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Determinants of an extended metric of agricultural commercialization in Ghana

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ABSTRACT

For smallholder farmers in sub-Saharan Africa, increasing productivity and agricultural commercialization are mooted as one of the pillars for agricultural development. However, the measurement of agricultural commercialization has been restricted to the household crop commercialization index (HCCI) that focuses on crops neglecting livestock. This study develops an extended metric of agricultural commercialization named household crop-livestock commercialization index (HCLCI), which combines crop and livestock commercialization with the argument that it is superior to the overly used HCCI. Fractional regression is used to estimate the determinants of the extended metric using secondary and primary data from Ghana. Results indicate that agricultural commercialization is low when examined with the HCCI and the HCLCI. However, the HCLCI (at 26.44 % and 29.76 %, respectively, for the GLSS7 and primary data) is much lower relative to the HCCI (at 35.20 % and 38.24, respectively) but higher than the livestock commercialization index (10.93 % and 8.21 %, respectively). The underlying simultaneous factors that boost agricultural commercialization are infrastructure variables (i.e., road, market, transport, and bank), institutional variable (i.e., agricultural cooperatives) and scale of production (i.e., land endowment and crop production diversity). These findings imply that Ghana needs to invest in infrastructure and farmer institutional development to boost agricultural commercialization.

Introduction

The agricultural development economics literature acknowledges the role commercial agriculture plays in the socioeconomic development of farmers and economies [1–5]. Therefore, the agricultural commercialization literature is one of the thematic areas in agriculture that is widely discussed in both the empirical and policy circles. Central to the measurement of agricultural commercialization is the definition of the concept itself. In general, agricultural commercialization is viewed as a sustained shift from subsistent-dependent, consumption-focused production to a marketed-focused production [6–8]. Agricultural commercialization involves a structural transformation of agricultural production from consumption-led orientation to market-orientation [9]. This

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transformation does not necessarily imply a transition from the production of food crops to cash crops or the continuous marketing of output, but one characterized by intensification of the use of modern farm technology, boost in farm productivity relating to land and labour, generation of marketable surpluses and changes in incomes levels [10]. This implies that commercialization is achieved when farm production decisions are undertaken based on incentives and motivation from the market.

Market-incentive production implies that it is not only crop output that drives farm households to participate in the market but also participation is stimulated by the marketing of livestock. Indeed, livestock production is an essential part of smallholder agriculture, providing the needed liquidity to complement incomes from crop production, especially between the period of planting and harvesting crops, and during crop failures. Thus, livestock commercialization, though often ignored, is an essential part of agriculture. The assertion is that agricultural commercialization, in addition to crop output market participation (essentially the household crop commercialization index [HCCI]), involves the degree to which farm households engage the market to sell livestock. Despite this two-sided connotation of agricultural commercialization, the literature has failed to develop a comprehensive measure that simultaneously encapsulates these sides. This study aims to develop an appropriate composite measure of agricultural commercialization that encapsulates crop and livestock dynamics of agriculture – named the household crop-livestock commercialization index (HCLCI) – and estimate the determinants of this extended metric of agricultural commercialization.

The development of the extended metric is fundamentally based on existing standalone metrics of commercialization in literature – that is the HCCI and the household livestock commercialization index (HLCI). The motivation following from this contribution are two. First, the development of an extended metric of commercialization reflecting both the crop and livestock sides of commercialization would be more theoretically and empirically appealing than current standalone measures of crop and livestock commercialization. Second, a more realistic metric of commercialization has the benefit of gauging the real progress of farmers, especially smallholders, in their commercialization drive. A more realistic progress monitoring from a more realistic metric is an essential policy ingredient for evidence-based policy making geared towards stimulating commercialization of farmers.

The rest of the paper is as follows. A brief review of relevant literature follows next. This is then followed by the methodology employed. Results and discussion follow the methodology and then followed by conclusion and policy implications.

Brief review of literature

In the empirical measurement of agricultural commercialization, while Jaleta et al. [11] point to the lack of common base for measurement, the literature seems to be unanimously and fixatedly settled on the HCCI defined generally as the value of the proportion of total crop output sold relative to the value of total crop output produced. This is mathematically defined following the works of Strasberg et al. [12] and Govereh et al. [13] as:

$$HCCI_{ij} = \left[\frac{Gross\ value\ of\ crop\ sale_{hhi,year\ j}}{Gross\ value\ of\ all\ crop\ production_{hhi,year\ j}}\right] * 100 \tag{1}$$

where the estimated value of $HCCI_{ij}$ in each household ranges between 0 and 100 (i.e., $0 \leq HCCI_i \leq 100$), which implies that all of the crops produced can be sold or none may be sold. For situations where $HCCI_i = 0$, such households are described as totally subsistence-oriented households or aurtakic and households described as commercial have higher values of $HCCI_i$. A fully commercialized household is one with $HCCI_i = 100$. While the HCCI is a composite measure of all crops produced and marketed by a household, most empirical studies adapt it to measure the commercialization of single crops by individuals [14–16].

In more recent studies [17,18], the HCCI is simply restated as:

$$HCCI_i = \frac{\sum_{k=1}^{K} \overline{P}_k S_{ik}}{\sum_{k=1}^{K} \overline{P}_k Q_{ik}} \tag{2}$$

where S_{ik} is farm household i's market sales quantity of crops k valued at community average price $\overline{P}_k$, Q_{ik} is the quantity of all crops K produced also evaluated as the average community level price $\overline{P}_k$. When all crop production is sold, $S_{ik} = Q_{ik}$ and $HCCI_i = 1$, and when none is sold $S_{ik} = 0$ and $HCCI_i = 0$.

Interestingly, the wide application of the HCCI [17,2,19,5] does not imply that it is a perfect measure of commercialization. Several studies (e.g., [20,11]) stress that the HCCI does not incorporate commercialization of livestock and the input dimension of commercialization and is very prone to yielding misleading indices. In fact, the HCCI is completely inadequate in satisfying the overall definition of commercialization. Therefore, the continuous side-lining of livestock commercialization is a fundamental lacuna in the literature. Most studies just mention their relevance in passing and not launch approaches to capturing them, a situation that justifies this study.

Methodology

Data sources and descriptive statistics

This study uses the seventh round of Ghana Living Standards Survey (GLSS7) collected by the Ghana Statistical Service between October 2016 and October 2017. The GLSS7 is a household survey data that involves a nationally representative and stratified random sample of 14,009 households in 1000 enumeration areas. The data is collected on key areas including socio-demographic characteristics (e.g., education, health, employment, migration, tourism, housing conditions), household agriculture, household income/expenditure and access to financial services.

However, to provide for validation of the results from the GLSS7 dataset, the study collected primary data from northern Ghana (i.e., Northern, North-East, Savannah, Upper East and Upper West regions), which has the largest proportion of households owning or operating a farm (Ghana Statistical Service [21]). Maize production data in the 2021/2022 season was used as basis of selecting a representative sample because it is the highest cultivated crop in northern Ghana GSS [21]. In all a total of 858 farm households were sampled across the five regions through a multi-stage sampling procedure involving three stages (see Table S1 for the distribution of the sample and Fig. S1 for the map of study area in the supplementary material). The first stage was the selection of districts in each region in consultation with the regional offices of MoFA based on the objective criterion of those that had higher production of maize in the 2020/2021 production season. The second stage was an objective selection of three communities in each sampled district based on maize production level (i.e., the three topmost maize-producing communities). The final stage was the random sampling of farm households in the selected communities. A list of all farm households in each community was compiled by enumerators assigned to the respective regions. Microsoft Excel's "RAND()" function was used to draw the random sample from the respective lists. Focused group discussions involving key informants were also conducted in each community to obtain community-level data such as market, bank, extension, road, availability of public transport and agricultural cooperatives. Structured questionnaires were developed and programmed through computer-assisted personal interview.

