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RESEARCH ARTICLE

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Heterogeneous impacts of GlobalGAP adoption on net income in small-scale pineapple farming in Ghana: Does farm size matter?

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Abstract

Adoption of Global Good Agricultural Practices (GlobalGAP) improves food quality and safety along fresh produce value chains. However, adoption rates have been low among small-scale pineapple farmers in Ghana, but with possible heterogeneous responses due to farm size economies. This study estimates the impact of GlobalGAP adoption on net incomes earned by small-scale pineapple farmers in Ghana's main producing region, and examines size-induced heterogeneous effects of adoption on income. Household and farm-level data gathered from 546 small-scale farmers were analyzed using a two-stage regression model to estimate the impact of GlobalGAP adoption on per hectare pineapple net income. Robustness of the results was checked by re-estimating the two-stage model using a maximum likelihood extended regression model. GlobalGAP adoption reduced net income on small farms growing less than 1 ha of pineapples, but increased net income on small farms growing more than 1 ha of pineapples. We conclude that GlobalGAP adoption and

Abbreviations: ATE, average treatment effect; BRC, British Retail Consortium; DiD, difference-in-differences; ERM, extended regression model; EUREPGAP, Euro-retailer produce working group good agricultural practices; FAO, Food and Agriculture Organization of the United Nations; FASDEP, Food and Agriculture Sector Development Policy; FLO, Fairtrade Labelling Organization; GlobalGAP, global good agricultural practices; IFA, integrated farm assurance; IV, instrumental variable; MOAP, Market Oriented Agriculture Programme; NTAEs, nontraditional agricultural exports; OLS, ordinary least squares; PFS, private food standards; PSM, propensity score matching; UNCTAD, United Nations Conference on Trade and Development.

farm size are not independent determinants of profitability, and recommend that extension and other interventions intended to promote GlobalGAP adoption among pineapple farmers in Ghana should be targeted at those who are willing and able to grow more than 1 ha of pineapples [EconLit Citations: Q16, Q13].

KEYWORDS
food safety standards, impact assessment, instrumental variable regression, treatment model

1 | INTRODUCTION

Global food trade is identified as an effective tool to reduce rural poverty and improve livelihoods in developing countries (Food and Agriculture Organization of the United Nations [FAO], 2004; Harris et al., 2001; Subervie & Vagneron, 2013; Swinnen & Kuijpers, 2020) as it has strong potential to link smallholders with markets in the developed world (Birthal et al., 2007; Dolan, 2001; Kleemann et al., 2014). Rising incomes, new technology, and greater efficiency in market distribution channels have increased global consumption of tropical fruit and vegetables (Trienekens, 2011). Although horticultural exports from developing countries have grown substantially over the past three decades (Asuming-Brempong, 2013; Weinberger & Lumpkin, 2007), it does not necessarily follow that smallholders are responsible for this growth. On the contrary, there is growing concern that stringent food quality and safety standards are excluding smallholders from high-value markets because they are unable to benefit from the economies of size necessary for adopting these standards (Barrett et al., 2002; Dolan & Humphrey, 2000; Hatanaka et al., 2005; Reardon & Berdegué, 2002). In this case, anticipated improvements in smallholder incomes and livelihoods are not fully realized, and developing countries with relatively few large-scale producers may suffer additional losses in export volumes and earnings. Ghana's pineapple sector is a case in point.

Fresh pineapple is Ghana's leading horticultural export. Trade peaked in 2004 with exports of 56,094 metric tons valued at US$68.343 million, accounting for 36%–39% of nontraditional agricultural exports (NTAEs) earnings, making Ghana the second largest African exporter of pineapples (Kasalu-Coffin et al., 2005). Over the next decade, Ghana maintained its position as the second largest African exporter of pineapples after Cote d'Ivoire (UNCTAD, 2016), but more recent data show a steady decline in Ghana's pineapple exports with volumes falling at an average annual rate of 9.9% between 2015 and 2020 (FAO, 2020). Ghana's share of global pineapple exports declined from 3.05% in 2004 to 0.44% in 2021 (FAO, 2023). Continued access to international markets has significant implications for Ghana's export earnings and for the welfare of rural communities. Smallholders accounted for more than 50% of Ghana's pineapple exports when exports peaked in 2004 (Gatune et al., 2013), but their share of exports dropped to 39% in the early 2010s (Boansi et al., 2014) and to 30% in the late 2010s (Kpare, 2016).

