from a survey of commercial farmers in five Ghana regions: Northern, Bono, Ashanti, Western, and Volta. Compared across the regions, a higher proportion of the commercial farmers in the Northern region incur nontariff measures, followed by commercial farmers in Bono, Ashanti, Volta, and Western regions, respectively. Regarding the extent to which farmers participate in the market (intensity of commercialization), the Northern region experienced the lowest commercialization, followed by the Western, Bono, Volta, and Ashanti regions (Figure 1). The list of commercial farmers sampled for the study was obtained from the Ministry of Food and Agriculture (MoFA) and the Savanna Agricultural Research Institute (SARI). We employ a multi-stage sampling technique that combines stratified and random sampling techniques to select 603 commercial farmers.

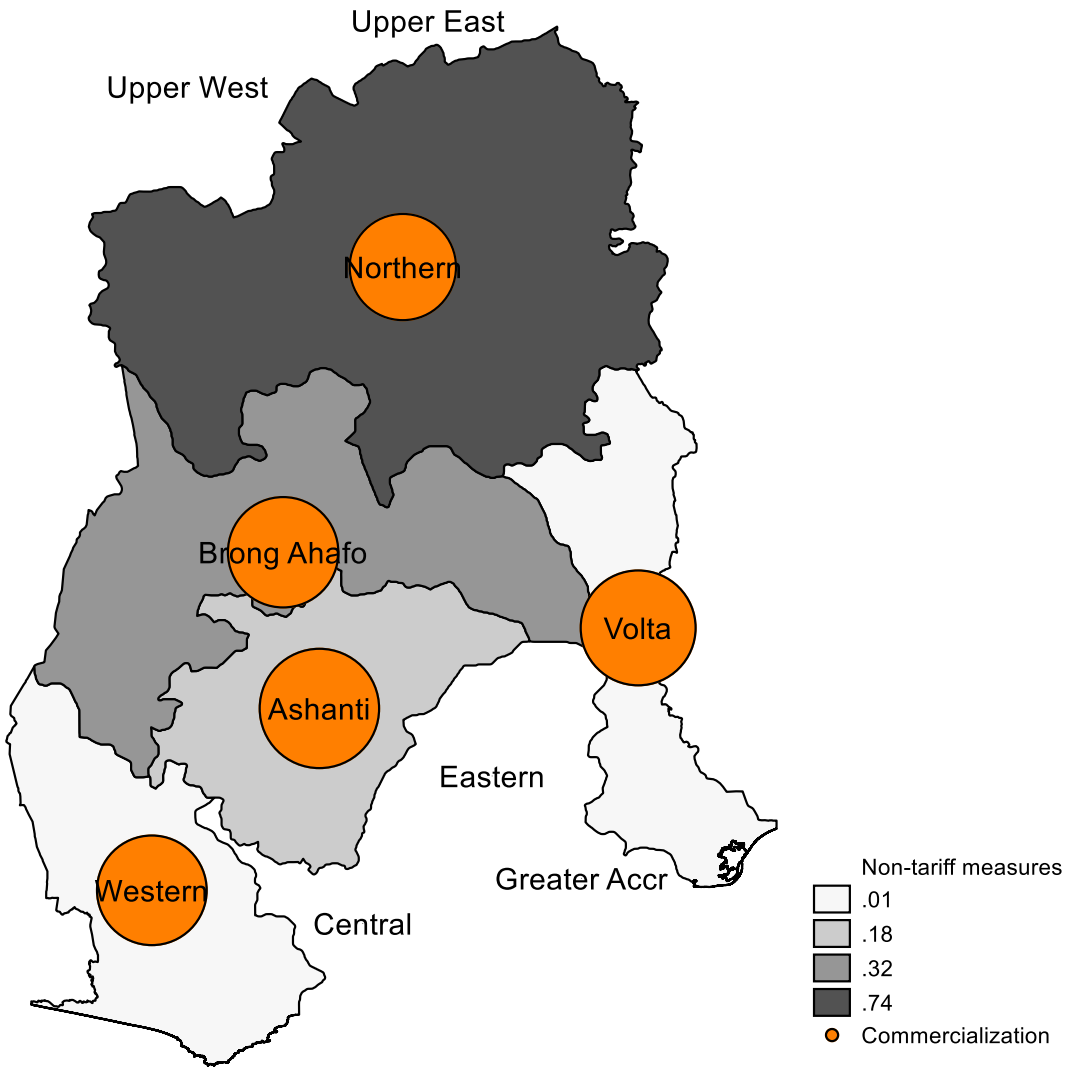


**FIGURE 1** Administrative map of the study area. The round ball represents the intensity of commercialization, and the map's color refers to the number of farmers who incur nontariff measures.

However, the data is restricted to commercial farmers who produce cereals (maize and rice); thus, the sample used for the analysis was reduced to 455.

The data for the study includes detailed information on household demographics (sex, education, marital status, household size, nativity, etc.), farming activities (crops cultivated, area under cultivation, production, and costs), market participation, quantity of produce sold, quantity of produce consumed, and quantity of produce given out as gifts, institutional factors (member of farmer organization, access to credit, extension), awareness and knowledge of nontariff measures, transaction costs related to nontariff measures, and other constraints to production and marketing of agricultural produce, expenditure and household income, household assets, food security status, and poverty levels. This current paper focuses mainly on the data section that captures the socioeconomic characteristics, production information, marketing, cost related to nontariff measures, and location-specific dummies to account for agroecological and farming system differences in the study area.

### 2.1.1 | Nontariff measures

The nontariff measures considered in this paper are export licensing, customs facilities, testing and certification, SPS, technical regulations and packaging standards, quotas, global GAP standards, and fairtrade and organic standards. However, the commercial farmers interviewed incur either one or multiple types of NTMs based on which the commercial farmers are characterized. The classification is based on a dummy measurement (1/0). A commercial farmer who incurs one or more of the nontariff measures is classified as a nontariff measure commercial farmer. In contrast, commercial farmers who do not experience nontariff measures are considered not to incur nontariff measures. The nontariff measures incurred by commercial farmers depend mainly on the markets they face and the type of cereals they cultivate. This makes the construct of the nontariff measures possibly endogenous.

### 2.1.2 | Crop production

Crop production captures the quantity of cereals produced in the past 12 months and measured in tonnes. Our production data consists of the quantity of maize produced with and without the nontariff measures.

### 2.1.3 | Cereal commercialization

We computed the level of cereal commercialization by using the commercialization index (CI), which captures the ratio of cereal sales to cereals produced (Carletto et al., 2017; Govereh et al., 1999; Strasberg et al., 1999). The index measures the extent to which household crop production is oriented toward the market. A value of zero signifies a subsistence-oriented household; the closer the index to one (1), the higher the degree of commercialization (Martey et al., 2012).