The descriptive statistics of all variables pertaining to the samples are reported in Table 1. Most households have males as heads (75.9 % and 87.8 %, respectively for GLSS7 and primary data). The mean household size is about 6 people apiece for the GLSS7 and primary data. Farm households typically have a maximum formal educational qualification of primary school, as the mean level of education is 4.7 years and 4 years, respectively, for the GLSS7 and primary data.

The GLSS7 data indicates that 16.0 % of farm households diversified into nonfarm activities while 34.1 % received cash remittance. For northern Ghana (i.e., primary data), 16.8 % of farmers engaged in nonfarm activities with 8.5 % receiving cash remittance. The average number of crops produced by farmers is 2.3 (i.e., about 3 crops). In northern Ghana, the number of crops cultivated is slightly lower (1.8). On average, farm households own 11.2 ha of agricultural lands, However, in northern Ghana, the land endowment is lower (7.1 ha). In terms of investment in productivity enhancing inputs, the evidence shows low investments. For example, the average expenditure on agrochemicals (i.e., inorganic fertilizer, insecticides and herbicides) per hectare is GHS221.2. Expenditure on these inputs is however higher in northern Ghana (GHS390.2).

Conceptual framework

The conceptual model[1] that underpins the measurement of agricultural commercialization is presented by Fig. 1, which indicates that the production capacity of farmers is defined by the agricultural farm system which comprises the various interactions of the farm household, the public sector (government), the biophysical environment and the input market. The farm household is the pivot of the system and allocates its productive capacity gained through the numerous interactions in the farm system to the production of basic staples, high-valued or cash crops and livestock. The production of cash crops directly contributes to crop output commercialization since such crops are not readily used by farm households.

However, the output of staple crops is in most cases used to prepare important delicacies for the food needs of the household. Therefore, the relationship between the output of staple crops and the market introduces the concept of marketable surplus, defined as difference between the output produced and the consumption needs of the household.

The marketable surplus generated then serves as the basis to make market entry decisions; if the household decides to participate in the market, the participation contributes to crop output commercialization. The production and the decision to sell some livestock provides the livestock output commercialization. The crop output and the livestock output commercialization define the extended metric – household crop-livestock commercialization index. This implies that, the commercialization of farm households is defined as an amalgam of the crop and livestock and commercialization. Therefore, the measurement of commercialization should embody these two dimensions.

Empirical strategy

Measurement of agricultural commercialization

Following from the weaknesses of the previous measures of commercialization in the literature and the conceptual model presented by this study, we define a composite measure of agricultural commercialization, named the household crop-livestock commercialization index (HCLCI) and defined mathematically as:

$$HCLCI_i = \frac{\sum_{k=1}^{K}\overline{P}_k S_{ik} + \sum_{l=1}^{L}\overline{A}_l M_{il}}{\sum_{k=1}^{K}\overline{P}_k Q_{ik} + \sum_{l=1}^{L}\overline{A}_l N_{il}} \tag{3}$$

[1] It is important to note that this model is premised on a sample where there is at least a farm household producing both crops and livestock. This model breakdown when the sample is for only crop or only livestock producers. Further explanation is provided in Section "Measurement of agricultural commercialization".

Table 1
Descriptive statistics of variables.

Variable	GLSS7 (n = 7332)		Primary (n = 858)	
	Mean	S.D.	Mean	S.D.
Socioeconomic characteristics				
Gender of head (1=male)	0.759	0.428	0.878	0.328
Age of head (years)	48.74	15.57	45.44	12.92
Household size (number)	5.103	3.123	5.605	2.422
Head's marital status (1=married)	0.739	0.439	0.907	0.291
Education of head (years)	4.675	4.965	3.992	5.710
Cash remittance (1=yes)	0.341	0.474	0.085	0.279
Nonfarm engagement (1=yes)	0.160	0.367	0.168	0.374
Value of assets (GHS)	661.1	8776	7244	16123
Stop work due to illness (number)	0.700	2.354	5.362	28.29
Farm characteristics				
Number of crops produced (number)	2.383	1.641	1.795	0.791
Agric land endowment (ha)	11.17	298.5	7.106	35.41
Expenditure on agrochemicals (GHS/ha)	221.2	1054	390.2	674.7
Expenditure on hired labour (GHS/ha)	130.5	620.1	148.0	480.4
Community characteristics				
Agric extension office (1=yes)	0.145	0.353	0.371	0.483
Agric cooperatives (1=yes)	0.106	0.308	0.166	0.372
Irrigation fields (1=yes)	0.112	0.316	0.233	0.423
Perceived rain pattern (1=better)	0.567	0.496	0.685	0.465
Navigable road (1=yes)	0.676	0.468	0.605	0.489
Public transport availability (1=yes)	0.535	0.499	0.547	0.498
Mobile phone network (1=yes)	0.524	0.499	0.934	0.249
Bank (1=yes)	0.156	0.363	0.099	0.299
Market (1=yes)	0.234	0.424	0.354	0.479
Location characteristics				
Resides in rural area (1=yes)	0.830	0.376		
Lives in southern Ghana/NR (1=yes)	0.454	0.498	0.300	0.458
Lives in coastal zone/UER (1=yes)	0.113	0.317	0.273	0.446
Lives in forest zone/UWR (1=yes)	0.361	0.480	0.202	0.401
Lives in savannah zone/SR (1=yes)	0.521	0.500	0.121	0.327
Lives in Greater Accra area/NER (1=yes)	0.005	0.070	0.105	0.307

Notes: NR (northern region), UER (upper east region), UWR (upper west region), SR (savannah region) and NER (northeast region) pertain only to the primary data; physical quantities of agrochemicals (comprising fertilizer, insecticides and herbicides) and hired labour are not used because the GLSS7 data only capture amount spent; Produced by authors using the GLSS7 and Primary Data.

where $\frac{\sum_{k=1}^{K}\overline{P}_k S_{ik}}{\sum_{k=1}^{K}\overline{P}_k Q_{ik}}$ is the HCCI defined earlier in Eq. (2). The measure, $\frac{\sum_{l=1}^{L}\overline{A}_l M_{il}}{\sum_{l=1}^{L}\overline{A}_l N_{il}}$ defines a household livestock commercialization index (HLCI). M_{il} is the total number of livestock sold at the average sale price $\overline{A}_l$, N_{il} is the total number of livestock owned and L is a vector of all livestock. The HCLCI will also lie between 0 and 1 (i.e., $0 \le HCLCI_i \le 1$). If a household does not participate in both crop and livestock markets, $HCLCI = 0$, but if the household participates in one of the markets, it will be $0 < HCLCI_i < 1$. Since it is an average, HCLCI will penalize a household in two ways; first, for not participating in either the livestock or crop market sides of commercialization, and second, when participation on one side is low. Given that the HCLCI is an amalgam of the HCCI and the HLCI, it is decomposable into HCCI and HLCI. It is important to note that the HCLCI is irrelevant if and only if an agricultural sample consists of only crop producers or only livestock producers. If a household engages in only crop production (a situation more likely given the dominance of crop production relative to livestock production), the HCLCI collapses into the HCCI since $\frac{\sum_{l=1}^{L}\overline{A}_l M_{il}}{\sum_{l=1}^{L}\overline{A}_l N_{il}} = 0$. On the other hand, if a household engages in only livestock production, the HCLCI collapses into the HLCI since $\frac{\sum_{k=1}^{K}\overline{P}_k S_{ik}}{\sum_{k=1}^{K}\overline{P}_k Q_{ik}} = 0$. However, the case of only crop producers is highly unlikely in a random sample of farmers given that livestock production is an integral part of agriculture, especially for smallholder farmers. Also, it is highly unlikely for the case of only livestock producers in a random sample of farmers given the dominance of crop relative to livestock production. Thus, purposive considerations of only crop producers or only livestock producers render the HCLCI needless.