Food safety has been a major concern as incidents of food contamination increased with growth in trade of high-value food products since the early 1990s (Barrett et al., 1999; Newell et al., 2010; Ouma, 2010). High-profile disease outbreaks triggered a proliferation of food safety standards (FAO, 2004). Private food standards (PFS) have become increasingly important in governing global food trade (Humphrey, 2008; Subervie & Vagneron, 2013; Suzuki et al., 2011). These PFS include Global Good Agricultural Practice (GlobalGAP), British Retail Consortium (BRC), Fairtrade Labelling Organization (FLO) and a host of national organic certifications. GlobalGAP is the most widely used voluntary food safety standard in global fruit and vegetable supply chains (Henson et al., 2011).

Supermarket chains in the United Kingdom (UK) and other European countries require their suppliers to be GlobalGAP certified (Graffham et al., 2007), and rapid expansion of modern retail chains in developing countries has added to the emphasis on food standards (Minten & Reardon, 2008; Weatherspoon & Reardon, 2003). It is estimated that 85% of Ghana's export-oriented pineapple producers are GlobalGAP certified (Gatune et al., 2013), but adoption of GlobalGAP and other internationally recognized food standards is low amongst small-scale pineapple farmers (Quartey et al., 2023).

Ghana's pineapple exports declined with diminishing smallholder participation in the export market after 2007 when GlobalGAP standards were introduced (FAO, 2023; Kuwornu & Mustapha, 2013). This raises questions about the magnitude and nature of costs incurred by farmers who adopt and maintain these standards. Adoption requires substantial investment in fixed improvements such as chemical and equipment storerooms, and recurring fixed costs associated with employee training, record keeping, assessments of work methods and results, and annual on-farm inspections of work procedures by external auditors (Yudin & Schneider, 2008). Small-scale farmers cannot spread these fixed costs over large volumes of output. This inability to benefit from size economies reduces the profitability of compliance with GlobalGAP standards (Holzapfel & Wollni, 2014; Müller & Theuvsen, 2015) and is therefore expected to discourage their adoption. Feder et al. (1985) clearly link adoption of technology to its profitability. In addition, van Berkum et al. (2017) report that smallholders in developing countries struggle to meet the costs of adopting and maintaining GlobalGAP standards.

Public and private sector stakeholders in Ghana responded to the loss of pineapple exports with interventions aimed at encouraging small-scale pineapple farmers to adopt GlobalGAP standards. Beginning in 2008, the German Technical Cooperation's Market Oriented Agriculture Programme (MOAP) was launched in Ghana, with the aim of improving the capacity of farmers, processors, and other actors in the agricultural sector to compete in national, regional, and international markets (MOAP, 2009). However, the value of these interventions is questionable when little is known about the impact that GlobalGAP adoption has on smallholder incomes.

Several previous studies (e.g., Annor et al., 2016; Asfaw et al., 2009b; Henson et al., 2011; Kleemann et al., 2014; Lemeilleur, 2013; Muriithi et al., 2011) assessed the determinants of GlobalGAP adoption, but few have assessed the profitability of GlobalGAP adoption in developing countries. Subervie and Vagneron (2013) used propensity score matching (PSM) and difference-in-differences (DiD) to estimate the impact of GlobalGAP on quantities sold and prices received by small-scale lychee farmers in Madagascar. PSM helps to remove endogeneity bias in estimates of impact when observed variables that influence the outcome of adoption also influence the decision to adopt. However, PSM does not address endogeneity bias introduced by unobserved variables that influence both adoption and the outcome of adoption. Impact assessment is prone to endogeneity bias when farmers with particular personal, household, and farm attributes self-select into the adopter group or are targeted for support by development agencies. DiD has the advantage of accounting for endogeneity introduced by observed variables and time-invariant unobserved variables, but it requires comparable observations made on adopters and nonadopters over time or across multiple locations. Subervie and Vagneron (2013) lacked comparable cost data and were therefore unable to estimate the impact of GlobalGAP on net income. Henson et al. (2011) combined PSM with DiD to estimate the impact of GlobalGAP on quantities and prices of fresh produce sold by exporter firms in 10 sub-Saharan African country. Although these firms sourced products from small-scale farmers, most (64%) of their exports came from large estate farms. This, and the absence of cost data, prevented the researchers from assessing the impact of GlobalGAP adoption on smallholder net income.

