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Does shifting from subsistence to commercial farming improve household nutrition and poverty? evidence from Malawi, Tanzania and Nigeria

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A R T I C L E I N F O

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A B S T R A C T

The current study sought to assess the effect of smallholder crop commercialization on household nutrition security and poverty status. Recent government efforts have gone beyond investing in agricultural production, thereby establishing markets for smallholder farmers in order to commercialize the agricultural sector. As such, developing countries like Malawi, Tanzania, and Nigeria are slowly transitioning to a market economy in order to improve the livelihoods of their people. To that effect, the study used country-wide representative data from Malawi, Tanzania, and Nigeria collected under the World Bank Living Standards Measurement Surveys (LSMS) and employed an instrumented-censored (probit and tobit) model to solve for endogeneity bias. The results show that poverty and nutrition insecurity were higher among subsistence farmers, emphasizing the need for a shift towards commercialization of the country's agricultural sector. Furthermore, farmer social and institutional context significantly influenced market participation. The study hence recommends a tailor-made extension delivery system, cutting across gender divides and other social barriers among smallholder farm households, in order to improve crop production among subsistence farmers, ensure household food security, and increase income from the sale of surplus crop output.

Introduction

Worldwide, there have been continued strides to graduate smallholder farmers from subsistence farming to commercial farming (Abate et al., 2022). Agricultural scientists and extensionists have therefore engaged themselves in advocating for a change in farming systems (Manda et al., 2021). Thus, the adoption of farming systems that enhance increased food production has always been at the center of attention for scientists and extension workers. Agricultural commercialization has received a surge of multidimensional attention in recent decades due to the plethora of benefits that it confers. Agricultural commercialization has been praised for its potential to improve household food security and income (Asfaw et al., 2022; Tabe Ojong et al., 2022; Matthys et al., 2021). Commercializing agriculture not only increases productivity and leads to economic growth and a reduction in unemployment, but it also enhances the food supply system in urban areas (Kihiu and Amuakwa-Mensah, 2021; Ogutu et al., 2020; Jayne et al., 2019). It enhances the intensification of agricultural production systems through the use of advanced farming methods (Sekyi et al., 2023; Bolarinwa et al., 2021). Sustained commercialization of agriculture among smallholder farmers is the best conduit for reducing rural poverty to a desirable level, thus contributing to the achievement of the Sustainable Development Goals. It is imperative to note that several development agents, including international development agencies, governments, research institutions, and nongovernmental organizations (NGOs), view agricultural commercialization as a precursor to achieving macroeconomic development outcomes (Usman and Callo-Concha, 2021; Brenya et al., 2022). This is why numerous agrarian countries are searching for several agricultural commercialization options in order to enhance sustained improvements in production, income, and the welfare of the population (Tafesse et al., 2020; Linderhof et al., 2019). Because agricultural commercialization has been lauded for its potential

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to spur economic growth, numerous concerted efforts have been redirected toward commercializing agricultural production in the developing world. Several studies with different policy directions have been carried out.

On-going debate on the role of smallholders in agricultural development shows that some researchers believe that smallholders cannot cope with current trends in market demands due to their cost, technology, resource, and skills challenges and part-time commitment (IFPRI, 2005). However, others argue that small farms are important players with significant shares in agricultural resources, activities, and outputs; hence, they should lead agricultural growth (Hazell et al., 2007; World Bank, 2008; Pingali, 2010; Salami et al., 2010). In most developing countries, smallholders are preferred in new poverty alleviation strategies because: they own the bulk of production resources like land and livestock; they directly benefit from income and food supply growth; and they can efficiently use land and cheaper family and local labor (Hazell et al., 2007; World Bank, 2008; Salami et al., 2010). It is therefore inevitable for smallholders to be incorporated into the market system in response to growing demand, which current production cannot fulfill (Picciotto and Anderson, 1997; IFPRI, 2005). There is a need for the development of new market models that will ensure that smallholder producers who are disadvantaged by pre-existing social, economic, environmental, and political conditions are included in high-value commercial markets without jeopardizing their food security and livelihoods.

Definitions of commercialization differ in focus and breadth, which has also influenced its measurement. While some authors narrowly view it as increasing the proportion of marketed output (Govereh et al., 1999; Okezie et al., 2008) or increasing cash crop production (Kennedy and Cogill, 1987), others broadly view it as a transition from subsistence towards market-oriented production (Brush and Turner, 1987; von Braun and Kennedy, 1994; Pingali and Rosegrant, 1995). In southern Africa, commercial production has been mainly associated with large-scale farmers, and smallholder commercialization has mainly been understood from a narrow perspective (Govereh et al., 1999; Rukuni et al., 2006).

Most developing countries, including Malawi and Tanzania, are slowly transitioning into a market economy (Kissoly et al., 2020). Thus, agriculture is slowly moving from subsistence-based to commercial-based, with farmers selling at least part of their output. Commercial crop farmers are those who participate in the market by selling at least part of their crop output. As pointed out by Yaseen et al. (2018) and Van Asselt & Useche (2022), increased commercialization leads to higher average farm earnings by farmers and hence lowers farm income inequality. It can therefore be deduced that commercialization has the potential to improve smallholder farmers' income and their food security status. However, despite these attributes, studies extending the benefits of commercialization to livelihood outcome variables like dietary diversity and poverty levels still remain scantly done. If governments and other stakeholders are to promote commercialization, its effect on livelihood outcomes like poverty, food, and nutritional security has to be well established. It is for this reason that a study of this dimension is imperative.