This study argues that HCLCI is more important in measuring farm households' commercialization than the standalone measures. The HCLCI is relatively more capable to identify farm households which are regarded as subsistent than the HCCI, because, in the case of the latter, a household may participate in the livestock market but not the crop market and still classified as a non-market participant (i.e., have 0 HCCI) but the former will at least capture the livestock participation. It also easily solves the criticism of the HCCI not capturing the livestock dimensions of commercialization. Again, by including HLCI, it solves the issues of misleading estimates of commercialization provided by the HCCI.

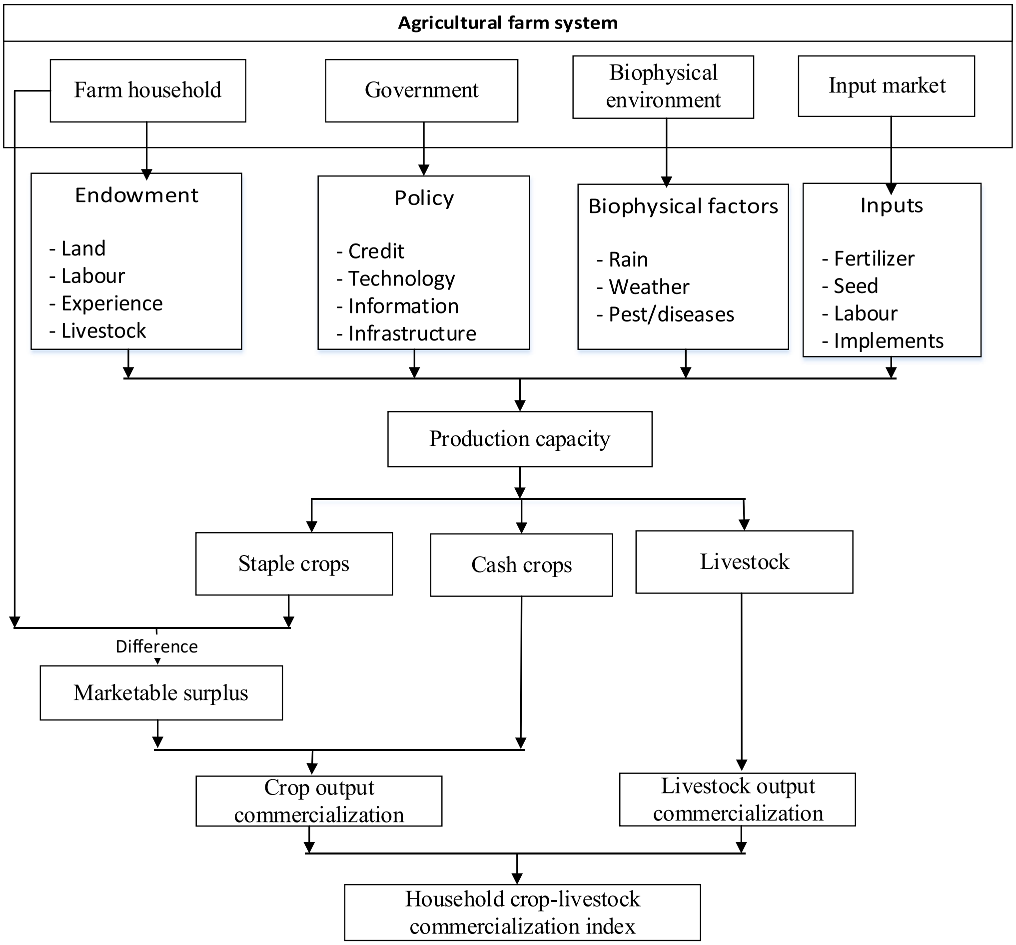

Fig. 1. Conceptual model of the household crop-livestock commercialization index.

Estimating determinants of the extended metric of agricultural commercialization

Given that the HCLCI is a fraction that yields an index from 0 to 1, implying a case where non-market participants are still included in the sample, the appropriate econometric approach to modelling its determinants is the fractional regression model. The fractional regression framework is applied to empirical studies where the outcome of interest is a fraction (i.e., either between 0 and 1 or from 0 to 1) such as proportions and rates or more generally a closed interval [0, 1]. This modelling framework has been applied to several empirical works including labour market participation rates of employees' retirement plans [22], examination pass rates of students [23], financial leverage decision of firms [24], firm capital structure [25] and efficiency score analysis [26].

The fractional response regression is a quasi-likelihood estimator that fits a model using the mean of the outcome variable conditioned on a vector of covariates using probit, logit, loglog, complementary loglog (cloglog) and heteroskedastic probit models. The general log-likelihood function for fractional response models is specified as:

$$\ln L = \sum_{j=1}^{N} w_j y_j \ \ln\left\{G\left(x_j'\beta\right)\right\} + w_j\left(1 - y_j\right) \ \ln\left\{1 - G\left(x_j'\beta\right)\right\}$$

where N represents the observations, y_j denotes the dependent variable, w_j represents the optional weights, $\ln L$ is derived through a maximization process. As indicated, $G\left(x_j'\beta\right)$ can be modelled following probit, logit, loglog, complementary loglog (cloglog) and heteroskedastic probit. For example, if the functional form underlying $G\left(x_j'\beta\right)$ is a cumulative normal distribution density function, then the probit specification can be specified as $\Phi\left(x_j'\beta\right)$. x_j represents a vector of all covariates and Φ represents the standard normal cumulative density function. Therefore, it is imperative to test the assumption about $G\left(x_j'\beta\right)$. To achieve this, the RESET test for fractional models proposed by Papke and Wooldridge [22] and specifically developed by Ramalho and da Silva [24] is used to determine the appropriate functional form (see also [25–28]).

The fractional response model is applied to fit the parameters of the following model:

$$HCLCI_i = \beta_0 + \beta_1 SEC_i + \beta_2 FC_i + \beta_3 CC_i + \beta_4 LC_i + \epsilon_i \quad (4)$$

where *SEC*, *FC*, *CC* and *LC*, respectively, represent vectors of household socioeconomic, farm, community and location characteristics that are hypothesized to influence the level of commercialization (see Table 1). The use of these variables is influenced by literature [29,15,5,30]. Socioeconomic variables such as age and education proxy for the managerial and technical capacity of farm households which are key in making farm decisions. Socioeconomic characteristics that indicate household endowment (such as assets, remittances, and nonfarm income) provide essential resources for farm investments, whiles household size is a proxy for labour. These variables have implications for commercialization. Farm characteristics provide useful information on farm investments and maintenance level that are also key for commercialization.

Community characteristics proxy for the level of social networks, community endowments and resource base, which stimulate commercialization. For example, presence of agricultural cooperatives in community, agriculture extension office in community and bank in community are used as proxies for membership in agricultural cooperatives, access to extension services and credit/financial inclusion, respectively. Location characteristics proxy for environmental and biophysical characteristics that affect production.

In the GLSS7 data, two models are estimated, including (i) a model without correcting for selectivity bias and (ii) a model that corrects for selectivity bias. The rationale for accounting for selectivity bias in the GLSS7 but not in the primary data is because, in the former case, out of the 14,009 sample, only 7,332 households produced either crop or livestock or both. Therefore, the HCLCI is constructed for only this subsample which is used for estimations. Therefore, using the subsample out of the total sample presents potential selectivity bias and must be accounted for[2]. However, in the primary data, all the 858 randomly selected households produced either crop or livestock or both, for which HCLCI is constructed for all. Selection bias will be corrected using a two-part model, which is a type of Heckman selection model where a first stage probit model will be estimated with the dependent variable of participating in the market to sell crop and livestock (i.e., 1 for the case where a household sells crop and livestock and 0 otherwise). After estimating the probit model, an inverse mills ratio will be estimated and then added to the fractional regression model to simultaneously detect and correct for selectivity bias in the second stage.

