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RESEARCH

Market channel and other drivers of tomato farmer production and handling practices in Nigeria

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Abstract
Non-contract farming arrangements remain the dominant marketing option for poor, often food-insecure smallholder farmers in low-and middle-income countries (LMICs), yet such farming arrangements are less studied than contract farming. Using a case study of 1,673 Nigerian tomato farmers, this study examined whether selling to midstream actors such as wholesalers and aggregators (via informal market arrangements) supports farmers' adoption of good agricultural practices. We first explored the drivers of farmer sales to different market channels using a multinomial logit model. Then, using multivariate probit analysis, we identified factors associated with the adoption of good agricultural practices (GAP) and good handling practices (GHP) with particular attention to a farmers' market channel. We found that larger smallholder farmers using modern irrigation are more likely to sell to midstream actors. We also found that selling to wholesalers and aggregators is an important determinant of farmers' adoption of GAP and GHP, and this holds even for the smallest smallholder farmers. These results confirm that even where informal trading arrangements dominate (as is common in most LMICs), value chain actors in the midstream of food supply chains can support farmer adoption of GAP and GHP. These relationships have important implications for food security via enhancing the livelihoods of smallholder producers and improving the availability and safety of fresh produce for consumers, and thus should be leveraged in the design and implementation of efforts to expand farmer adoption of GAP and GHP.

Keywords Midstream actors · Market channel · Non-contract farming · Good agricultural practices · Good handling practices · Nigeria

1 Introduction

Recent studies have documented the rapid transformation of the food systems in low- and middle-income countries (LMICs) (Nuhu et al., 2021; Reardon et al., 2019). This transformation is partly driven by rising consumer demand- and the accompanying shift in consumption patterns - associated with increased urbanization and income (Nuhu et al., 2021; Reardon et al., 2019; Tschirley et al., 2015). A key feature of this transformation is the growth of activities in the midstream and downstream food supply chains, including processing, logistics, wholesale, and retail (Liverpool-Tasie et al., 2020; Reardon et al., 2021). Though this transformation provides additional market and employment opportunities for farmers, their impact on smallholder farmer behaviour and food security is uncertain, and they are often vilified for exploiting farmers (See Sitko & Jayne, 2014; Grabs et al., 2024). While Liverpool-Tasie et al. (2020) note several

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cases where midstream actors provide support to farmers who sell to them (e.g., credit or logistical support), their role in promoting farmer adoption of good agricultural practices (GAP) and good handling practices (GHP) remains largely unexplored, particularly in the context of informal market arrangements in LMICs.

GAP and GHP along food supply chains are important for smallholder productivity. On the farm, yield and product quality are affected by farmer practices at different stages of production, i.e., pre-planting, planting, and post-planting (Mengistie et al., 2017; Harrison et al., 2013). Smallholder farmers' non-compliance with these on-farm practices could increase the risk of foodborne illness among consumers and have serious environmental and human health consequences (Estrada-Acosta et al., 2014; Lepper et al., 2021; Marine et al., 2016; Materon et al., 2007). Farmer adoption of GAP and GHP remains low in LMICs, spurring continued interest in how farmer adoption of GAP and GHP can be encouraged (Lazaro et al., 2017).

Recent studies emphasize that GAP and GHP have implications not only for agricultural productivity but also for broader food security outcomes across the value chain (Arah et al., 2016; Estrada-Acosta et al., 2014; Lepper et al., 2021; Marine et al., 2016; Materon et al., 2007; Yami et al., 2025). For upstream actors such as smallholder producers, adherence to safe pesticide use and management practices, a critical component of GAP, supports compliance with food safety standards (Yami et al., 2025). For instance, farmer's ability to identify counterfeit pesticides on the market may enable them to avoid such products and apply appropriate chemicals at the right dosage, time, and frequency. These practices (along with proper disposal of chemical containers) are among the major components of GAP for vegetable farming (Arah et al., 2016; Mengistie et al., 2017) and have important implications for compliance with pre-harvest intervals and reduction of pesticide residues (Yami et al., 2025). These improvements at the production level translate into downstream benefits by enabling consumers to access safer, fresher, and more nutritious foods, particularly in informal urban markets where supply chain inefficiencies, poor postharvest management, and weak regulatory enforcement persist (Arah et al., 2016; Dinham, 2003; Yami et al., 2025). Although the relationship between market channel and farmer behaviour, particularly technology adoption, has been studied quite widely (Janssen & Swinnen, 2019; Liverpool-Tasie et al., 2022; Llewellyn & Brown, 2020; Marine et al., 2016; Saenger et al., 2013; Schipmann & Qaim, 2010; Suprehatin, 2021), most studies have focused on formal trading arrangements, such as contract farming (Barrett et al., 2012; Bellemare & Novak, 2017; Euler et al., 2017; Gatto et al., 2017; Marine et al., 2016; Monson et al., 2008; Saenger et al., 2013; Ton et al., 2017; Veldstra et al., 2014). More recently, de Steenhuijsen Piters et al. (2025) highlight the contributions of informal food systems and present an analytical framework to understand their motivations and strategies, demonstrating how they respond to incentives that encourage them to enhance their contributions to improved food system outcomes.

Despite these recent trends, there is still extremely limited information on how farmers' interactions with informal market channels, which smallholders largely engage in, in the absence of formal contracts, can stimulate their adoption of GHP and GAP. This is particularly relevant in the context of LMICs, as actors in the informal sector play a major role in the domestic food supply from primary production to retail, but their crucial role in sustainable food systems provision and their potential contribution to improved food systems outcomes are generally not well recognized because of the informal nature. As a result, informal sectors are insufficiently included in the efforts of governments, non-governmental organizations (NGOs), and development partners to improve livelihoods and the safety and accessibility of healthy foods (Termeer et al., 2022, as cited in de Steenhuijsen Piters et al., 2025). Thus, this paper contributes to this thin literature by examining how engagement with different market channels influences farmers' adoption of GAP and GHP with evidence from the tomato value chain in Nigeria. We deliberately focused on non-contract farming sales because, though the link between contract farming and smallholder behaviour (and welfare) has been studied extensively, less attention has been paid to non-contractual arrangements that still dominate smallholders' access to markets.

The tomato value chain in Nigeria provides an ideal case for examining this relationship for several reasons. First, tomato farmers typically engage with supply chains via informal but repeated interactions (Liverpool-Tasie et al., 2020; Termeer et al., 2024). This allows for examining the impact of selling to micro, small, and medium-scale enterprises (MSMEs) in the midstream (in the absence of formal contracts) on farmer behaviour. In Nigeria, tomatoes are transported from farmers in the North to consumers in the South through several key actors. Farmers sell primarily to aggregators, wholesalers, and retailers, often at the farm gate (Yami et al., 2024). Aggregators are typically residents of local communities who move between farms and farmer clusters, collecting tomato produce in plastic crates ranging from approximately 110 to 1,000 crates (roughly 2.2–20 metric tons). They organize transportation, usually via hired trucks, to major southern markets, such as the Mile-12 international vegetable market in Lagos, where they supply large wholesale dealers. The role of aggregators, however, varies. In some cases, they purchase the produce outright, assume the marketing and transport risks, and sell to wholesalers in urban markets, effectively functioning as independent rural wholesalers. In other cases, they operate on behalf of wholesalers, acting as brokers or commission agents who are remunerated by transaction. In such arrangements, the wholesaler bears the risk and controls the terms of trade. Retailers, by contrast, handle smaller quantities and typically purchase directly from farm gates or local rural markets for immediate resale. Second, tomato is a highly perishable commodity with increasing consumption in the country (Adeoye et al., 2016; Parkhi et al., 2023), yet production and quality remain constrained by postharvest losses and poor handling (Yami et al., 2024). Understanding how GAP and GHP for tomatoes can be promoted is therefore vital to improve the efficiency of the overall value chain (including the cost and quality of the tomatoes received by consumers) and thus support higher consumption. Building on these, this study examines how engagement with different market channels influences tomato farmers' adoption of GAP and GHP in Nigeria. Specifically, we (i) identify factors influencing farmers' participation in these channels, and (iii) assess how market channel choice affects compliance with GAP and GHP standards. We hypothesize that farmers selling to aggregators and wholesalers, who serve more distant urban markets (with preferences for certain product characteristics that aggregators and wholesalers then require of farmers), are more likely to adopt improved food safety practices compared to those selling to local retailers serving nearby rural markets.