## 2.2 | Descriptive statistics

Table 1 describes the dependent and explanatory variables used in the analysis. The summary of the dependent variables indicates that about 9%, 3%, 2.6%, and 86% of harvested cereals are consumed, given out as gifts, stored as seeds, and sold, respectively. The results show that most cereals produced by commercial farmers are sold. Concerning the socio-demographics, 84% of the sampled respondents are

**TABLE 1** Summary statistics of dependent and explanatory variables.

| Variable | Definition | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| **Dependent variable** | | | | | |
| Proportion consumed | Proportion of crop harvest and consumed | 0.086 | 0.160 | 0 | 1 |
| Proportion harvest as gift | Proportion of crop harvest and given out as gift | 0.030 | 0.066 | 0 | 0.69 |
| Proportion of harvest as seed | Proportion of crop harvest and stored as seed | 0.026 | 0.064 | 0 | 0.72 |
| Proportion harvest sold | Proportion of crop harvest and sold | 0.859 | 0.205 | 0 | 1 |
| **Explanatory variables** | | | | | |
| *Socioeconomic characteristics* | | | | | |
| Sex | 1 if household head is male, 0 otherwise | 0.840 | 0.367 | 0 | 1 |
| Age | Age of household head in years | 48 | 11 | 18 | 85 |
| Married | 1 if household head is married, otherwise | 0.833 | 0.373 | 0 | 1 |
| Education | 1 if farmer is formally educated, 0 otherwise | 0.670 | 0.471 | 0 | 1 |
| Years of education | Years of formal education | 5.925 | 4.884 | 0 | 14 |
| Literate | 1 if farmer is literate, 0 otherwise | 0.655 | 0.476 | 0 | 1 |
| Males (>60 years) | Number of males above 60 years | 0.189 | 0.545 | 0 | 8 |
| Household size | Total number of household members | 7.270 | 5.809 | 0 | 35 |
| Dependent | Total number of members who depend on farmer | 5.086 | 3.966 | 0 | 21 |
| Native | 1 if native, 0 otherwise | 0.664 | 0.473 | 0 | 1 |
| Migrate | 1 if migrant members in household, 0 otherwise | 0.193 | 0.395 | 0 | 1 |
| Income (log) | Farmer income from all sources (log) | 12.525 | 0.320 | 11.994 | 13.087 |
| Asset index | Asset index | −0.016 | 1.032 | −1.270 | 5.635 |
| *Farm characteristics* | | | | | |
| Years of farming | Number of years of farming | 21 | 13 | 1 | 65 |
| Own land | 1 if farmer owns land, 0 otherwise | 0.275 | 0.447 | 0 | 1 |
| Labor (log) | Cost of labor (log) | 6.274 | 1.666 | 0 | 12.899 |
| Fertilizer (log) | Cost of fertilizer (log) | 5.537 | 2.512 | 0 | 10.714 |
| Mechanization (log) | Cost of mechanization (log) | 4.370 | 2.594 | 0 | 9.616 |
| Farm size (log) | Farm size (log) | 2.543 | 0.585 | 1.099 | 5.094 |
| *Institutional characteristics* | | | | | |
| Extension access | 1 if farmer has access to extension, 0 otherwise | 0.686 | 0.465 | 0 | 1 |
| Farm insured | 1 if farm insured, 0 otherwise | 0.035 | 0.184 | 0 | 1 |
| Willingness to insure farms | 1 if farmer is willing to insure farm, 0 otherwise | 0.486 | 0.500 | 0 | 1 |

**TABLE 1** (Continued)

| Variable | Definition | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| Contract | 1 if farmer engages in contract farming, 0 otherwise | 0.127 | 0.334 | 0 | 1 |
| Credit | 1 if harmer has access to credit, 0 otherwise | 0.233 | 0.423 | 0 | 1 |
| Government/customer support | 1 if farmer receives support, 0 otherwise | 0.123 | 0.329 | 0 | 1 |
| *Social capital characteristics* | | | | | |
| Member of farmer-based organizations | 1 if member of farmer-based organization, 0 otherwise | 0.371 | 0.484 | 0 | 1 |
| *Geographical characteristics* | | | | | |
| Bono Region | 1 if farmer resides in Bono Region, 0 otherwise | 0.200 | 0.401 | 0 | 1 |

*Note*: SD means standard deviation.

males, and the average age is 48 years. The data show that 83% and 67% are married and have formal education with 6 years of formal education. About 66% of the farmers are literate (read and write), and the average number of male members above 60 years is 0.19. The number of household members and dependents is seven and five, respectively. At the same time, 66%, 19%, and 37% of the sampled commercial farmers are natives, have migrant household members, and belong to farmer-based organizations (FBO), respectively. A farmer in our sample has been farming for 21 years, and 28% own land, while 69% and 4% of the sampled farmers have access to extension services and have insured their farms, respectively. However, 49% are willing to insure their farms. About 13%, 23%, and 12% of the sampled farmers engage in contract farming, have access to credit, and receive government or customer support, respectively. The average asset index is −0.016 with a standard deviation of 1.032, farmer mean log income is 12.5. Concerning the factors of production, the log of costs of labor, fertilizer, mechanization, and farm size is GHS6.2, GHS6, GHS4.4, and 2.5 hectares, respectively.

Figure 2 shows the percentage of respondents whose production and marketing activities are influenced by nontariff measures. A relatively large proportion of the sampled farmers (35%) reported customs to be the main nontariff measures influencing production and marketing which are being followed by testing and certification (18%), SPS measures (13%), packaging standards (11%), quota (3%), and fairtrade (1%) and export license (1%). Figure 3 reports the cost associated with nontariff measures incurred by the sampled farmers. The highest NTM costs are packaging standards followed by a testing certificate, customs, and SPS.

Figure 4 shows a non-parametric local polynomial regression to ascertain the relationship between the production volume and the cost of nontariff measures. The results reveal that the relationship between the quantity produced and the cost of nontariff measures (log) is both positive and negative, with the negative relationship dominating for a cost between five (5) and nine (9). The relationship between the quantity of cereals sold and the cost of nontariff measures is reported in Figure 5. The negative relationship between the quantity of cereals sold and the cost of NTMs occurs within the cost of nontariff measures (log) between 6.5 and 8.5. However, much of the relationship is positive for the cost of nontariff measures (log) from 3.5 to 6.5. Despite the relationship established, we cannot make a causality claim given that both observable and non-observable characteristics may be driving the relationship. In the subsequent sections, we established the effect of nontariff measures or cost associated with nontariff measures on production by controlling for relevant covariates.