Results and discussion

Extended metric of agricultural commercialization

Before discussing the results on the extended metric of agricultural commercialization, discussion is first presented on the separate crop and livestock commercialization indices (Table 2). In the GLSS7 data, 90.52 % of the sample households produced at least one crop in the 2016/2017 production season whiles all households in the primary data produced at least one crop. A disaggregation of the data based on food and non-food crop production reveals that, expectedly, more households (82.7 % and 100.0 %, respectively, for GLSS7 and primary data) produced food crops relative to non-food crops (14.8 % and 0.12 %, respectively). Further, cereals are the major crops households produced than any of the other food categories (i.e., legumes, roots and tubers, vegetables, fruits, and cash crops) in both datasets, whiles fruits and cash crops are the least produced, respectively.

In terms of selling crop produce, 62.95 % and 74.13 % of crop-producing households sell at least one crop within a production season for the GLSS7 and primary data, respectively. As expected, more cash crops are sold relative to food crops. In addition, cash crops (cereals) are the most (least) sold by households. The estimate of the level of crop commercialization for all farm households (using the crop commercialization index) shows that 35.20 % and 38.24 % of all crops produced are sold for the GLSS7 and primary data, respectively. This represents surplus-oriented agriculture of Ghanaian farmers based on the classification of FAO [31]. Thus, Ghanaian farmers on average have not yet made the needed transition to commercial-oriented production. However, when agricultural commercialization is conditioned on only crop producers, commercialization increases to 55.91 % and 51.59 % for the GLSS7 and primary data, respectively. Expectedly, non-food crops have better commercialization than food crops, explained by the fact that the food consumption needs of households would have to be met before marketed surpluses are generated. Cash crops have higher commercialization indices than the other crop categories for all the sample or when conditioned on only crop producers. Table S2 (in the supplementary material) provides more details on crop-specific commercialization indices. For example, the evidence shows that among cereals, maize is the dominant crop produced in the GLSS7 (62.82 % of households producing) and in the primary data (74.59 % of household producing).

Now considering the livestock dimension of commercialization, almost all farm households (99.02 %) reared at least one livestock in the GLSS7 data. In the primary data, the proportion of livestock rearing (83.22 %) is lower. Thus, in Ghana, more households engage in livestock production than crop production (i.e., 99.02 % versus 90.52 %, respectively). However, considering the sale of crops and livestock, the narrative changes to a situation where more households sell crops (62.95 % and 74.13 %, respectively, for the GLSS7 and primary data) than livestock (38.25 % and 44.96 %, respectively, for the GLSS7 and primary data). The level of livestock commercialization follows a similar pattern where 10.94 % and 8.10 % are the respective commercialization indices for the GLSS7 and primary data, which are lower than crop commercialization indices. Conditioned on livestock production, the commercialization indices are higher (28.56 % and 18.01%, respectively, for the GLSS7 and primary data), but still much lower than crop commercialization. Several reasons may account for the low livestock commercialization relative to crop commercialization. A notable factor may be the

[2] The households administered agricultural production modules were not randomly assigned ex-ante to participate. Had this group been randomly assigned ex-ante, there would have been no need to worry about selectivity bias.

Table 2
Crop and livestock commercialization indices.

Product	GLSS7				Primary data			
	% producing ($n = 7332$)	% selling among producers	CI among producers	CI conditional on producing and selling	% producing ($n = 858$)	% selling among producers	CI among producers	CI conditional on producing and selling
Crops								
All	90.52	62.95	35.20	55.91	100.0	74.13	38.24	51.59
Food	82.73	54.88	31.60	50.03[a]	100.0	74.13	38.24	51.59[a]
Non-food	14.76	92.05 [a]	73.10 [a]	79.05 [a]	0.12	100.0 [a]	85.11 [a]	85.11 [a]
Cereals	70.38	41.45	29.70	52.05 [a]	83.45	62.15	36.00	52.32 [a]
Legumes	35.42	50.13	24.82	43.27	57.11	78.98	44.41	53.67
Roots/ tubers	27.50	59.52	42.76 [a]	57.94	8.86	85.53	45.60 [a]	51.87
Vegetables	9.68	55.77	39.68 [a]	56.35 [a]	0.70	100.0	55.04 [a]	55.04 [a]
Fruits	1.77	86.15 [a]	67.02 [a]	70.48 [a]	0.35	100.0 [a]	93.33 [a]	93.33 [a]
Industrial	16.58	89.06 [a]	69.85 [a]	77.60 [a]	0.12	100.0 [a]	100.0 [a]	100.0 [a]
Livestock								
All	99.02	38.25	10.94	28.56	83.22	44.96	8.10	18.01
Large	9.96	25.34	8.06	31.82 [a]	27.51	16.10	5.04	31.29 [a]
Small	56.71	36.05	10.59	27.03	66.40	26.49	7.76	21.63
Poultry	69.05	33.46 [a]	10.93	28.24	65.97	30.92 [a]	8.21	15.41

Note(s): 40 and 17 different crops are considered in the GLSS7 and primary data, respectively (see Table S2 in the supplementary material). Out of this, 32 and 16 are respectively food crops, 8 and 1 are, respectively, non-food crops. At the specific crop level, 4 apiece are, respectively, cereals, 2 and 5 are, respectively, legumes, 5 and 3 are, respectively, roots and tubers, 9 and 3 are, respectively, vegetables, 10 and 1 are, respectively, fruits, and 10 and 1 are, respectively, industrial. For livestock, 11 and 12 are, respectively, included. CI is commercialization index; "a" denotes difference between the corresponding values across the two datasets are not statistically significant at 1 % or 5 % or 10 %.

difference in gestation period between crops and livestock. Whiles the output of crops is harvested every production season, and may be produced twice in the season, it takes relatively more time for livestock to reach maturity and become available for sale. The traditional and cultural views of keeping livestock could also explain the difference. Traditionally, livestock (especially, large and small) is kept as a store of wealth for households rather than for commercial purposes [32,33]. With this view, livestock is sold when there is no alternative, especially when crops fail, and households need to smoothen consumption.

Table 3 shifts attention to the estimates of HCLCI which starts with joint production and sales of crops and livestock. Out of the sample of 7,332 farm households for the GLSS7 data, 89.54 % simultaneously produced at least one crop and livestock in the 2016/2017 season. In the primary data, 83.22 % of northern Ghana farmers jointly produce crop and livestock. Considering joint crop and livestock sales, the evidence shows that only 21.96 % of farmers jointly sold crop and livestock in the 2016/2017 production season. Though the observation is higher for the primary data (29.95 %), the level of joint crop and livestock sales in Ghana can be described as low. While the production of crop, livestock, and crop and livestock have similar statistics (90.52 %, 99.02 % and 89.54 % respectively), the same cannot be said about sales in Fig. 2, which shows that sale of crop is consistently higher than sale of livestock and joint sale of crop and livestock for the two datasets. Thus, the use of crop commercialization to measure agricultural commercialization reveals higher sale decision of farm households. However, when the livestock dimension of commercialization is accounted for, the sale decision is relatively lower.