2 Materials and methods

2.1 Study area and data

This study relies on primary data collected from 1,673 tomato farmers across four Local Government Areas (LGAs) with the highest tomato production in Kano State, northwest Nigeria. The study sample was selected using a multi-stage sampling approach. First, the four LGAs with the highest tomato production potential—Garun Mallam, Bunkure, Bichi, and Karaye - were purposively selected. Of these LGAs, 84 villages were randomly selected from a total pool of 103. Then, a census of tomato producers was conducted in all the villages from May 9 to 17, 2023. Households were included in the census if they had produced tomatoes in each of the preceding two years and expressed intentions to continue production. From this roster, 20 farmers per village were randomly selected using the research randomizer tool (Urbanika, 2013). Data were initially collected from 1,680[1] farmers using Computer-Assisted Personal Interviewing (CAPI) between June and July 2023. The survey gathered detailed information on farmers' (and their households') demographics, production practices (including various post-harvest storage, handling, and transport technologies), and farmers' perceptions about and use of GAP and GHP for the 2022/2023 production season. Given the study's focus on informal market arrangements, the final analytical sample was restricted to households that sold their produce in non-contract farming. This left us with a final sample size of 1,581 households.

2.2 Overview of GAP and GHP indicators

Production of perishable agricultural commodities such as tomatoes involves multiple management and handling practices at various stages, from cultivation to marketing. Following existing studies (Harrison et al., 2013; Arah et al., 2016; Mengistie, 2017; Yami et al., 2025), this study considers eight recommended practices, grouped as three pre-harvest and five harvest and post-harvest GAP and GHP relevant to tomato production. The pre-harvest GAP include (i) identifying counterfeit pesticides and avoiding their use, (ii) staking and pruning, and (iii) wearing protective gear during pesticide application. The ability to identify counterfeit pesticides in the market reflects farmers' awareness of pesticide quality and safety. This capacity influences both the type and frequency of pesticide use, as counterfeit products are often ineffective and have contributed to insect resistance in the study area. Hence, this practice serves as a proxy for compliance with safe pesticide management and pre-harvest interval requirements under GAP. The GHP encompasses (i) harvesting at the optimal ripeness stage, (ii) using gloves during harvesting, (iii) pre-cooling of tomatoes, (iv) cleaning, and (v) sorting and grading before marketing. The harvest-stage variable identifies the specific stage at which growers harvest their tomatoes. Tomatoes, a climacteric fruit, can be harvested in either the mature green, partially ripe, or ripe state. The stage of harvest is often determined by the proximity of the target market for sale and market preferences. In this study, harvesting at the light red and red stages was considered as the recommended practice for farmers because of the prevalence of on-farm and local market sales. Enumerators provided farmers with a color-coded tomato-ripening chart to indicate the stage of their harvest. Each practice was coded as a binary indicator (Table 1). The key explanatory variable, market channel, classifies the main buyer of tomatoes as aggregator, wholesaler, and retailer. These channels capture informal but recurrent trading relationships typical of Nigeria's horticultural markets. Descriptive statistics of the sample and adoption levels of GAP and GHP are presented in the results section.

[1] Seven observations were dropped during data validation due to incomplete responses.

Table 1 Overview of GAP, GHP, and market channel indicators used in the study

Category	Indicator	Description
GAP (pre-harvest)	Identification of counterfeit pesticides	Farmers' ability to identify fake or substandard pesticides (self-reported)
	Staking and pruning	Practice of staking tomato plants and pruning excess leaves or shoots
	Use of protective gear	Use of protective clothing (e.g., gloves, mask, boots) while applying pesticide
GHP (harvest & post-harvest)	Harvesting stage	Harvesting tomatoes at pink or red ripeness stages
	Use of gloves	Use gloves during harvesting to avoid physical damage and contamination
	Sorting and grading	Sorting and grading of tomatoes before sale
	Pre-cooling or shade storage	Temporary storage of tomatoes under shade or cool conditions
	Cleaning before sale	Washing or cleaning tomatoes before marketing
Market Channel	Primary buyer of tomato production	Main buyer of farmers' bulk tomato output- aggregator, wholesaler, or retailer (reference: retailer)

Following the description of GAP and GHP indicators, we next describe the explanatory and control variables included in the analysis (Table 2). These variables capture household, farm, institutional, and market characteristics that are expected to influence the adoption of GAP and GHP among tomato farmers. Within the institutional characteristics, farmers were asked whether they received any training on GAP and GHP from different training providers including research institutes, farmer associations such as Tomato Growers' Association of Nigeria (TOGAN), agro-dealers, processors, or government extension agents under the Federal Ministry of Agriculture and Food Security (FMAFS). For analysis, these providers were grouped into governmental extension services (FMAFS and public extension agents) and non-governmental extension services (NGOs, agro-dealers, processors, farmer associations, and research institutions).

2.3 Empirical strategy

Our empirical analysis combined several multivariate regression approaches. Using a multinomial logit model, we explored the drivers of farmer sales to different market channels. The framework for the multinomial logit model used in the study context has each producer facing three possible market channel options for marketing their produce: (1) aggregators, (2) wholesalers, and (3) retailers.

Table 2 Description of control variables used in the analysis

Variable category	Variable	Description	Type
Household characteristics	Age	Age of the household head (years)	Continuous
	Gender	Gender of household head (male or female)	Binary
	Education	Whether the household head completed formal schooling	Binary
	Household size	Number of household members	Continuous
	Farming experience	Years of experience in tomato farming	Continuous
Economic assets	Wealth quintile	Household wealth index ranked into five quintiles (1 = poorest to 5 = richest) (reference: quintile 5)	Categorical
	Mobile phone ownership	Ownership of a mobile phone by the household head	Binary
Farm characteristics	Farm size	Tomato cultivated area (hectares)	Continuous
	Production system	Type of production (rained, irrigated, or both) (reference: both)	Categorical
	Distance to market	Distance from household to nearest tomato market (kilometers)	Continuous
	Distance to farm	Walking time from household to main farm plot (minutes)	Continuous
Institutional access and services	Extension access	Whether the household received advice or visits from extension agents during the season	Binary
	Credit access	Whether the household accessed formal credit	Binary
	GAP training	Participation in any formal GAP training program	Binary
	Farmer association (%)	Whether the household is a member of a farmer association or a cooperative	Binary
	Position in the community	Whether the household head holds a social or leadership position in the community	Binary

Economic agent i's representative utility is derived from his market choice j, j = 1, 2, 3, as follows:

$$V_{ij} = X_i\beta_j + \varepsilon_{ij} \quad (1)$$

where V_{ij} represents the latent (unobserved) utility that farmer i obtains from selecting market channel j. The term X_i is a vector of socioeconomic characteristics that includes the household, farm, market, and institutional variables listed in Table 2 above, which served as adjustment terms in the estimation of the model. The vector β_j denotes the parameters to be estimated, while the term ε_{ij} represents the random error term capturing unobserved factors that affect a farmer's choice of market channel. The assumption is that each farmer faces a set of discrete, mutually exclusive choices of market channels that yield the highest expected utility.

Next, using a multivariate probit analysis, we explored the factors associated with adopting GAP and GHP. We are particularly interested in investigating how a farmer's market channel influences their adoption of GAP and GHP. Unlike univariate models such as probit and logit, the multivariate Probit (MVP) model accounts for potential interdependence between the eight binary outcomes by estimating them jointly (Greene, 2010). Thus, the MVP model estimates the influence of market channels and other covariates on the adoption of the eight GAP and GHP options simultaneously while accounting for the possibility that the adoption of any particular strategy could be correlated with the adoption of the other strategies. Formally, let Y_{im} denote the adoption of a particular practice for each practice m adopted by farmer i. The multivariate probit model can be expressed as:

$$Y_{im}* = \beta_m^{'} X_{im} + \epsilon_{im}, m = 1, \ldots M \tag{2}$$

$$Y_{im} = 1 if y_{im}* > 0 \text{ and } 0 \text{ otherwise} \tag{3}$$

where $\epsilon_{im}, m = 1, \ldots M$ (with M=8) are multivariate normal distributed error terms, with a mean of zero (Capellari & Jenkins, 2003). Here we have the corresponding variance–covariance matrix V with values of 1 on the lead diagonal while the correlations of $\rho_{jk} = \rho_{kj}$ are the off diagonal elements representing the unobserved correlation between the stochastic components of the different adoption choices (Capellari & Jenkins, 2003). We derived the estimates of the average partial marginal effects for each explanatory variable on the probability of adopting each practice.