Asfaw et al. (2009b) used a two-stage regression model to identify the determinants of GlobalGAP adoption and the impact of adoption on the net incomes of 439 small-scale vegetable producers in Kenya. This study attempted to address endogeneity attributed to observed and unobserved variables by including adoption propensity scores estimated in the first stage (probit) regression as an instrument alongside the adoption and control variables used to predict net farm income in the second stage (OLS) regression. However, the validity of the instrument was not established, and important fixed costs were excluded from the measurement of net income. Kleemann et al. (2014) investigated the impacts of GlobalGAP and organic certification on profitability in a sample of 386 small-scale pineapple farmers in Ghana. Endogeneity introduced by observed and unobserved variables was addressed using endogenous switching regressions (ESR) that included predicted values of the inverse Mills ratio to capture bias. Profitability was expressed as the ratio of net income per crop cycle to the initial cost of certification—an estimate of the return on the farmer's investment in certification. However, the costs of fixed improvements (like storerooms for chemicals and equipment) incurred by farmers who adopt GlobalGAP were excluded from the initial investment.

The first objective of the study we present in this paper is to provide a contemporary and unbiased estimate of GlobalGAP's impact on pineapple net income in a sample of 546 small-scale growers located in Ghana's main pineapple-producing region. In this study, net income accounts for the annualized costs of fixed improvements and durable assets, recurring fixed costs, and variable costs incurred by pineapple farmers who adopt GlobalGAP. Second, we consider the heterogeneous impact of GlobalGAP adoption on the incomes of smaller and larger small-scale farmers. Our sample excluded farmers operating pineapple enterprises exceeding 5 ha based on Clarke's (2010) evidence of significant size economies for adopters of PFS operating areas of six or more hectares. While revenue is scale-dependent, sizable costs associated with adopting and maintaining GlobalGAP standards are not scale dependent, making the profitability of adoption sensitive to scale on smaller farms (Mbowa & Nieuwoudt, 1998). Farm size heterogeneity therefore has implications for policy interventions and their targeting (Kunzekweguta et al., 2017; Mwangi & Kariuki, 2015; Nakhumwa & Hassan, 2003). Pineapple farmers confronting severe land, labor, or capital constraints may benefit more from linkages with domestic markets that value good quality pineapples than from contracts with exporters who require compliance with GlobalGAP standards. Our study aims to provide nuanced policy and farm-level insights that will benefit small-scale pineapple farmers in Ghana, with potential for such insights to be relevant in other agricultural industries and developing countries.

Results from this study reveal that small-scale farmers who cultivate more than 1 ha of pineapples achieve positive and significantly higher net farm income from Global adoption, making it beneficial to sustain their certification. Small-scale pineapple farmers who do not meet the 1-ha size threshold would get more benefit from quality extension services and improved varieties that appeal to high-end but less regulated domestic markets. Unlike previous studies such as Asfaw et al. (2009b) and Kleemann et al. (2014), this study accounts for fixed cost improvements and consequently presents more realistic conclusions.

Section 2 of this paper outlines key features of GlobalGAP certification relevant to Ghana's small-scale pineapple farmers. Section 3 describes the methods and data used in this analysis, and Section 4 presents and discusses empirical findings. Section 5 concludes the study with key considerations for the design and implementation of policies intended to promote GlobalGAP adoption among Ghana's small-scale pineapple farmers.

2 | FEATURES OF GLOBALGAP CERTIFICATION RELEVANT TO GHANA'S SMALL-SCALE PINEAPPLE FARMERS

GlobalGAP is a farm assurance standard established in 2007 by a consortium of European food retailers as an upgrade to the former EUREPGAP standard with a global focus aimed at ensuring hygienic and safe food production (Kuwornu & Mustapha, 2013). The goal of GlobalGAP is to change the attitudes of farm managers and workers from being purely production-oriented to being fully aware of the impacts of their operations on consumer health and safety. GlobalGAP requires growers to follow minimum performance standards with defined criteria, intended to mitigate any adverse effects of their production practices on food quality and safety (Yudin & Schneider, 2008).

GlobalGAP certification comes in four options: In option I, certificates are issued to an individual farmer for a specific crop, or crops on a specific farm. Any produce not named on the certificate is not covered by the standard. In option II, legally constituted farm associations can obtain a group certificate covering all their members if they run internal inspection systems that comply with GlobalGAP regulations. Option III applies to an option I farmer who intends to benchmark or harmonize with other production standards (e.g., Safe Quality Food 1000). Likewise, option IV allows option II farmer groups to benchmark with other standards (Asfaw et al., 2009a). Options I and II are commonly practiced in Ghana. Large-scale farmers who adopt GlobalGAP usually follow option I, while virtually all small-scale farmers who adopt GlobalGAP follow option II. Since this study focuses on small-scale farmers, the sample and data analyzed relate only to GlobalGAP option II certification.