The overall levels of agricultural commercialization among farm households (producing either crop or livestock) measured using the extended metric of commercialization developed in this study are 26.44 % and 29.76 % for the GLSS7 and primary data, respectively. The joint sale of crops and livestock is lower than sale of either crop or livestock. This implies that in a production season, farm households in Ghana sell 26.44 % (or 29.76 % using the primary data) of their joint crop and livestock output. Compared to the level of agricultural commercialization in Ghana using the crop commercialization index (35.2 %), the evidence indicates the extended metric is lower. It is however important to note that both the extended metric and the crop index show the same characterization of agriculture in Ghana (i.e., surplus-oriented agriculture) because the average indices fall within the surplus-oriented classification. The difference is however that the extended metric includes the livestock dimension of commercialization and thus captures the true state of agricultural commercialization since livestock production cannot be disentangled from agriculture. The extended metric is better in estimating the level of commercialization because unlike the crop commercialization metric which ignores engagement in livestock production, the extended metric considers it in the estimation. Therefore, the crop commercialization index overstates the level of commercialization. Accounting for farmers who jointly produced crops and livestock, similar levels of commercialization are obtained (i.e., 28.38 % and 28.26 % for the GLSS7 and primary data, respectively).

The level of commercialization is also reported based on gender in Table 3, showing gender disparity in agricultural commercialization. Male-headed households have higher commercialization ratios for the overall level of commercialization and commercialization conditioned on the joint production of crop and livestock, and the differences are statistically significant. However, when commercialization is conditioned on joint production and sale, female-headed households have higher commercialization ratios, with a statistically significant difference. The evidence on differences in commercialization based on farm size shows that large-scale farmers commercialize more than small-scale farmers when commercialization is conditioned on the joint production of crop and livestock. However, small-scale farmers have slightly higher commercialization ratios than large farmers when conditioned on the

Table 3
Indices of extended metric of commercialization.

Metric	GLSS7 %	Primary %	Significant diff. between datasets
Produced crop and livestock for all farm households ($n = 7332$ | $n = 858$)	89.54	83.22	Yes
Sold crop and livestock for all farm households ($n = 7332$ | $n = 858$)	21.96	29.95	Yes
Sold crop and livestock for crop and livestock producers ($n = 6565$ | $n = 714$)	24.52	35.99	Yes
Sold at least crop or livestock ($n = 7332$ | $n = 858$)	72.90	81.59	Yes
Sold at least crop or livestock for only crop and livestock producers ($n = 6565$ | $n = 714$)	77.94	85.01	Yes
HCLCI for all farm households ($n = 7332$ | $n = 858$)	26.44	29.76	Yes
HCLCI for only crop and livestock producers ($n = 6565$ | $n = 714$)	28.38	28.26	No
HCLCI for only crop and livestock producers and sellers ($n = 1610$ | $n = 257$)	40.44	33.92	Yes
HCLCI for only crop and livestock producers and sellers of at least crop or livestock ($n = 5117$ | $n = 607$)	36.21	33.24	Yes
HCLCI for only crop producers ($n = 6637$ | $n = 858$)	28.31	29.76	No
HCLCI for only livestock producers ($n = 7260$ | $n = 714$)	26.49	28.26	No
HCLCI for crop and livestock producers but only crop sale ($n = 4146$ | $n = 543$)	41.24	36.03	Yes
HCLCI for crop and livestock producers but only livestock sale ($n = 2581$ | $n = 321$)	30.78	29.07	No
Female headed ($n = 1766$ | $n = 105$)	24.38*	22.13*	No
Female headed (conditioned on joint production) ($n = 1520$ | $n = 75$)	26.91*	19.42*	Yes
Female headed (conditioned on joint sales) ($n = 299$ | $n = 12$)	45.33*	34.28*	No
Female headed (conditioned on at least one sale) ($n = 1170$ | $n = 67$)	36.45	34.69	No
Male headed ($n = 5566$ | $n = 753$)	27.10*	30.82*	Yes
Male headed (conditioned on joint production) ($n = 5045$ | $n = 639$)	28.83*	29.30*	No
Male headed (conditioned on joint sales) ($n = 1311$ | $n = 245$)	39.32*	33.90*	Yes
Male headed (conditioned on at least one sale) ($n = 4175$ | $n = 633$)	35.95	36.66	No
Farm size (conditioned on joint production)			
Less than 0.5 ha ($n = 1175$ | $n = 32$)	18.34	9.14	Yes
Between 0.5 and 1 ha ($n = 1013$ | $n = 52$)	24.58	13.74	Yes
Between 1 and 2 ha ($n = 1653$ | $n = 117$)	28.09	22.04	Yes
2 ha or more ($n = 2724$ | $n = 513$)	34.30	32.34	No
Farm size (conditioned on joint sales)			
Less than 0.5 ha ($n = 152$ | $n = 2$)	43.43	32.71	No
Between 0.5 and 1 ha ($n = 183$ | $n = 8$)	43.03	22.59	Yes
Between 1 and 2 ha ($n = 391$ | $n = 23$)	40.21	35.71	No
2 ha or more ($n = 884$ | $n = 224$)	39.48	34.15	Yes
Farm size (conditioned on at least one sale)			
Less than 0.5 ha ($n = 691$ | $n = 19$)	30.60	16.71	Yes
Between 0.5 and 1 ha ($n = 725$ | $n = 38$)	34.46	35.79	No
Between 1 and 2 ha ($n = 1339$ | $n = 110$)	35.00	36.00	No
2 ha or more ($n = 2394$ | $n = 533$)	39.19	37.32	No

Note(s): First sample sizes are for GLSS7 and second sample sizes are for Primary data
* denotes that differences between males and females are statistically significant; Source: Produced by author using the GLSS7 and Primary Data.

joint sale of crop and livestock.

Farm households are characterized based on their commercialization levels (Fig. 3) following the categorization of FAO [31] and Pingali and Rosegrant [34] that: (i) farmers who sell less than 25 % of their produce (i.e., $sales < 25\%$) are characterized as subsistent-oriented; (ii) farmers who sell at least 25 % but less than 50 % of their produce (i.e., $25\% \leq sales < 50\%$) are characterized as surplus-oriented; and (iii) farmers who sell at least 50 % of their produce (i.e., $sales \geq 50\%$) are characterized as commercial-oriented. The results reveal that the majority of farmers are described as subsistent-oriented farmers, irrespective of the subsamples of commercialization or data considered. For example, 59.0 %, 55.9 % and 33.7 % of farmers are subsistent-oriented farmers for all the sample farm households, a subsample of joint crop and livestock production and a subsample of joint crop and livestock sale, respectively, in the case of the GLSS7 data.

This evidence suggests that though on average Ghanaian agriculture is characterized as surplus-oriented (because the average levels of crop-livestock commercialization of 26.44 % and 29.96 % for the GLSS7 and primary data, respectively are within the surplus-oriented classification), majority of farm households are subsistent-oriented when the analysis is done at the class level.