Ensuring food security remains a major policy challenge in many developing countries (Carletto et al., 2017). Food security can be defined as a situation where all people have physical and economic access to adequate, safe, and nutritious food at all times to meet their dietary needs and preferences for a healthy and active life. The governments of Malawi, Tanzania, and Nigeria independently established different food security policies whose goal is to achieve food security at all levels through promotion of agricultural productivity and diversity, sustainable agricultural growth, and development. Commercialization of crop production can thus help to improve physical and economic access to food, which entails poverty reduction and, again, nutritious food (dietary diversity) at all times.

However, the status of agricultural commercialization in the three countries has not sufficiently improved over time. Owusu and İşcan (2021) studied the drivers of agricultural commercialization in Tanzania and Nigeria. The study was built on the foundation that there is little evidence of farm-level factors that affect agricultural commercialization. The study maintains that resource endowment and farm characteristics do not matter in predicting farmers' participation in markets and transition from subsistence farming into commercial farming. However, the said factors were positively related to commercialization. Carletto et al. (2017) also observe that agricultural commercialization remains low in Malawi and Tanzania despite its positive correlation with nutrition outcome variables. Even though there is a low level of agricultural commercialization in the three countries, it has been observed that the infusion of agricultural commercialization interventions has proved to have positive results. For example, a study by Etuk and Ayuk (2021) discovered that beneficiaries of agricultural interventions pioneered by CAADP were better off in terms of agricultural commercialization than non-beneficiaries.

From the reviewed studies, it is apparent that little has been conducted in the three countries to jointly evaluate the relationships that exist among agricultural commercialization, nutrition, and poverty. The study therefore contributes to the literature in three ways. First, the study uses nationally representative data to evaluate the impact of agricultural commercialization on dietary diversity and poverty in Nigeria, Malawi, and Tanzania. Second, the study fills the existing evidence gap on the relationship between agricultural commercialization, nutrition, and poverty. Third, by combining disparate pieces of research on agricultural commercialization, nutrition, and poverty, the study provides a conduit for coordinated policy use and design.

Methodology

Data sources

This study used the Malawi Fifth Integrated Household Survey (IHS5), the Tanzanian Third Integrated Survey, and the Nigerian Fourth Integrated Survey data collected by the National Statistical Offices (Malawi and Nigeria) and the National Bureau of Statistics (NBS Tanzania). The gathered data were from a nation-wide sample survey that was designed to generate information on various aspects of household welfare in Malawi, Tanzania, and Nigeria. Through the funding of the World Bank, they collected data from 12,447 households across the three regions of Malawi, 3352 across the 7 zones of Tanzania, and 4590 across the 6 zones of Nigeria. The data are on the living standards of the people, which are part of the World Bank's Living Standards Measurement Surveys (LSMS). From the sampled households, the study focused on 6439 crop-producing households in Malawi, 1423 crop farmers in Tanzania, and 1746 crop-producing farmers in Nigeria. The data set can be accessed on http://microdata.worldbank.org/index.php/catalog/2936.

The collected data are representative at national, district, urban, and rural levels; this enables the provision of reliable estimates for the specified levels. As standard practice, the statistics offices used a stratified two-stage sample design in which the primary sampling units selected at the first stage were the census enumeration areas (EAs) that were defined for the previous population and housing census. The enumeration area (EA) serves as the smallest operational census area with well-defined boundaries commensurate with the workload of an individual enumerator. Simple random sampling (SRS) was then used to select the households interviewed in the surveys.

Indicators used in the study

Household commercialization index

The starting point for commercialization is market participation; however, market participation as a binary variable is not enough to draw conclusions (Ogutu & Qaim, 2019). Different studies propose the degree

Table 1
Food Groups and Weights.

Food Group	Weight
Cereals & Tubers (Staples)	2
Pulses	3
Vegetables	1
Fruit	1
Meat & Fish	4
Milk	4
Sugar	0.5
Oil	0.5

of commercialization as an alternative, which is measured using the household commercialization index (Boka, 2017), specified as follows:

$$HCI = \frac{\sum_{k=1}^{k} p_k Q_{ik}^{s}}{\sum_{k=1}^{k} p_k Q_{ik}^{T}} \quad (1)$$

The HCI is an index from 0 to 1, where $p_k Q_{ik}^{s}$ is the total value of the quantity allocated towards sales and $p_k Q_{ik}^{T}$ is the total value of the harvest.

Measures of dietary diversity

Dietary diversity was one of the indicators of household welfare in this study. It was selected because it relates to the level of households' living standards, which is expected to improve with production returns if the household produces beyond subsistence. It thus relates to the food security status of the household, specifically their ability to access food, and is also likely to be achieved if the household looks beyond subsistence production. Commercialization provides income to farmers and enhances their food security and nutrition status (Gebremedhin et al., 2009).

