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Determinants of commercialization among smallholder maize farmers in Tanzania: a Tobit regression analysis

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ABSTRACT

Agriculture is fundamental to Tanzania's economic development with smallholders producing 85% of the nation's maize. However, their market participation remains constrained. This study exemines determinants of maize commercialization among smallholder farmers in Tanzania, focusing on household characteristics, assets, access to information, and market engagement. Using data from 1,529 households drawn fromWave 5 of the Tanzania National Panel Survey and applying Tobit regression model, the study identifies key factors influencing the intensity of commercialization. Durable assets ownership, market information and number of adult household members significantly enhence maize commercialization. Conversely, higher household income, unmarried household head, older age, and larger plot sizes are associated within lower levels of commercialization. These findings suggest that while asset ownership and information access support commercialization by easing the separation of production and consumption decision, social-cultural factors often override profit-maximizing behaviour. Wealthier and older farmers tend to prioritize household food security and kinship affairs over maize sales, while land and labor decisions are shaped by inheritance norms and gender roles. The study recommends multi-pronged policy approach, including improved access to finance, strengthern digital and extension-based information systems, enhanced,market infrastructure, and targeted support for women and youth, alongside sustainable intensification strategies to improve productivity and resilience.

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1. Introduction

In many developing nations, agriculture forms the backbone of the economy, where smallholder farmers are key to promoting food security, reducing poverty, and supporting economic progress (Food and Agriculture Organization (FAO), 2021; Modi, 2019; Neglo et al., 2021; Raghupathi et al., 2012). Approximately 50% of the global population depends on agri-food systems, which employ 1.23 billion people (Davis et al., 2017, 2023). In many developing countries, especially in Africa, the agri-food systems are primarily centered around staple and cereal food products. In Sub-Saharan Africa (SSA), most households engage in small-scale farming, typically cultivating less than two hectares of a wide range of crops for both personal consumption and sale (Kakar et al., 2023; Kibirige, 2016; Kissoly et al., 2020). However, a significant majority are subsistence farmers who rarely participate in agricultural markets (Collier & Dercon, 2014, Kavuma & Kisaame, 2023). Smallholder farmers also dominate Tanzania's agricultural landscape, cultivating approximately 5.1 million hectares annually (Jayne et al., 2016), with around 85% of this land

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devoted to food crop production. These smallholders, who predominantly depend on traditional farming techniques, account for over 75% of the country's total agricultural output, much of which is consumed domestically. While they typically diversify crop production, the majority focus on cereals, for example, smallholder farmers produce an estimated 85% of maize, with medium- and large-scale farmers accounting for the remaining 10 and 5%, respectively. The emphasis on cereals is intended not only to ensure food security (Ayele et al., 2021; Kakar et al., 2023) but also the availability of fodder for livestock among farmers practicing integrated crop-livestock production systems (Abate et al., 2021).

Maize is a crucial cereal crop in both developed and developing nations (Erenstein et al., 2022). In Africa, it serves as the most important staple food due to its adaptability to diverse climatic conditions, ease of cultivation, economic significance, and its nutritional value (FAO, 2021). The utilization of maize differs between developed and developing nations; in developed countries, maize is primarily used for animal feed, industrial raw materials, and exports. In contrast, in SSA, more than 95% of cultivated maize is consumed at the household level (Balana & Oyeyemi, 2022). Despite its critical role in food security and nutrition, maize yields in SSA remain low, with production levels amounting to only 20% of those in developed nations. This disparity is largely attributed to the reliance on traditional farming methods and the dominance of smallholder farmers who cultivate on small plots of land with limited resources (Nguluma & Kimaro, 2020).

As in many other parts of Africa, maize is the widely produced cereal crop in Tanzania. It is considered a key staple crop, playing a substantial role in food security, economic growth, and rural livelihoods. In the 2020/2021 farming season, Tanzania produced approximately 7.2 million tons of maize, making it one of the leading maize-producing nations in Eastern Africa (Ministry of Agriculture, 2019). Despite the country's capability to achieve self-sufficiency in food production, the growth in maize output remains modest and is largely driven by the increase of cultivated land rather than improvements in productivity (Beyene & Kassie, 2015). Productivity stagnation in Tanzania is associated with several challenges, including small-scale farming practices, poor soil fertility, prevalence of pests and diseases, low levels of mechanization, inadequate access to capital, and post-harvest losses (FAO, 2021).

Although smallholder farmers play a pivotal role in the country's agricultural sector and contribute significantly to food security, their involvement in domestic and regional markets remains relatively low. This limited engagement is largely due to low crop productivity and restricted access to critical market support services such as credit facilities, infrastructure, and extension services (Balana & Oyeyemi, 2022; Nguluma & Kimaro, 2020). Addressing these constraints through policy interventions and investment in modern agricultural technologies could enhance maize productivity and strengthen food security in Tanzania and the broader sub-Saharan region. Despite advancements in agricultural technology globally, the adoption of modern farming methods in Tanzania remains low and uneven, leaving most of maize smallholder farmers reliant on traditional practices. Reliance on traditional methods can limit agricultural productivity, hinder economic growth, and exacerbate poverty (Amayo et al., 2021; Langyintuo, 2020).

This study defines the commercialization of an agricultural crop as the transition from production for home consumption to selling produce in commodity markets. The transition is considered a viable means to increasing intensification, output, food security, and farm incomes (Bolarinwa et al., 2021; Getahun, 2020; Kipkorir et al., 2023; Ochieng et al., 2020). The transition is often driven by farmers' incentives to invest in better technologies and sustainable practices by shifting their focus from consumption to profit. Ultimately the shift leads to increased productivity, higher rural incomes, and reduced poverty as it creates additional demand for services like transportation and storage, which generates non-farm jobs and builds more integrated economic systems. However, evidence from research, including a meta-analysis by Shiferaw et al. (2023) and a study by Nkegbe et al. (2024), confirms that commercialization significantly improves farm productivity, household welfare, and income, making it a key driver of agricultural transformation.

In summary, there is a two-way relationship between productivity and commercialization of crop production. Farmer must first produce surpluses beyond their own consumption needs before they can engage in the commodity markets (Kavuma & Kisaame, 2023), which supports the view that productivity drives commercialization. However, the intention to sell in the market (commercial orientation) creates the incentives and provides the means to increase productivity (Degefu et al., 2024), this supports the view that commercialization drives productivity. An earlier study by Pingali and Rosegrant (1995) confirms this two-way relationship, noting that even a small marketable surplus initiates a cycle where the

resulting income is reinvested in productivity-enhancing inputs, leading to a greater surplus and further commercialization.

Tanzania's maize market comprises two sectors: the formal, which includes large millers and government agencies, and the informal, made up of local, small-scale traders. While the formal sector offers higher prices, its strict requirements for scale, quality, and information make it largely inaccessible to smallholder farmers (Mather et al., 2023; Sulle, 2023). As a result, smallholder farmers operate in the informal market, which, although it offers lower prices, is much more accessible because of its minimal regulation and proximity.

To boost agricultural commercialization, the Tanzanian government and development partners have launched programs to improve farmers' access to inputs, markets, and post-harvest practices (Ashimogo & Lazaro, 2021; Ministry of Agriculture, Food Security and Cooperatives, 2013; URT, 2020). While these initiatives have helped some of the smallholder farmers to shift to medium-scale operations (Jayne et al., 2016; Ringo & Adam, 2018), most of the smallholder farmers continue to produce for own consumption. This outcome is attributed to a critical shortage of affordable, high-quality advisory services. Large agribusinesses offer these services at a price that is out of reach for most farmers, traders, and processors in the domestic food market. Although smaller organizations like Non-governmental Organizations (NGOs) are attempting to fill this gap, their efforts are limited in scale and are not enough to address the widespread demand for such support (Wilson & Lewis, 2015). Ultimately, the persistent shortage of accessible advisory services remains a major barrier to the broader commercialization of maize production among smallholder farmers in Tanzania. Recent studies emphasize that the primary barrier to widespread agricultural commercialization is not the absence of policies or inputs but limited access to well-integrated support systems (Mather et al., 2023; Sulle, 2023). Although a few successful commercialization cases have emerged from out-grower schemes and donor-funded projects, these remain isolated examples. Achieving widespread commercialization requires tackling the persistent challenge of limited access to advisory services.

Another major obstacle to maize commercialization in Tanzania is smallholder farmers' limited access to affordable credit. Most financial institutions prioritize the Warehouse Receipt System (WRS), which reduces lending risk by using stored maize as collateral. Although the WRS presents a promising, scalable model for financing the maize sector, its implementation is still at an early stage. Therefore, accelerating commercialization requires not only expanding smallholder participation in the WRS but also addressing underlying challenges, especially inadequate rural infrastructure, low cooperative membership, and gender-based disparities in asset ownership, which continue to hinder a full shift toward a market-oriented maize economy (Mather et al., 2023; Sulle, 2023).

