Heliyon 9 (2023) e19573

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Assessing financial literacy and food and nutritional security relationship in an African country

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ARTICLE INFO

Keywords:
Financial literacy
Food security
Endogenous treatment regression
Householder
Ghana

ABSTRACT

This study investigates the relationship between rural Ghanaian household food and nutrition security and financial literacy. We used the endogenous treatment regression (ETR) technique to address the analysis's potential selection bias problem. The findings of our study demonstrated a beneficial relationship between food and nutrition security and financial literacy. According to further studies, the relationship between food security and financial literacy is heterogeneous. Our findings may have some ramifications for promoting food and nutritional security while preserving rural development methods.

1. Introduction

Accomplishing the zero hunger agenda of the Sustainable Development Goal (SDG) on a local, national, and international scale has proven to be extremely difficult, with about 927.6 million people experiencing food insecurity worldwide in 2020 [1–3]. The Food and Agriculture Organization report in 2021 estimated that nearly 60% of Africa's population was affected by moderate to severe food insecurity, with 26% experiencing severe food insecurity in 2020 [3]. Africans are likely to experience the severe blunt of food hunger and its impact on household wellbeing if innovative strategies are not established to overcome the likely surge in food insecurity in the continent. Therefore, most development agendas now incorporate food and nutrition security objectives, especially, in Africa.

The studies of Tuholske et al. [4], Lokossou [5], and Annim and Frempong [6] have identified that food and nutrition security occurs "when all people, at all times, have physical, social, and economic access to enough food that is safe and nutritious and satisfies their dietary needs and food choices for an active and healthy life". The research of [6] has also defined food and nutrition security as a situation in which everyone has access to enough food (in terms of quantity, quality, safety, and socio-cultural acceptability) at all times to promote a healthy and happy lifestyle. Although nutrition security depends on having an appropriate quantity of a variety of food and a number of other criteria, food security focuses largely on the availability of food, economic and physical access to food, and the stability of food sources [3].

Factors contributing to food and nutritional insecurity at the household level in developing nations, including Ghana, have been examined by researchers; nevertheless, poor financial and economic wellbeing of households is considered a major factor [3,6,7].

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https://doi.org/10.1016/j.heliyon.2023.e19573
Received 8 December 2022; Received in revised form 7 August 2023; Accepted 26 August 2023
Available online 28 August 2023

Although income is proven to ensure food security, Coleman-Jensen et al. [8] study showed that high-income earning households also experience food insecurity. Thus, it is one thing creating wealth and another thing improving the wealth created to smooth household consumption continuously. Therefore, it is essential to have a relook at the assessment of food insecurity determinants from perspectives that can help improve householders' financial skills and knowledge to patronize financial products and services (an enhancer of household welfare), hence, smoothing consumption. While, in developing countries, accessing financial services could serve as a channel for enhancing household wellbeing, approximately 2 billion adults are not financial market participants (unbanked) [9]. This menace is due to several challenging factors from the supply and demand sides in the financial market; nevertheless, one major attribute emanating from the demand side is low financial literacy [10–12].

According to Klapper and Lusardi [13], financial literacy refers to "an individual's ability to conceptualize or develop economic and financial understanding and make knowledgeable decisions about financial planning, wealth accumulation, debt, and pensions management." The implication gathered from the definition is that financially illiterate individuals are more likely to demonstrate poor financial decisions and behaviors [12,13], i.e., less likely to patronize financial services, which can affect their livelihood. Those with broad knowledge about financial concepts, products and terminologies seek suitable financial information to optimize their wants and incomes [13]. As financially literate people create wealth with their financial skills and knowledge, they become less vulnerable to food insecurity, all other thing remaining constant. Despite the potential connection between financial literacy and food safety, existing studies have marginalized financial literacy in the food and nutrition security development and transition literature in developing countries like Ghana. We add to literature using data from Ghana.

Using Ghana as an analytical lens presents an interesting discussion. About 1.5 million people in Ghana are considered food insecure. Also, micronutrient deficiencies persist at all stages of life due to undernutrition, overnutrition, and malnutrition in the country [14,15]. Malnutrition in Ghana is having negative impact on both economic and human development [16]. Since the causes are multifaceted and complex, establishing food and nutrition security is fraught with difficulties. These issues have consequences in the areas of poor economic growth, health, education, cleanliness, and environmental exploitation. Also, the majority of rural populations lack financial literacy, according to studies by Ankrah Twumasi et al. [17]. Hence, assessing financial literacy determining attributes by rural households and financial literacy-food and nutrition security association is beneficial and on time for the national government's policy designing programs geared towards the agenda of curbing poverty and hunger.

The marginal contributions deduced from this study are as follows. First, considering previous literature examining food and nutrition security determinants, studies exploring the connection between financial literacy and food and nutrition security in an emerging economy, particularly a Sub-Sahara Africa (SSA) nation are few. However, it is imperative examining this phenomenon, looking at the potential association between financial literacy and food and nutrition security. Second, the study analyzes the connection between financial literacy and food and nutrition security heterogeneously, using technology adoption as a yardstick to gain insight into policy design. Third, the potential issue of endogeneity related to financial literacy, which is mostly ignored by researchers, is taken into account using fitting econometrics methods to provide consistencies and validity in the research findings.

The remainder of the essay is divided into the following sections, with Section 2 presenting the theoretical analysis. The methodology was then explained in Section 3. The study's findings and discussions were provided in Section 4. Finally, Section 5 summ arized the study's findings and their implications for policy.