According to FAO (2011), food and nutritional security are measured in a number of ways, including (1) the calories per capita method, (2) the household income and expenditure method, (3) the anthropometry method, and (4) the dietary intake method. This study focuses on the dietary intake method in explaining the effect of crop commercialization on food and the nutritional status of smallholder farm households in Malawi. It is argued that the dietary diversity method is unique in measuring food security as it measures food consumption directly, going beyond initial food availability; in addition, the method addresses the intake of both micro and macro nutrients and the caloric intakes at household and individual levels (FAO, 2011). The method thus regards people who consume insufficient calories as being food insecure. Besides these measures, there are other food security indicators used by many studies as a proxy for the calorie intake measure; these include the dietary diversity score (DDS), self-reported food security, and land holding (Hossain et al., 2016). Among these three indicators, DDS, which is defined as the sum of different food groups consumed by an individual over a given period of time, is a commonly used proxy of calorie intake (Hossain et al., 2016). However, the DDS method suffers from no standard cutoff point for what number of food groups consumed represents low or high dietary diversity (Hossain et al., 2016). In order to solve for this, the study will use the Household Dietary Diversity Score (HDDS) and expand it to the Simpson Index in order to have a clear picture of the dietary diversity of the crop-commercializing households with respect to the subsistence households.

For a more robust measure, the study considered the Food Consumption Score (FCS). The FCS is a composite score that measures the dietary diversity, food frequency, and relative nutrition importance of various food groups (WFP, 2008). Normally, the FCS uses a seven-day recall period (as compared to the Household Dietary Diversity Score, which considers either 24 h or a week) and considers eight weighted food groups as opposed to ten unweighted groups in the HDDS. The eight food groups used in calculating the FCS are: staples; pulses; vegetables; fruits; meat, fish, and eggs; milk; sugar; and oils. Research has shown that the FCS is significantly positively correlated with other food security indicators such as the Household Dietary Diversity Score, assets, the Months of Adequate Household Food Provisioning, and expenditure (WFP, 2012; Perez-Escamilla, 2017). WFP (2008) assigns weights to each food group consumed in a space of 7 days (week) based on the food group's nutrition value. The consumption frequency of each food group is multiplied by its assigned weight, and the values are summed together to get the FCS (Table 1).

Poverty status

In the World Bank study of poverty and inequality, Haughton and Khandker (2009) explain that poverty levels can be measured using three different indices, such as (1) the head count index, (2) the poverty gap index, and (3) the squared poverty gap index, which are part of the Foster-Greer-Thorbecke (FGT) poverty indices. The head count index is the most common measure of poverty, which measures the proportion of the population that is poor. However, despite being the easiest poverty index to construct, the head count index still fails to measure the intensity of poverty. The poverty gap index, on the other hand, is a moderately popular measure of poverty that adds to the extent to which households fall below the poverty line and expresses it as a percentage of the poverty line. The poverty gap index explains the minimum cost of alleviating poverty but fails to explain the inequality among the poor. Improving on this index, the squared poverty gap, also called the severity index, takes into account the inequality amongst the poor. The index thus gives a weighted summation of the proportion of the poverty line. The FGT is the most widely used measure of poverty as it combines poverty and inequality, making it the most popular index in economics. The FGT thus puts more weight on the poorest individuals, and it is presented as shown in equation (4).

$$FGT_{\propto} = \frac{1}{N}\sum_{i=1}^{H}\left(\frac{Z - y_i}{Z}\right)^{\propto} \quad (2)$$

In this equation, z represents the poverty line, N is the number of crop farming households, and H is the number of poor crop farming households whose incomes are below the poverty line. z, y are the incomes of the crop farming households, and α is the degree of concern about the depth of poverty. Thus, when $\alpha = 0$, the FGT index reduces to a head-count index and measures the incidence of poverty, and when $\alpha = 1$, the FGT index reduces to the poverty gap index. The indices are computed for the household considering adult equivalence and the household consumption poverty line.

Instrumented-Censored model

The indexes of poverty depth and severity are censored to zero at the stage of poverty incidence if a household is not poor. Similarly, the FCS is continuous but has discrete properties. A second critical assumption is the potential endogeneity between HCI and household livelihood parameters, whereby subsistence needs, which are the imagery description of smallholder farmers, constrain market output (Mutsami & Karl, 2020).

To account for both scenarios, an instrumented-censored model is recommendable. For poverty incidence, an instrumental probit model is used, and for the other measures, an instrumental tobit model is employed. According to Newey (1987), an instructional-censored model is specified as follows:

$$y_{ij}^{*} = HCL_i\gamma + z_{ij}^{'}\beta + \mu_i = x_i^{'}\alpha + \varepsilon_i, \quad (3)$$

Observed as;

$$y_{ij} = \begin{cases} y_{ij}^{*} if 0 < y_{ij}^{*} < 1 \\ 1 if y_{ij}^{*} \geq 1 \\ 0 if y_{ij}^{*} \leq 0 \end{cases} \quad (4)$$

Table 2
Descriptive Statistics.