Previous research on smallholder commercialization has examined both its impact on farmers' livelihoods and the context-specific enablers and barriers that shape its trajectory. The literature highlights that smallholder commercialization is influenced by multiple factors, including crop selection and the extent to which certain commodities contribute to smallholder farmers' economic well-being (Kissoly et al., 2020). The pathways through which commercialization affects livelihoods vary, encompassing direct effects on income and employment, second-order effects on health and nutrition, and broader macroeconomic implications (Getahun, 2020).

While scholars have identified factors affecting commercialization and the realization of expected outcomes among smallholder farmers (Kissoly et al., 2020; Newsham et al., 2023; Ochieng, 2019), empirical evidence on farm-level determinants of commercialization in Tanzania remains limited. Owusu and İşcan (2021) conducted an extensive analysis of smallholder farmers' likelihood of engaging in commercial vis-à-vis subsistence agriculture. Their study employed a binary probit model to estimate the probability of transitioning between subsistence and commercial farming based on observable characteristics. However, this binary approach may not adequately capture the continuous nature of commercialization levels among maize farmers. Thus, a censored regression is a more suitable modelling approach for understanding commercialization as a gradual process among smallholder maize farmers. The use of the Tobit model is regarded as an important contribution to addressing methodological issues in modeling commercialization.

Maize, as the most widely cultivated and consumed cereal in Tanzania, holds the potential to increase farmers' incomes and strengthen food security. However, the economic benefits of commercialization are

contingent upon farmers' ability to participate in markets as informed and strategic actors (Jayne et al., 2016). Scholars support the view that the realization of such benefits depends less on commercialization itself and more on the presence of supportive institutions, including farmer organizations or cooperatives as well as NGOs and development organizations; and fair market access, which empower farmers to sell from a position of strength rather than necessity (Jayne et al., 2016; Loth & Kashumba, 2021). Smallholder farmers in Tanzania often struggle to change from producing for own consumption to commercial maize farming due to various structural and institutional constraints, especially the prevailing poor transportation infrastructure and farmers' limited access to financial services (Loth & Kashumba, 2021). There is a need for further empirical analysis of the specific factors influencing this transition, particularly given the observed transition from small-scale to medium-scale farming in Tanzania (Jayne et al., 2016). This study addresses the following research question: What are the key socioeconomic, institutional, and market-specific determinants that drive or hinder maize commercialization among smallholder farmers in Tanzania? The question underscores the need to go beyond simply recording the results of commercialization and instead emphasizes identifying the specific factors that shape a farmer's decision and capacity to shift from subsistence production to commercial maize farming.

Addressing these knowledge gaps is critical for informing policy decisions and development interventions. By identifying the level and key drivers of maize commercialization amongst smallholder farmers, policymakers and development agencies can design targeted strategies to improve market participation, enhance productivity, and support sustainable agricultural transformation in the Tanzanian maize sector.

A clear understanding of the enablers and barriers to maize commercialization is essential because Tanzania's market is defined by a pronounced and unequal dual structure. On the supply side, smallholder farmers dominate, accounting for roughly 75% of marketed maize through fragmented, small-scale sales, while farmer groups (15%) and large-scale commercial farmers (10%) constitute the remainder (Rates, 2003). This supply base interacts with a highly uneven buyer landscape: informal traders purchase around 75% of maize, providing access but depressing farmgate prices due to farmers' urgent cash needs and information asymmetries, whereas the formal private sector (20%) offers stable but often lower returns due to quality standards and market power, and public agencies (5%) operate too sporadically to provide an effective price floor (Rates, 2003; Wilson & Lewis, 2015). This fragmented market structure, exacerbated by informal cross-border trade, raises transaction costs, widens farmgate-consumer price gaps, and ensures smallholders, who often must repurchase maize at a loss during lean seasons, capture only a minimal share of final value (Rutatora & Mattee, 2001).

Critically, this context reveals why commercialization risks deepening existing inequalities (Giger et al., 2022; Saha et al., 2022). The process tends to be inherently selective, favoring the already-advantaged farmers with larger holdings, better capital access, and proximity to markets, enabling them to secure contracts and invest in productivity. Conversely, the majority of resource-poor smallholders, including women and remote farmers, are often marginalized by stringent quality requirements, a lack of collateral, and weak bargaining power. Without deliberate intervention, commercialization can thus exacerbate the wealth gap and consolidate resources within a dominant, powerful group.

Effective commercialization therefore requires more than simply increasing farmers' participation in markets; it must also promote fair and balanced terms of exchange. Interventions such as expanding storage capacity, strengthening farmer organizations to support collective marketing, and improving access to timely price information can enable smallholders to sell more strategically, enhance their incomes, and reduce vulnerability to food insecurity. Taken together, these measures can create a virtuous cycle in which higher earnings stimulate investment in productivity and human capital, ensuring that market engagement drives inclusive rural development rather than deepening existing inequalities.

2. Literature review

2.1. Theoretical model

This study is guided by the Agricultural Household Model (AHM), which is particularly relevant for analyzing the decisions of smallholder farmers transitioning from producing for own consumption to commercial farming. The model aligns with the study's focus on how smallholders balance utility maximization

(satisfying consumption needs) and profit maximization (market participation). It explains how households in transitional phases pursue dual objectives: ensuring food security while gradually shifting towards market-oriented production, which is a key theme of this research.

According to the AHM, household objectives are shaped by market orientation and decision separability. Subsistence farmers typically operate within non-separable decision-making structures, prioritizing utility maximization from their farming activities. In contrast, commercial farmers engage in separable decision-making processes, emphasizing profit maximization. Households in transitional phases between these two structures pursue a dual objective function, balancing both utility and profit (Adeoti et al., 2014; Mottaleb et al., 2014). As commercialization intensifies, the focus gradually shifts from utility maximization toward profit maximization. Smallholder and low-income farmers primarily engage in agricultural markets when they achieve surplus production or need cash to meet family obligations. Due to limited landholdings, most farmers allocate a significant portion of their land to food crops to ensure self-sufficiency, which reduces the area available for cultivating cash or higher-value crops (Barrett & Dorosh, 2021; Chegere & Kauky, 2022; Fikadu et al., 2023).

The evolution of farming practices from producing for own consumption to market orientation occurs through two primary mechanisms. The input-side transformation involves a greater reliance on purchased inputs, which enhances production capacity beyond the household's consumption requirements. Conversely, the output-side transformation is characterized by an expanding market surplus, typically measured as the ratio of the value of output sold to the total value of output produced (Bolarinwa & Adebayo, 2021; Ochieng et al., 2016). The literature also identifies an additional aspect of commercialization involving the cash crop production alongside or in place of staple crops. Furthermore, commercialization includes the expansion and intensification of household market transactions related to both inputs and outputs (Barrett & Dorosh, 2021; Rabbi et al., 2019).

Embedding firm theory and utility maximization within the AHM helps illustrate how households function both as producers (similar to firms) and as consumers. This dual perspective frames their decision-making in terms of profit and utility maximization, which is crucial for understanding agricultural behavior and the socioeconomic dynamics of rural households, particularly in the context of commercialization and resource allocation. Based on firm theory, producers of agricultural commodities are rational actors, and they usually opt for a blend of production that maximizes profit (Feder et al., 1985). A core assumption of the AHM is that households reallocate resources between agricultural activities in response to changes in relative output prices, shifting production towards those with higher expected net returns. These changes in profit motivate farmers on what types of crops to farm. Therefore, output prices are critical for steering farmers' decisions regarding investments (Reardon & Vosti, 1997).

However, the AHM that hinges on the foundational assumption of separable production and consumption decisions collapses under distress sales when farmers cannot act as price-takers operating in perfectly competitive markets (Barrett, 2010). Consequently, it fails to accurately capture the welfare outcomes and allocative inefficiencies of distress sales, as it cannot account for the coercive, non-optimizing behavior driven by vulnerability rather than profit maximization. This shortcoming highlights the need to combine the statistical insights derived from parametric models, such as the one used in this study, with the informed inferences gained through qualitative analysis of farmers' profiles and their unique circumstances.

A general formulation of a farmer's problem involves maximizing profit subject to the constraints imposed by market prices, technological limitations, and market size is given as:

$$\begin{aligned} Max\,\pi_t &= P_t * Y_{it} - \left(r * K_t + wL_t + nM\right) \\ &s.t. \\ Y &= f\left(K, L, M\right) \end{aligned} \tag{1}$$

In Eq. (1), the variables Y, P, and M denote vectors representing production, prices, and wealth endowment, respectively. Capital goods and labor are represented by K and L. In the equation, r and w, are vectors of prices for capital goods, and labor and endowed resources, respectively. The subscripts i and t identify the individual farmer and the specific time period of the decision-making process.