3 Results

3.1 Descriptive characteristics

Table 3 below summarizes the demographic characteristics of the study sample. The average farmer is a 42.8-year-old male with some formal education (63.0%). The average household size was 11.6. Formal credit access is low in our study sample (at 8.0%), with about half of the farmers (51.0%) practicing irrigated tomato production. Wholesalers were the most common buyers, with 64.0% of farmers selling their bulk production to wholesalers. Only 19.0% of the farmers had attended a GAP training, and 22.0% of farmers are members of a farmers' association. Phone access was widespread, with 97.0% of the tomato farmers having access to a phone.

Table 3 Descriptive characteristics of tomato farmers

Variable	Mean/%	SD[a]
Age of household (years)	42.8	11.4
Male-headed household (%)	98.0	
Education (%)	63.0	
Household size (persons)	11.6	6.2
Farming experience (years)	14.6	7.7
Wealth quintile (reference: wealth quintile 5)[b] *(%)*		
1	22.0	
2	22.0	
3	23.0	
4	15.0	
Farm size (ha)	0.9	0.7
Mobile ownership (%)	97.0	
Market channel (reference: retailer)[b]		
Sold to aggregator (%)	27.0	
Sold to wholesaler (%)	64.0	
Distance to market (km)	11.6	8.1
Distance to farm (minutes)	2.4	2.5
Access to extension (%)	27.0	
Access to credit (%)	8.0	
GAP training (%)	19.0	
Farmer association (%)	22.0	
Leadership position (%)	12.0	
Production system *(reference: both)*[b]		
Rainfed (%)	39.0	
Irrigated (%)	51.0	

[a]Note: S.D. stands for standard deviation

[b]Reference categories are shown in parenthesis

3.2 GAP and GHP training access

Figure 1 illustrates the primary sources of GAP and GHP training providers for tomato farmers, distinguishing between governmental and non-governmental extension services. Around 19.0% of farmers reported receiving training on GAP and GHP over the past three seasons. Among those who received training, 58.0% and 69.0% of farmers obtained training from non-governmental service providers.

3.3 Adoption of GAP and GHP indicators

Table 4 presents the extent of the adoption of GAP and GHP by farmers in our sample. We found that 56.6% of tomato farmers were able to distinguish counterfeit pesticides, and 56.3% take precautions by wearing protective gear during pesticide spraying. Only 17.8% of the farmers reported adopting and implementing staking and pruning in our sample. About 77.9% of farmers reported that tomatoes were collected for sale at a light red or red stage of ripeness. The most prevalent GHP among tomato farmers in our sample was sorting and grading before sale; adopted by

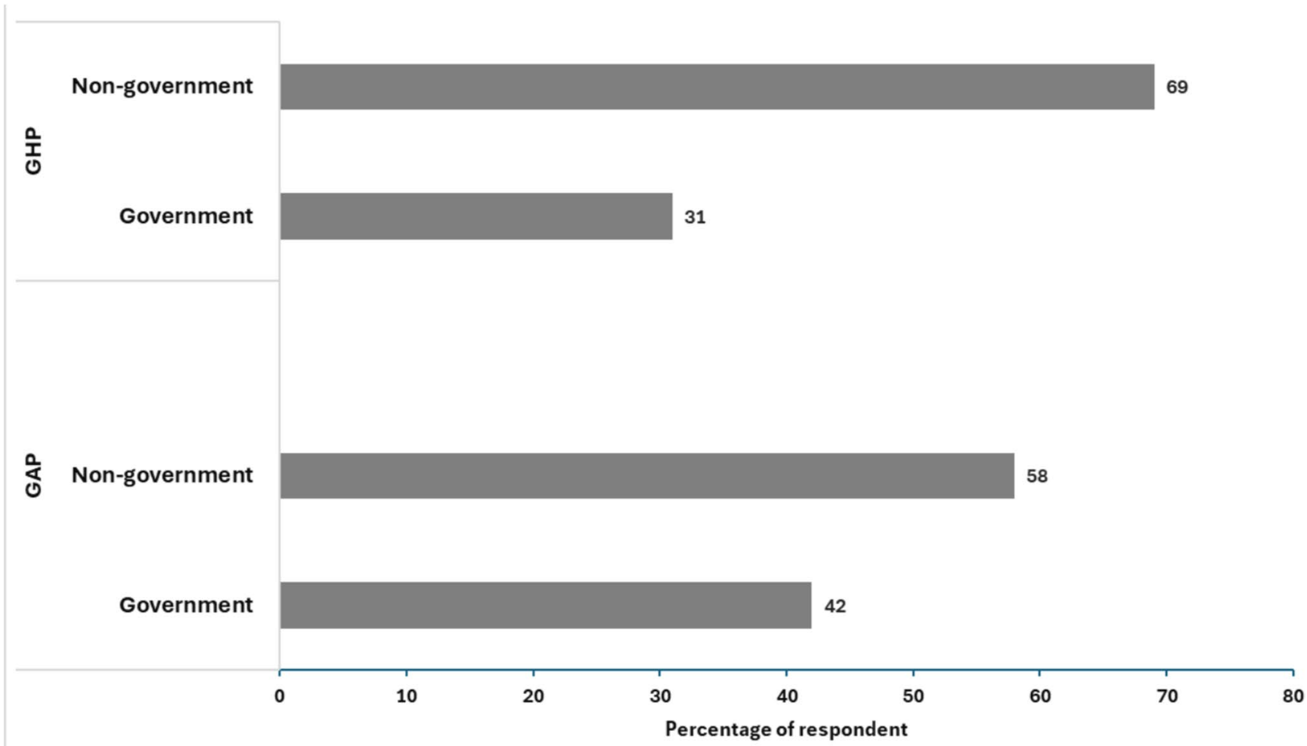

Fig. 1 Main training providers of good agricultural and handling practices

Table 4 Adoption rates of GAP and GHP outcome variables

	Frequency	%
Panel 1. GAP adoption during planting		
Distinguish counterfeit pesticides	1,437[a]	56.6
Wearing protective gear	1,581	56.3
Staking and pruning	1,581	17.8
Panel 2. GHP adoption in harvest and marketing stages		
Harvest stage	1,581	77.9
Use gloves	1,581	11.0
Sorting and grading	1,581	67.4
Cooling	1,581	5.4
Clean before sale	1,581	4.4

[a]Note: This question was only asked of farmers who reported using pesticides

Table 5 Market channel utilized by farmers (%)

Top buyer of bulk sale	Full sample (N = 1581)	Operating on less than 0.8 ha (N = 666)	Operating on 0.8 ha + (N = 915)
Aggregator	27.1	28.1	26.4
Retailer or directly to consumers	8.1	10.5	6.3
Wholesaler	64.8	61.4	67.2

approximately 67.4% of farmers. We also found that only a handful of farmers apply cooling (5.4%) and clean tomatoes (4.4%) before marketing.

3.4 Determinants of market channel choices

Table 5 presents the main market channel sources for tomato farmers. Overall, the findings demonstrate that most farmers were supplying to wholesalers (64.8%), followed by aggregators and retailers or directly to consumers with 27.1% and 8.1%, respectively. While a larger (67.2%) share of farms operating on 0.8 ha or more appear to channel their produce through wholesalers compared to smaller farms operating less than 0.8 ha (61.4%), a similar share of small and large farms sells to aggregators.