1.1. Theoretical analysis

Financial literacy and how it influences farm household livelihood, a food and nutritional security contributor, can be analyzed theoretically if we follow the expanded version of the farm household model recommended by Fernandez-Cornejo et al. [18]. The model suggests that regarding a budget constraint, farm householders' utility can be characterized as a function of welfare development anytime an individual maximizes utility. In the model, the household is assumed to maximize a unitary household utility function, and this can be presented as shown below:

$$Max\ U = U\ (G, W) \tag{1}$$

where $U =$ utility , $G =$ normal goods, and $W =$ household welfare development functions for a household (see equation (1)). We assume that consuming normal goods and ensuring household welfare development (e.g., improving food and nutrition security) is subject to budget constraint, which is a function of income (I) and financial literacy (FL). Thus, with enhancement in income and financial literacy, householders can patronize normal goods (G) connected with a price (P_g) and increase their daily food consumption with a price (P_w). Given this assumption, a new model is generated (equation (2)):

$$P_g G + P_w W \leq I + FL \tag{2}$$

Based on the study's objective, the household food and nutrition decision may be expressed as follow (equation (3));

$$Food\ and\ Nutrition\ security = f\left(FL, I, P_g, P_w\right) \tag{3}$$

This framework is consistent with concepts and studies that show a direct connection between financial literacy and household wellbeing. Ankrah Twumasi et al. [19] and Xu et al. [11] contend that financial literacy is necessary for making wise financial decisions about the best time, place, reason and ways to make investments to build wealth and raise the standard of living of households (e.g., smoothing daily food consumption patterns, increasing purchasing power, and establishing businesses). People who are financially literate also long for access to accurate financial information; as a result, they are likely to use financial products and services to

increase their financial security or income, which usually enables them to meet their basic demands, including food [13,20]. Moreover, a financially literate peasant who has the ability to utilize financial services (such as secure credit, own an account and obtain an insurance policy) could potentially be capable of acquiring inputs for farming [21] and embracing risky but lucrative agricultural technologies [22], which can result in food and nutrition security through improved farm productivity and household income. A better level of financial literacy is likely to impact one's income, allowing households to acquire sufficient funds and, as a result, helping them attain a steeper indifference curve. When all other factors are held constant, a financial literate person may create wealth to consume normal goods while ensuring food and nutrition security.

Referring to equation (3), the direct financial literacy-food and nutrition security nexus is inhibited by failure in the market of finance, mainly due to increase in transaction costs [23]. In accordance with Han [24], we divided these transaction costs from the demand side into various groups such as financial, in-kind, and psychic. Transportation expenditures to participate financial literacy seminars and the expenses imposed by financial specialists to gain financial knowledge are among the expenses arising from the financial cost category. In-kind fees include the opportunity cost of the effort spent looking for an analyst in finance as well as the scheduling or period of wait at the expertise office. The emotional burden of applying newly learned financial information and skills to real-world situations is the psychological cost. According to the aforementioned research, individuals who associate with to financially literate people are more likely to grow their financial literacy skills than those with no association [17]. Given the fact that transaction costs are included, financial literacy becomes a potential endogenous variable; as a result, evaluating equation (3) using models incapable of dealing with endogeneity is likely to result in inconsistent estimates. Because of the transaction costs divisional structures, it is difficult to account for them in the model. Thus, there is a difficulty with endogeneity brought on by omitted variable issues. Although we can take into account the expenses of the financial transaction's costs, it is difficult to account for the other two costs (in-kind and psychic). The instrumental variable (IV) estimate method has been employed in earlier research studies to examine the relationships between financial literacy and welfare augmentation [25], the practice of gambling [26], and financial inclusion [27]. In line with these academics, we likewise used an IV estimation strategy, with our instrument being "financial education" (i.e., whether the household head has a relative/friend with an economics/financial education background). The methodology section explains the IV approach's specifics. We test the validity of the theoretical claim that securing a higher financial literacy may positively affect food and nutrition security among farm households and, if so, to what extent?

2. Methodology

2.1. Empirical model selection

The goal of the study is to show that financial literacy is a potential endogenous variable because agricultural households might choose to improve their financial literacy capacity. Therefore, householders' decisions to increase their degree of financial literacy are not arbitrary; rather, they are impacted by a number of obvious and subtle factors. We used the endogenous treatment regression (ETR) model to solve this endogeneity problem linked to financial literacy to assure reliable and consistent estimates in this investigation. The ETR is preferred since it addresses a dummy treatment endogenous variable due to its advantages over other econometric methods like regression adjustment (RA) estimator, propensity score matching (PSM), inverse probability-weighted with regression adjustment (IPWRA), and inverse-probability weighting (IPW) estimator [28]. Thus, the ETR model corrects for biases emanating from factors that cannot unobserved [29,30]. While endogenous switching regression (ESR), a popular estimate model that considers both observable and latent variabilities, can address both types of heterogeneities, it cannot assess the treatment's direct impact on the outcome variable [29]. The ESR method mostly depends on estimations of the average treatment effects. Nevertheless, we cannot calculate the direct effects of financial literacy on the predicted variables (HDDS and HFIAS) using the ESR model rather than ETR [31]. As a result, the study's analysis was conducted using the ETR technique.

2.1.1. Endogenous treatment regression model

The ETR method employs a double-stage computing procedure. We can find the respondents features and other elements that influence their decision to build financial literacy status in first stage, where the household's decision to raise financial literacy is stated as a standard binary choice model. Now, we made the assumption that each household/householder will yearn to improve their financial literacy level only after carefully weighing the potential benefits of doing so. A latent variable with the specification $FL_i^* = U_{i1}^* - U_{i0}^* > 0$ represents the gain realized from being financially literate where U_{i1}^* and U_{i0}^* denote literates and illiterates accordingly. The error term, other qualities, and observable householder/household parameters are used to analyze this latent variable, IU_i^*, It is stated as;

$$FL_i^* = \beta Z_i + \mu_i \; FL_i = \begin{cases} 1 \; if, FL_i^* > 0 \\ 0 \; if, otherwise \end{cases} \tag{4}$$

where FL_i indicates the status of financial literacy (1 = literate, and 0 = illiterate) (equation (4)). A vector of independent factors for the outcome variables and internet usage status makes up the variable Z_i (HDDS and HFIAS), which includes characteristics of the households as well as other determinants such as the years of school attainment, gender, age, number of working children, geographical location, regional dummies and many more; μ_i stands for a randomly chosen extraneous term, and β indicates the parameters for determining the control variables.