While the rational expectations approach (Shaw, 1987), which posits that farmers invest solely to maximize profits, offers a simplified perspective of farmer behavior, it is an incomplete representation of reality. Farmers, as both producers and consumers, may have multifaceted objectives beyond profit maximization. A classic example involves risk-averse smallholder farmers who frequently prioritize increasing family's food security over maximizing profit (Daba & Azmeraw, 2018; Molla et al., 2020; Von Braun & Kennedy, 2020). These farmers may prioritize utility maximization, which could be significantly influenced by a wide range of social considerations or consumption needs, potentially resulting in decisions that deviate from strict profit maximization.

Given that farmers aim to maximize their overall satisfaction, or utility, a utility maximization framework can be adopted to analyse their decision-making. While this approach does not explicitly model the psychological underpinnings of preferences, it is more flexible than a purely profit-maximizing model. This perspective posits that individuals rank various practices based on their preference levels, subject to resource constraints. Thus, the relevant maximization problem can generally be expressed as:

$$\begin{aligned} &Max\, U(Y_i) \\ &s.t. \\ &P_i Y_i \leq M \end{aligned} \tag{2}$$

The primary assumption underlying utility maximization is that decision-makers have perfect knowledge of what is best for them. However, this assumption has faced criticism due to information asymmetries, which can lead to less informed decisions about what is optimal. Consequently, their actions may not genuinely reflect their best interests (Mallard, 2015).

Therefore, the objective function should be viewed as a non-separable model that can occur when households opt out of market participation due to excessively high transaction costs. This phenomenon explains why certain households choose to maintain food self-sufficiency (Kidane, 2019; Vance & Geoghegan, 2004). Despite the barriers imposed by high transaction costs, some farming households have successfully engaged in the market by implementing strategies that minimize these costs, such as joining cooperatives or other institutions that facilitate economic activities through entrepreneurial coordination (Borda-Rodriguez et al., 2016).

2.2. Conceptual framework

Given that smallholder farmer commercialization does not align perfectly with either profit maximization or utility maximization, it is assumed to be an integral component of the farm household's broader income, investment, and consumption strategy. Consequently, the analytical framework adopted for this study (Figure 1) encompasses three key considerations: the farm household as an investor, the farm household as a consumer, and the influence of policy-related and physical factors on the farm household. It is broadly conceived to encompass a wide range of factors that underpin the commercialization of smallholder farming (Barrett & Dorosh, 2021; Tesafa et al., 2023). The framework suggests that the outcome of market-oriented production is primarily influenced by market orientation (Yaseen et al., 2018). This induced effect is driven by market, socio-economic, and institutional factors.

Market orientation is induced by a blend of socio-economic, market-specific, and institutional influences. These could include access to information, pricing mechanisms, and social capital. Market, Socio-Economic, and Institutional Elements: These operate as mediators or drivers that affect how smallholder farmers engage with markets. Socioeconomic determinants might include education, household size, and income levels, while institutional factors could include farmer's involvement in cooperatives, market regulations, and access to financial services.

2.3. Analytical model

Agricultural commercialization can be quantified through various indicators, including the incidence of market participation among producers (Adong et al., 2021), the share of farm output allocated

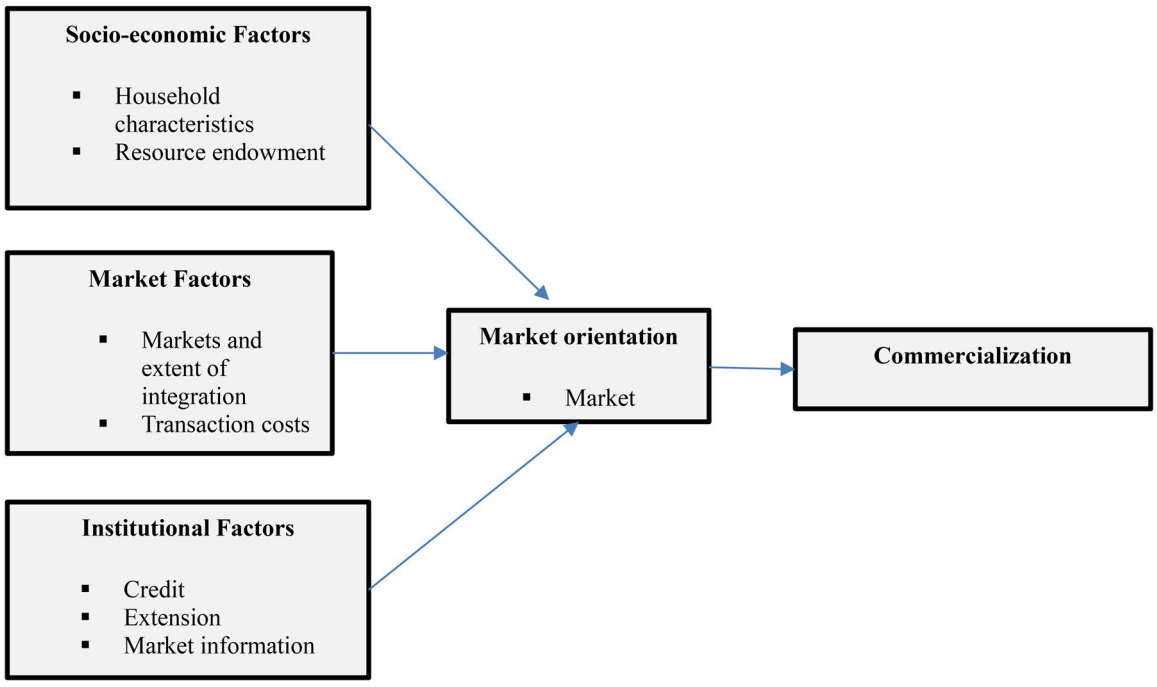

Figure 1. Conceptual framework.

to market sales (Endalew et al., 2020), and the proportion of externally sourced inputs utilized in the production process (Fikadu et al., 2023). Researchers often assess both the incidence and intensity of farmer market participation (Awotide et al., 2016; Mmbando et al., 2015). Incidence, typically measured as a binary variable, indicates whether a farmer engages in market sales. Intensity, represented by the volume or proportion of output sold, is commonly measured using a commercialization index.

Normally the index classifies smallholder farmers into three categories: subsistence-oriented, semi-commercialized, and commercialized, representing a progressive shift from producing for own consumption to fully commercialized production, with increased sales value reflecting a stronger commercial orientation (Alawode & Makinde, 2021). Given the bounded nature of the commercialization index, a Tobit model is the preferred statistical method to assess the factors affecting its levels. The model is adopted to analyze factors that influence the level of commercialization for a bounded dependent variable (the commercialization index).

3. Method

3.1. Data and data source

This article used data extracted from the National Panel Survey Wave 5 (NPS Wave 5), a comprehensive survey conducted by the World Bank in collaboration with the Tanzania Bureau of Statistics (NBS, 2022). This survey, which covered both Tanzania Mainland and Zanzibar, targeted four geographical areas: Dar es Salaam, Urban Mainland, Rural Mainland, and Zanzibar. A stratified, multi-stage cluster sampling design was implemented, with systematic sampling employed to select households within each region. This approach ensured the collected data is representative of the national population. Although the original survey encompassed a wide range of agricultural and business-related topics, this study focused on factors that are particularly relevant to the commercialization of smallholder maize farming.

The Maize farmer was selected based on a variable representing the type of the crop cultivated. Effectively, households with maize crops were selected. Thus, the sample size was reduced from 5,010 to 1,529 households after the selection.

3.2. Empirical model

The Tobit model adopted to analyse the relationship between a censored dependent variable and independent variable is given as:

$$Y_i* = \beta' X_i + \ldots_{i'}, y_{i=} \begin{Bmatrix} Y_i * if Y* > 0 \\ 0 if Y* \leq 0 \end{Bmatrix} \quad (3).$$

In this context, Y_i* represents an unobserved latent variable that influences the observed outcome variable Y_i, which denotes the ratio of marketed output to the total market value of agricultural output for each observation $i = 1, \ldots, n$. Here, β' is a vector of parameters to be estimated, X_i represents a vector of explanatory variables, and μ_i is the error term, assumed to be independently and normally distributed.

The use of a Tobit model is suitable when analyzing the commercialization index due to its ability to handle censored data, acknowledge the prevalence of zero values, preserve information from the entire dataset, and provide more accurate and efficient estimates compared to OLS, Probit, and Logit models. This approach is more relevant as it allows understanding the factors that influence commercialization among smallholder farmers deeply.

3.3. Determinants of commercialization

While existing literature has employed various approaches and indicators to quantify farm commercialization, this study follows a widely accepted approach outlined by Demeke and Haji (2014). In general, Household Crop commercialization Index (CCI) is measured by calculating the ratio of value of marketed output to the total market value of output produced, using pertinent variables in the dataset. It is computed as:

$$CCI_i = \frac{\sum P_i S_{ij}}{\sum P_i Q_{ij}} \quad (4).$$

In the expression (Eq. 4), S_ij represents the amount of crop i sold by farm j, Pi is the average price of that crop in the community, and Q_ij represents the total amount of crop i produced by farm j. However, since the P_i is the same, the equation is often simplified to a ratio of quantities, which is easier to calculate in field surveys.