The findings for the Multinomial Logit Regression Model (MNL) with sales to retailers as a reference category are shown in Fig. 2 below (see Appendix Table 6 for the full model results). We found that smallholders who produce with modern irrigation are more likely to sell to midstream actors such as aggregators. In particular, using modern irrigation is associated with an 8.2 percentage points higher probability of selling to an aggregator ($p < 0.01$). Farm size is also an important factor in the market channel choice for smallholder farmers in our sample. We found that a one-hectare increment in land allocated to tomatoes is associated with a 3.6 percentage points

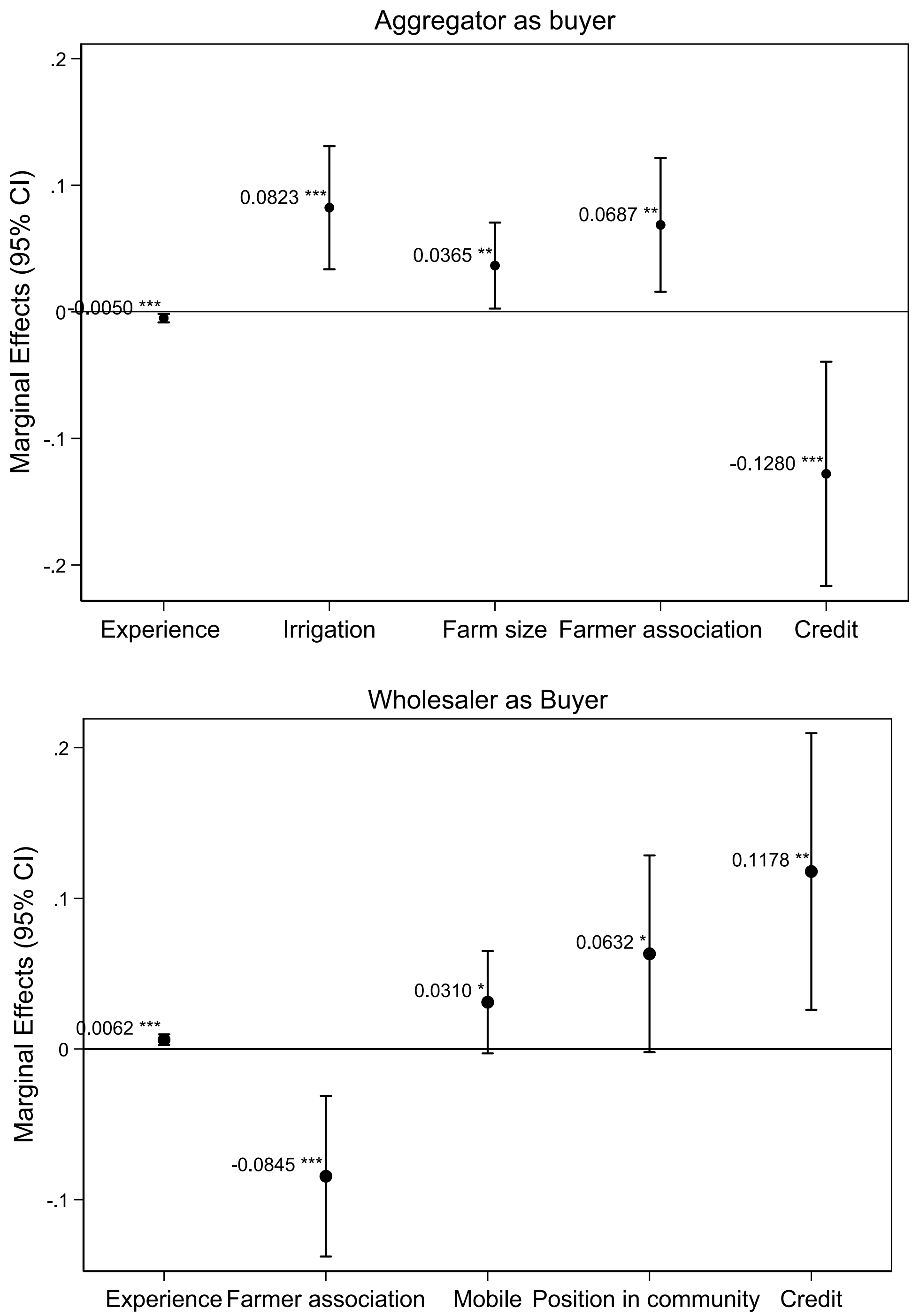

Fig. 2 Multinomial Logit estimation of the determinants of market channel choice of tomato growers selling to aggregators and wholesalers versus the retail market outlet (N = 1,581). The retail market channel is the reference category. This figure displays average partial marginal effects and their corresponding 95% confidence intervals as error bars. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors are clustered at the village level. The models are estimated with additional controls such as the age of the household head, tomato production experience, production system, distance to market, distance to farm, tomato farm size, membership of farmers' associations, position in the community, mobile ownership, access to extension, and access to formal credit. Full models are reported in Appendix Table 6

higher probability of selling to aggregators ($p<0.05$) compared to growers who primarily marketed their produce through other channels, such as retailers. Surprisingly, we found that smallholders integrated into producer associations are more likely to sell to aggregators. Producers who belong to a producer's association or cooperatives are associated with a 6.8 percentage points higher probability of selling to an aggregator ($p<0.05$) and an 8.4 percentage points ($p<0.0$). We found that information communication technologies also influence farmers' market channel choice ($p<0.1$). Farmers with mobile phones have a 3.1 percentage points higher probability of selling their produce to wholesalers than to retailers.

3.5 Drivers of adoption of GHP and GAP

Figures 3 and 4 present the multivariate probit results on the drivers of GAP and GHP adoption among tomato farmers,