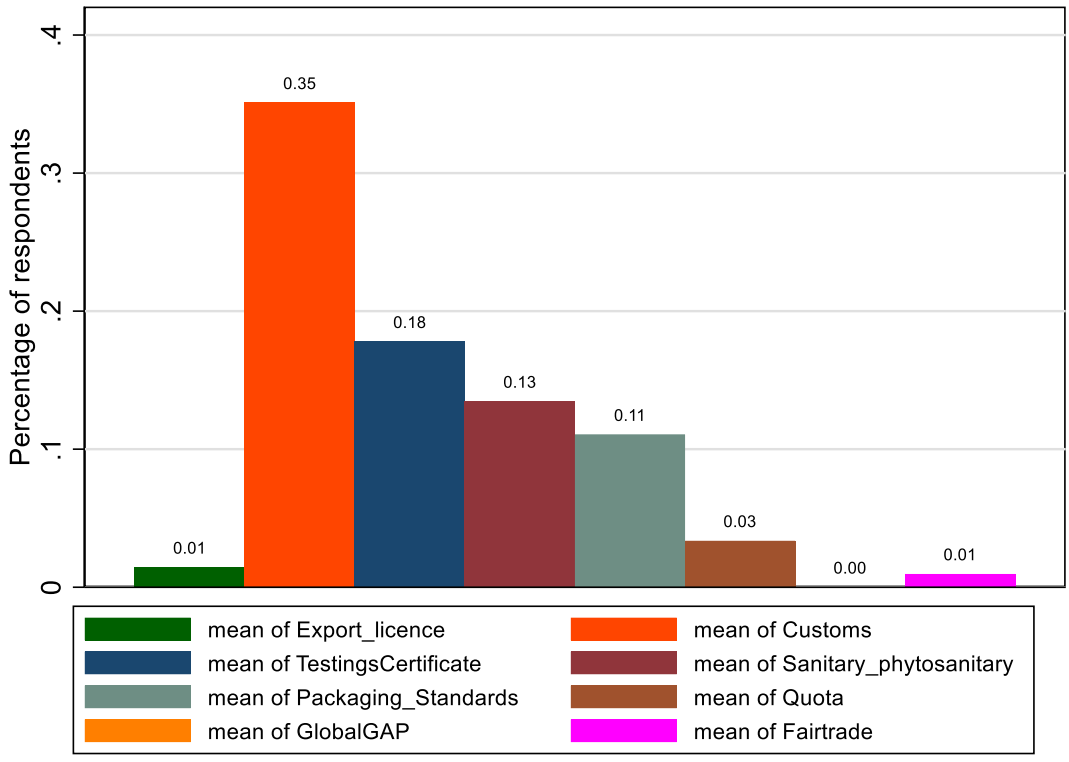


**FIGURE 2** Nontariff measures impacts on production and marketing.

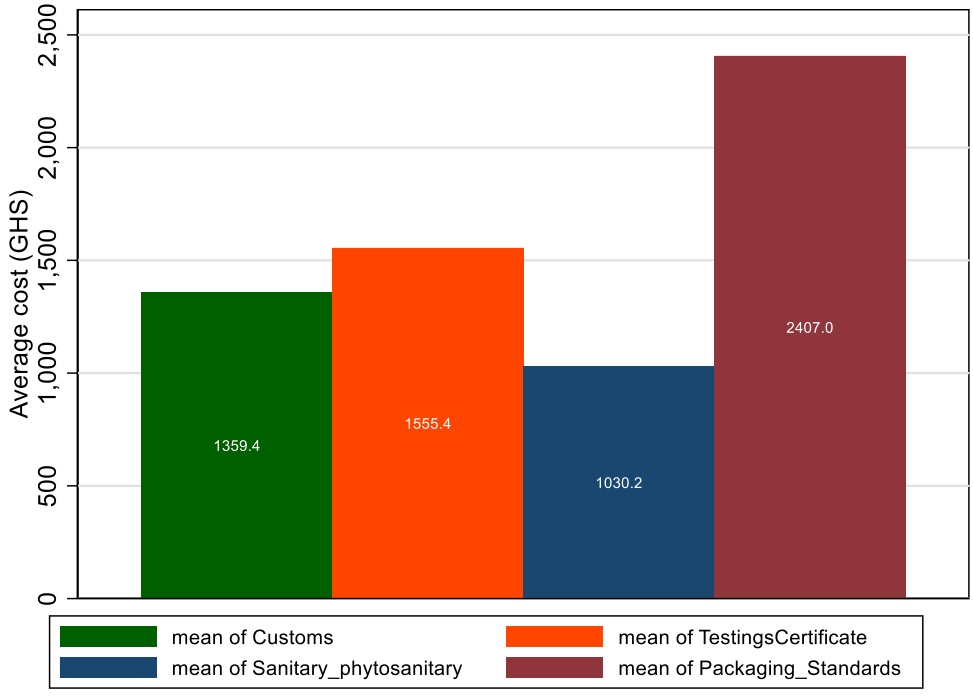


**FIGURE 3** Average cost of nontariff measures.

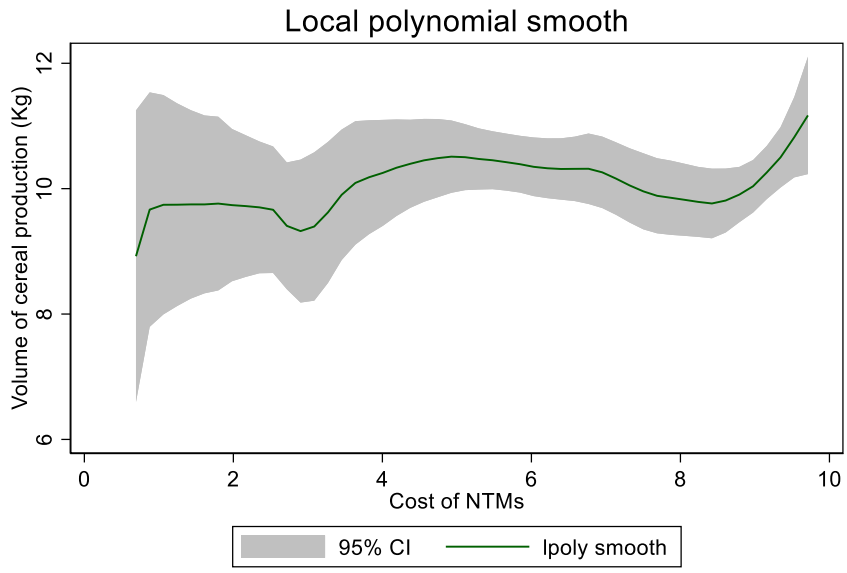


**FIGURE 4** Cereal production and cost of nontariff measures (NTMs) (log).

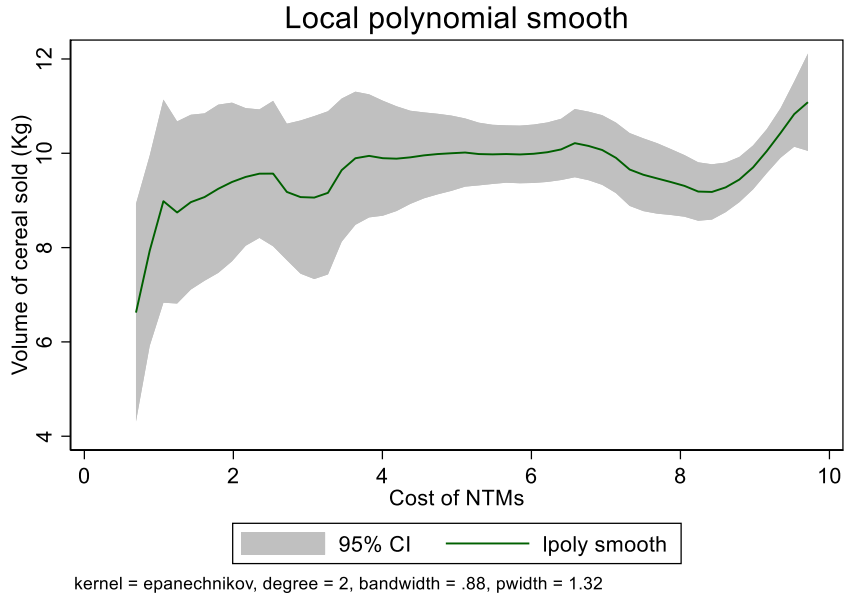


**FIGURE 5** Cereal sold and cost of nontariff measures (log).

Figure 6 shows the boxplot of the production allocation decisions for cereals. Cereal production is distributed based on consumption, gift, seed, and commercialization. The graph shows the proportion of each distribution to the total production. We observed that the proportion of cereal sold is the highest, followed by consumption, gift, and seed. The result shows that a higher proportion of cereal produced is commercialized, especially among the commercial farmers.