This measure provides an in-depth view of the agricultural commercialization spectrum, ranging from producing for household's consumption (index = 0) to complete commercialization (index = 100). By transcending basic classifications, such as seller vis-à-vis non-seller, it enables a more comprehensive analysis of market engagement. This metric serves as a clear and insightful tool for evaluating the level of commercialization among smallholder farmers.

A key limitation of the index is its inability to distinguish between a small-scale farmer who sells a high proportion of their limited output and a larger-scale farmer who sells only a portion of a larger yield. Despite producing less, the small-scale farmer may appear more commercialized due to a higher sales ratio. However, in developing countries, farmers who produce more tend to sell a larger share of their output. Thus, the index remains relevant in these contexts, where smallholders typically market a smaller portion of their production and larger farms rarely retain all their output for non-commercial purposes (Hagos & Geta, 2016).

While commercialization aims to shift smallholder agriculture from subsistence to market-oriented production, distress selling can subvert this process as it forces farmers into poorly timed, low-value sales. Distress selling does not only diminish income but also undermine the structural foundations of sustainable commercialization, such as strategic market engagement, price responsiveness, and reinvestment capacity (Chamberlin & Jayne, 2013; Komarek et al., 2020). Despite the fact that small-scale farmers often face distress selling resulting from factors such as limited cash, inadequate storage, and

unpredictable markets, the index is still a vital measure of ongoing structural transformation within the agricultural sector. In Tanzania, for example, small-scale maize farmers are increasingly transitioning from growing just enough to eat to selling some of their crops (Mather et al., 2013; Sheahan & Barrett, 2017). This phenomenon is more apparent in areas with improved road infrastructure, mobile phone coverage, and access to input and output markets.

The study adopts specific thresholds that are widely used in empirical studies across Sub-Saharan Africa to assess the depth of smallholder participation in maize markets. According to the established thresholds, households with indices below 25% are generally classified as subsistence-oriented, those between 25 and 50% as semi-commercialized, and those above 50% as commercialized (Mihretie, 2021; Saha et al., 2022).

The commercialization of agriculture is a complex practice and is influenced by a variety of factors operating at both the household and macro levels (Awotide et al., 2016; Ebata et al., 2017; Mmbando et al., 2015; Muriithi & Matz, 2015). At the household level, factors such as agroclimatic conditions, market access, resource availability, input and labor markets, regulatory frameworks, and cultural preferences all play a significant role (Kangile et al., 2020; Kipkorir et al., 2023). External drivers like population growth, urbanization, technological advancements, infrastructure development, and macroeconomic policies further shape the agricultural landscape. These factors collectively impact the supply and demand dynamics of agricultural commodities, affecting prices, transaction costs, and risks for all stakeholders in the agricultural value chain (Ebata et al., 2017; Molla et al., 2020). The specific variables that were included in the empirical model are described in Table 1.

There is a context-specific relationship between household expenditures on durable goods and the level of staple crop commercialization, contingent upon the characteristics and intended use of the assets. Productive durable goods such as farming equipment (Madzivanzira et al., 2024), storage infrastructure (Chegere et al., 2022) and means of transport (Changalima & Ismail, 2022) can significantly enhance the ability of farmers to increase production, reduce post-harvest losses, and access distant markets. These investments support commercialization by improving efficiency and market participation. While durable goods can boost a farmer's ability to invest in their farm, it can also have the opposite outcome if a farmer prioritizes acquiring non-productive, luxury items. A decision of small-scale farmers with limited funds to buy fancy and expensive durable goods diverts money away from more important agricultural investments. This shift from reinvestment in farming to consumption-related expenses reduces

Table 1. Description of the explanatory variables used in the tobit model.

Variable	Description	Measurement	Expected sign
Durables	Household's total expenditures on durable goods as a proxy for asset ownership (US $)	Continuous	+ or -
Information	Farmers' access to communication device (s) as a proxy for access to market information	Binary (1 Yes; zero otherwise)	+
Sex	Sex of the household head	Binary (1 for male; zero otherwise)	+
Age	Age of household head	Continuous	+ or -
Marital	Marital status of household head	Binary (1 for married; 0 otherwise)	+ or -
Income	Total annual income of the household from maize cultivation (US $)	Continuous	+ or -
Non-farm	Whether involved in non-farm activities	Binary (1 if yes, zero otherwise)	+ or -
Casual labour	Whether employed and get wages as casual labour	Binary (1 if yes, zero otherwise)	–
Adult equivalent	Ratio/number of adults in the household	Continuous	+ or -
SACCOS	Whether the household head is a member of a savings and credit society	Binary (1 if yes, zero otherwise)	+
Distance	Distance to the main road (Km)	Continuous	–
Education	The highest level of education attained by the household	Categorical (1 = No formal education; 2 = Pre-primary or primary; 3= Above primary)	+ or -
Plot size	Total hectares under maize cultivation (Ha)	Continuous	+ or -

the surplus crops available for the market and slows down the process of commercialization (Balana et al., 2022; Combary, 2022).

Studies show that farmers who have better access to market information, especially through the use of information and communications technology (ICT), are more likely to commercialize their crops. Farmers' access to current market data is crucial for enhancing their access to commodity markets, and communication devices are a powerful tool for getting that information (Akrong et al., 2021; Nwangwu et al., 2024).

The household head's sex is expected to influence the level of market orientation. Males are generally anticipated to have a greater likelihood of engaging in market activities compared to females (Djurfeldt, 2021; Mujeyi et al., 2020). The dual burden of farming and independently managing all household responsibilities often constrains female-headed households, limiting their capacity to commercialize crop production and participate effectively in markets.

Marital status can significantly influence a farmer's ability to commercialize the production of staple crops, but its effects are complex and often shaped by gender. On one hand, marriage may offer advantages such as shared risk and decision-making, and a larger household labor force can enhance production and marketing capacity (Gcaba et al., 2025). These factors often help married farmers, especially men, to engage more effectively in commercial agriculture when their spouses shoulder household chores. On the other hand, the impact of marriage on farmers' crop commercialization is not uniformly positive. Research indicates that married women frequently face constraints due to limited control over productive resources, reliance on spouses for key decisions, and unequal access to markets (Badstue et al., 2020). Additionally, differences in household responsibilities and labor availability linked to marital status can affect individual productivity and commercialization potential (Kilombele et al., 2023). While marriage can be a supportive factor in some contexts, its effect varies notably between men and women, often reinforcing existing gender disparities in commercialization of agricultural crops.

Scholars offer different views on the relationship between household income and commercialization of crop production. A predominant view supports the existence of a positive association where higher income provides the capital needed to invest in farming, leading to greater commercialization (Dzanku, 2019; Ochieng et al., 2019; Ogutu et al., 2020a, 2020b). An opposite view suggests that when households earn more from non-farm work, they may divert labor and focus away from farming, treating agriculture as a fallback rather than a main business. This can lead to a decrease in crop sales (Kousar & Abdulai, 2020; Matsumoto & Yamano, 2011). The observed relationship between income and commercialization is also shaped by other factors, including the relative profitability of farming and whether off-farm and on-farm activities are complementary or competing undertakings (Davis et al., 2017).

Literature reveals a positive association between household's available labor force and its level of agricultural commercialization, as a larger workforce is expected to manage more effectively the intensive demands of market-oriented production (Dedehou et al., 2023; Ogutu et al., 2020a). However, this relationship is context-specific. It is often moderated by factors such as the level of mechanization and the opportunity cost of labor. In settings where off-farm employment is readily available, the labor force may be diverted from maize production, potentially weakening the positive association between adult equivalent and commercialization (Kansanga et al., 2021).

The age of the household head is expected to be positively associated with market participation, as it normally serves as a proxy for experience and resource availability. Older, more experienced heads may possess better decision-making skills and stronger networks, facilitating cost-effective market opportunities (Kilima et al., 2016; Subert et al., 2018). Conversely, younger heads might be more receptive to adopting innovative practices that can enhance productivity and marketing efficiency (Ashimogo & Lazaro, 2021; Endalew et al., 2020).

Engagement in non-farm enterprises can potentially enhance commercialization by providing diverse income sources, which can stimulate investment in agricultural operations and lead to higher levels of commercialization of crop production (Nkegbe et al., 2024). However, if other activities are more profitable, they may discourage investment in the crop, thereby hindering commercialization (Tafesse et al., 2023; Wassihun et al., 2022). Thus, its effect is generally uncertain.