Variable	MALAWI Commercial Producers (n = 1,674) Mean	Subsistence Producers (n = 6,504) Mean	P-value	TANZANIA Commercial (n = 471) Mean	Subsistence (n = 952) Mean	P-value	NIGERIA Commercial (n = 1003)	Subsistence (n = 742)	P-value
Continuous									
Land Size (Acres measured)	2.32	1.49	0.000***	2.13	2.08	0.011**	0.74	0.29	0.07*
Age (Years)	43.51	45.26	0.000***	44.8	47.2	0.00***	54.5	52.2	0.001***
Household Size	4.57	4.61	0.457	5	6	0.79	7	8	0.00***
Number of adults	2.59	2.52	0.023**	3	3	0.97	3	3	0.951
Education Years	7.54	6.70	0.000***				9.1	9.6	0.00***
HCI (Household Commercialization Index)	0.34	0	0.000 ***	0.50	0	0.000 ***	0.18	0	0.00 ***
FGT_1 (Poverty gap index)	0.04	0.07	0.000***	0.077	0.09	0.28	0.15	0.21	0.00
FGT_2 (Squared poverty gap index)	0.02	0.03	0.000***	0.031	0.035	0.52	0.07	0.1	0.0**
FCS	48.98	43.63	0.000***	52.1	48.1	0.07*	49.8	46.2	0.00***
Binary									
FGT_0 (Head count index, Poor = 1)	0.25	0.38	0.000***	0.27	0.332	0.02**	0.42	0.56	0.00***
Gender (male = 1)	0.76	0.66	0.000***	0.77	0.73	0.1	0.828	0.859	0.08*
Locality (Urban = 1)	0.07	0.08	0.079*	7.81	17.4	0.00 ***	6.72	7.69	0.58
Credit access (yes = 1)	0.34	0.29	0.000***	0.163	0.148	0.44	0.194	0.179	0.42
Extension access (yes = 1)	0.64	0.53	0.000***	0.184	0.123	0.00***	0.108	0.61	0.001***
Cultivates dry season (yes = 1)	0.09	0.08	0.030**				0.014	0.034	0.01**
Used Organic Fertilizer (yes = 1)	0.10	0.16	0.000***	0.227	0.224	0.91	0.26	0.23	0.252
Agroforestry Practice (yes = 1)	0.26	0.28	0.048**						
Used Inorganic Fertilizer (yes = 1)	0.44	0.38	0.000***	0.223	0.158	0.00***	0.597	0.52	0.00***
Input Subsidy (yes = 1)	0.15	0.13	0.008***	0.312	0.411	0.00***	0.212	0.272	0.00***
Marital Status			0.000***			0.042**			0.46
Married	0.76	0.69	0.000***	80.04	73.32		79.74	82.48	
Separated/Divorce	0.11	0.15	0.000***	6.58	9.98		1.6	1.21	
Widow/widowed	0.11	0.14	0.000***	11.04	13.76		16.77	14.29	
Never married	0.02	0.02	0.824	2.34	2.94		1.9	2.02	
Perception of Soil Quality						0.047**			0.00***
Good	0.53	0.50	0.009***	46.87	40.09		79.16	83.4	
Fair	0.34	0.34	0.969	44.92	49.79		20.64	15.65	
Poor	0.13	0.16	0.000***	8.21	10.13		0.2	0.94	
Soil Type						0.304			
Sandy	0.13	0.18	0.000***	14.47	18.02				
Between sandy & clay	0.64	0.59	0.000***	68.47	64.71				
Clay	0.23	0.24	0.813	17.07	17.27				

***Significant at 1 percent, **Significant at 5 percent and *Significant at 10 percent.

Table 3
Instrumental variable test for Malawi Data.

	Poverty Incidence	Poverty Depth	Poverty Severity	Dietary Diversity
F-Statistic	216.91	216.91	216.91	216.91
Coefficient	−0.210*	−0.056	−0.032	12.303
	(0.298)	(0.027)	(0.018)	(5.079)
Wald-test (p-value)	0.092*	0.036**	0.055*	0.015**
	.	.	.	.

Standard errors in parentheses for coefficient.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

Table 4
Instrumental variable test for Nigeria Data.

	Poverty Incidence	Poverty Depth	Poverty Severity	Dietary Diversity
F-Statistic	22.15	3.90	3.90	22.15
Coefficient	−0.000	0.001	0.003	−0.001
	(0.001)	(0.001)	(0.002)	(0.006)
AR-test (p-value)	0.0009***	0.0117**	0.0661*	0.0337**
	.	.	.	.

Standard errors in parentheses.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

Where y^{*}_{ij} is the latent variable with j as poverty indicators and dietary diversity: α represents the model estimated parameters, $\alpha \supseteq (\gamma,\beta)$: While x_i' is a vector of all observed covariates, $x_i' \supseteq (HCL_i, z_{ij}')$ and $z_{ij}' = (z_{iy}', z_{ihcl}')$ includes both exogenous and instrumental variables, respectively: μ_i, ε_i are the error terms with a multivariate normal distribution (μ_i, ε_i) $N(0,\Sigma)$ which conforms to a maximum likelihood approach.

The validity of an instrument originates from the theoretical frameworks before the analytical tests (Ogutu & Qaim, 2019). Within the literature arguments, Ogutu & Qaim (2019) and Mutsami & Karl

Table 5
Instrumental variable test for Nigeria Data.