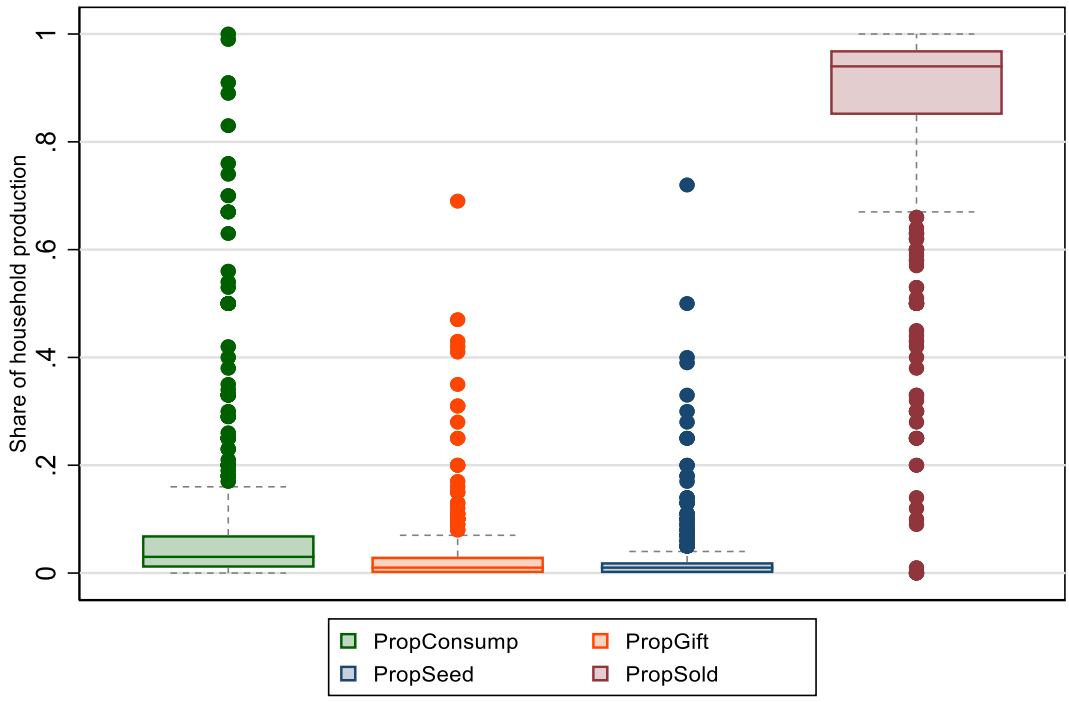


**FIGURE 6** Cereal production allocation decisions.

## 3 | EMPIRICAL STRATEGY

### 3.1 | NTM effects on production and commercialization

Our study examines the effect of nontariff measures on cereal production and cereal commercialization while controlling for socioeconomic, farm, institutional, social capital, and geographical characteristics. We estimate the following model:

$$Y_i = \beta + \varphi Z_i + \vartheta \mathrm{NTM}_i + \delta X_i + \varepsilon_i, \quad (1)$$

where $Y_i$ represents the quantity of cereal produced (kg) for individual $i$ at the time of the interview and $\mathrm{NTM}_i$ is the nontariff measure; $Z_i$ is the production factors (land, labor, fertilizer, and chemicals); $X_i$ is a vector of individual characteristics and other relevant control factors and $\varepsilon_i$ is the stochastic error term. The coefficient of interest $\vartheta$, measures the effect of nontariff measures on cereal production and commercialization. We hypothesize that the high cost of production due to nontariff measures may reduce cereal production and commercialization ($\vartheta < 0$). However, in the case of our cereal commercialization model, we excluded the production factors.

We estimate the effect of nontariff measures on maize production and commercialization conditional on village-level factors using the ordinary least squares (OLS) regression (for continuous outcome variables). To check for possible omitted variable bias, we followed the approach of Altonji et al. (2005) and Oster (2019) to quantify the level of omitted variables required to explain away the effect of nontariff measures on production and commercialization. However, other sources of endogeneity may be due to reverse causality and measurement errors. Due to the possible endogeneity in the construct of the nontariff measures, we interpret the coefficient of nontariff measures on production and commercialization as associations.

## 3.2 | Seemingly unrelated regression (SURE) model

Given that a commercial farmer has fixed production, the factors affecting the probability of allocating production to a specific use could also affect the probability of allocating production to other uses. A commercial farmer who allocates more production to consumption may allocate less production for other uses. Modeling output or production allocation decisions requires a framework that accounts for the correlation of the error terms among the set of equations. According to Zellner (1962) and Kokoye et al. (2013), the so-called seemingly (un)related regression (SUREG) model accounts for the correlation of the error terms of production use functions. The limitation of the SUREG is its inability to ensure that the estimated shares add up to one, which the fractional multinomial logit model addresses. In this paper, the SUREG model jointly estimates a set of four simultaneous empirical equations of production allocation decision (share of consumption, gift, seed, and sale) which are expressed as:

$$\begin{cases} y_{i1} = \gamma_1 X_{i1} + \beta_1 R_{i1} + \varphi_1 I_{i1} + \vartheta_1 \text{NTM}_{i1} + \mu_{i1} \\ y_{i2} = \gamma_2 X_{i2} + \beta_2 R_{i2} + \varphi_2 I_{i2} + \vartheta_2 \text{NTM}_{i2} + \mu_{i2} \\ y_{i3} = \gamma_3 X_{i3} + \beta_3 R_{i3} + \varphi_3 I_{i3} + \vartheta_3 \text{NTM}_{i3} + \mu_{i3} \\ y_{i4} = \gamma_4 X_{i4} + \beta_4 R_{i4} + \varphi_4 I_{i4} + \vartheta_4 \text{NTM}_{i4} + \mu_{i4}, \end{cases} \tag{2}$$

where production allocation decision is expected to be influenced by factors such as socioeconomic ($X$), production ($R$), institutional ($I$), and nontariff measures (NTM). $\gamma_m$, $\beta_m$, $\varphi_m$, and $\vartheta_m$ are the parameters to be estimated; $\mu_{im}$ are the error terms.

We test for potential multicollinearity in the explanatory variables using the variance inflation factor (VIF) test (Baltagi, 2013). The test result rejects the null hypothesis of multicollinearity in the explanatory variables. The Breusch–Pagan[2] (BP) test (Breusch & Pagan, 1979) is used to validate the set of regression models on production and commercialization allocation decisions. The test result is shown in Supporting Information: Table A1. The explanatory variables used in the regressions (Equations 1 and 2) are based on literature (Kabiti et al., 2016; Knoesslsdorfer et al., 2021; Kokoye et al., 2013).

## 3.3 | Inverse probability weighting with regression adjustment (IPWRA)

We employ the inverse probability weighting with regression adjustment (IPWRA), which is both "doubly robust"[3] and imposes fewer restrictions on the functional form of the treatment reduction model to examine the relationship between nontariff measures, consumption, and market commercialization. The IPWRA consists of two methods combining inverse probability weighting (IPW) and regression adjustment (RA). The IPW models the factors influencing nontariff measures, while the RA focuses on outcomes by controlling selection bias and confounding factors at both stages. The primary outcome model is estimated as follows:

$$Y_i = f(\text{NTM}s_i, \varphi) + \varepsilon_i. \tag{3}$$

The treatment model is expressed as follows:

[2]The Breusch–Pagan (BP) test is a formal statistical test used to determine the presence of heteroskedasticity in a linear regression model (Breusch & Pagan, 1979).