The second phase involves defining the dependent variables in regard to their interactions with endogenous (financial literacy) and

explanatory (households and other factors listed in equation (4)) variables. The estimation formula appears as

$$Q_i = \varnothing FL_i + \gamma Z_i + v_i \quad (5)$$

Q_i denotes the nutritional and food security factors (Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Score (HFIAS)) for household i; FL_i and Z_i denote a vector of intrinsic and extrinsic factors, accordingly, as seen in the first equation; whiles $\varnothing$ and γ denotes dimensional limits to be estimated; and v_i is a random disturbance term. A maximum likelihood estimator was used to jointly estimate Equations (4) and (5) which helped in estimating the correlation coefficients between the error terms μ_i and v_i in equations (4) and (5) respectively, i.e., $\rho_{\mu v}$. The $\rho_{\mu v}$ coefficient must be significant or negligible in order to claim that endogeneity connected to financial literacy is either present or absent [28]. When the $\rho_{\mu v}$ sign is positive, there is a strong selection bias, suggesting that households that have higher (lesser) than average HDDS(HFIAS) decisions to acquire financial education (financially literate) are more likely to expand, while households with lesser (greater) than the average HDDS (HFIAS) are more likely to decline.

Additionally, some variables must be used as instruments in order to apply the ETR model. As a result, at least one explanatory variable in equation (5) that influences Z_i should be left out. This particular variable should be highly associated with financial literacy status but its connection with the HDDS and HFIAS should be indirect. Following [19], the instrument selected for the study is "education background" (i.e., "whether the household head has a relative/friend with an economics/financial education background"). The chosen instrument impacts financial literacy, but it has no effect on the HDDS and HFIAS variables, implying that it is suitable for our estimation method. The study also used a Pearson correlation coefficient analysis to check the chosen IV's reliability. Although there is a positive and statistically significant relationship between both the IV and the treatment variable (financial literacy), as illustrated in Table A1 in the appendix, there is little to no relationship between the IV and the outcome variables (HDDS and HFIAS), demonstrating that the intrument used in this research is the proper one.

2.2. Data source and measurement of key variables

The target population for the study was Ghanaian farm householders (farmers). We used an interview arrangements method for the data collection from June to August 2018. In order to reduce questionnaire errors, we first conducted a pretest survey. Next, we employed a thorough face-to-face interview to determine the study's sample size. For the interviewing process, we had assistance from capable research assistants. The survey was used to collect information for analysis on food and nutrition consumer behavior, socioeconomic traits of farmers and farm households, financial literacy levels, and other pertinent study objectives.

The multi-stage sampling method was utilized in the investigation. In the initial phase, four regions were chosen: Northern, Bono East, Ashanti, and Western. According to the Ghanaian poverty mapping research, the majority of the country's poor people reside in these four regions [32]; as a result, there may be a high probability that they have food and nutrition insurance. Additionally, farmers make up the bulk of the people in these rural areas. Premised on the agro-ecological zone, six districts were chosen from each of the four regions for stage two. In the Northern region, we chose the districts of Kpandai and Nanumba South; for the Bono East region, the districts of Techiman North and Atebubu Amantin, and in the Western and Ashanti regions, we chose the districts of Prestea-Huni Valley and Asante Akim South. We chose three localities in each district, making a total of 18 communities for this current study (Details of communities sampled are presented in Fig. A2). The last stage was randomly choosing 20 to 30 farmers from each hamlet. Ultimately, 493 farmers were made accessible for the study after thoroughly reviewing the submitted questionnaires. Let us note that we verbally obtained an informed consents from the participants and they agreed to participate in the data collection. Thus, the issues of confidentiality and anonymity were adequately considered. For our analysis, we employed Stata 14 and SPSS 26.

We had three dependent variables based on the study's goal: financial literacy and the other two are nutrition and food security. The financial literacy variable eventually evolved into a treatment variable (the primary explanatory variable), and the others were considered as our study's outcome variables. The term " financial literacy" used in the study is a binary variable, i.e., 1, if the participant is financially literate and 0, otherwise. This was done after providing the respondents with a set of 7 questions (see Table A2 in appendix) developed following previous scholars [11,13,33]. Each respondent may have received an overall score between 0 and 7 as a result of these questions. Then, we converted these scores into binary variables, using one (1) for financially literate scores, i.e., above the median score of total financial literacy and zero (0) for financially illiterate scores, i.e., below the median score of total financial literacy. This estimation approach was implemented by prior studies such as Ankrah Twumasi et al. [34], Wachira [35]and Andoh et al. [33].

Additionally, we used the household dietary diversity score (HDDS) from Swindale and Bilinsky [36] to evaluate the second outcome variable and the food insecurity access score created by Coates et al. [37] to measure the first end variable (HFIAS). The HFIAS measurement has been used by other academics [2,38]. HFIAS is an easy tool for quantifying and scaling the questions on food insecurity, and it can assist us in capturing the intricate and nuanced psychological aspects of food insecurity across households [37, 38]. The HFIAS is a nine-question survey measuring the frequency of skipping meals because of inadequate access to food and diet consumption. For the purpose of our study, respondents were given a seven-day recall period to help them remember their consumption habits. A household with food security receives a score of 0, while a household with food insurance receives a score of 27, which is the highest possible score. Therefore, a larger HFIAS score denotes greater food insecurity.

On the other hand, the HDDS, used by previous scholars [39,40] to calculate household dietary quality scores, is considered a good measurement for household food and nutritional security indicator as well. Twelve separate food categories—eggs, vegetables, tubers and roots, cereals, fish, fruits, pulses and nuts, milk and milk products, legumes, meat and poultry, sugar and honey, fats and oil, and other miscellaneous—are used to classify the family food consumed over the preceding seven days. Consequently, the range of the

HDDS is 0–12. The highest result (12) shows that the household's dietary diversity and food quality have grown. The greatest score (12), therefore, represents how a household is well-fed and nourished.