Determinants of the extended metric of agricultural commercialization

Table 4 reports the results of the determinants of the extended metric of agricultural commercialization. The results of the RESET test for the appropriate functional form are reported in Table S3 in the supplementary material. The evidence shows that the probit specification is the only appropriate specification or functional form since its test p-value falls outside the conventional significance levels. Therefore, the models are estimated with the probit version of the fractional model. In Table 4, Columns 1 (without correcting for selectivity bias) and 2 (correcting for selectivity bias) report the results for the GLSS7 data and column 3 reports that of the primary data. The results of the probit model based on which the IMR is constructed to detect and correct for selectivity bias are reported in

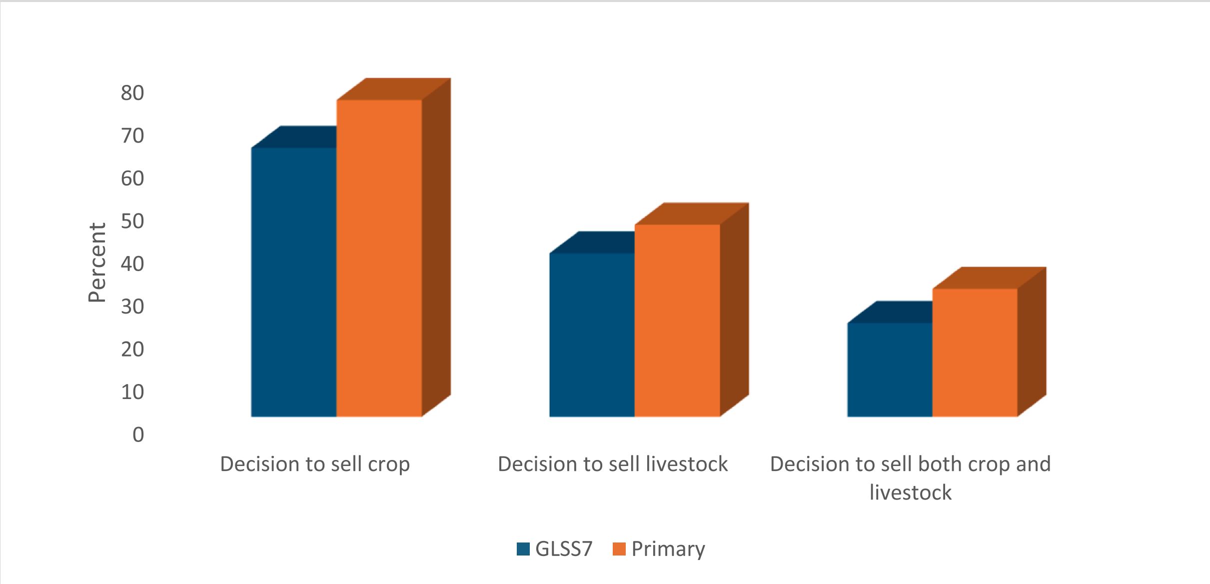

Fig. 2. Sale of crop and livestock.

Table S4, column 1 in the supplementary material. The IMR estimate is negative and statistically significant. This implies that there is indeed selectivity bias for using the subsample from the original sample and intrinsically corrects for it. The negative coefficient implies that farm households with relatively low agricultural commercialization propensity are more likely to self-select into market participation. Generally, the model without correcting for selection bias has large coefficients, implying selection bias causes upward bias of the coefficients.

The results reveal two classes of determinants – robust determinants across the GLSS7 and primary data (i.e., determinants from the GLSS7 that are validated by the determinants from the primary data in terms direction/sign and statistical significance) and determinants that are not robust across the two datasets (i.e., determinants from the GLSS7 that are not validated by the determinants from the primary data). Thus, robust determinants are simultaneously significant determinants of agricultural commercialization in the two datasets with the same or different sign. The robust determinants are ownership of nonfarm enterprise, agricultural cooperative in community, bank in community, number of crops cultivated, agricultural land endowment, presence of community market, navigable road to community, access to public transport and presence of irrigation in community. All these determinants exhibit homogeneous effects on agricultural commercialization (i.e., they have the same directional effects) except presence of irrigation in community, which has different effects for the GLSS7 and primary data.

Households that engage in nonfarm enterprises sell lower proportions of crops and livestock (specifically 7.8 % and 12.1 % less, respectively, for the GLSS7 and primary data) relative to households that do not participate in nonfarm enterprises. Given the liquidity-relaxing and lost-labour transmission channels between nonfarm engagement and agricultural commercialization presented in the literature [35,36], this observation is consistent with the latter. The lost-labour transmission channel argues that the allocation of household labour to nonfarm activities yields extra income that is further invested in nonfarm activities and household consumption dampens agricultural investments ultimately reducing agricultural commercialization [35]. Thus, nonfarm engagement in this regard competes for labour and investment with agricultural production and commercialization. This finding corroborates the evidence reported by Sekyi et al. [16] which suggests that engagement in nonfarm activities through the ownership of nonfarm business equipment by Ghanaian farm households reduces commitment to production and commercialization.

Farm households which have agricultural cooperatives in their communities tend to be more commercialized in crop and livestock produce relative to those in communities without cooperatives. Specifically, presence of cooperatives respectively increases commercialization by 31.1 % for the GLSS7 and 29.2 % for the primary data. These findings meet expectation and corroborate several studies in the literature [14,37–39]. Agricultural cooperatives provide participants with the relevant farming techniques that help increase farm production and raise marketable surpluses [40]. Farmer-based organizations may also facilitate access to productivity-enhancing inputs [41]. Agricultural cooperatives provide members with collective bargaining power that helps obtain favourable market prices and thus stimulate commercialization [42]. Cooperatives also help in providing relevant market information that stimulates commercialization. Aku et al. [37] noted that farmer organizations improve farmer welfare by improving market access, reducing transaction costs to agricultural marketing, and providing social capital.

Farm households that reside in communities with banks or financial institutions sell respectively 44.7 % and 25.5 % more in crop and livestock produce than farmers who reside in communities without any financial institution for the GLSS7 and primary data. The presence of financial institutions serves as a proxy for financial inclusion, and the role of financial inclusion in the agricultural commercialization literature is clearly emphasized [14,43,16]. For example, Abu and Issahaku [14] report that financially included