[3]According to Wooldridge (2010), IPWRA is 'doubly robust' because it combines two methods (IPW and RA) which requires that only one of the two methods needs to be accurately specified to obtain consistent estimates.

$$P_r(D_i = 1, 0) = g(X_i, \beta) + \mu_i, \tag{4}$$

where $NTMs_i$ are nontariff measures incurred by an individual $i$, $X_i$ is a vector of explanatory variables explaining whether a farmer incurs transaction cost due to nontariff measures, $\varphi$ and $\beta$ are parameter estimates of the effect of NTMs on consumption and market commercialization and the correlates of farmers' cost due to NTMs, respectively. We hypothesize that the parameter of interest ($\varphi$) is positively ($\varphi > 0$) associated with consumption and negatively ($\varphi < 0$) associated with market commercialization.

We estimate the following expected outcome (consumption and market commercialization) equations to calculate the doubly robust estimates of consumption and market commercialization for commercial farmers who incur or do not incur costs related to nontariff measures.

Commercial farmers who incur nontariff measures cost ($D = 1$),

$$\frac{Y_{NTMs=1}}{P(X)} - \frac{\hat{Y}_1}{P(X)}(1 - P(X)). \tag{5}$$

Commercial farmers who do not incur nontariff measures cost ($D = 0$),

$$\frac{Y_{NTMs=0}}{1 - P(X)} - \frac{\hat{Y}_0}{1 - P(X)}(P(X)), \tag{6}$$

where $P(X)$ is the propensity score, $Y_{NTMs=1}$ is the observed outcomes (consumption and commercialization) for the commercial farmers who incur the cost of nontariff measures and $Y_{NTMs=0}$ is the observed outcome for commercial farmers who do incur the cost of nontariff measures. $\hat{Y}_1$ and $\hat{Y}_0$ are the predicted outcomes given that a commercial farmer incurs nontariff measures $E(Y|NTMs = 1, X)$ and $(Y|NTMs = 0, X)$, respectively.

## 3.4 | Lewbel two-stage least squares (2SLS)

We employ the Lewbel (2012) 2SLS technique for more reliable estimate and robustness checks to address potential endogeneity in nontariff measures. We anticipate two sources of endogeneity: The first is that the type of market a farmer engages in can influence the type of nontariff measures incurred. We do not expect the endogeneity due to self-selection into a particular market to be profound, since almost all the sampled commercial farmers face the same market (urban and regional markets in-country). At the same time, less than 4% are engaged in the export market. Second, the cereal farmers crop production may also influence the type of nontariff measures they incur. The data shows that the sampled consumers grow either maize or rice.

The Lewbel 2SLS exploits heteroskedasticity in the data to generate internal instruments that address endogeneity. We explore both internal and external instruments for the analysis. The construction of the external instrument is based on the peer-effect literature. This study uses the number of neighbors who incur nontariff measures as a potential instrument. The instrument measures the ratio of farmers who incur nontariff measures to the number of farmers in the community. The instrument is constructed using the "rangestat" code in STATA (Picard et al., 2017). The proposed instrument captures the proportion of commercial farmers involved in cereal production in the community. The variable is considered a good candidate for an instrument because contacts with cereal farmers in the same community allow individuals to communicate more closely among themselves. Continuous communication influence participation in cereal production. The share of people in the communities engaged in cereal production and incurring nontariff measures is a potential indicator for opportunities in the community.

Similarly, the instrument serves as a measure of social (peer) influence on economic behavior. For example, the number of neighbors who incur nontariff measures as a result of engaging in commercial farming is more likely to influence the reference farmer's likelihood of engaging in commercial farming (due to the benefits) or shifting production resources to different crops with less cost due to the high costs of production. Supporting Information:

Table A2 shows that the instrument highly correlates with the probability of a farmer incurring nontariff measures. The instrument's strength is tested based on the *F*-statistic test proposed by Stock and Yogo (2005).

# 4 | RESULTS AND DISCUSSION

## 4.1 | Determinants of production allocation decisions

Table 2 reports the results of the SUREG on the determinants of production allocation decisions. The BP test is statistically significant at a 1% level, which justifies using the SUREG model. nontariff measures, nativity, membership in FBO, extension access, contract farming, and credit access significantly influence the proportion of cereal consumed. Commercial farmers who incur transaction costs due to nontariff measures are more likely to increase their share of production to consumption. The result indicates that as production declines due to the high cost resulting from nontariff measures, commercial farmers tend to prioritize the consumption of their production, given that they are also consumers and purchase food items from the market.

An increase in nontariff measures may have a general equilibrium increase in price effects in the market economy, thus reducing the number of purchases from the market. As observed previously, nontariff measures are negatively associated with the intensity of commercialization. nontariff measures do not have any statistically significant association on the share of gifts and seeds. However, we observed a positive association suggesting that commercial farmers are more likely to be positively associated with the share of their cereal production to gifts and seeds. Compared to the female farmers, male commercial farmers recorded a relatively higher proportion of their production to consumption but reduced the share of cereal sold. The result is consistent with the a prior expectations, given that females are more likely to engage in the market to supplement household food requirements. Farmers who are married are more likely to reduce the share of their production to seed but increase the proportion of cereal sold. The proportion of cereal as gifts is lower among educated commercial farmers than non-educated farmers. However, farmers who can read and write are more likely to increase the proportion of cereal production as a gift. Education enhances the cognitive ability of farmers to make informed decisions. This could be a case where farmers' objective is to maximize profit, thus reducing the share of production as gifts. However, there is the possibility of farmers being more altruistic and not necessarily profit maximizers. The allocation of production to consumption and market increases and decreases, respectively, for farmers who are native relative to settlers. Commercial farmers with migrant household members is positively associated with the proportion of cereal production allocated as gifts.

Membership in FBO is negatively associated with the share of production to consumption and seed but positively associated with the share of production sold. Members of FBO are more likely to increase the commercialization of cereals due to the reduction in transaction costs as they engage in bulk purchasing and group marketing. Consistent with the a-priori expectation, we find that access to extension is positively associated with the intensity of commercialization but decreases the proportion of consumption, gift, and seed. The result highlights agricultural extension agents important role in ensuring food production and supply. Increasing commercial farmers' access to extension is likely to increase cereal supply and revenues. Commercial farmers who engage in contract farming are more likely to be positively associated with the proportion of cereal consumed and negatively associated with the proportion of cereal sold. There is a tendency for individuals to renege on their contractual obligations for varied reasons, especially where the opportunities outside the contract are more enticing.