Although different indicators exist for food and nutrition security measurement, including calorie consumption and food purchases [41], HDDS and HFIAS are equally considered better options for nutrition and food security measurement. International agencies such as the World Food Program (WFP), FAO, and USAID have endorsed these criteria for examining the trends in food security in rising economies [40]. Although the HFIAS and HDDS methods are straightforward, easy, and helpful, they have significant drawbacks that must be fixed. First, the study did not account for seasonal nutrition and food security variations since it only employed a seven-day recall. To add to this, HFIAS and HDDS only indicate the quality and quantity of actual food supplies. Note that, despite these restrictions, our analysis is not biased because both financially literate and illiterate in the study locations may experience these problems. In terms of other control variables, we take into account household characteristics and other factors used by other scholars [38,39,42,43] and data available. Table 1 shows the descriptions of this study's variables.

3. Results and discussions

3.1. Descriptive statistics

Table 1 displays the descriptive statistics of our analysis. The respective HFIAS and HDDS mean reported is 9.06 and 5.16, and 31% of the people interviewed were financially literate. About 65% of the farmers are male. The average age of farmers and their level of education are around 39 and 7 years, respectively, whereas 42% of the tested group has at minimum one family member employed mostly in the city. While 52% of respondents use farm technology, roughly 22% of those surveyed had a family member who has a chronic illness. The average distance between the farmer's home and the market center is 2.76 km. The percentage of those who were credit constrained, with non-farm jobs, with access to the Internet and members of a union are 54%, 57%, 41% and 44%, respectively. The group sampled reveals that 31% of the interviewees have friends or family with who have knowledge in economics/finance. Finally, residents of Ashanti, Bono East, Northern, and Western regions is about 26%, 27%, 22%, and 25%.

Table 2 depicts the average differences between the chosen variables using literate and uneducated as a dimension. HFIAS value is low while HDDS is high for financially illiterate farmers, meaning the financially literate peoples' food and nutrition security is profound. This variation conforms with Figs. 1 and 2, which show that the HDDS and HFIAS for financially literate farmers based on regional locality high and low, respectively, than their financially illiterate counterparts. From the results, financially literate farmers are young, educated, farm technology adopters, Internet users, non-farm workers and less likely to be credit constrained. The estimate reveals that farmers with friends or related backgrounds in economics/finance are financially literate. While this section gives us a fair understanding of the study, it requires caution when interpreting because the table only displays a simple mean difference that does not account for factors that cannot be observed from the householder/household. Hence, we assess the association between financial literacy and food and nutrition security quantitatively by applying a suitable, appropriate econometric method (ETR) to ensure unbiased estimation.

3.1.1. Empirical analysis

Table 3 displays the ETR model evaluation results. Equations (1) and (2) are jointly calculated using the maximum likelihood estimator in the ETR technique (2). The statistical significance of the correlation coefficient of $\rho_{\mu v}$ which is shown at the bottom of Table 3, suggests that there may be a selection bias resulting from non-observable factors [29,31]. Also, we witnessed a significant

Table 1
Variables explanation and descriptive statistics.

Variables	Description	Mean	Std. Dev
HDDS	Household food insecurity access score	9.06	3.44
HFIAS	Household dietary diversity score	5.16	3.82
Financial literacy	1 if the farmer is financially literate, 0, otherwise	0.31	0.48
Gender	1 if the farmer is a male, 0, otherwise	0.65	0.51
Age	Age of the farmer	39.13	7.72
Education attainment	Farmer's years of schooling formally	6.90	4.51
Working children	1 if the household has at least a member with a job (formal/informal) in the city, 0, otherwise	0.42	0.45
Chronic disease	1 if the household has at least a member with a chronic disease, 0, otherwise	0.22	0.34
Farm technology adoption	1 if the farmer adopted any farming technologies (e.g., improved seed or climate smart) last year, 0, otherwise	0.52	0.48
Credit constraint	1 if the farmer was credit constrained, 0, otherwise	0.54	0.48
Market distance	Distance from the farmer's house to the market center (in km)	2.76	1.24
Non-farm job	1 if the farmer holds a non-farm job, 0, otherwise	0.57	0.51
Internet use	1 if the farmer is an Internet user, 0, otherwise	0.41	0.49
Union member	1 if the farmer is a farm union member, 0, otherwise	0.44	0.47
Ashanti	1 if the farmer is Ashanti region resident; 0 otherwise	0.26	0.48
Bono East	1 if the farmer is Bono East region resident; 0 otherwise	0.27	0.51
Northern	1 if the farmer is Northern region resident; 0 otherwise	0.22	0.48
Western	1 if the farmer is Western region resident; 0 otherwise	0.25	0.44
Education background	1 if the farmer has a relative/friend with an economics/financial education background	0.31	0.44

Source: survey results, 2018. Note: 1 USD = GH'4.9. M = mean and SD= Standard deviation

Table 2
Financial literate and illiterate key variables' average differences.

Variables	Financial literate	Financial illiterate	Mean Differences
HDDS	10.06	7.09	2.97***
HFIAS	3.97	6.48	−2.51***
Gender	0.59	0.64	−0.05
Age	34.12	44.27	−10.11***
Education attainment	11.24	4.56	6.68***
Working children	0.39	0.43	−0.04
Chronic disease	0.24	0.21	0.03
Farm technology adoption	0.58	0.47	0.12**
Credit constraint	0.38	0.61	−0.23***
Market distance	2.48	2.94	−0.46
Non-farm job	0.63	0.54	0.09*
Internet use	0.52	0.38	0.14**
Union member	0.44	0.43	0.01
Ashanti	0.29	0.22	0.07*
Bono East	0.27	0.28	−0.01
Northern	0.18	0.31	−0.13**
Western	0.26	0.24	0.02
Education background	0.47	0.19	0.28***
Sample size	153	340	493

Survey results, 2018. Note: ***, ** and * respectively means 1, 5 and 10% significant level.