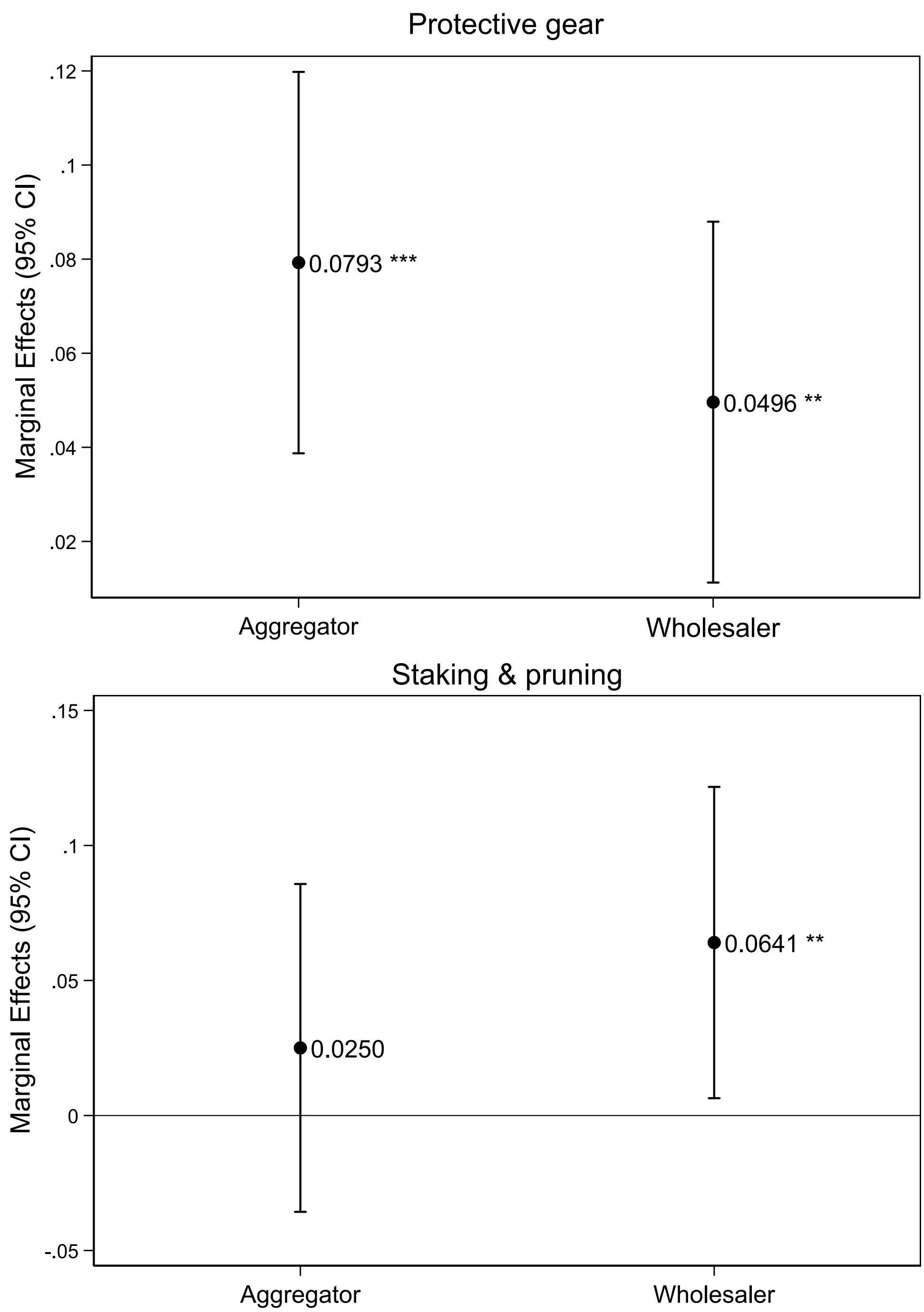

Fig. 3 Effects of midstream actors on the adoption of pre-harvest good agricultural practices. This figure displays average partial marginal effects and their corresponding 95% confidence intervals as error bars. The marginal effects are estimated using the multivariate probit regression approach with 1,581 observations. The presence of an asterisk (*) indicates the level of significance (***$p<0.01$, **$p<0.05$, *$p<0.1$). The models are estimated with additional controls such as the age of the household head, household size, formal education, production system, membership of farmers' associations, mobile ownership, wealth, and access to formal credit. Full models are reported in Appendix Table 7

and three key findings.[2] First, we found that "market channel" is a key driver of farmer adoption of GAP and GHP. Compared to farmers selling to retailers or directly to consumers, farmers who sell to aggregators and wholesalers are more likely to use protective gear when applying chemicals ($p<0.01$ and $p<0.05$), more likely to harvest tomatoes at the recommended time ($p<0.05$), and sort and grade their tomatoes ($p<0.05$ and $p<0.01$) before sale. Farmers who marketed their produce primarily through aggregators and wholesale channels were 7.9 and 4.9 percentage points more likely to wear protective gear while spraying chemicals in the tomato field. Compared to farmers who marketed their produce exclusively through retailers, those who primarily utilized aggregators and wholesale channels had 1.9 and 1.7 percentage points greater likelihood of harvesting tomatoes at the recommended time (to align with consumer preferences).

[2] The full estimation results for each model are shown in Appendix Table 7

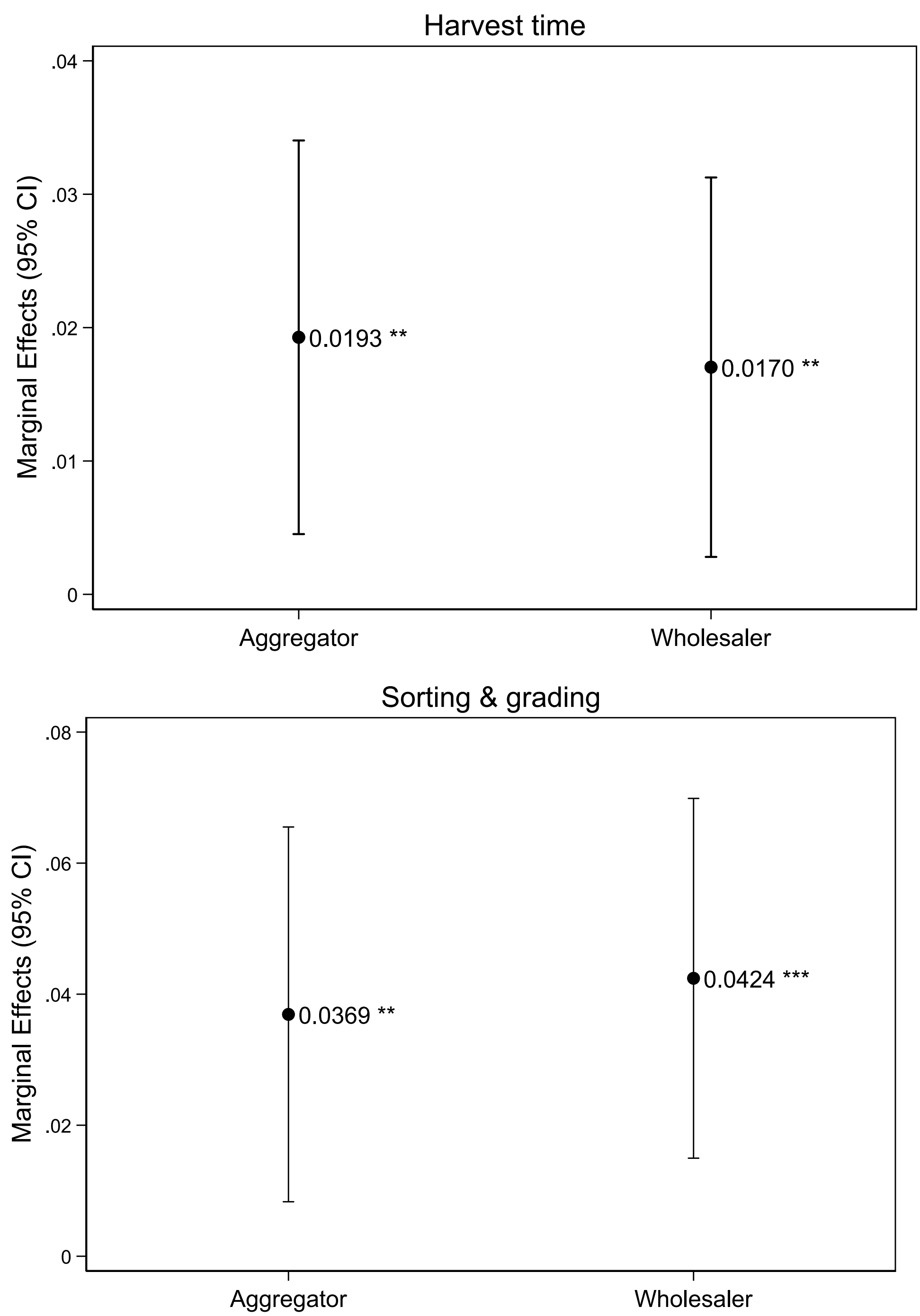

Fig. 4 Effects of midstream actors on the adoption of harvest time, sorting, and grading. This figure displays average partial marginal effects and their corresponding 95% confidence intervals as error bars. The marginal effects are estimated using the multivariate probit regression approach with $N = 1{,}581$ observations. The presence of an asterisk (*) indicates the level of significance (***$p < 0.01$, **$p < 0.05$, *$p < 0.1$). The models are estimated with additional controls such as the age of the household head, household size, formal education, production system, membership of farmers' associations, mobile ownership, wealth, and access to formal credit. Full models are reported in Appendix Table 7

In a similar vein, farmers selling to wholesalers are more likely to practice staking and pruning ($p < 0.05$) compared to retailers. Farmers selling to wholesalers were 6.4 percentage points more likely to practice staking and pruning, while growers supplying to aggregators and wholesalers were 3.7 and 4.0 percentage points more likely to sort and grade their harvested product before selling, respectively.

Second, we found that the presence of farmers' associations, as well as capacity building and awareness training, is an important driver of farmer adoption of GAP. Farmers who have received training on GAP ($p < 0.1$) and members of farmers' associations ($p < 0.1$) were 3.0 and 2.0 percentage points more likely to identify counterfeit pesticides during the pre-harvest stage. Similarly, farmers attending GAP training were 19.0 percentage points more likely to use gloves ($p < 0.01$). Surprisingly, we found that farmers who received GAP and GHP training were less likely to use sorting ($p < 0.05$), cleaning ($p < 0.1$), and harvesting at the optimum harvest stage ($p < 0.01$). Harvesting at the optimum harvest stage is, however, strongly correlated with selling to both aggregators ($p < 0.05$) and wholesalers ($p < 0.05$).