Access to credit is estimated to be positively associated with allocating cereal production to consumption but negatively associated with the proportion of cereal sold. Our result suggests that access to credit may not necessarily be used for production activities but for investment in human capital, health, and the purchase of consumer and durable goods. Farmers who receive support from the government or customers are more likely to be positively associated with giving a proportion of their produce as gifts. The result is not surprising given that

**TABLE 2** Determinants of production allocation decisions (SUREG model).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Production allocation decisions | | | |
| Variables | Consumption | Gift | Seed | Sold |
| Nontariff measures (1/0) | 0.047** | 0.009 | 0.008 | −0.065*** |
| | (0.019) | (0.008) | (0.008) | (0.025) |
| Sex | 0.029 | 0.006 | 0.010 | −0.043 |
| | (0.021) | (0.009) | (0.009) | (0.026) |
| Age | −0.000 | 0.000 | 0.000 | −0.000 |
| | (0.001) | (0.000) | (0.000) | (0.001) |
| Married | −0.018 | −0.003 | −0.025*** | 0.045* |
| | (0.021) | (0.009) | (0.009) | (0.026) |
| Formal education | −0.031 | −0.033** | 0.000 | 0.066 |
| | (0.033) | (0.014) | (0.014) | (0.043) |
| Years of education | 0.000 | 0.001 | −0.001 | −0.000 |
| | (0.003) | (0.001) | (0.001) | (0.004) |
| Literate | −0.016 | 0.027*** | 0.005 | −0.017 |
| | (0.023) | (0.010) | (0.009) | (0.029) |
| Household size | −0.001 | −0.001 | −0.001 | 0.003 |
| | (0.001) | (0.001) | (0.001) | (0.002) |
| Native | 0.049*** | 0.006 | −0.001 | −0.053** |
| | (0.016) | (0.007) | (0.007) | (0.021) |
| Migrant household member | −0.011 | 0.015* | −0.003 | 0.001 |
| | (0.019) | (0.008) | (0.008) | (0.024) |
| Membership in farmer-based organizations | −0.041*** | 0.010 | −0.009 | 0.038* |
| | (0.016) | (0.007) | (0.006) | (0.020) |
| Years of farming | 0.001 | −0.000 | −0.000 | −0.000 |
| | (0.001) | (0.000) | (0.000) | (0.001) |
| Own land | 0.032* | −0.004 | 0.012 | −0.041* |
| | (0.018) | (0.008) | (0.008) | (0.023) |
| Extension access | −0.050*** | −0.024*** | −0.020*** | 0.094*** |
| | (0.017) | (0.007) | (0.007) | (0.022) |
| Willing to insure farm | −0.018 | 0.001 | −0.009 | 0.027 |
| | (0.015) | (0.006) | (0.006) | (0.019) |
| Contract farming | 0.060*** | 0.004 | 0.009 | −0.072*** |
| | (0.022) | (0.009) | (0.009) | (0.028) |

**TABLE 2** (Continued)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Production allocation decisions | | | |
| Variables | Consumption | Gift | Seed | Sold |
| Credit | 0.047*** | −0.001 | −0.009 | −0.038* |
| | (0.018) | (0.007) | (0.007) | (0.022) |
| Government/customer support | −0.004 | 0.032*** | 0.004 | −0.033 |
| | (0.022) | (0.010) | (0.009) | (0.029) |
| Income (log) | −0.028 | −0.012 | −0.018* | 0.059* |
| | (0.024) | (0.010) | (0.010) | (0.030) |
| Bono region | −0.049* | 0.027** | −0.016 | 0.038 |
| | (0.026) | (0.011) | (0.011) | (0.034) |
| Constant | 0.454 | 0.173 | 0.288** | 0.070 |
| | (0.297) | (0.126) | (0.122) | (0.379) |
| Observations | 455 | 455 | 455 | 455 |
| $R^2$ | 0.135 | 0.101 | 0.082 | 0.154 |
| Breusch–Pagan test of independence | 584.02*** | | | |

*Note*: Nontariff measures is a dummy (1/0) variable measured as whether or not the commercial farmer encounters any form of nontariff measures. Robust standard errors are in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

relatively poor households benefit from government support in the form of exogenous transfers, which do not translate to market orientation but subsistence production. The data show that about 13% of commercial farmers receive support from the government and trading partners in the form of cash and input credit. Income is positively associated with the intensity of commercialization but negatively associated with the proportion of seed allocated to seed. Commercial cereal production is capital intensive, so farmers who earn higher incomes are more likely to invest in quality seeds and other inputs to boost production and commercialization. Concerning location, farmers in the Bono region are more likely to allocate a higher proportion of their produce as gifts and increase the likelihood of market participation. However, the latter is not statistically significant.

## 4.2 | Effects of nontariff measures on cereal production and commercialization

The results showing the estimates of nontariff measures on production and commercialization are presented in Table 3. The full result is not discussed in the interest of brevity but is presented in the appendix (Supporting Information: Table A2). The differences in the observations (376 and 454) are due to missing data in some of the explanatory variables used to explain production and commercialization decisions. Columns (1) and (2) of Table 3 show the results of the extensive margin (dummy for nontariff measures) results for production and commercialization, respectively. Columns (3) and (4) show the intensive margin of nontariff measures (measured in terms of cost) on production and commercialization, respectively. The results show that nontariff measures are negatively associated with cereal production and commercialization by 38% and 4.1 percentage points, respectively. Regarding the intensive margin results, we observed a statistically significant inverse relationship

**TABLE 3** Effect of nontariff measures (NTMs) on production and commercialization (ordinary least squares [OLS] estimates).

| Variables | (1) Production | (2) Commercialization | (3) Production | (4) Commercialization |
|---|---|---|---|---|
| Nontariff measures (1/0) | −0.375*** | −0.041*** | | |
| | (0.130) | (0.014) | | |
| Cost of nontariff measures (log) | | | −0.044** | −0.005** |
| | | | (0.019) | (0.002) |
| Controls | Yes | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes | Yes |
| Observations | 376 | 454 | 376 | 454 |
| $R^2$ | 0.084 | 0.195 | 0.077 | 0.189 |

*Note*: Robust standard errors are in parentheses. Refer to Supporting Information: Table A3 for the full results.
***$p < 0.01$; **$p < 0.05$.

between the cost of nontariff measures and the quantity of cereal produced, and the intensity of commercialization. Costs associated with nontariff measures for a specific crop type have the potential to influence household land, production, and commercialization decisions. The computed elasticities indicate that the quantity of cereal produced and extent of commercialization by commercial farmers could decrease by 4.4% and 0.5 percentage points, respectively, with a unit increase in transaction costs attributed to nontariff measures in terms of customs checkpoints, testing, SPS, packaging technical regulations, quotas, global GAP standards, and fairtrade. The results suggest that commercial farmers who incur nontariff measures are more likely to reduce their production of cereals and the extent of market participation in the quantities of cereals they sell. The high costs associated with nontariff measures may discourage farmers from investing long-term production resources to increase production and intensify commercialization. Despite the anticipated reduction in cereal production by commercial farmers, there is the possibility of shifting the cost to off-takers, with the consumer experiencing the highest effect in terms of the price increase, which may subsequently increase their food insecurity. Our findings are consistent with several past studies on nontariff measures. For example, Maziku and Mashenene (2020) find that in Tanzania, a unit increase in transaction costs attributed to nontariff measures in terms of roadblocks, weighbridges, police checkpoints, custom procedures, and council permits reduces the quantity of maize produced by 16%. Studies conducted in Tanzania by FAO (2013), World Bank (2012), and KI (2011) show that trade barriers imposed by the government reduced the volume of maize produced and supplied.