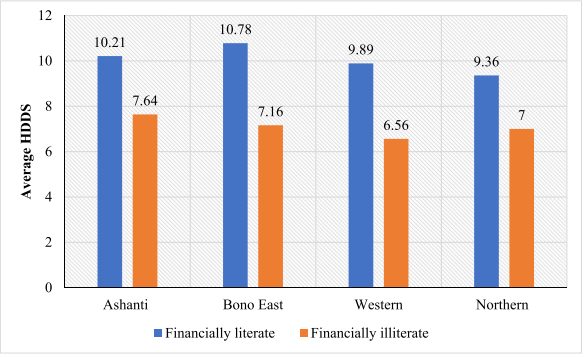

Fig. 1. Financial literacy and average HDDS by regions.

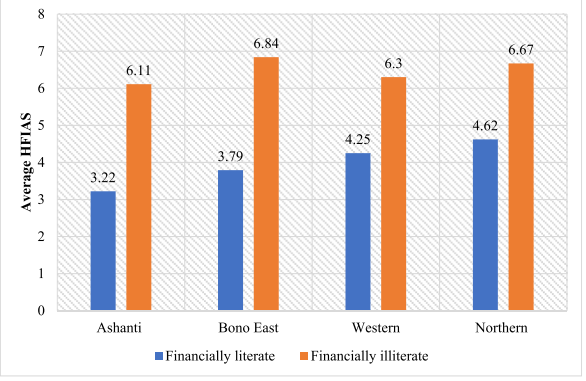

Fig. 2. Financial literacy and average HFIAS by regions.

Wald test χ^2 for Models 1 and 2, indicating that rejection of the null hypothesis of no association existing between the outcome and errors of the treatment equation. The above results endorse the use of the ETR model in this study. In addition, the residuals of the two variables (Internet use and education attainment), estimated from the first-stage regression of the ETR approach, are insignificantly different from zero. This signifies that simultaneity bias does not exist and that the estimated coefficients are consistent [44].

Table 3
Factors affecting financial literacy and the outcome variables (HDDS and HFIAS) ETR method.

Variables	Model 1		Model 2	
	Financial literacy	HDDS	Financial literacy	HFIAS
Financial literacy		0.131 (0.042)***		−0.089 (0.022)***
Gender	0.022 (0.003)	0.021 (0.098)	0.019 (0.003)	−0.038 (0.058)
Age	−0.053 (0.021)	0.089 (0.059)	−0.052 (0.021)	0.018 (0.046)
Education attainment	0.102 (0.036)***	0.060 (0.005)***	0.106 (0.037)***	−0.014 (0.006)*
Working children	0.076 (0.131)	0.031 (0.014)**	0.073 (0.131)	−0.022 (0.002)***
Chronic disease	−0.243 (1.231)	0.016 (0.022)	−0.241 (1.231)	0.039 (0.012)
Farm technology adoption	0.009 (0.027)	0.102 (0.051)*	0.009 (0.027)	−0.048 (0.021)*
Credit constraint	−0.025 (0.012)*	−0.019 (0.076)	−0.021 (0.012)*	0.037 (0.014)**
Market distance	0.003 (0.017)	0.058 (0.025)	0.003 (0.017)	−0.021 (0.019)
Non-farm job	0.082 (0.031)**	0.044 (0.019)**	0.080 (0.032)**	−0.083 (0.041)*
Internet use	0.050 (0.019)***	0.069 (0.028)**	0.051 (0.019)***	−0.036 (0.005)***
Union member	0.049 (0.023)*	0.076 (0.016)***	0.053 (0.023)*	−0.068 (0.047)***
Ashanti	0.011 (0.005)*	0.112 (0.053)*	0.013 (0.005)*	−0.078 (0.029)**
Bono East	0.032 (0.083)	0.083 (0.085)	0.031 (0.083)	−0.021 (0.010)*
Western	0.010 (0.008)	0.001 (0.003)	0.009 (0.008)	−0.016 (0.030)
Education background	0.093 (0.028)***		0.095 (0.028)***	
Residual (Education attainment)	0.025 (0.032)		0.026 (0.030)	
Residual (Internet use)	0.019 (0.048)		0.021 (0.048)	
Constant	1.340 (0.291)***	0.176 (0.052)***	1.342 (0.290)***	1.151 (0.207)***
$\rho_{\mu\nu}$	−0.107 (0.018)***		−0.054 (0.006)***	
Log-likelihood	−1927.049		−933.931	
Wald test X^2	$X^2(1) = 96.07$***	Prob > $X^2 = 0.0000$	$X^2(1) = 34.98$**	Prob > $X^2 = 0.0481$
Observations	493		493	

Survey results, 2018. Note: ***, ** and * respectively means 1, 5 and 10% significant level. Standard errors in parentheses. Northern = reference region.

3.1.1.1. Factors influencing financial literacy. In Table 3 column 2, we provide estimates of the factors affecting financial literacy. Besides controlling for gender and age, we controlled for other correlates of household characteristics such as education attainment, working children, technology adoption, credit constraints, non-farm job, internet use, union membership and location (region). We examined how education background, captured as our instrument variable, affected financial literacy. Our findings show that financial literacy was positively and statistically significantly impacted by education background. According to estimates, farmers have a higher likelihood to be financially educated than those who do not connect with people who are knowledgeable about financial matters. This result corroborates the works of other researchers who found a positive association between having a friend who is financially literate and improvement in one's financial literacy status [13,28]. As a result, farmers who have acquaintances or relatives can consult them for financial guidance in order to improve their financial capabilities and knowledge, as opposed to those who have not acquired any financial education [28].

The result also shows that being credit constrained is negatively linked to financial literacy. The empirical evidence shows that, a farmer who is financially constraint is 0.025% less likely to be financially literate. Numerous sources of evidence point to a connection between financial literacy and financial market participation. Accessing financial services (e.g., obtaining loan) enable an individual access various financial educational platforms which will broaden their knowledge in financial issues such as costing, investments and making sound speculations relating to finance [12,42].

Again, our study underscores the role of internet use in improving the rate of financial literacy in agricultural households. Thus, the estimates reveal that a farmer who is an Internet user tends to be financially literate as opposed to their counterpart who does not use the Internet. The Internet has become the go-to place to learn practically any subject [45]. Carlsson et al. [46] contend that as Internet usage increases, consumer financial management practices necessarily change quickly.