	Poverty Incidence	Poverty Depth	Poverty Severity	Dietary Diversity
F-Statistic	6.23	5.98	5.98	5.93
Coefficient	0.000	0.006	0.003	−0.001
	(0.001)	(0.004)	(0.002)	(0.000)
AR-test (p-value)	0.0294**	0.0233**	0.0767*	0.0017***
	.	.	.	.

Standard errors in parentheses.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

(2020) proposed the number of market participants per enumeration area as the instrumental variable. This is built from the bandwagon effect (Mingolla, et al., 2021) – whereby market participation is an imitiative behaviour. Basically, z'_{ihcl} has an effect on HCL_i and its only through HCL_i that it affects y^*_{ij}.

Results and discussion

Descriptive statistics of observable covariates

Table 2 presents descriptive statistics for both commercial and subsistence crop producers. Statistical mean differences between the two groups were tested using chi-square and student t-tests. Out of the sampled 8 178 crop-growing smallholder farm households in Malawi, 1 674 were commercial crop producers, representing about 20.4 percent,

Table 6
effect of crop commercialization on household poverty and dietary diversity in Malawi.

	Poverty Incidence	Poverty Depth	Poverty Severity	Dietary Diversity
Commercialization Index	−0.570***	−0.108***	−0.066***	5.928***
	(0.108)	(0.020)	(0.012)	(1.202)
Region (Base North)				
Central	0.515***	0.090***	0.053***	−7.880***
	(0.075)	(0.014)	(0.009)	(0.763)
South	0.111	0.015	0.006	−3.854***
	(0.071)	(0.013)	(0.008)	(0.758)
Age	0.005***	0.001***	0.001***	0.039***
	(0.001)	(0.000)	(0.000)	(0.014)
Gender *(Male = 1)*	−0.023	−0.005	−0.001	0.828
	(0.060)	(0.010)	(0.007)	(0.594)
Marital Status *(Base: Married)*				
Separated/Divorced	0.121*	0.025**	0.016**	−2.012***
	(0.068)	(0.011)	(0.007)	(0.667)
Widow/widower	0.045	0.002	0.000	−0.044
	(0.078)	(0.013)	(0.008)	(0.776)
Never Married	0.220	0.041*	0.032**	−2.342*
	(0.138)	(0.022)	(0.015)	(1.203)
Education (Years)	−0.077***	−0.014***	−0.009***	1.079***
	(0.006)	(0.001)	(0.001)	(0.058)
Cultivates dry season *(Yes = 1)*	−0.075	−0.010	−0.006	−0.508
	(0.061)	(0.011)	(0.007)	(0.654)
Land Size (Acres)	−0.107***	−0.022***	−0.014***	0.683***
	(0.017)	(0.003)	(0.002)	(0.149)
Soil Type *(Base: Sandy)*				
Between clay and sand	−0.119***	−0.024***	−0.015***	−1.274***
	(0.044)	(0.008)	(0.005)	(0.417)
Clay Soil	−0.006	0.003	0.002	−2.299***
	(0.055)	(0.009)	(0.006)	(0.541)
Perception of Soil Fertility (Base: Good)				
Fair	−0.082*	−0.021**	−0.014***	0.872*
	(0.049)	(0.009)	(0.005)	(0.509)
Poor	−0.076	−0.019*	−0.012**	0.366
	(0.058)	(0.010)	(0.006)	(0.583)
Access to credit *(Yes = 1)*	−0.268***	−0.053***	−0.032***	1.377***
	(0.044)	(0.008)	(0.005)	(0.420)
Access to extension services *(Yes = 1)*	−0.082**	−0.011*	−0.007*	1.391***
	(0.036)	(0.006)	(0.004)	(0.381)
Used Organic Fertilizer *(Yes = 1)*	0.002	−0.003	−0.004	−0.885*
	(0.057)	(0.010)	(0.006)	(0.507)
Used inorganic Fertilizer *(Yes = 1)*	−0.243***	−0.046***	−0.029***	2.741***
	(0.040)	(0.007)	(0.004)	(0.416)
Input Subsidy *(Yes = 1)*	−0.058	−0.014	−0.009	−0.657
	(0.057)	(0.010)	(0.006)	(0.526)
Agroforestry Practice *(Yes = 1)*	−0.043	−0.006	−0.003	−0.325
	(0.043)	(0.008)	(0.005)	(0.431)
Household Size *(Persons)*	−0.076***	−0.018***	−0.012***	−0.116
	(0.014)	(0.002)	(0.001)	(0.131)
Number of adults *(Persons)*	−0.193***	−0.033***	−0.020***	0.734***
	(0.024)	(0.004)	(0.003)	(0.235)
Model Chi-square / Likelihood	1006.292***	−666393.83***	−35875.519***	48.41***
N	8178	8178	8178	8178

Standard errors in parentheses.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

Table 7
effect of crop commercialization on household poverty and dietary diversity in Tanzania.