## 4.3 | Unobserved heterogeneity and coefficient stability

We perform a coefficient stability test following the approach of Oster (2019) and Altonji et al. (2005) to ensure that our estimates are credible and robust to the addition of controls. We follow the Oster (2019) approach to determine if the existence of unobserved heterogeneity could bias the estimates based on the assumption that the relationship between the covariate of interest and unobservables can be recovered from its relationship with observables. In our estimation, first, we assume that selection on observables is proportional to selection on unobservables and calculate bias-adjusted coefficient values of the effect of nontariff measures on production and commercialization. We use 1.1* ($R^2$) and 1.3* ($R^2$) to assess the magnitude of the change in the estimated coefficients. In the second stage, we calculate a delta value which suggests the degree of selection on

unobservables relative to the observables that would be required to explain away the estimated association between nontariff measures, production, and commercialization. Per the results in Table 4, the bias-adjusted coefficients for all the outcome variables are relatively similar in both magnitude and sign to the old estimates. The estimated Oster deltas in column (5) of Table 4 indicate that selection on unobservables would have to be 5.5 times the selection on observables to explain away the estimated negative relationship between nontariff measures and production. For commercialization, the selection of unobservables would have to be 30 times the selection on observables to explain away the estimated negative relationship between nontariff measures and commercialization. Based on the findings, we note that our estimates seem robust to unobserved heterogeneity.

## 4.4 | Robustness check—Lewbel 2SLS

Table 5 shows the results of the Lewbel 2SLS method. The first stage results show that the ratio of cereal farmers who incur nontariff measures to the total number of farmers in the community is highly correlated with nontariff measures. The *F*-value is greater than indicating that the instrument is not weak. Consistent with the OLS results, we find that nontariff measures are positively associated with the logs of cereal production and commercialization by 59% and 13 percentage points, respectively. In reference to the intensive margin, the elasticity of cereal production and commercialization with respect to the cost associated with nontariff measures are negative. The results suggest that a 1% increase in the cost of nontariff measures is positively associated with a 0.065% and 0.019 percentage points decrease in cereal production and commercialization, respectively.

## 4.5 | Robustness check—IPWRA estimates

To test the robustness of our results, we employ the IPWRA model to estimate the association between nontariff measures on production allocation decisions. We first conduct two diagnostic tests to ensure the estimates are reliable—overlapping and balancing tests. We examine the common support and overlap conditions to establish the basis for comparing farmers who incur nontariff measures and those who do not (Figures 7 and 8). The result shows sufficient overlap for weighting regressions. The balancing tests (Figure 7) indicate that all the variables used in the estimation were balanced given that standardized %bias across covariates is within the conventional thresholds

**TABLE 4** Check for coefficient stability.

| | Controlled | | Bias-adjusted | | Oster delta |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | |
| | Coeff. | $R^2$ | Coeff. | $R^2$ | (5) |
| Production | −0.375*** | 0.080 | −0.039*** | 0.090 | −5.55 |
| | (0.130) | | (0.073) | | |
| Commercialization | −0.041** | 0.195 | −0.043*** | 0.250 | 29.91 |
| | (0.014) | | (0.013) | | |

*Note*: Columns (1) and (2) present the results with the inclusion of controls. Columns (3) and (4) present the bias-adjusted estimate, which assumes that the degree of selection on unobservables equals selection on observables. The Oster delta values in column (5) indicate how large selections on unobservables must be relative to observables to explain away the estimated relationships. Coefficients are reported with robust standard errors in parentheses, but bootstrap standard errors are reported for the bias-adjusted coefficient (column 5).

***$p < 0.01$; **$p < 0.05$.

**TABLE 5** Lewbel two-stage least squares (2SLS) estimates of nontariff measures (NTMs) on production and commercialization.

| Variables | (1) Production (log) | (2) Production (log) | (3) Commercialization (log) | (4) Commercialization (log) |
|---|---|---|---|---|
| Nontariff measures (1/0) | −0.461* | | −0.119*** | |
| | (0.238) | | (0.030) | |
| Cost of NTMs (log) | | −0.065* | | −0.019*** |
| | | (0.033) | | (0.005) |
| Controls | Yes | Yes | Yes | Yes |
| Region fixed effects | Yes | Yes | Yes | Yes |
| **First stage** | | | | |
| Neighbors who incur NTMs | 0.884*** | 6.306*** | 0.943*** | 6.010*** |
| | (0.075) | (0.559) | (0.067) | (0.433) |
| **Diagnostics** | | | | |
| *F*-statistic | 140 | 127 | 196 | 192 |
| Observations | 375 | 375 | 454 | 454 |
| $R^2$ | 0.078 | 0.069 | 0.137 | 0.124 |

*Note*: NTMs refer to nontariff measures. Robust standard errors are in parentheses. The percentage effect is computed based on the formula $-100 \times (e^A - 1)$, where A is the coefficient on the nontariff measure. Refer to Supporting Information: Table A4 for the full results.