Empirical evidence shows that distance from main roads is a key barrier to commercialization of crop production, as it raises transport and transaction costs (Gollin & Rogerson, 2019; Shiferaw et al., 2023). It

generally constrains farmers' access to markets, inputs, and extension services. Thus, it disincentivizes surplus production (Ogutu et al., 2020b).

Many studies find that smallholder farmers who allocate more land to a given staple crop tend to commercialize (Gidelew et al., 2022; Haile et al., 2022; Tafesse et al., 2020). This positive relationship is attributed to factors such as farmers' ability to produce enough surplus beyond household consumption; their potential to gain from economies of size in the use of resources and vital services; more ability to specialize; and perhaps better bargaining power when sale volumes are larger. However, some studies find a negative relationship between plot size and commercialization. This relationship is mainly attributed to the inverse relationship (IR) between farm size and land productivity initially formalized by a seminal work by Sen (1962) who found that smaller farms produced more per unit area than larger farms. The primary cause is seen to be higher labor intensity and family labor efficiency on small plots, which reduces the supervision burden and shirking problems, as farmers who rely more on family labor tend to work more diligently, maintain the land better, and achieve higher yields per hectare compared to larger farms that depend more on hired labor. Empirical studies have verified this relationship (Holden & Ghebru, 2016; Larson et al., 2014).

Education is predominantly anticipated to have a positive association with commercialization, as it enables farmers cognitive and managerial capabilities. It empowers individuals to make informed and independent production and marketing choices (Hlatshwayo et al., 2022; Magesa et al., 2020). However, education may motivate farmers to shift from maize to high-value or cash crops (Muhammad-Lawal et al., 2014). Higher levels of education may also encourage farmers to abandon rural farming life in favor of higher-paying professional careers (Dube & Guveya, 2016).

Farmer organizations can effectively address liquidity constraints and other challenges faced by individual farmers. While concerns such as agency costs and increased bureaucracy may arise, the potential benefits of membership often outweigh these drawbacks (Nilsson, 2018). In the context of agricultural production and marketing, collective action can enable farmers to access better financial services, equipment, storage facilities, and transportation at lower costs. Moreover, through collective bargaining, groups can negotiate favorable prices with buyers due to increased volume and improved quality control. Additionally, organizations can collaborate to gather crucial market information and access essential business support services that may be inaccessible to individual farmers (Borda-Rodriguez et al., 2016). Therefore, farmer organizations are expected to positively impact commercialization.

Before fitting the Tobit model, independent variables were tested for multicollinearity using Variance Inflation Factor (VIF), which is a more robust and reliable measure of multicollinearity than simple correlation coefficients because it captures the combined linear dependence of a variable on all other predictors in a regression model. This measure also works with both continuous and dummy variables, making it a more versatile and informative diagnostic tool in regression analysis (Gujarati & Porter, 2009; Wooldridge, 2016). The results presented in Appendix 1, demonstrate that there was no severe multicollinearity between the explanatory variables since the VIF values did not detect severe multicollinearity (VIF < 10).

3.4. Ethical consideration

This study utilized secondary data from the Tanzania National Panel Survey (NPS) Wave 5. The data are generally available for public use, we were granted access to the data after securing an online formal authorization from the NBS (Appendix 2). The survey, conducted between December 2020 and January 2022 as a continuation of the previous four waves, was implemented by the NBS in collaboration with the World Bank LSMS-ISA initiative. The study was conducted in accordance with the ethical principles of Declaration of Helsinki. Ethical approval was obtained from the Directorate of Research and Postgraduate Studies (DRPS) of Moshi Co-operative University, Kilimanjaro, Tanzania (Reference No: HD/T/MoCU/049/19/37). Ethical considerations for respondent participation were guided by the Statistics Act (Cap 351 R.E. 2019) and received approval from the Ministry of Finance Tanzania, the European Union (EU), the World Bank, the Office of the Chief Government Statistician Zanzibar (OCGS), and the NBS (2022).

The NBS ensured strict adherence to ethical standards, including the protection of respondent identities and the confidentiality of data. During data collection, verbal consent from respondents was incorporated into the electronic questionnaires and verified by the survey's Technical Committee from the

NBS after the interviews, before aggregating the responses into the microdata. The questionnaires were designed to include clear briefings on the survey's objectives, the confidentiality measures in place, and the voluntary nature of participation before respondents answered the questions. Only those who provided their verbal consent were included in the survey. Verbal consent was preferred due to the large-scale nature of the national survey and to accommodate respondents with varying literacy levels, ensuring that all participants could understand the information without the need for reading or writing. The public-use dataset used for this analysis has been fully anonymized to protect respondent privacy and is accessible through the NBS and the World Bank Microdata Library.

4. Findings and discussion

4.1. Characteristics of respondents

The results presented in Table 2 reveal that almost 75% of the interviewed smallholder maize farmers were male, aged between 36 and 59 years old (47%). In Tanzania, this age category comprises middle-aged adults (Ministry of Health, Community Development, Gender, Elderly and Children, 2021). A significant majority (85%) have had at least some pre-primary and primary schooling. Also, most of them were not members of savings and credit societies (96%) and did not participate in non-farm activities (61%), but they were employed as casual labor (54%). These results support the findings of Ayele et al. (2021), Gebre et al. (2021) and Ojulu (2021) who in different circumstances established that most of the household heads who are commercialized are middle-aged male with at least pre- and primary education. However, previous studies pinpoint that being a member of a savings and credit society or agricultural cooperative enhances farmer's access to market information and strategies that promote commercialization (Israel et al., 2022; Tilahun et al., 2019). Also, farmer's engagement in non-farm activities are ideal means to boost earnings and investment in crop production, hence increasing their level of commercialization (Woldeyohanes et al., 2017).

4.2. Description of other quantitative variables

Table 3 presents mean differences in key quantitative variables between commercialized and uncommercialized farmers, shedding light on factors influencing commercialization. The significance of differences

Table 2. Characteristics of respondents.

Variable	Frequency	Percentage
Sex		
Female	388	25.38
Male	1141	74.62
Information		
Yes	666	43.56
No	863	56.44
Casual labour		
No	701	45.85
Yes	828	54.15
Non-farm		
No	938	61.35
Yes	591	38.65
SACCOS		
No	1467	95.95
Yes	62	4.05
Marital		
Yes	1131	73.97
No	398	26.03
Education		
Pre-primary and primary	1294	84.63
Above primary	151	9.88
No formal education	84	5.49
Age		
Youth and young adults (18–35 years)	403	26.36
Middle-aged adults (36–59 years)	712	46.57
Older adults (60 years and above)	358	23.41
Total	1,529	100

Source: Extracted from NBS (2024).

is tested using *t*-statistics, with *p*-values indicating the statistical significance of observed variations. The results in Table 3 indicate that commercialized farmers have had a significantly larger mean area under maize cultivation (3.09 hectares) than uncommercialized farmers (2.44 hectares), with a statistically significant mean difference ($p < 0.05$). Although the difference is statistically significant, the relatively large standard errors and variability depicted by the standard deviation of 7.23 for uncommercialized farmers, suggest heterogeneous landholding patterns within the sample. The larger areas among commercialized farmers may enhance the capacity to produce surplus maize and diversify production, thereby reducing per-unit risk and facilitating market participation. This prior expectation concurs with recent evidence suggesting that land endowments are positively associated with commercialization through economies of scale (Fikadu et al., 2023; Jayne et al., 2019; Ouedraogo, 2019).

Table 3 also shows that farmers who predominantly produced maize for own consumption reported a higher average annual income from maize farming (392.050 US $) compared to commercialized farmers (322.46 US $), resulting in a significant mean difference ($p < 0.01$). This counterintuitive result may indicate that commercialization involves a strategic reinvestment of income into production inputs, technology, or market infrastructure, rather than an immediate increase in cash income. Recent studies have noted that lower short-term incomes among commercialized farmers can reflect higher risk-taking and long-term investment strategies aimed at achieving greater production efficiencies (Ayele et al., 2021; Ouedraogo, 2019; Dangia et al., 2019).

The results revealed that the mean distance to the road is significantly greater for commercialized farmers (9.53 Km) compared to those who predominantly produced maize for own consumption (7.02 Km), with a statistically significant difference ($p < 0.01$). This finding appears counterintuitive, as proximity to transport infrastructure is typically expected to lower transaction costs and improve market access. However, the result may imply that the mere distance is a crude proxy and that other infrastructural dimensions (e.g. road quality or frequency of transport services) might be more relevant determinants of transaction costs and market access. Ojulu (2021) and Dangia et al. (2019) emphasize that the quality and connectivity of rural roads, rather than just absolute distance, are critical in shaping market access and integration.