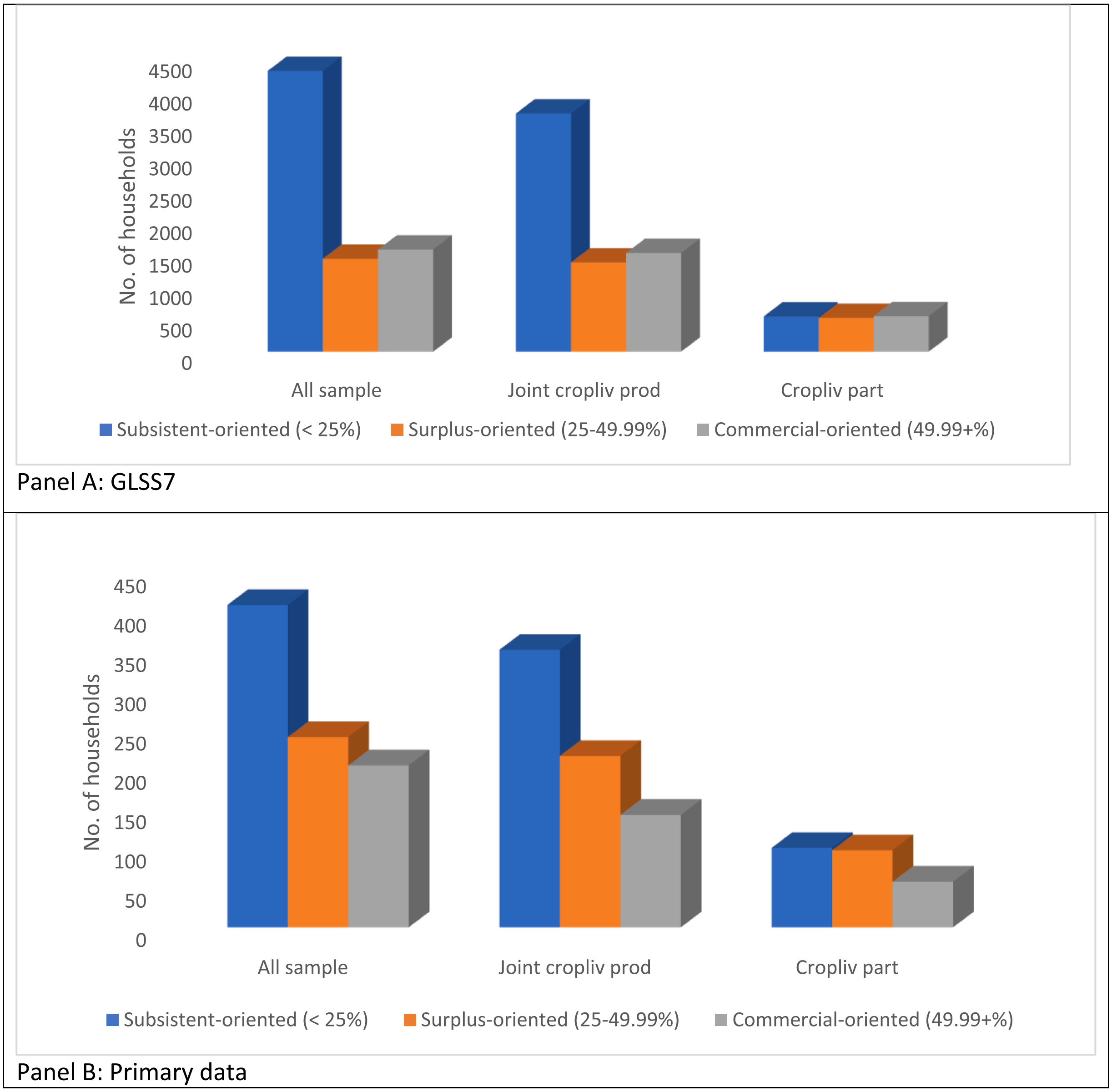

Fig. 3. Categorization of farmers based on degree of commercialization.

farmers sell higher quantities of their farm produce than financially excluded farmers in Ghana. They argue that the presence of financial institutions serves as an advertisement for farmers to participate in financial services (e.g., credit and savings). Some literature [14,44,16] have shown how access to credit stimulates agricultural commercialization.

Access to infrastructure is a key stimulant of joint crop and livestock commercialization. Farm households from communities with designated markets, navigable roads and with access to public transport tend to be more commercialized in crop and livestock produce relative to farm households without this infrastructure. The presence of market increases commercialization in crop and livestock produce by 65.2 % and 31.0 %, respectively, for the GLSS7 and primary data. Access to navigable roads increases commercialization in crop and livestock by 39.8 % and 50.4 %, respectively, for the GLSS7 and primary data, while access to transport increases commercialization in crop and livestock produce by 13.9 % and 43.3 %, respectively, for the GLSS7 and primary data. These findings are expected and corroborate several earlier findings in the literature that emphasized the stimulating role of infrastructure in increasing agricultural commercialization [14,45,43,16]. Markets, roads and transport are productivity boosters as they facilitate technology adoption [46–48]. Moreover, markets, roads and transport availability directly influence commercialization as they further reduce transaction costs in selling farm produce.

The scale of production is important in boosting agricultural commercialization as the number of crops produced and agricultural land endowment are positive determinants. This implies that diversified crop production and large-scale production increase

Table 4
Determinants of an extended metric of agricultural commercialization.

Variable	Dependent variable: HCLCI		
	GLSS7		Primary
	(1) Fractional regression	(2) Fractional regression (IMR)	(3) Fractional regression
Sex of head	0.047	0.029	0.056
	(0.034)	(0.035)	(0.070)
Age of head	-0.001	-0.001	-0.005***
	(0.001)	(0.001)	(0.002)
Household size	-0.017***	-0.019***	0.006
	(0.004)	(0.004)	(0.010)
Locality of household	0.467***	0.395***	
	(0.065)	(0.067)	
Marital status of head	-0.024	-0.015	-0.199**
	(0.029)	(0.030)	(0.078)
Years of education of head	0.000	0.001	0.005
	(0.003)	(0.003)	(0.004)
Received cash remittance	0.016	0.016	0.020
	(0.027)	(0.026)	(0.069)
No. of days stop work due to ill-health	-0.003	-0.002	0.001
	(0.004)	(0.004)	(0.001)
Ownership of nonfarm enterprise	-0.091***	-0.078**	-0.121**
	(0.031)	(0.032)	(0.060)
Agric cooperative in community	0.253***	0.311***	0.292***
	(0.063)	(0.065)	(0.073)
Bank in community	0.484***	0.447***	0.255**
	(0.049)	(0.048)	(0.102)
Mobile phone network in community	0.050	0.027	-0.825***
	(0.050)	(0.048)	(0.116)
Agric extension office in community	0.100**	0.068	0.169***
	(0.047)	(0.048)	(0.055)
Irrigated fields in community	0.314***	0.456***	-0.124**
	(0.074)	(0.078)	(0.056)
Perceived rain pattern in community	-0.064	-0.054	0.001
	(0.042)	(0.040)	(0.078)
Log of expenditure on agrochemicals	0.012*	-0.001	-0.002
	(0.007)	(0.007)	(0.009)
Log of expenditure on hired labour	0.012**	0.007	-0.007
	(0.006)	(0.006)	(0.009)
No. of crops produced	0.056***	0.024**	0.078***
	(0.012)	(0.011)	(0.028)
Log of total value of household assets	-0.007	-0.004	-0.055***
	(0.005)	(0.005)	(0.010)
Log of agric land endowment	0.067***	0.064***	0.139***
	(0.020)	(0.020)	(0.028)
Market in community	0.622***	0.652***	0.310***
	(0.044)	(0.044)	(0.051)
Navigable road to community	0.752***	0.398***	0.504***
	(0.112)	(0.132)	(0.075)
Access to public transport	0.254***	0.139**	0.433***
	(0.081)	(0.059)	(0.080)
Household in southern Ghana/NR	-0.125**	-0.115**	-0.640***
	(0.054)	(0.053)	(0.090)
Household in coastal zone/UER	-0.052	-0.117	-0.767***
	(0.107)	(0.112)	(0.084)
Household in forest zone/UWR	0.106	0.014	-0.795***
	(0.103)	(0.108)	(0.116)
Household in savannah zone/SR	-0.205*	-0.297**	-0.695***
	(0.116)	(0.121)	(0.108)
Inverse mills ratio		-0.305***	
		(0.060)	
Constant	-2.108***	-1.322***	0.438**
	(0.129)	(0.203)	(0.194)
Observations	7332	7332	858
F-statistic/Wald chi-square	98.995***	96.612***	1194.111***

Note(s): * $p < 0.1$
** $p < 0.05$

*** $p < 0.01$; HCLCI is the household crop-livestock commercialization index; Standard errors in parentheses; Survey weights are applied in estimating the GLSS7 data; Columns 1 and 3 are results without correcting for selectivity bias, while column 2 corrects for selectivity bias; Source: Produced by the author using GLSS7 and Primary Data.

commercialization. An additional crop produced increases commercialization in crop and livestock by 2.4 % and 7.8 %, respectively, for GLSS7 and primary data. On the other hand, an additional hectare of land endowment increases commercialization in crop and livestock by 0.064 % and 0.139 %, respectively, for the GLSS7 and primary data. When farm households diversify crop production, the opportunity to increase marketed surplus increases, boosting increase commercialization. Tesfaye [49] reports that crop diversification improves farm income (essentially through commercialization). This finding corroborates the evidence of Sekyi et al. [16] who reported increased commercialization when farm households produce multiple crops. Agricultural land endowment can increase the scale of production thus increasing output and marketed surplus. This is consistent with the evidence of Abu and Issahaku [14], who reported that agricultural land endowment provides the potential to expand farm sizes. The results also corroborate studies that observed that large farm sizes and/or land endowment are associated with increased agricultural commercialization [43,30,16].

For the non-robust determinants, the results reveal that an additional household member reduces the level of commercialization in crop and livestock by 1.9 % for the GLSS7. This is consistent with the commercialization literature [29,45,39,43] that explains that more household members increase food consumption and reduced marketable surplus. The primary data shows that an additional year of a farmer reduces commercialization in crop and livestock by 0.5 %. This is consistent with the findings of Sekyi et al. [16], Abu and Issahaku [14], Abu et al. [50] and Alhassan et al. [45] that explain that older farmers may be more concerned with meeting food security needs of households than selling.