Farmers who participate in off-farm activities are much more inclined to be financially knowledgeable than their counterparts without any type of off-farm employment, according to the significant and positive coefficient of non-farm jobs. One of the highest-risk businesses is agriculture. Due to this, farm owners try to diversify their sources of income and implement additional measures to keep their revenue stable. Studies have shown that higher earners are more likely to be financially knowledgeable [11,47].

Our research shows that farmers who are members of a farm group are more likely to be financially literate than those who are not. It is asserted that members of such social groups earn various talents from one another. Such associations occasionally bring in resource people from the finance industry to instruct their members on personal finance topics, including planning, saving, investing, and money management, all of which have an impact on their financial behavior [19,48]. Additionally, we discovered that compared to their counterparts in the Northern region, farmers in the Ashanti region are more financially literate than those in the Northern region. Research works have demonstrated severe inequalities in Ghana's educational system. For instance, work done by Takyi [49] an overview of Ghana's educational system found that geographically, there exists a discrepancy between northern and southern Ghana, which might be attributed to the unequal distribution of resources and educational facilities.

3.2. Financial literacy and household food and nutrition security nexus estimation

The findings in Table 3, column 3 and 5 show financial literacy can assist in raising HDDS and lower HFIAS; hence, there is a substantial positively significant association between a farmer being financially literate and HDDS and a significant and negative association between a farmer being financially literate and HFIAS. Understanding whether households face food insecurity may be made easier with the help of financial literacy. It has been demonstrated that household behavioral and financial literacy indicators influence wealth creation and wellbeing. Higher levels of financial literacy result in easier financial decision-making, which is reflected in a better ability to budget or save resources (e.g., money) to act as a safety net [50]. This result aligns with earlier studies that have discovered a favorable relationship between financial literacy and household food consumption [51,52]. According to Ref. [52], greater financial literacy levels are linked to increased household consumption, thereby reducing food insecurity. Families with less financial literacy are more likely to struggle with food insecurity.

The outcome also demonstrates that farmers' years of schooling (Education attainment) significantly and positively influence HDDS while it significantly causes HFIAS to decline. The likelihood that the household will fall into the high dietary diversity category by an additional increase in the years of schooling by the farmer will rise by 0.060, and the likelihood that HFIAS will fall by 0.014. This could be explained by the fact that educated farmers are often more inclined to participate in decisions regarding how to allocate household resources, which will tend to increase the status of the household members' access to food. Education has a strong and favorable impact, showing that educated farmers are more aware of diversified meals and nutritionally-balanced diets [38].

A household with a member in a formal or informal job in the city was positively and statistically significant for HDDS and negatively correlated with HFIAS. This demonstrates that households with at least one person who works outside the home had higher HDDS and improved HFIAS. This is because they may serve as the family's primary provider of remittances, food, and other necessities, so they assume responsibility for enhancing the welfare of rural households. Households having access to remittances can buy a wider variety of wholesome meals [53].

Farm technology adoption and food and nutrition have a positive and significant coefficient, implying that if farmers adopt farming technology, they are likely to be food secure. The outcome suggests that greater access to and use of agricultural technologies, as well as increased investment in agricultural technology, considerably raise the welfare of farm households. Farm technology adoption, such as improved seeds and climate smarts, add incentives to farm production; hence, increasing farmers' consumption [25].

The coefficient of the credit constraint variable is negative but insignificant for HDDS; however, it is statistically significant and positively correlated with HFIAS, indicating that credit constraint leads to food insecurity in the household. Access to credit is a great

Table 4
Effect of Financial literacy on HDDS and HFIAS by Internet use and Technology adoption status (ETR model).

	HDDS				HFIAS			
Variables	Internet users		Technology adoption		Internet users		Technology adoption	
	Yes	No	Yes	No	Yes	No	Yes	No
Financial literacy	0.116**	0.072***	0.084*	0.052*	−0.093***	−0.041*	−0.073*	−0.036*
	(0.048)	(0.015)	(0.035)	(0.022)	(0.031)	(0.019)	(0.031)	(0.017)
Gender	0.033**	0.072	0.021	0.052	−0.054*	−0.005	−0.023*	−0.062
	(0.013)	(0.049)	(0.017)	(0.063)	(0.022)	(0.003)	(0.011)	(0.071)
Age	0.061	−0.023	0.031**	−0.036	−0.008	0.016	−0.042*	0.014
	(0.084)	(0.045)	(0.014)	(0.034)	(0.015)	(0.043)	(0.024)	(0.034)
Education attainment	0.081*	0.012*	0.037***	0.015	−0.017**	−0.031*	−0.024**	−0.032*
	(0.035)	(0.005)	(0.009)	(0.031)	(0.006)	(0.015)	(0.009)	(0.015)
Working children	0.026*	0.004	0.022	0.017	−0.051**	0.033	−0.047	−0.014
	(0.012)	(0.009)	(0.0017)	(0.041)	(0.019)	(0.026)	(0.067)	(0.019)
Chronic disease	0.043	−0.023	0.014	−0.006	−0.021	0.009	−0.039*	0.038
	(0.042)	(0.029)	(0.028)	(0.004)	(0.019)	(0.031)	(0.028)	(0.071)
Farm technology adoption	0.036*	0.016*			−0.023*	−0.025		
	(0.017)	(0.008)			(0.010)	(0.043)		
Credit constraint	−0.058	−0.038	0.044*	−0.018	0.049 (0.051)	0.027*	−0.029	0.011
	(0.087)	(0.034)	(0.019)	(0.007)		(0.015)	(0.044)	(0.009)
Market distance	0.057**	0.038	0.021	−0.011	−0.030*	0.009	−0.037	0.015
	(0.023)	(0.098)	(0.053)	(0.007)	(0.013)	(0.016)	(0.029)	(0.011)
Non-farm job	0.042**	0.013*	0.083***	0.057*	−0.052**	−0.022*	−0.051**	−0.017*
	(0.014)	(0.006)	(0.014)	(0.028)	(0.021)	(0.010)	(0.022)	(0.008)
Internet use			0.041*	0.029			−0.037*	−0.015
			(0.020)	(0.027)			(0.015)	(0.017)
Union member	0.031	0.021	0.073*	0.006	−0.054	0.101	−0.019**	−0.062
	(0.030)	(0.014)	(0.033)	(0.011)	(0.117)	(0.077)	(0.007)	(0.047)
Constant	1.055***	0.652	2.124***	0.121***	0.339**	1.251***	0.132***	0.330***
	(0.225)	(1.124)	(0.713)	(0.040)	(0.126)	(0.032)	(0.021)	(0.011)
Regional variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald test X^2	13.26**	32.31***	17.22*	4.01**	40.21***	36.10*	5.54*	27.40**
Observation	202	291	256	296	237	291	296	237