4.3. Commercialization index results

Household Crop Commercialization Index is used to assess the percentage of maize produced by smallholder farmers that is sold in the market. Table 4 shows that 66.32% of the farmers mainly produced maize for own consumption, 8.76% were semi-commercialized and 24.92% were commercialized. This indicates that most smallholder maize farmers are primarily focused on ensuring food safety rather than producing a surplus for sale. This finding concurs with research by Mmbando et al. (2015), which indicates that many smallholder farmers in Tanzania sell only a small portion of their produce as they prioritize food security. The shape of the CCI is evaluated in terms of its kurtosis and skewness to assess how closely it aligns with the standard normal distribution (Table 5).

Table 3. Mean differences in quantitative variables between commercialized and uncommercialized farmers.

Variable	Category	Observations	Mean	Std. err	Std. dev	[95% conf.	interval]	Mean difference i.e. *b-a* (std. err)	*t*-statistic (*p*)
Durables (US $)	Uncommercialized[a]	1,001	93,648.38	6,886.30	217,872.60	80,135.14	107,161.60	222,002.8 (20,937.42)	10.6032 (0.0000)
	Commercialized[b]	528	315,651.20	25,709.58	590,761.10	265,145.30	366,157.00		
	Combined	1,529	170,311.20	10,311.79	403,216.10	150,084.40	190,538.00		
Plot size (ha)	Uncommercialized[a]	1,001	2.44	0.23	7.23	1.99	2.89	0.65 (0.350)	1.84 (0.065)
	Commercialized[b]	528	3.09	0.21	4.87	2.67	3.50		
	Combined	1,529	2.66	0.17	6.52	2.34	2.99		
Income (US$)	Uncommercialized[a]	1,001	392.05	14.92	472.17	362.76	421.34	−69.59 (23.20)	3.00 (0.002)
	Commercialized[b]	528	322.46	14.82	340.44	293.35	351.56		
	Combined	1,001	392.05	14.92	472.17	362.76	421.34		
Distance (km)	Uncommercialized[a]	1,001	7.02	0.25	7.94	6.52	7.51	2.52 (0.51)	4.79 (0.0000)
	Commercialized[b]	528	9.53	0.54	12.52	8.46	10.60		
	Combined	1,529	7.89	0.25	9.84	7.39	8.38		
Adult equivalent	Uncommercialized[a]	1,001	3.32	0.06	1.84	3.20	3.43	0.004 (0.10)	0.05 (0.9610)
	Commercialized[b]	528	3.31	0.08	1.93	3.15	3.48		
	Combined	1,529	3.32	0.05	1.87	3.22	3.41		

Table 4. Description of commercialisation levels.

Category	Frequency	Percent
Subsistence-oriented ϕ	1014	66.32
Semi-commercialized	134	8.76
Commercialized	381	24.92

Table 5. Kurtosis and skewness of commercialisation index.

Statistic	Value
Kurtosis	−0.17
Skewness	1.17
N	1.529

Kurtosis measures the shape of the distribution, specifically its peakiness compared to a normal distribution. When the number is positive, it indicates a more peaked distribution, whereas negative number suggests a flatter distribution. Generally, a kurtosis value above +2 indicates a distribution that is too peaked, while a value below −2 indicates a flatter distribution. The observed kurtosis value of −0.17 implies that the distribution of farmers' commercialization indices is slightly flatter than what would be expected when such a distribution is perfectly aligned with the standard normal distribution. This pattern reflects greater heterogeneity or diversity in commercialization levels among the sampled farmers. It suggests that farmers' progression toward commercialization is not a uniform process but rather a spectrum where individuals are spread across a wider range of low, medium, and high values.

Skewness values measure the asymmetry of a distribution. A skewness value between −0.5 and 0.5 shows that the distribution is approximately symmetric. The observed positive skewness value of 1.17 for the farmers' commercialization index indicates a right-skewed distribution, meaning that many smallholder farmers cluster at relatively low levels of commercialization, while a smaller subset achieves substantially higher values, creating a long tail extending to the right; this pattern means that the transition to commercial agriculture is not uniform across the population but is instead limited to a minority, suggesting that structural barriers or specific enabling factors allow only a few farmers to reach high levels of market integration while most remain at lower, potentially subsistence-oriented, levels.

The relatively low commercialization index observed in this study highlights the trade-off farmers face in prioritizing production for consumption vis-à-vis for sale. The low level of commercialization cannot be attributed to a single factor but a complex interplay of factors, including a predominant focus on household consumption over market sales to ensure family food supplies (Muzo et al., 2022). Additional challenges for those seeking to pursue commercial production may include significant post-harvest losses (World Bank, 2023), inefficient and costly markets (Kadigi et al., 2024), and the prevalence of diversified livelihoods (Msuya, 2023). Accelerating their transition into commercial farming requires a holistic approach that uses integrated interventions to resolve their complex constraints simultaneously.

4.4. Factors affecting the degree of commercialization

The results of the Tobit model analysis are presented in Table 6, and average marginal effects obtained after estimation are provided in Appendix 2. The results indicate that the ownership of durable assets and communication devices, marital status, household's income, adult equivalent, farmer's age, and size of the cultivated plot are the significant explanatory variables.

Results reveal a statistically significant positive association between ownership of durable assets and extent of commercialization of maize production ($p < 0.01$). Based on empirical evidence from Tanzania, the ownership of durable assets influences the commercialization through several interconnected pathways. Productive assets, such as tractors and irrigation pumps, directly enhance land productivity and timeliness of operations, leading to higher yields and a greater marketable surplus (Majebele et al., 2025). Concurrently, transport assets like motorcycles reduce the transaction costs and physical barriers associated with market access, enabling farmers to reach more profitable, distant buyers (Changalima & Ismail,

Table 6. Tobit model and marginal effect results on factors influencing maize commercialisation.

				Number of observations = 1,529		
Limits: Lower = 0				Uncensored = 1,515		
Upper = 100				Left-censored =		
				Right-censored= 0		
				LR X^2 = 299.89		
				Prob > X^2 = 0.00		
Log likelihood = −3337.550				Pseudo R^2 = 0.043		
CCI	Coefficient	Std. err	*p*>|t|	dy/dx	Std. err	*p*>|z|
Durables	27.419***	1.926	0.000	0.139***	0.007	0.000
Information	14.340**	6.854	0.037	0.073**	0.035	0.036
Sex	−5.169	6.468	0.424	−0.026	0.033	0.424
Marital	−13.982**	6.452	0.030	−0.071**	0.032	0.029
Income	−15.097***	3.265	0.000	−0.076***	0.016	0.000
Adult equivalent	3.041**	1.200	0.011	0.015**	0.006	0.011
Age	−0.624***	0.239	0.009	−0.003***	0.001	0.008
Non-farm	−6.728	4.214	0.111	−0.034	0.021	0.109
Distance	0.764	0.551	0.166	0.004	0.003	0.164
Plot size	−1.365***	0.519	0.009	−0.007***	0.003	0.008
Pre-primary	2.460	8.776	0.779	0.012	0.044	0.779
Above primary	13.971	10.681	0.191	0.071	0.054	0.190
SACCOS	6.263	10.247	0.541	0.032	0.052	0.541
Constant	−177.222	39.856	0.000			
Var (e. HCI)	27.419	1.926	0.000	0.139		

Note.:
***significant at 1%.
**significant at 5%.

2022). The ownership of processing equipment and hermetic storage facilities has been found to significantly mitigate post-harvest losses and facilitate value addition, a crucial step in shifting households from producing for own consumption to market-oriented production (Mutungi et al., 2023). Other studies demonstrate that farmers' assets are more than just physical tools; they are instrumental in fundamentally transforming a household's capacity, risk profile, and its core orientation, shifting production from subsistence to market focus. Beyond increasing yields, assets such as irrigation pumps and tractors could fundamentally reshape how farmers perceive and manage risk. By reducing farmers' exposure to rainfall variability, these climate-smart assets enable them to allocate more land to market-oriented maize production rather than diversifying crop production to safeguard household food needs (Abebe et al., 2025; Dyer & Shapiro, 2023). The resulting decrease in uncertainty acts as both a psychological and strategic catalyst for commercialization.

Results reveal a positive relationship between farmers' access to communication devices and commercialization of maize production ($p < 0.05$). These devices give farmers real-time access to market prices from various buyers, allowing them to make informed decisions about when and where to sell their surplus maize for best profit, rather than accepting the first offer they receive (Achieng et al., 2025; Kisena & Kwesigabo, 2023; Quandt et al., 2020). Additionally, this connectivity facilitates direct communication with buyers, simplifies the logistics of input delivery and output collection, and provides access to valuable agricultural advice, all of which are crucial for a more commercially successful, market-oriented approach to farming (Kisena & Kwesigabo, 2023).

Qualitative research from Tanzania and similar settings indicates that access to communication devices catalyzes a fundamental transformation in farmers' market engagement by enhancing their individual agency, expanding social networks, and reshaping cognitive approaches toward market engagement. Essentially, these devices strengthen social capital and foster trust-based transactions. Direct communication enables farmers to build enduring relationships with traders, facilitating repeated business and informal agreements that mitigate transactional risks. Furthermore, effective use of this technology supports peer learning within digital networks and empowers farmers to negotiate collectively for improved terms (Almasi et al., 2023).