More endowed farmers (i.e., in terms of assets) tend to be less commercialized in the primary data. This may suggest that endowed farmers prioritize food security over selling, since they already have the liquidity to meet household needs. This corroborates the finding of Fafchamps and Hill [51] who reported that wealthy farmers have a lower probability of selling coffee at the market, explaining that the higher shadow value of their time may be responsible for this behaviour. The primary data further indicate that farmers who reside in communities with agricultural extension offices have higher commercialization ratios implying that extension services provide technical knowledge that boost productivity and thus more marketable surpluses [14,39,43]. Key unexpected evidence relates to the negative coefficient of mobile phone network in community in the primary data, which is a proxy for information access. This means that farmers who reside in communities with mobile phone network sell low proportions of crop and livestock relative to their counterparts. Perhaps, the changing trends in the use of mobile phones for other activities (e.g., games, gambling and other entertainments) may explain this contradictory observation.

Beyond the estimates of the baseline determinants of agricultural commercialization, some additional models were estimated to provide robustness. The first robustness model estimates the determinants using an alternative specification that is similar to the fractional regression model – the Tobit model (truncated from both below and above). The results are reported in Table S5 in the supplementary material. The Tobit estimates are similar to the fractional regression estimates. Therefore, the fractional regression model is generally robust to similar alternative specifications. However, the main difference between the fractional and Tobit results here is that the fractional regression estimates are consistently larger in magnitude relative to the Tobit estimates.

The second robustness model estimated the determinants of agricultural commercialization on the subsample of households who sold at least 25 % of their crop and livestock output. The rationale for this consideration is the observation by FAO [31] that farmers who sell at least 25 % of their produce are defined as surplus-oriented (sales between 25 and 50 %) or commercial-oriented (sales of at least 50 %). This estimation drops the sample of farmers characterized as subsistent-oriented (sales less than 25 %). Table S6 in the supplementary material presents the results (Table S4, columns 2 and 3, reports the probit models for estimating IMR for the GLSS7 and primary data, respectively). Generally, the estimates of the subsamples from the two datasets are similar to the estimates of the respective full samples. The only exceptions are that age of farmer, expenditure on agrochemicals, expenditure on hired labour, perceived rain pattern and extension are significant determinants in the GLSS7 subsample results unlike in the main results.

The third robustness model (Table S7 in the supplementary material) estimated the determinants of crop commercialization and livestock commercialization separately and compared these with the extended metric. It is revealed from the comparison that the determinants of agricultural commercialization from the three separate measures (i.e., HCLCI, HCCI and HLCI) are generally similar in terms of robust determinants across the measures. However, the key difference between the HCLCI determinants on the one hand, and the HCCI and HLCI on the other hand is that the HCLCI determinants are generally larger in coefficients than the estimates of determinants from the HCCI and the HLCI. This implies that the HCCI and HLCI underestimate the effects of the determinants of agricultural commercialization.

Finally, the results of the determinants disaggregated by household size are presented in Table S8 in the supplementary material. All households with sizes less than the median household size of 5 in both the datasets are categorized into one class (referred to as small household size) and those with sizes more than or equal to the median household size are categorized into another class (referred to as large household size). Generally, based on the direction of influence of variables, there is little evidence of differences between small and large households. For example, among the only four variables which are simultaneously significant in the two datasets across small and large households, namely, agricultural cooperatives in community, navigable roads to community, market in community and access to public transport, there is no evidence of differences in commercialization between small and large households. Further, there is no evidence of differences between small and large households based on variables that are simultaneously significant in GLSS7 (i.e., locality and ownership of nonfarm enterprise) and primary data (i.e., marital status, mobile phone network in community, presence of extension office in community and agricultural land endowment). However, the differences between small and large households are observable in terms of the magnitude of influence. Consistently, small households have higher commercialization ratios relative to large households. For example, small households in communities with agricultural cooperatives sell 36.6 % and 51.5 % of their produce, respectively for the GLSS7 and primary data relative to 24.8 % and 16.5 % of large households, respectively for the GLSS7 and primary data.

Conclusion and policy implications

This paper developed and presented evidence on an extended metric of agricultural commercialization that amalgamates crop and livestock commercialization indices and estimated the underlying factors that determine it. Agricultural commercialization is low when examined with the much-used HCCI and the HCLCI. However, the HCLCI is much lower relative to the HCCI but higher than the HLCI. The underlying simultaneous factors that boost agricultural commercialization are infrastructure variables (i.e., navigable road, market, availability of transport and bank), institutional variable (i.e., agricultural cooperatives) and scale of production (i.e., agricultural land endowment and number of crops produced). The study concludes that agricultural commercialization is characterized as surplus-oriented in Ghana, and the HCLCI is a better measure of agricultural commercialization than the HCCI because the latter overstates the level of agricultural commercialization relative to the former and livestock production is an essential part of agriculture and cannot be disentangled from it. It further concludes that the main drivers of market centre-focused commercialized production of crops and livestock are infrastructure, farmer institutional characteristics and scale of production (i.e., crop production diversity).

To induce a shift from subsistent focused agricultural production to commercial oriented one, investing to boost infrastructure in agricultural producing areas – which are basically rural – cannot be ignored. Rural infrastructure remains a challenge in Ghana. Commercialized agriculture can be stimulated if the government of Ghana aggressively embarks on a rural infrastructure investment. One way to achieve this is to meet the Comprehensive African Agriculture Development Programme (CAADP) commitment of annually allocating 10 % of the national budget to agriculture. Ghana is currently not meeting this commitment. From 2003 (when CAADP's commitment was declared) to 2021, Ghana's average share of agriculture expenditure of total government expenditure is 3.8 % according to data from the Regional Strategic Analysts and Knowledge Support System[3]. Meeting this commitment will provide extra financial resources to make the needed investments. Moreover, strategies and interventions that promote the effectiveness and efficiency of farmer institutions by a collaboration and cooperation of the Ministry of Employment and Labour Relations under which the Department of Cooperatives operates and MoFA are needed. For example, the Department of Cooperatives and MoFA should be empowered to co-produce a functional and active digital register of farmer organizations that provides the platform to track, monitor, and deliver relevant group efficiency information, trainings, and other essential services such as government-subsidized inputs.

Despite the improvement of the HCLCI over the HCCI, there are still some lingering challenges with it. For example, it does not address the challenge of ignoring subsistence needs, a situation that plagues the HCCI too. For example, it overlooks the fact that households prioritize their subsistence needs before selling surplus crops. Also, it does not provide an indication of distress sales that may arise from, example, poor crop yields, financial pressures and adverse economic conditions. Another weakness of this study is not examining the welfare implications of the extended metric on farm households, a situation that further studies could explore.

Ethical declaration

Ethical clearance, with number ECBAS 080/20-21, was obtained from the Ethics Committee for Basic and Applied Sciences (ECBAS), University of Ghana for the collection of primary data. All participants signed a consent to participate form indicating their willingness to be interviewed.

Data availability statement

The data used for this study are available from the corresponding author upon request.

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CRediT authorship contribution statement

Benjamin Musah Abu: Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing – original draft, Writing – review & editing. **Daniel Bruce Sarpong:** Methodology, Supervision, Writing – review & editing. **Yaw Bonsu Osei-Asare:** Methodology, Supervision, Writing – review & editing. **Charles Yaw Okyere:** Methodology, Supervision, Writing – review & editing. **Taeyoon Kim:** Methodology, Supervision, Writing – review & editing.

[3] The data can be found at http://www.resakss.org/. Data accessed on 15/01/2024.

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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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sciaf.2024.e02412.

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