Survey results, 2018. Note: ***, ** and * respectively means 1, 5 and 10% significant level. Standard errors are presented in parentheses; Northern = reference region. For the sake of brevity, the ETR model's first stage findings are not presented.

motivator for household welfare development, which is a prerequisite for food security assurance [38,42]. Our finding also corroborates the notion of the substantial positive link between credit availability and household food security, as discovered by Ref. [38].

Our study also reveals that respondents with non-farm employment are more likely to have high HDDS and improve their HFIAS. The conclusion is that those households may purchase nutrient-dense goods that healthy diets when they increase their household income through non-farm income. This outcome is in line with what some authors have discovered [54].

The findings further demonstrate that HDDS and HFIAS respectively rise and decline should the farmer utilize the Internet; as a result, there is a strong and positive correlation between the utilization of the Internet and HDDS and a strong and adverse relationship between the utilization of the Internet and HFIAS. This means that households using the Internet would experience reduced food insecurity. Internet users receive many benefits, including knowing where to locate off-farm jobs and market and sell their farm or other products. This can lead to improved income to enhance household welfare (food security). This finding confirms the works of [42].

The union membership variable coefficient is positive(negative) under HDDS(HFIAS). The implication is that the outcomes of household food security are improved when the farmer actively engages or joins a farm union. Cooperatives serve as an avenue for farmers to obtain marketing linkage; hence, impacting their sales and profitability to improve their wellbeing. This finding is consistent with other works that found a significant positive relationship between being a group member and the household food security status [55]. Another notable outcome from the study is that farmers residing in the following regions (Ashanti and Bono East), compared to those in the Northern region, have higher HDDS and lower HFIAS. This finding can be related to geographical settings and policies.

3.2.1. Further analysis

Although we have analyzed the financial literacy-nutrition and food security nexus homogeneously in Table 3; we argued that a heterogeneous estimation will bring more insights to our findings. Therefore, we further assess the heterogeneous analysis of financial literacy-food and nutrition security nexus based on technology accessibility (i.e., Internet use and farm technology adoption) status (Table 4). Even though the presence of technology has improved most farm household welfare according to prior studies [56–58], there exist other studies [50,59–61] claiming that without proper financial management, access and adoption of technologies which are considered as poverty cycle breaker becomes difficult; hence, affecting household food consumption. Thus, this heterogeneous estimation becomes necessary.

In Table 4, Columns 2–5 and 6–9 present the calculated findings for the heterogeneous analysis of financial literacy-nutrition and food security nexus dependent on Internet use and farm technology adoption of HDDS and HFIAS, respectively. The findings indicate that the financial literacy variable's coefficient values are statistically significant, positive for the HDDS models, and statistically significant, negative for the HFIAS models. This is an indication that financial literacy enhances food and nutrition security for Internet users and nonusers' as well as adopters and non-adopters farm households. However, the impact of financial literacy on the outcome variables for Internet users and farm technologies adopters is greater than their counterparts who did not enjoy such advantages. Moreover, compared to Tables 3 and it can be seen that the interaction effect of financial literacy coupled with technology adoption impact on HDDS and HFIAS is profound (Table 4). In all, we can argue that improving peasant households' technology accessibility is important but there is also a need to provide policies aimed at enhancing their financial literacy level to achieve sustainable livelihood.

4. Conclusion and policy implications

Using Ghanaian data, we used ETR approach to assess how financial literacy relates to food and nutrition security due to its ability to deal with endogeneity problems stemming from factors that cannot be observed. Again, we assess the heterogeneous analysis of financial literacy-food and nutrition security nexus based on technology accessibility (i.e., Internet use and farm technology adoption) status. Particularly, we augment literature on how financial elements can empower households' livelihood in this current study.

The analyses from the estimations showed financial literacy could assist raise HDDS and lower HFIAS; hence, there is a substantial and positive correlation between a farmer being financially literate and HDDS and a significant and negative association between a farmer being financially literate and HFIAS. Concerning the results from the heterogeneous estimation, our results depicted that financial literacy enhances food and nutrition security for Internet users and nonusers as well as adopters and non-adopters' farm households. However, the impact of financial literacy on the outcome variables for Internet users and farm technologies adopters is greater than their counterparts. Additionally, other control variables such as educational attainment, working children, farm technology adoption, internet use, non-farm jobs and union member significantly affected HFIAS and HDDS.

The policy implications deduced from the findings to ensure food and nutrition safety are as follows. First, it was observed that financial literacy's role in achieving the UN SGDs to get rid of hunger, curtail poverty, and improve food accessibility in the domestic setting is profound. Therefore, we recommend that financial education should be an important variable in policy decision-making. To improve the financial abilities and understanding of its population, organizations and national governments could, for instance, implement programs on all national television and radio stations for a certain time period. Where people cannot access radio and television information, financial education training and meetings should be organized in public parks by local political executives/administrators. Second, we propose that government and many other agencies prioritize Internet use and farm technology adoption education and training programs via extension service officers. The government can support and encourage Internet providers to extend their nationwide connectivity. This is because we observed that the magnitude of the impact of financial literacy on food accessibility was huge when the households have access to technology adoption (e.g., access to the Internet and adopters of farm technologies).