Third, we find that socioeconomic factors, such as farmer education, financial ability (facilitated through access to formal credit), and wealth, are significantly associated with the adoption of GAP and GHP. Credit availability has a significant positive effect on the ability of farmers to identify counterfeit pesticides ($p < 0.1$) and adoption of good harvesting and marketing practices, such as sorting and grading ($p < 0.01$), pre-cooling ($p < 0.01$), and cleaning before sale ($p < 0.05$). Households with credit access were 4.0 percentage points more likely to identify counterfeit pesticides and apply sorting and grading, and 14.0 and 10.0 percentage points more likely to apply and adopt pre-cooling and cleaning before sale.

4 Discussion

This study examined the role of midstream actors in promoting farmer adoption of GAP and GHP in non-contract farming sale arrangements with evidence from Nigeria's fresh tomato value chain. The results of the multinomial Logit regression analyses on the determinants of market choice reveal consistent findings with the literature that farmers' choice of marketing channels is influenced by supply-side factors, including farm size, irrigation access, and distance to market (Abdoulaye et al., 2018). We find that growers who produce with modern irrigation are more likely to sell to midstream actors. In Sub-Saharan Africa (SSA), where a significant portion of the population relies on agriculture for their livelihoods, the role of irrigation in shaping market choices is crucial. Irrigation gives farmers more control over water availability, allowing them to cultivate crops year-round and mitigate the impacts of low or variable rainfall. This ability to manage water supply can guarantee more stability and availability of agricultural products for the market (Mabhaudhi et al., 2017).

We also found that large-scale growers tend to market their produce through midstream actors. Smaller farms often have limited resources and production capacity, making it difficult for them to access larger markets or compete with larger-scale producers. As a result, smallholder farmers with smaller farms are more likely to participate in local markets, where they can sell their products directly to consumers or retailers. The result is similar to that of Low and Vogel (2011) and Martinez et al. (2010), who indicated that small-scale growers tend to rely on direct-consumer marketing channels in order to avoid some requirements demanded by the wholesale market channel. Additionally, smaller farms may face challenges regarding postharvest loss, lack of market information, and high transaction costs (Aworh, 2021; El-Otmani et al., 2011; Gligor et al., 2018; Ntsoane et al., 2019; Sheahan & Barrett, 2017; Unnevehr, 2015), which is more prevalent in vegetable commodities in Africa. This can lead to a need for immediate sales at low prices (Negede et al., 2023), resulting in a loss of market share.

Interestingly, although the estimated effect size of farm size holds the expected positive sign, it is not significant for wholesalers. These findings contrast with what Hernández et al. (2006) found for tomato growers in Guatemala, where farmers selling to wholesalers tend to be at the upper end of the small farmer category and have more capital, particularly irrigation, and larger farms. This allows them to supply all year, attain greater productivity and consistency, and be much more specialized in commercial horticulture in general and tomatoes in particular. Our results reflect that while midstream actors may generally target larger farms for their tomatoes (i.e. to get sufficient volumes and reduce costs on coordination), aggregators can be more selective than wholesalers. Since aggregators are typically local, they have more information to engage with the farmers and can capitalize on that to get the volumes they need at the lowest transaction cost. However, wholesalers (who usually come from outside the communities) are limited with information to access the large volumes compared to other marketing actors. Thus, they are willing to buy from farmers who are more experienced, have social status in the community, and have access to credit to achieve desired volumes with a lower risk (see Fig. 2 above). From the findings, we can conclude that aggregators are the preferred intermediaries for larger farmers. This result is consistent with the current practices in the study areas, as most farmers (78%) sell on-farm. It is also consistent with the fact that aggregators are often residents in rural communities and are able to access the more remote farmers compared to wholesalers, who often come from outside the community. The prevalence of traditional harvesting and packaging materials, such as raffia baskets, can also exacerbate the postharvest loss for those farms far from home.

Our empirical analysis of the drivers of GAP and GHP suggests that market channels influence farmers' decisions to implement GAP and GHP pre-harvest and post-harvest. A significant and positive correlation was observed between market channel and the utilization of protective equipment during chemical application, adherence to harvest timing, and postharvest sorting and grading of tomatoes. Farmers who marketed their produce primarily through aggregators and wholesale channels were more likely to wear protective gear while spraying chemicals in the tomato field. This behavior is particularly relevant given that over 90% of tomato farmers applied pesticides for pest management. In the study areas, it is typical to overuse pesticides to control the invasive tomato leaf miner (*Tuta absoluta*) pest disease. The use of personal protective equipment and adherence to harvest timing, therefore, have important implications for food safety, environmental sustainability, and public health (Mengistie, 2017).

These upstream practices carry critical implications for food security, particularly in terms of the utilization dimension by ensuring consumers have access to safe and nutritious food. A recent multi-country study by Tambo et al. (2024) found that consumers in LMICs cited pesticide residues on fruits and vegetables as their top food safety concern. This concern is especially relevant in Nigeria, where fresh tomatoes are widely consumed in daily diets (Adeoye et al., 2017). Previous research by Yami et al. (2025) revealed that 40% of tomato farmers in northern Nigeria do not adhere to recommended pre-harvest intervals, harvesting tomatoes within 1–5 days after pesticide application, which is below the 7-day safety guideline. This increases the risk of pesticide residues entering the food chain. Studies consistently report the presence of excessive pesticide residues in Nigeria's fresh produce markets (Ibrahim et al., 2018; Omeje et al., 2022; Oyinloye et al., 2021). For example, Omeje et al. (2022) identified the presence of 38 different pesticide residues in sampled fruits and vegetables. These findings highlight the urgent need to promote GAP, particularly safe pesticide management and adherence to on-farm food safety standards, as pathways to improving consumer food safety. This is especially important for fresh produce supplied to informal urban markets, where regulatory enforcement is weak (Dinham, 2003).

We also found that compared to farmers who marketed their produce exclusively through retailers, those who primarily utilized aggregators and wholesale channels had a greater likelihood of harvesting tomatoes at the recommended time (to align with consumer preferences while preserving nutrient composition). In a similar vein, farmers selling to wholesalers are more likely to practice staking and pruning and are more likely to sort and grade their harvested product before selling it, respectively. This may be due to the fact that wholesalers usually supply major urban markets (such as the Mile-12 international vegetable market in Lagos and supermarkets) that have food safety requirements that must be fulfilled. Midstream actors, particularly for tomatoes, tend to reject low-quality or pest-infested produce and inspect produce closely prior to purchase, a pattern also documented in Tanzania (Kamrath et al., 2016). Midstream actors also consider the purchasing preferences of urban consumers when buying farmers' produce. Urban consumers in Nigeria generally prefer buying fresh tomatoes (Adeoye et al., 2016). Therefore, midstream actors typically purchase tomatoes that are harvested in the light red and red stages. This allows the product to align with consumers' expectations and be sold immediately while maintaining its nutrient composition. Therefore, implementing pre-harvest and post-harvest GAP, such as pruning and staking after harvest, as well as sorting and grading, can effectively enhance the quality of produce by preventing or controlling certain pests and diseases (Tilman et al., 2002). Additionally, these practices can also cater to consumer preferences and tastes (Adeoye et al., 2016). The results of this study corroborate those of Marine et al. (2016), who found that vegetable producers who primarily sold to wholesalers had a greater propensity to implement food safety procedures. Additionally, according to Fulponi (2006), wholesalers exerted pressure on farmers to adopt more stringent food safety standards by utilizing their purchasing power. Nevertheless, it is worth mentioning that the aforementioned two studies have examined the influence of market channels on farmers' adoption of sustainable food production practices under formal contract arrangements.