***$p < 0.01$; *$p < 0.1$.

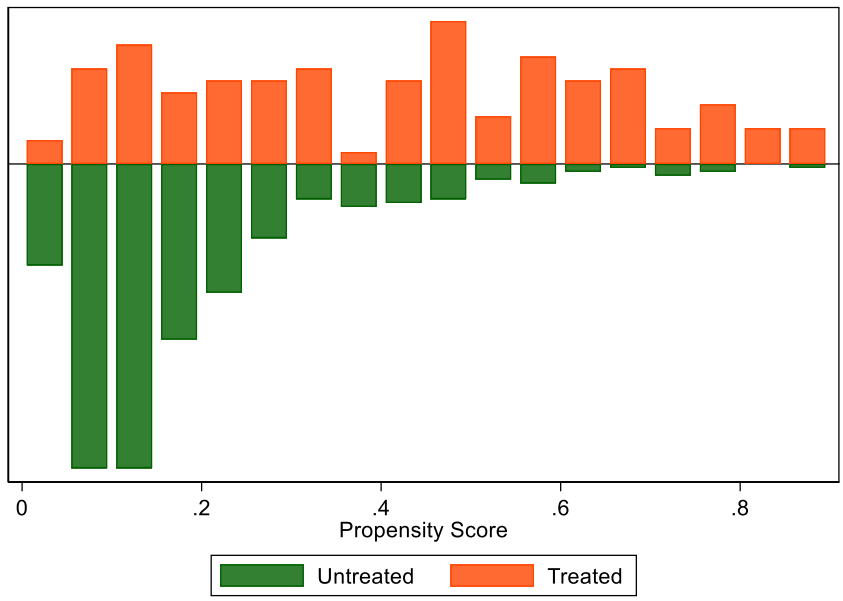


**FIGURE 7** Distribution of propensity scores.

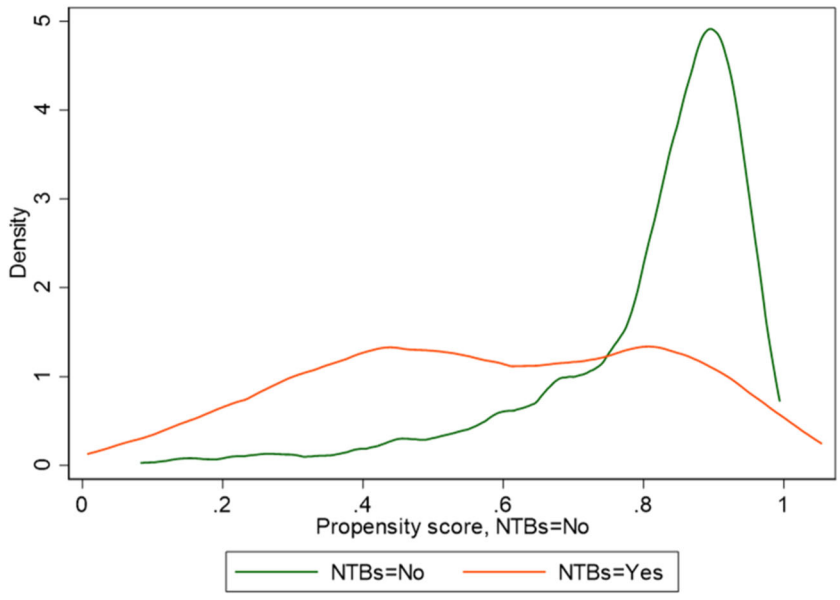


**FIGURE 8** Overlap and common support.

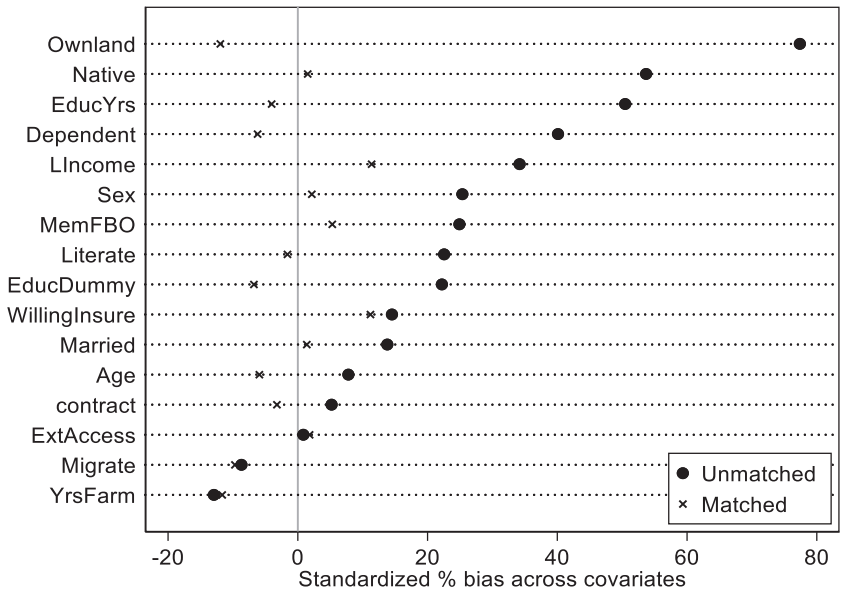


**FIGURE 9** Balancing test for farmers who incur nontariff measures.

(Imbens & Wooldridge, 2009) without reducing our sample size. We then estimate the average treatment effect after satisfying all the conditions required for estimating IPWRA (Figure 9).

Table 6 presents the relationship between nontariff measures and production allocation decisions. Consistent with the SUREG results, we find a positive (negative) statistically significant relationship between nontariff measures and consumption (commercialization). Incurring NTMs are positively associated with the proportion of production allocated to the consumption of cereals by 4.5% but negatively associated with the proportion of

**TABLE 6** Nontariff measures and production allocation decisions (inverse probability weighting with regression adjustment [IPWRA] estimates).

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Production allocation decisions | | | |
| Outcomes | Consumption | Gift | Seed | Sold |
| Nontariff measures (1/0) | 0.045** | 0.005 | 0.006 | −0.057** |
| | (0.023) | (0.009) | (0.006) | (0.027) |
| POMean | 0.075*** | 0.031*** | 0.022*** | 0.087*** |
| | (0.012) | (0.007) | (0.004) | (0.017) |
| Controls | Yes | Yes | Yes | Yes |
| Observations | 445 | 445 | 445 | 445 |

*Note*: Nontariff measures is a dummy (1/0) variable measured as whether or not the commercial farmer encounters any form of nontariff measures. Robust standard errors are in parentheses.

***$p < 0.01$; **$p < 0.05$.

production sold (intensity of commercialization) by six percentage points. We did not find any statistically significant effect of nontariff measures on the proportion of production as gifts and seeds. Despite this non-significance, the positive coefficient of nontariff measures indicates that incurring nontariff measures can potentially worsen the use of recycled seeds.

## 5 | CONCLUSION

Most empirical studies on nontariff measures have focused on interregional trade with limited evidence on intraregional trade, especially within a developing country with a high transaction cost of agricultural production and commercialization. We contribute to the literature by examining the relationship between nontariff measures and cereal production allocation decisions from a developing country perspective. To do this, we use a cross-sectional data of 455 commercial cereal farmers from Ghana. We study nontariff measures from both an extensive (experience of nontariff measures) and an intensive (cost of nontariff measures) perspective.

Overall, nontariff measures are significantly associated with lower cereal production and commercialization. Regarding production allocation decisions, nontariff measures increase the consumption of cereals with no significant effects on the proportion of cereal production given out as gifts and stored as seeds. These results are robust to alternative estimation methods using the IPWRA and Lewbel 2SLS, and the results are unlikely to be driven by unobserved heterogeneity. The negative association between nontariff measures and cereal production suggests that commercial farmers are likely to underinvest in cereal production when the cost of cereal production, including nontariff measures, is not commensurate with profit level. Agricultural commercialization is a potential pathway to enhancing agricultural profitability, increasing household incomes, food security, and improving household nutrition through purchasing marketed food (van Asselt & Useche, 2022). Reduction in production, and commercialization transaction costs may improve household income and food security. The lack of statistically significant association between nontariff measures and allocation of cereal produced as gift or reused as seed indicates that decisions to give away cereal produced as gift or re-used as seed is independent of nontariff measures.

Following the conclusion of the study, we draw two main implications. First, nontariff measures are regressive and likely to erode the gains made towards realizing the SDGs, reducing poverty, and enhancing food security.

Given this, policies that emphasize and promote agricultural production by reducing transaction costs attributed to nontariff measures must be vigorously pursued and sustained. Second, commercialization can be improved through consultative and time-bound programs with the private sector players to reduce or eliminate some regressive nontariff measures. Such policies may not only improve the quantity of agricultural commodities transported but will also reduce travel time to preserve the quality of the produce as well as reducing tendencies for spatial arbitrage. It may also encourage purchasing marketed and highly nutritional dense food not produced in the household.

We acknowledge two main limitations of our study. First, we are unable to make a causality claim due to the use of cross-sectional data and possible endogeneity in the measure of nontariff measures. While we perform robustness checks and coefficient stability tests, we argue that there is a need for future studies to use panel data to build on our findings to establish a more robust causality of nontariff measures. Second, while we acknowledged the important role of cash and horticultural crops for households, the study is limited in establishing an empirical link between nontariff measures and production allocation decisions for cash and other relevant crops for households. This is extremely important from a policy perspective, given that exogenous trade shocks such as nontariff measures can influence crop allocation decisions and, thus, the type of interventions that can be promoted to improve economic outcomes. Third, we admit that the instrument used for the robustness check may not be "perfect" therefore, our finding should be interpreted as an association and not causation. Future studies may investigate the role of nontariff measures on cropland allocation decisions and their effects on food security.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## PEER REVIEW

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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