	Poverty Incidence	Poverty Depth	Poverty Severity	Dietary Diversity
Commercialization Index	−0.064*	−0.061*	−0.031*	2.534***
	(0.035)	(0.035)	(0.018)	(0.015)
Gender (male = 1)	−0.119***	−0.091**	−0.042*	0.020
	(0.041)	(0.043)	(0.022)	(0.017)
Education Level (years)	−0.004	−0.006	−0.003	−0.002
	(0.007)	(0.007)	(0.004)	(0.003)
Marital Status				
Married (R)	1	1	1	1
Separated/Divorced	−0.020	0.018	0.016	0.033
	(0.053)	(0.054)	(0.027)	(0.022)
Widow/widower	−0.098**	−0.097*	−0.047*	0.018
	(0.047)	(0.055)	(0.028)	(0.021)
Never Married	−0.135*	−0.157	−0.071	0.008
	(0.072)	(0.098)	(0.050)	(0.032)
Land Size	0.460	0.592	0.311	−0.062
	(0.318)	(0.426)	(0.237)	(0.038)
Credit Access	−0.101***	−0.098***	−0.047**	1.534***
	(0.035)	(0.037)	(0.019)	(0.014)
Locality (urban = 1)	−0.377***	−0.433**	−0.221**	2.101***
	(0.136)	(0.184)	(0.102)	(0.020)
Age squared	−0.000	−0.000	−0.000	−0.141***
	(0.000)	(0.000)	(0.000)	(0.000)
Household Size	0.132***	0.133***	0.064***	−0.020**
	(0.018)	(0.019)	(0.010)	(0.008)
Number of adults	−0.133***	−0.138***	−0.066***	0.021**
	(0.023)	(0.024)	(0.012)	(0.010)

Standard errors in parentheses.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

Table 8
effect of crop commercialization on household poverty and dietary diversity in Nigeria.

	Poverty Incidence	Poverty Depth	Poverty Severity	Household Diversity
Commercialization Index	−0.219***	−0.266***	−0.157***	3.247***
	(0.070)	(0.061)	(0.035)	(0.014)
Marital Status				
Married (R)	1	1	1	1
Separated/Divorced		−1.966***	−1.201***	−0.015
	.	(0.082)	(0.056)	(0.029)
Widow/widower	−0.275***	−0.246**	−0.134**	−0.010
	(0.099)	(0.101)	(0.055)	(0.016)
Never Married	−0.188	−0.171	−0.097	0.031*
	(0.120)	(0.118)	(0.067)	(0.018)
Gender (Male = 1)	−0.083	−0.054	−0.026	−0.034**
	(0.108)	(0.100)	(0.055)	(0.016)
Locality (urban = 1)	−0.197***	−0.141**	−0.087**	2.038***
	(0.067)	(0.064)	(0.036)	(0.012)
Credit Access	−0.015	−0.059*	−0.041**	1.043***
	(0.042)	(0.035)	(0.021)	(0.008)
Education (years)	−0.010*	−0.006	−0.003	−0.000
	(0.006)	(0.005)	(0.003)	(0.001)
Land Size	−0.059*	−0.034	−0.018	−0.042***
	(0.036)	(0.032)	(0.018)	(0.015)

Standard errors in parentheses.
*** significant at 1 percent, ** significant at 5 percent, * significant at 10 percent.

while the remaining 6 504 farm households (about 79.5 percent) were subsistence crop producers. For Tanzania, out of the 1423 crop farming households, 471 were commercial farmers, representing 33.1 percent. Nigeria, however, had a majority of commercial farmers, as 57 percent of the 1745 farmers were commercial farmers. The statistics for Malawi and Tanzania show that the majority of the smallholder crop-growing farmers produce for self-consumption. Tanzania has the highest level of commercialization at about 50 percent, with Nigeria being the lowest at 18 percent. Further, Malawian farmers who sell their harvest reports allocate an average of 34 percent of their harvest towards sales. Average landholding sizes for commercial crop producers were significantly larger (2.32, 2.13, and 0.74 acres for Malawi, Tanzania, and Nigeria, respectively) than the 1.49, 2.08, and 0.24 acres held by subsistence farmers in Malawi, Tanzania, and Nigeria, respectively. The average age of commercial producers was lower than that of subsistence farmers, at 44 years in Malawi, 45 years in Tanzania, and 54 years in Nigeria, while that of subsistence producers was 45 years in Malawi, 47 in Tanzania, and 52 years in Nigeria. Thus, commercial producers were a little bit younger than subsistence producers.

Regarding the education variable, on average, Malawian commercial producers spent more years in school than their subsistence farmer counterparts. The average number of years spent in school by commercial farmers is 8, and it is significantly different from the average of 7 years spent in school by subsistence farmers. In Nigeria, the average number of years spent in school by commercial crop farmers was 9.1 years, while subsistence farmers spent 9.6 years.

With regards to gender, 76 percent of the commercial producers from Malawi were male-headed households, compared to 66 percent of male-headed households in the subsistence crop-producing category. In Tanzania, there were no significant differences observed with regards to the gender of the household head between commercial farmers and subsistence farmers. Whereas in Nigeria, there was evidence that 83 % of male-headed commercial households were different from the 85 % of male-headed households in the subsistence farmers' category. There were significant differences in access to agricultural extension between commercial crop farmers and subsistence producers across all three countries. About 64 percent of commercial producers had access to extension, compared to 53 percent of subsistence farmers in Malawi. Likewise, 18 percent and 12 percent, 10 percent and 61 percent of commercial and subsistence producers in Tanzania and Nigeria, respectively, had access to extensions. About 9 percent of commercial crop producers in Malawi engaged in dry-season cultivation involving irrigation farming, compared to 8 percent of their subsistence crop producer counterparts. In Nigeria, about 1.4 percent of commercial farmers practiced dry season farming compared to 3.4 percent of subsistence farmers who also cultivate in dry season, with a significant difference at the 5 percent level.