Furthermore, the heterogeneity effects of market channels with respect to farm size are illustrated in Appendix Tables 8 and 9. Farm size remains an important factor in the Nigerian context, as highlighted by Abdoulaye et al. (2018). In general, our heterogeneity analysis suggests that the influence of market channels on the adoption of GAP and GHP practices was consistent across farm scales. Contrary to the findings by Marine et al. (2016), our evidence suggests that smallholders with access to aggregators and wholesale markets are equally likely to adopt improved food safety practices. Our findings for the smaller smallholders are encouraging, as it means that even if the decision to sell to wholesalers or aggregators is endogenous and more likely among the high-ability and more progressive farmers, those tomato farmers operating small land areas are not excluded from the opportunity to sell to these midstream actors and to see an impact of their engagement on their behaviour. These findings have important implications for food system transformation in LMICs. As emphasized by Reardon et al. (2009), inclusive agrifood systems transformation requires smallholders, often considered at risk of exclusion in modernizing value chains, to integrate into high-value chains. We are not able to distinguish between whether adoption results from assistance provided by the MSMEs (as noted by Liverpool-Tasie et al., 2020) or if they are a requirement to be able to sell to these actors. However, finding an association indicates the potential for these actors to be an avenue to increase smallholder adoption of these practices. Additional research on the mechanisms can better inform actual strategies to further support these sorts of associations in mutually beneficial ways. We found that aggregators and wholesalers provide a premium for tomatoes that is 30% and 20% higher than the average price paid to those who sell to retailers or directly to consumers. This suggests that there are likely synergies between smallholder farmers and MSMEs in the midstream, which support the adoption of these practices by farmers and the receipt of high-quality products by aggregators and wholesalers. These sorts of synergies are important for the sustainability of such interactions and their positive outcomes on farmer and consumer food security. Together, these results provide evidence that even where informal trading arrangements dominate (as is common in most developing countries), smallholder growers can benefit from the opportunity of engagement with value chain actors in the midstream of food supply chains through increased adoption of GAP and GHP. These on-farm improvements in food safety practices have direct implications for food security, as they enhance both the livelihoods of smallholders and the availability and safety of fresh produce for consumers.

While this study provides empirical evidence on the role of market channels in informal, non-contract settings shaping farmers' adoption of GAP and GHP, a few methodological limitations should be acknowledged. First, the indicators of GAP and GHP adoption were self-reported rather than directly observed, and responses may have been affected by social desirability bias, with farmers potentially overstating their compliance with recommended practices, such as the identification of counterfeit pesticide products. Second, the data were collected using CAPI, which minimized data-entry errors and allowed for real-time consistency checks. However, the cross-sectional nature of the survey limits the ability to verify changes in behavior over time. Finally, the decision to sell to midstream actors (wholesalers and aggregators) is potentially endogenous, and reverse causality could arise if farmers' adoption of GAP and GHP determines their market channel choice. Therefore, our findings should be interpreted as important correlations rather than causality.

5 Conclusion

This study examined the role of midstream actors in promoting the adoption of GAP and GHP among farmers, using evidence from Nigeria's fresh tomato value chain. We focused on non-contract farming sales that account for the majority of sales by smallholder producers in LMICs, and considered three important recommended tomato preharvest practices and five harvest and post-harvest practices.

We found consistent evidence that a farmer's market channel is an important determinant of their adoption of GAP and GHP. Compared to farmers selling to retailers or directly to consumers, farmers who sell to aggregators and wholesalers are more likely to use protective gear (when applying chemicals), harvest tomatoes at the recommended time, and sort and grade their tomatoes before sale. We also found that farmers selling to wholesalers are more likely to practice staking and pruning, which supports better tomato growth. Our results confirm that the correlation between market channel and GAP adoption holds even for smallholders operating less than the median land size of 0.8 ha. Together, these results confirm that even where informal trading arrangements dominate (as is common in most LMICs), value chain actors in the midstream food supply chains can support increased farmer adoption of GAP and GHP even in the absence of formal contracts. These have direct implications for food security by enhancing both the livelihoods of smallholders and the availability and safety of fresh produce for consumers. While we cannot distinguish between whether adoption results from assistance provided by the MSMEs (as noted by Liverpool-Tasie et al., 2020) or if they are a requirement to be able to sell to these actors, our results reveal the potential for midstream actors to be a mechanism to support increased smallholder adoption of GAP and GHP. Further research is needed on the nature of these relationships to better understand how they can be supported or refined.

We found that aggregators and wholesalers provide a price premium of 30% and 20% higher than the average price received by farmers who sell to retailers. We interpret this as evidence of some synergies between smallholder farmers and these MSMEs in the midstream. These MSMEs either support farmers' adoption of these practices to be able to receive high-quality products or require them. For smallholder tomato growers, whose produce is often a primary source of household income, such price differences have significant implications for livelihoods and food security. As African governments and development partners strive to identify ways to support improved smallholder productivity, actors in the midstream of food supply chains should not be ignored or dismissed but rather included. Midstream actors are often physically and socially closer to smallholder farmers than the government, NGOs, and researchers. They are profit-oriented and have something to gain from farmers' production of more and better-quality products. These sorts of synergies are extremely important for the sustainability of such interactions and their positive outcomes. These synergies can also support successful partnerships between some of these midstream actors and government or development practitioners when trying to learn how to design programs to support smallholder adoption of improved technologies and good agricultural practices.

Overall, these findings suggest that strengthening midstream actors can serve as a practical entry point for the transformation of food systems in LMICs. By aligning MSMEs with public objectives on food safety, governments and development partners can scale GAP and GHP without relying solely on formal contracts. Programs that provide incentives to midstream actors in the informal food system through price setting and supply preference, postharvest reduction innovations, market integration, and financing schemes, combined with skills enhancement strategies, could amplify their positive spillovers to smallholders. This would enhance consumer access to and trust in local produce, improve dietary quality, and food safety. Integrating these insights into national agricultural and food safety strategies can help achieve more resilient, inclusive, and sustainable food systems.

Appendix

Table 6 Factors associated with farmer sales to different market channels

	Aggregators		Wholesalers	
	Average partial marginal effect	Delta-method std.err	Average partial marginal effect	Delta-method std.err
Age	2.84×10^{-3} **	0.001	-2.90×10^{-3} ***	0.001
Experience	-4.99×10^{-3} ***	0.002	6.15×10^{-3} ***	0.002
Irrigation (base = **rainfed**)[a]	0.082***	0.026	-0.041	0.026
Both irrigation and rainfed	0.030	0.045	-0.016	0.042
Distance to Market	2.42×10^{-3}	0.002	-1.32×10^{-3}	0.002
Distance to farm	-7.13×10^{-4}	0.005	-3.59×10^{-3}	0.005
Farm size	0.037**	0.017	0.019	0.022
Farmer association	0.069**	0.027	-0.084***	0.027
Mobile	-0.010	0.016	0.031*	0.017
Position in community	-0.029	0.031	0.063*	0.033
Credit	-0.128***	0.045	0.118**	0.047
Access to extension	-0.019	0.026	0.022	0.027
Pseudo r-squared	0.028			
Log pseudolikelihood	-1370.1035			
Chi-square	99.063			
Prob > chi2	0.000			
Akaike crit. (AIC)	2792.207			
Bayesian crit. (BIC)	2933.158			
Observations	1,581			

[a]Reference categories are in boldface and shown in parenthesis

*** $p<0.01$, ** $p<0.05$, * $p<0.1$; Standard errors are clustered at the village level

Table 7 Regression results of the determinant of GAP and GHP during pre-harvest, post-harvest, and marketing stages, full sample ($N=1581$)