The analysis revealed that marital status has a negative and statistically significant influence on the likelihood of maize smallholder farmers achieving a higher level of commercialization ($p < 0.05$). Empirical evidence from Tanzania shows that marital status has negative influence on commercialization of maize because of the heightened household consumption pressure from a larger family size, which prioritizes food security over market surplus and directly reduces the marketable volume (Kangile et al., 2020).

Furthermore, married household heads, or spouses whose preferences matter in household decision, exhibit higher risk aversion and are less likely to adopt improved agricultural technologies such as high-yielding seeds that would increase potential surplus but come with uncertain returns (Achieng et al., 2025; Magnan et al., 2020). Also, married, male-headed households tend to have larger household sizes and more intra-household labor commitments, which limit their ability to produce a surplus for sale as they normally focus on retaining more maize for consumption (Adam et al., 2020).

The negative link between marital status and commercialization can be further explained by three key social and relational factors. First, negotiations between spouses over their limited resources often lead to risk-averse compromises that prioritize subsistence farming. Second, married household heads may face increased social obligations to share maize with their extended social and family networks, which can potentially divert surplus from the market. Finally, cultural expectations pressure married men, as providers, to avoid risky commercial ventures in favor of stable food security. Together, these social and normative dynamics reinforce a subsistence-oriented logic over a commercial one (Fischer & Qaim, 2012).

Household income demonstrated a negative and significant association with the predicted level of commercialization among smallholder maize farmers ($p < 0.01$). Empirical evidence from Tanzania attributes the seemingly contradictory link between household income and commercialization of maize production to the fact that wealthier households have the potential to successfully diversify their sources of income, often through stable off-farm businesses or other cash crops like sugarcane or sesame (Mkamilo, 2004). This diversification lessens their dependence on maize sales to meet cash needs. As a result, maize cultivation shifts from being a primary commercial activity to a strategy for ensuring household food security. This is a rational and deliberate risk-aversion tactic, as higher-income households can prioritize feeding their families with their own harvests, even if they have the capacity to produce a surplus for the market (Van Dijk, 2022).

While the negative link between household income and maize commercialization is often explained by economic diversification, it can also be explained by social and personal reasons (Fischer & Qaim, 2012). Homegrown maize could be perceived by wealthier farmers as a reliable source of family food that provides peace of mind, which money alone cannot provide. Furthermore, a surplus harvest is often shared within community and kinship networks to build social respect and fulfill obligations that come with such respect, a practice that can be more valued than cash sales (Poulton et al., 2010). Aspirations may also shift, with families prioritizing education or off-farm jobs, leading them to treat farming as a simpler, subsistence activity rather than a business venture (Muyanga & Jayne, 2019). Ultimately, the choice is frequently about long-term security, cultural values, and community ties than immediate financial gains from crop sales.

Adult equivalent was found to be positively associated with farmers' commercialization index ($p < 0.05$). Previous studies from Tanzania and other African countries have found that households with a more active labor force, as measured by the adult equivalent, enabled households to cultivate larger area and manage maize plots more effectively. This labor use efficiency led to a greater marketed surplus, creating a positive link with the commercialization index (Kansiime et al., 2018; Utonga, 2022). These findings are also attributed to concept of economies of size, where larger households achieve greater efficiency in balancing the need to retain some of the produce for home consumption and market sale (Gebre et al., 2022). Although a larger household's absolute consumption increases, this rise is proportionally smaller than the increase in total production, as fixed costs of production are spread across a larger output, leading to a decrease in the proportion of total production reserved for home consumption.

The positive link between a larger adult household size and commercialization cannot be fully explained by just having more labor for farming. There are other qualitative factors worth considering. The factors include: the skills and physical ability of the workers, which affects how efficiently labor is converted into marketable surplus (Moser & Barrett, 2006); gender roles that may divert women's labor away from crop production to other family and social obligations (Doss, 2001); social and ceremonial obligations that consume surplus produce; and the lifecycle stage of the household, which determines if labor and resources are fundamentally used for investment or immediate consumption needs (Ellis, 2000). Therefore, the relationship depends heavily on the household's internal social structure and cultural context, not merely on the size of its workforce.

Results reveal that older farmers have a systematically lower underlying commercialization index ($p < 0.01$). The negative relationship between age and commercialization index among Tanzanian maize farmers is strongly linked to a well-documented "age-technology adoption gap." Older farmers tend to be more risk-averse and reliant on traditional farming methods, leading to lower productivity and, consequently, less surplus to sell. According to research by Asfaw et al. (2012), older farmers in Sub-Saharan Africa prioritize household food security over commercial gains, leading them to favor traditional, drought-resistant maize varieties with lower yields over potentially higher-yielding but riskier improved seeds. This risk-averse behavior limits their marketable surplus. A study in Tanzania by Manda et al. (2016) found that younger, more educated farmers are significantly more likely to adopt improved maize seeds and chemical fertilizers than older farmers. This preference for traditional farming methods among older farmers often leads to lower yields, leaving them with little surplus to sell after meeting their own consumption needs.

Beyond the established "age-technology adoption gap," the lower commercialization index among older Tanzanian maize farmers can also be explained by qualitative factors. The physical constraints of aging, which is normally linked to declining health and stamina, limit the capacity of older farmers to manage larger or more intensive plots regardless of their risk preference (Mazzucato & Niemeijer, 2000). Furthermore, as they age, farmers start thinking differently about the future and their family legacy. Consequently, they perceive their main role as keeping the land safe and productive for future generations (Porter, 2011). This is why they often stick with proven, low-risk subsistence farming instead of switching to riskier crop production or other investments. Their evolving social role as community elders embeds them in a moral economy of reciprocity, where fulfilling kinship obligations through in-kind food sharing often takes precedence over generating cash sales (Chapoto et al., 2016). Finally, differential access to contemporary information channels could be a significant barrier to older farmers who rely more on traditional knowledge and local networks than on digital platforms, leaving them less aware of emerging market opportunities (Mwalupaso et al., 2019). Thus, age reflects a complex confluence of bodily, temporal, social, and informational changes that collectively reinforce a subsistence orientation.

Results indicated a negative relationship between plot size and level of commercialization ($p < 0.05$). The IR between farm size and productivity highlights the complexity of agricultural systems in developing countries. It challenges the assumption that larger landholdings inherently lead to greater efficiency and output (Fikadu et al., 2023). Smaller farms in Tanzania are reported to achieve higher output per hectare and a greater proportion of sales due to more intensive application of scarce family labor and limited inputs like fertilizer, which cannot be efficiently scaled across larger plots due to binding liquidity and capital constraints (Palmas & Chamberlin, 2020; Wineman & Jayne, 2021). Large plots often produce a greater total output, but they are frequently managed less intensively. As a result, they tend to have a lower rate of marketable surplus and a lower commercialization index than smaller, more intensively managed farms.

While the IR between plot size and commercialization is often attributed to the intensive use of family labor on smaller holdings, it overlooks several critical qualitative dimensions. First, land acquisition and tenure security differ markedly across households; larger holdings are often obtained through inheritance or customary allocation, placing the acquired land within complex social obligations that tend to prioritize subsistence needs and social obligations over purely commercial use (Porter, 2011). In contrast smaller plots are often purchased and are normally viewed as a liquid business asset. Second, gendered labor dynamics are crucial; the delineation of tasks may follow stricter gendered divisions, potentially underutilizing women's labor or knowledge specifically geared toward market-oriented production or post-harvest technologies (Doss, 2001). Third, social identity and risk perception are intertwined with scale; managing a large ancestral holding may carry a cultural imperative to avoid risky commercial ventures that could jeopardize the family's primary asset and status, reinforcing conservative, subsistence farming (Muyanga & Jayne, 2019). Fourth, the ecological and crop diversity logic differs; smaller plots often support more diverse, nutrient-sensitive cropping systems for direct household use, which can incidentally include high-value vegetables for local markets, whereas larger plots may be dedicated to mono-cropped staple grains with lower commercial intensity per hectare. Finally, the nature of market relationships may vary, where smallholders with smaller surpluses engage in trusted, repeated transactions with local buyers, while larger farmers, lacking such networks for their bigger volume, face higher

transaction costs and thus may decide to selling locally at lower prices or storing for consumption. These social, cultural, and relational factors fundamentally shape how land size translates into commercial intent.

5. Conclusion

Owning durable assets supports maize commercialization by boosting yields and generating a marketable surplus through equipment such as tractors and irrigation pumps. This impact is further strengthened when households also have transport assets that help them reach distant markets and storage facilities that reduce post-harvest losses. Together, these resources lower the risks of both production and marketing, influencing household financial decisions and shifting their focus from growing maize mainly for consumption to producing a surplus for sale. In the context of the AHM, a portfolio of these assets can potentially reduce the joint production and market risks that typically bind households to subsistence, thereby enabling a shift from subsistence to commercial orientation.