On soil fertility management, a significantly higher percentage (16 percent) of subsistence crop farmers in Malawi used relatively low-cost organic fertilizer (manure) than 10 percent of commercial crop producers. There were no significant differences in terms of organic fertilizer use between commercial and subsistence farmers in Tanzania and Nigeria. On the same note, more commercial crop producers across all countries managed to use high-cost inorganic fertilizers compared to subsistence farmers. In Nigeria, as many as 60 percent of commercial farmers apply inorganic fertilizers, while 52 percent of farmers produce for consumption only. Malawi registers slightly less inorganic fertilizer use, with 44 and 38 percent of commercial and subsistence farmers reporting usage, respectively. For Tanzania, 22 percent of commercial farmers and 15 percent of subsistence farmers used inorganic fertilizers.

In Tanzania, the majority of crop farmers were from the Lake Zone, with 24 percent being commercial crop farmers and 27 percent being subsistence farmers. More crop farmers in Nigeria were from the south-east zone, where 37.33 percent were commercial farmers and 19.14 percent were subsistence farmers. In terms of marital status, the majority (about 80 %) of crop farmers across all three countries and across the two categories were married. The least dominant category of marital status was for farmers who have never been married. In Malawi, 2 percent of both commercial and subsistence farmers were in this category. Similarly, 2.34 percent of commercial farmers and 2.94 percent of subsistence farmers in Tanzania have never been married. For Nigeria, the percentage of farmers who have never been married was 1.9 and 2.02 for commercial and subsistence farmers, respectively.

With regards to soil characteristics, a majority (53 percent) of the Malawi commercial producers perceived the quality of their soil to be good, while 34 percent of the subsistence producers perceived the soil to be good. 47 percent of commercial farmers in Tanzania had soil of good quality, while 40 percent of subsistence farmers were also perceived to have soil of good quality. About 80 percent of commercial farmers, compared to 83 percent of subsistence farmers from Nigeria, perceived the soil on their plots to be of good quality. Lastly, the actual soils were much better for the commercial producers, with a majority of 64 percent and 68 percent reporting to have between sandy and clay soils in Malawi and Tanzania, respectively.

Descriptive statistics of outcome variables

The results of the outcome variables show that all poverty indices are against the subsistence crop producers compared with commercial producers. About 38 percent of the Malawian subsistence crop farmer's fall below the consumption poverty line as opposed to the 25 percent of the commercial farmers (Head count index, FGT_0); 27 percent of Tanzanian commercial crop farmers fall below the poverty as compared to the 33 percent of subsistence farmers; and only 42 percent of the Nigerian commercial farmers fall below the poverty line as compared to the 56 percent of the subsistence farmers.

The results also show higher depth of poverty among subsistence producers, as consumption expenditure for Malawian farmers has to increase by 7 percent to push them over the poverty line as opposed to 4 percent of commercial producers. Again, consumption expenditure for Tanzanian subsistence farmers has to increase by 9 percent to push them over the poverty line as compared to the 7 percent for commercial farmers. Nigerian subsistence crop farmers would need their consumption expenditure to increase by 21 percent as opposed to the 15 percent for commercial crop farmers. Similarly, poverty severity is higher for subsistence producers than commercial producers. Further, the results of the Food Consumption Score show a significant difference in the dietary diversity between commercial crop producers and subsistence producer. This means that commercial producers are better off than the subsistence crop producers.

Effect of crop commercialization on poverty and dietary diversity

The instrumented-censored model is sensitive to validation and steps. For the instrumented-censored model, there is a need for instrument validation before estimation. Validity of the Instrument in the Censored Model.

Before providing the results of the instrumental probit and tobit models, the study first presents the choice of the instruments and their validity tests. The study uses the proportion of market-participating households per enumeration area as an instrument, following Boka (2017) and Ogutu and Qaim (2019). Participation intensity is assumed to increase individual household participation but not have an effect on household poverty and nutrition. It can only affect household welfare through household market participation. The analytical test is done in three steps: the first is the determination of the strength of the instrumental variable based on the F-statistic (Andrews & Stock, 2018); the second step is the insignificant direct correlation with the outcome's variable. In this case, the instrumental variable was regressed against the four outcome variables, and the results are in the subsequent Tables 3, 4, and 5. Endogeneity tests (Antoine & Lavergne, 2023) were later employed as a robust check and validation of the models.Table 6. Table 7.Table 8..

Instrument validation for Malawi data

The F-statistic of all the outcome variables is above 10, an indication of a strong instrument. The variables are significant at all levels based on the outcome indicators, which emphasize the zero first stage, and thirdly, the ward test rejects the null hypothesis of exogeneity.