Variable[a]	Pre-harvest			Post-harvest			Marketing	
	Counterfeit (*dy/dx*)	Protective gear (*dy/dx*)	Staking & pruning (*dy/dx*)	Harvest time (*dy/dx*)	Glove (*dy/dx*)	Cooling (*dy/dx*)	Sorting (*dy/dx*)	Cleaning (*dy/dx*)
Age	-1.23×10^{-4}	-0.61×10^{-4}	-1.05×10^{-3}	4.86×10^{-4} ***	-1.79×10^{-3} *	2.51×10^{-3} **	1.02×10^{-4}	5.22×10^{-4}
Credit	0.04*	-0.03*	0.02	4.94×10^{-3}	0.03	0.14***	0.04***	0.10**
Household size	8.24×10^{-4}	3.48×10^{-4}	1.72×10^{-3}	-6.85×10^{-4} **	3.18×10^{-3} *	-9.43×10^{-4}	1.06×10^{-3}	2.30×10^{-3}
Mobile	-4.08×10^{-3}	9.79×10^{-3}	-0.03	5.67×10^{-3}	-0.02	-0.15*	-9.84×10^{-3}	-0.05
Education	0.01	0.03***	-0.01	-2.41×10^{-3}	0.01	0.03	0.02***	0.01
Production system (both)[a]								
Rainfed	-0.05***	-0.01	-0.13***	-1.35×10^{-3}	-0.03	0.04	-0.02	0.01
Irrigated	-0.05***	-0.03*	-0.18***	5.11×10^{-3}	-0.02	2.03×10^{-3}	-0.01	-7.08×10^{-3}
Market channel (retailer)[a]								
Aggregator	-0.05**	0.08***	0.02	0.02**	0.03	0.04	0.04**	-0.01
Wholesale	4.56×10^{-3}	0.05**	0.06**	0.02**	-1.36×10^{-3}	-1.74	0.04***	-0.04
Wealth (wealth quintile 5)[a]								
1	-0.04**	-0.04**	-0.06**	-0.02***	-0.05*	-8.83×10^{-3}	-0.01	0.11***
2	-0.05***	-1.69×10^{-3}	-0.05*	-0.01***	7.08×10^{-3}	-0.01	8.29×10^{-4}	0.04
3	-0.03**	-0.01	2.48×10^{-3}	-2.22×10^{-3}	-0.01	-0.02	-7.43×10^{-3}	-4.84×10^{-4}
4	1.97×10^{-3}	5.19×10^{-3}	-3.67×10^{-3}	3.38×10^{-3}	3.86×10^{-3}	-9.14×10^{-3}	-0.01	0.03
Farmer association	0.02*	-0.01	0.03	-9.32×10^{-4}	7.41×10^{-3} ***	-4.03×10^{-3}	-5.64×10^{-3}	-0.01
GAP training	0.03*	0.02	0.04	-0.02***	0.19***	-0.08***	-0.03**	-0.04*
Log pseudolikelihood	-4954.3742							
Wald chi^2	448.92							
Prob > chi2	0.0000							

[a]Reference categories are in boldface and shown in parenthesis

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 8 Regression results of the determinant of GAP and GHP for farms operating more than 0.8 hectares

Variable[a]	Pre-harvest			Post-harvest			Marketing	
	Counterfeit (*dy/dx*)	Protective gear (*dy/dx*)	Staking & pruning (*dy/dx*)	Harvest time (*dy/dx*)	Glove (*dy/dx*)	Cooling (*dy/dx*)	Sorting (*dy/dx*)	Cleaning (*dy/dx*)
Age	3.22×10^{-4}	6.59×10^{-4}	2.49×10^{-4}	5.45×10^{-4} **	-1.74×10^{-3}	2.42×10^{-3}	8.37×10^{-4}	-3.71×10^{-4}
Credit	0.042*	-0.05**	-9.54×10^{-4}	0.01*	0.02	0.08	0.04**	0.06
Household size	2.52×10^{-5}	-9.23×10^{-4}	7.356×10^{-4}	-6.95×10^{-4} *	3.06×10^{-3}	-1.36×10^{-3}	1.50×10^{-3} *	2.08×10^{-3}
Mobile	0.03	-0.03	-0.02	7.27×10^{-3}	-0.03	-0.06	6.79×10^{-3}	-0.08
Education	0.03**	0.04***	6.50×10^{-3}	2.56×10^{-3}	0.04*	-7.91×10^{-5}	0.03***	7.82×10^{-4}
Production system (both)[a]								
Rainfed	-0.03	-5.32×10^{-3}	-0.07	5.38×10^{-3}	-1.80×10^{-4}	0.0	-0.02	-4.72×10^{-4}
Irrigated	-0.02	-0.02	-0.14***	9.05×10^{-3}	-7.98×10^{-3}	3.72×10^{-3}	-0.01	-8.52×10^{-3}
Market channel (retailer)[a]								
Aggregator	-0.05*	0.09***	0.09**	0.02*	0.03	0.09**	0.04*	0.03
Wholesale	-0.02	0.05*	0.09**	0.01	-0.02	0.06**	0.03	-9.66×10^{-3}
Wealth (wealth quintile 5)[a]								
1	-0.03	-0.04**	-0.07*	-0.02**	-0.05	-0.02	-9.95×10^{-3}	0.09**
2	-0.09***	-0.03	-0.09***	-7.51×10^{-3}	-0.02	-0.02	-3.48×10^{-3}	-5.03×10^{-3}
3	-0.04**	-0.02	-0.03	-5.53×10^{-4}	-0.05	-7.61×10^{-3}	-0.01	-0.02
4	-0.01	-0.02	-8.98×10^{-3}	8.54×10^{-3}	2.22×10^{-3}	-0.02	-0.01	0.02
GAP training	0.03	0.04**	0.02	-0.03***	0.22***	-0.10***	-0.03*	-0.07**
Farmer association	0.02	-6.13×10^{-3}	0.03	-5.14×10^{-3}	0.06*	3.71×10^{-3}	-0.02	-0.01

[a]Reference categories are in boldface and shown in parenthesis

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 9 Regression results of the determinant of GAP and GHP for farms operating less than 0.8 hectares

Variable[a]	Pre-harvest			Post-harvest			Marketing	
	Counterfeit (*dy/dx*)	Protective gear (*dy/dx*)	Staking & pruning (*dy/dx*)	Harvest time (*dy/dx*)	Glove (*dy/dx*)	Cooling (*dy/dx*)	Sorting (*dy/dx*)	Cleaning (*dy/dx*)
Age	3.23×10^{-4}	6.59×10^{-4}	2.49×10^{-4} **	5.45×10^{-4}	-1.74×10^{-3}	2.42×10^{-3}	8.37×10^{-4}	-3.71×10^{-4}
Credit	0.04*	-0.05	-9.54×10^{-4}	0.01	0.02	0.08***	0.04	0.06**
Household size	2.52×10^{-5}	-9.23×10^{-4}	7.36×10^{-4}	-6.95×10^{-4}	3.06×10^{-43}	-1.37×10^{-3}	1.50×10^{-3}	2.09×10^{-3}
Mobile	0.03	-0.03	-0.02	7.27×10^{-3}	-0.03	-0.06*	6.79×10^{-3}	-0.08
Education	0.03**	0.04	6.50×10^{-3}	2.56×10^{-3}	0.05	-7.91×10^{-5} **	0.03	7.82×10^{-4}
Production system (both)[a]								
Rainfed	-0.03**	-5.32×10^{-3}	-0.06***	5.38×10^{-3}	-1.80×10^{-4}	0.04	-0.02	-4.72×10^{-4}
Irrigated	-0.02***	-0.02	-0.14***	9.05×10^{-3}	-7.99×10^{-3}	3.72×10^{-3}	-0.01	-8.52×10^{-3}
Market channel (retailer)[a]								
Aggregator	-0.05	0.09**	0.09	0.02	0.03	0.09	0.04*	0.03
Wholesale	-0.02	0.05*	0.09	0.01*	-0.02	0.07	0.03***	-9.66×10^{-3}
Wealth (wealth quintile 5)[a]								
1	-0.03	-0.04	-0.07	-0.02**	-0.05	-0.02	-9.95×10^{-3}	0.09***
2	-0.09	-0.03	-0.09	-7.52×10^{-3} **	-0.02	-0.02	-3.48×10^{-3}	-5.03×10^{-3} ***
3	-0.04	-0.02	-0.03	-5.53×10^{-4}	-0.05	-7.61×10^{-3}	-0.01	-0.02**
4	-0.01	-0.02*	-8.98×10^{-3}	8.54×10^{-3}	2.22×10^{-3}	-0.02	-0.01	0.02**
GAP training	0.03	0.04	0.02*	-0.03	0.22***	-0.10	-0.03	-0.06
Farmer association	0.02*	-6.13×10^{-3}	0.03	-5.14×10^{-3}	0.06**	3.715×10^{-3}	-0.02	-0.01

[a]Reference category are in boldface and shown in parenthesis

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

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Data availability The datasets analyzed during the current study are available in the IITA CKAN data repository [Plastic crates RCT experiment in Nigeria – Datasets - IITA].

Declarations

Conflict of interest The authors declared that they have no conflict of interest.

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