Marriage negatively affects a farmer's maize commercialization level by creating three interconnected pressures: increased household consumption by family members, which directly reduces the marketable surplus; heightened risk aversion, which discourages the adoption of productivity-enhancing technologies; and expanded social and kinship obligations, which divert surplus away from the market. These factors are compounded by qualitative dynamics, such as prolonged intra-household negotiations and a higher inclination to fulfill family obligations, which collectively prioritize subsistence security and social commitments over maximizing commercial production. Thus, marriage can potentially intensify the non-separability of household production and consumption decisions within the AHM.

Access to communication devices positively drives maize commercialization through two main channels. First, it enhances economic efficiency by providing real-time price data, improving logistics, and easing access to agricultural advice, all of which optimize market decisions. Second, it fosters social and cognitive transformation by building trust with buyers, expanding social capital and peer-learning networks, and empowering collective negotiation. This dual influence fundamentally shifts farmers from passive producers to active, market-engaged agents. The implication for the AHM is that farmers' access to communication devices reduces both information asymmetry and transaction costs, which, in turn, enhances the separability between farmers' production and consumption choices and improves their overall market engagement.

The observed negative and significant association between household income and commercialization level may reflect a rational, multi-dimensional strategy of rich farmers rather than a market failure. While economic diversification explains how wealthier households reduce their reliance on maize sales by pursuing off-farm income or cash crops, this is further compounded by socio-cultural factors, as they may prefer to prioritize homegrown maize to ensure food security, fulfill social obligations through sharing, and support their aspirations for education or stable employment. Thus, for higher-income smallholders, maize production may be viewed less as a commercial activity and more as a strategy for safeguarding their household's long-term security. Their cautious economic choices could also be shaped by social ties and cultural preferences. These factors are often overlooked when the inferences are strictly derived from basic measures of commercialization. The intertwined factors underlying the relationship challenge the AHM's core assumption of profit maximization as the primary objective among higher-income households.

A larger adult household size, measured in adult equivalents, is positively associated with a higher level of maize commercialization, primarily through two economic mechanisms: the availability of a more robust labor force that enables the effective cultivation of larger areas, and the achievement of economies of size where increased production outpaces the growth in household food needs, resulting in a higher proportion of surplus for the market. However, this positive relationship could also be significantly mediated by qualitative social and demographic factors, including the physical capacity and skills of workers, intra-household gender roles, cultural obligations that consume surplus, and the household's lifecycle stage. The commercialization benefit of a larger family is strongly dependent on its internal social structure and not guaranteed by labor numbers alone. The implication for the AHM is that while household labor supply can enhance commercialization through economies of size, there is a need to also consider the potential influence of social and demographic mediators.

Older age is associated with lower levels of maize commercialization through several distinct pathways, including the established age-technology adoption gap, where risk aversion leads to the adoption of lower-yielding traditional methods; the physical constraints of aging that limit farming capacity; a shifting time perspective that prioritizes land stewardship and legacy over commercial risk; heightened social obligations as community elders prioritize diverting surplus to kinship networks; and reduced access to contemporary market information, all of which collectively reinforce a subsistence-oriented approach to farming. The implication for the AHM is that older age systematically shifts the household's objective function away from profit maximization by introducing a composite of physical, temporal, and social constraints such as shortened planning horizons, legacy motives, and heightened kinship obligations. Collectively the constraints encourage risk minimization and social investment over commercial surplus production.

Larger plot size is linked to lower maize commercialization through two connected pathways. Economically, it reflects the IR, where smaller farms achieve higher output and greater sales intensity per hectare because they use limited family labor and inputs more efficiently. In contrast, larger plots tend to be managed less intensively due to capital limitations. Socially and culturally, the relationship is influenced by qualitative factors: larger holdings are often inherited, carrying subsistence expectations and a strong, risk-averse desire to protect ancestral land. Smaller plots, which are often purchase, are more likely to be treated as commercial assets, supported by stronger local trading relationships and the flexibility to grow diverse, higher-value crops. Taken together, these dynamics imply that commercialization is not driven by size alone, but by the interaction of labor intensity, land tenure origins, social identity, and market access. The implication for the AHM is that it is vital to account for the social meaning and history of land, not just its size or productive capacity.

6. Implication of the study

In view of the key findings of the study, it is imperative to enhance farmers' access to credit and grants to buy assets like storage facilities to enhance value addition, transportation means to reduce transaction costs related to acquisition of inputs and marketing of produce, and machinery to ease manual farm operations. It is also vital to improve farmers' access to agricultural information by using simple digital tools like Short Message Service (SMS) and Unstructured Supplementary Service Data (USSD) to deliver real-time data directly to phones, while also strengthening traditional extension services and turning agro-dealers into local information hubs. Additionally, policies should promote labor-sharing mechanization programs to make farming less labor intensive and reserve labor to be used where its opportunity cost is the highest. To counter the observed negative association between income and commercialization, farming must be made attractive venture through reducing post-harvest losses, improving value addition, and strengthening market linkages. Support to smallholder farmers must be gender-responsive, providing female-headed households with labor-saving technologies and secure land rights. Land rental markets should be formalized to allow older farmers to lease to more productive, younger farmers. Finally, promoting sustainable intensification through improved seeds and soil fertility management is essential for increasing yields on existing plots, making smallholder commercialization viable.

7. Theoretical implications

The findings of this study offer critical theoretical implications for the AHM, which are organized into three themes: the conditional pathways to commercialized farming, the primacy of social objectives over profit maximization, and the redefinition of key productive factors.

First, the analysis identifies conditional pathways that alter the separability of decisions. The AHM posits that market failures cause production and consumption choices to be non-separable. The ownership of a complementary asset portfolio (production, transport, storage) and access to communication devices directly mitigate these failures by reducing production risk, transaction costs, and information asymmetry. The ownership enhances separability and enables a commercial orientation. Conversely, marriage fundamentally intensifies non-separability by embedding production within expanded consumption

needs and social obligations, making the household's production decisions inseparable from its reproductive and social goals.

Second, the findings demonstrate that social and cultural objectives can systematically override the AHM's core assumption of profit or income maximization. Higher total household income is associated with lower commercialization, as wealthier households rationally prioritize food self-sufficiency, social capital, and livelihood diversification. Similarly, older age is seen to predominantly shift the objective function toward risk minimization and social investment. In both cases, households may seek to optimize a utility function where security, kinship, and status carry greater weight than marginal commercial gains.

Third, the evidence proposes a reconceptualization of land and labor as socially embedded factors, not neutral inputs. The observed IR between plot size and commercialization implies that land's productivity could be mediated by its tenure origin (inherited vis-à-vis purchased) and associated social meaning, which can instil a subsistence imperative. Likewise, a larger adult labor force's positive effect is not automatic, it might be mediated by internal social structure, including gender roles and lifecycle stage. This underscores the to treat these factors not simply as scalable endowments but as variables whose economic function could be governed by social context.

In conclusion, these implications collectively argue for a more socially embedded AHM. There is a need to consider how enabling assets and constraining social institutions jointly determine a household's position on the subsistence-commerce spectrum, with factors like marriage, age, and land history actively reshaping the constraint set and the very objectives being maximized.

8. Limitations of the study

The key findings of this study require careful interpretation. The study did not assess the farmers' primary motives for producing maize, which, for some, could be meeting consumption needs rather than market sale. A low commercialization index does not necessarily indicate poor household welfare or a lack of commercial interest. Therefore, the index should be perceived as a useful starting point for understanding market participation and not be regarded as a definitive measure of agricultural success or household welfare. Farmers, livelihood strategies, and rational objectives for food security are critical layers that can fundamentally change the interpretation of this standard metric. A study that considers farmers' primary motives for producing maize, go beyond a simple sales-to-production ratio to integrating a composite index that account for farmers' additional sources of income and net profit margins from maize sales, will be more informative. It is equally important to integrate both the qualitative and quantitative analyses of factors underlying the commercialization of smallholder farming.

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Authors' contributions

CRediT: **Angela Burton Mboma**: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing; **Fredy T. M. Kilima**: Supervision, Writing – review & editing; **Alban D. Mchopa**: Supervision, Writing – review & editing; **Joachim G. Schäfer**: Supervision, Writing – review & editing.

Disclosure statement

The authors reported no potential conflicts of interest.

Ethical approval

Since the study involved human subject, the ethical principles of Declaration of Helsinki were considered. Ethical approval was obtained from the Directorate of Research and Postgraduate Studies (DRPS) of Moshi Co-operative University, Kilimanjaro, Tanzania (Reference No: HD/T/MoCU/049/19/37).

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Data availability statement

The data supporting the findings of this study are available from the corresponding author, A. B. Mboma, upon request.

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