Instrument validation for Tanzania data

Poverty incidence and SSID have an F-statistic above 10, which indicates that the instrument is strong. In contrast, poverty depth and severity have a lower than 10F-statistic, which indicates that the instrument is weak. For all the outcome variables, there is an indirect correlation, which is emphasized by the insignificant coefficients. An AR-test was adopted in this case due to the weak instrument case, and overall, all the tests are significant for all the outcomes, hence rejecting the null hypothesis of exogeneity.

Instrument validation for Nigeria Data.

Based on the F-statistic, the instrumental variable is weak. However, the variable is indirectly correlated with all the outcome variables due to the insignificance. AR-test which is more robust than Wald-test in estimating weak instrumental indicates significance for all the outcome variables providing sufficient evidence on the use of the instrument and the instrumental variable model.

Instrumental-Censored model results for Malawi data. For Malawi, all the parameters are significant at 1 percent with the differences in magnitude and direction between poverty and food security indicators. Statistically, commercialization index reduces the probability of being poor by 57.0 percent, poverty depth by 10.8 percent, and poverty severity by 6.6 percent. Commercialization significantly increases dietary diversity by 5.9 percent.

Instrumental-Censored model results for Tanzania data. In Tanzania, the commercialization index has a negative effect on the poverty indicators, all of which are significant at 10 percent. For the food security parameter, it is significant at 5 percent. Figuratively, commercialization reduces the probability of poverty incidence by 6.4 percent. A similar trend is noticed for poverty depth, with a reduction of 6.1 percent, and poverty severity, which is reduced by 3.1 percent. In terms of food security, the commercialization index improves dietary diversification by 3.4 %.

Instrumental-Censored model results for Nigeria data. Nigeria and Malawi share a similar outlook. All the considered parameters are significant at 1 percent, and commercialization has a negative effect on poverty while improving food security status. Poverty incidence and depth are the two parameters with a reduction of 21.9 percent and 26.6 percent, respectively. In contrast with Malawi, the effect of commercialization on poverty severity is 15.7 percent, not widely spaced with the other poverty parameters. Nonetheless, the food security component remains on the lower side, with an increase of 4.7 percent.

Conclusion and recommendations

This study assessed the effect of commercial crop production on dietary diversity and poverty status among smallholder crop farmers in Malawi, Tanzania, and Nigeria using the Living Standards Measurement Surveys data set of the World Bank. The outcome variables used in the study were the Foster Greer-Thompson poverty indices and the Simpson Index of dietary diversity. First, the study used a logistic regression (logit) model to determine factors that influence smallholder farm households' decisions to participate in the crop market through commercial production of the crop. The Logit results showed that among the household-specific factors used to match market participants and non-participants with a positive effect on farmer participation in commercial crop production, gender of household head (being male), number of adults in the household, dry season cultivation (irrigation farming), use of inorganic (chemical) fertilizer on the farm, marital status, especially widowhood and singlehood, and land size (farm size) were the two institutional factors that positively influenced commercial crop production. On the other hand, household size, age, use of organic fertilizer (manure), and farmers' perceptions of soil fertility as being "fair" and "poor," respectively, had a negative effect on smallholder farmers' decisions to embark on commercial crop production in Malawi. The instrumental-censored model attributes the benefits of commercialization to poverty and dietary diversity. Generally, commercialization is an addition to the income base of smallholder farmers, whereby the improvement in income base not only improves poverty status but also gives farmers an opportunity to allocate resources to other food components.

Based on the results and discussions, this study recommends that a tailor-made extension delivery system, cutting across gender divides and other social barriers among smallholder farm households, needs to be put in place to improve crop production among subsistence farmers to ensure household food security and increased income from the sale of surplus crop output. This would eventually enable smallholder subsistence farmers to graduate into commercial crop producers. Considering the small landholdings on which smallholder crop production takes place, increased output would require improvements in soil fertility and ensuring access to productivity-enhancing technologies and methods of crop production, including irrigation (dry season) farming. Agricultural extension ought to be organized to work in close collaboration with other key institutional support services, such as access to soft agricultural credit facilities and functional markets that can guarantee better pricing in the marketing of crops. Combined with a proper extension delivery system, affordable agricultural credit would enable smallholder farmers to access and expand the use of high-productivity farm inputs such as inorganic fertilizer, pesticides, and hybrid seed in the short run and capital tools, including irrigation equipment, in the long run (Narayanan, 2015). Such initiatives would increase technical efficiency in resource use on smallholder farms (Ayaz et al., 2011). These efforts would, in principle, generate increased welfare, food security, and nutritional benefits among smallholder crop producers in Malawi. The study further recommends the use of panel data in the upcoming studies.

CRediT authorship contribution statement

Wisdom R Mgomezulu: Conceptualization, Data curation, Formal analysis, Investigation, Methodology. **Moses M.N Chitete:** Formal analysis, Investigation, Methodology, Writing – original draft. **Beston B Maonga:** Project administration, Resources, Supervision. **Lovemore Kachingwe:** Data curation, Formal analysis, Software. **Horace H Phiri:** Resources, Validation, Visualization, Writing – original draft. **Mwayi Mambosasa:** Writing – review & editing. **Lonjezo Folias:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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