The study has some shortcomings, and they include the following. First, financial constraints limited us to only four (4) regions in

Ghana. This call for sample size expansion by future researchers. Second, farm households made up the sample group of the study. Future researchers can look at urban areas or conduct an urban-rural comparative study to broaden our understanding of the relationship between these two variables. We also suggest that studies related to financial literacy and food and nutrition security can consider rigorous interaction effect analysis for deeper understanding of the relationship between the two indicators.

Author contribution statement

Martinson Ankrah Twumasi: Conceived and designed the experiments; Analyzed and interpreted the data; wrote the paper. Gloria Essilfie: Analyzed and interpreted the data, Contributed reagents, materials, analysis tools or data. Huidan Xu: Contributed reagents, materials, analysis tools or data; Performed the experiments. Evans Brako Ntiamoah: performed the experiment; wrote the paper. Yuansheng Jiang: Contributed reagents, materials, analysis tools or data, Performed the experiments.

Data availability statement

Data will be made available on request.

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.

Acknowledgments

We are grateful to the anonymous reviewers for their helpful review and critical comments. The authors also extend enormous gratitude to the rural dwellers who participated in the data collection. Huidan Xu acknowledges the financial support from the Sichuan Insurance Association (No. 20222SCBX16).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e19573.

Appendix

Table A1
Selected instrumental variable validity test

Variables	Correlation coefficient	*p*-value
Financial literacy	0.054**	0.038
HDDS	0.081	0.135
HFIAS	0.006	0.174
Survey results, 2018. Note: ***p < 0.01, **p < 0.05, *p < 0.1		

Table A2
Questions about financial literacy and answers

Question	Answers
1. Suppose you had $100 in your savings account with a 2% annual interest. After 5 years, how much will you have in this account if you leave your money to gain interest? (Interest rate)	(a) more than $102 (b) exactly $102 (c) less than $102 (d)I do not know
2. Your savings account has a 1% annual interest, and the annual inflation is 2%. After a year, will you be able to buy more than today using the money saved in this account? (Inflation)	(a) Yes (b)No (c)I do not know
3. Is the following statement true or false? "Buying a single company stock usually provides a safer return than a stock mutual fund." (Risk diversification)	(a) True (b) False (c)I do not know
4. You want to borrow GH'500 from a moneylender (M1). He says that you can get it, but you must pay him GH'600 in a month. Another money lender (M2) says you have to pay GH'600 plus 15% in a month. Which one is better? (Borrowing)	(a)M1 (b)M2 (c)I do not know
5. Assume a friend inherits GH'10,000 today, and his sibling inherits GH'10,000 3 years from now. Who is richer because of the inheritance? (Time value of money)	(a) My friend (b) His sibling (c) They are equally

(*continued on next page*)

Table A2 (*continued*)

Question	Answers
	rich (d)I do not know
6. Suppose that in the year 2010, your income has doubled, and the prices of all goods have doubled too. In 2010, how much will you be able to buy with your income? (Money illusion)	(a) More than today (b) The same (c) Less than today (d)I do not know
7. Second-hand farm machinery is more expensive to insure than a brand new one? (insurance)	(a) True (b) False (d)I do not know

Source: (Ankrah Twumasi, Jiang, Adhikari et al., 2021b), (Lusardi and Mitchell, 2013) and (Andoh et al., 2015)

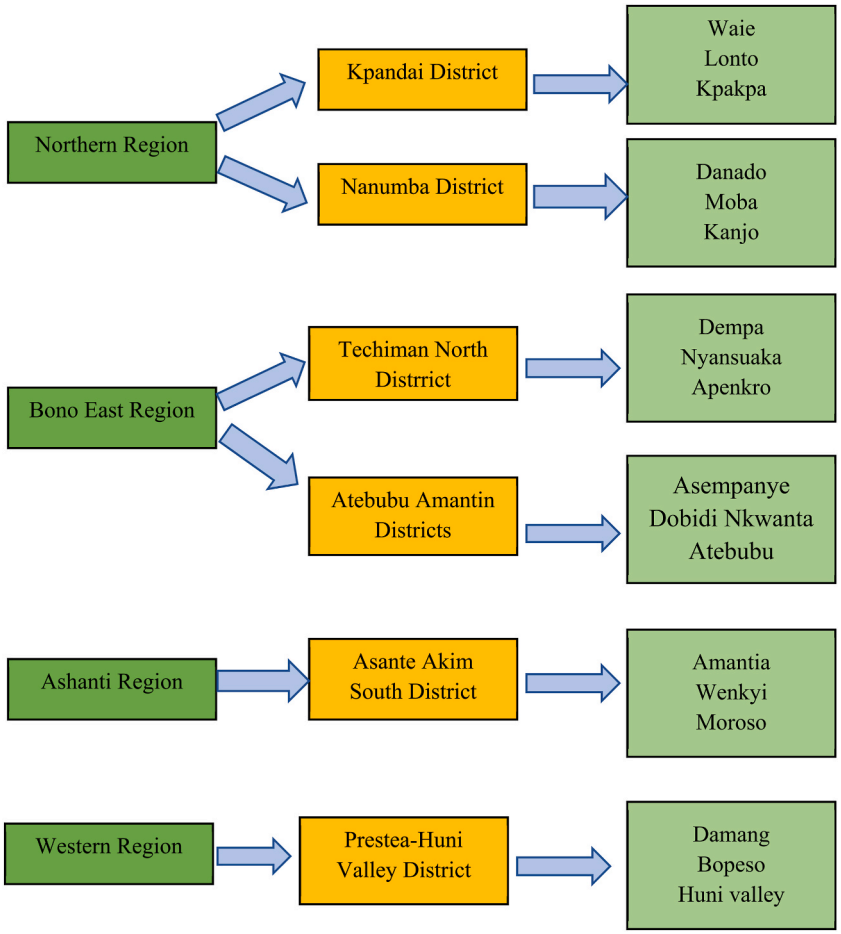

Fig. A2. Diagram of household sample selection procedure.

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