At the time of writing, farmers were expected to comply with the Integrated Farm Assurance Version Five (IFA V5) of GlobalGAP. The fruit and vegetable component of IFA V5 comprises 221 critical points. Food safety requirements account for 99 of these critical points, followed by environment and biodiversity requirements (69 points), workers' health and safety (28 points), and traceability requirements (25 points). These requirements are routinely updated to address current food safety needs. The next version, IFA V6, is expected to replace IFA V5 in 2024 (GlobalG.A.P., 2022).

In Ghana, certification costs are categorized as those borne by (a) the individual farmer, (b) farmer group, (c) exporter or buyer, and (d) donor agencies and government. This study is concerned with costs that small-scale pineapple farmers must cover if they decide to adopt GlobalGAP standards. These costs fall into categories (a) and (b). For example, adopters must finance their own changing rooms, toilets, disposal pits, soil testing and fumigation, and pay their share of costs incurred by farmer groups to finance quality control services and storerooms for chemicals and equipment. Some of these costs relate to fixed improvements and durable assets, others to more frequently recurring certification costs (see Section 4.2). All of these costs are largely independent of farm scale and relevant to farmers contemplating the adoption of GlobalGAP standards. Exporters usually bear some of the certification costs, while the cost of training and information provided to adopters is covered mostly by government agencies and donors. Expenses not incurred by farmers were excluded from the impact analysis as they do not affect their net income. However, adopters sampled in this study provided estimates of what these services would add to their costs in the absence of stakeholder support, and these estimates were considered in a parallel analysis to gauge the importance of this support.

3 | MATERIALS AND METHODS

3.1 | Sampling procedure and data collection

A multistage sampling approach was used to select districts, communities, and small-scale pineapple farmers. In this study, we sampled only small-scale pineapple farmers, defined earlier as farmers operating pineapple enterprises of 5 ha or less. In the first stage of sampling, two districts, Akuapem South and Awutu Senya-West, were purposively selected based on scale of pineapple production, small-scale farmer involvement in pineapple farming, and intensity of GlobalGAP adoption. Both districts are located in Ghana's southern horticultural belt. They share similar socioeconomic and ecological characteristics and are the country's leading districts for commercial pineapple production. Proximity to Ghana's two main export hubs, Kotoka International Airport and Tema Harbour, give these districts a competitive advantage in export-oriented pineapple production.

Second, five communities were selected from each district: Aburi, Amanfrom, Obodan, Pepawani, and Pokrom in Akuapem South, and Bawjiase, Ayensuako, Bontrase, Obrachire, and Mfafo in Awutu Senya-West. The incidence of GlobalGAP adoption is higher in these districts than in Ghana's other pineapple-growing regions owing primarily to their competitive advantage in export-oriented pineapple production. In addition, these districts host a relatively large number of estate farms that manage contract and out-grower schemes to source additional pineapples from certified small-scale farmers.

With the communities serving as primary sampling units, we generated a sampling frame by compiling lists of the small-scale pineapple farmers located in each of the selected communities. Samples of small-scale pineapple farmers were drawn randomly at the same rate (43%) from each community, producing an initial sample of 580 farm households. A small minority (6%) of these households was either unwilling or unable to provide responses, leaving a total of 546 households for analysis. Of these, 236 were GlobalGAP adopters and 310 were nonadopters.

Data pertaining to farm, household, and farmer characteristics were gathered in personal interviews conducted with household heads between July and September 2021, with the 2020 planting season as a specific reference for data collected. Responses were recorded in a structured questionnaire and complemented with personal observations made by the enumerators who visited each farm.

3.2 | Model to assess the impact of GlobalGAP adoption

To assess the impact of GlobalGAP adoption on pineapple net income using our cross-sectional data, we first specify a treatment (i.e., adoption) model. Empirical studies have shown that various farmer, household, and farm characteristics (e.g., gender, age, education, farming experience, household size, and farmland endowment), market features (e.g., cooperative membership, supply contracts, and export markets), and institutional support factors (e.g., access to extension and telecommunication services) influence farmers' decisions to adopt food safety standards (Asfaw et al., 2009b; Lemeilleur, 2013; Muriithi et al., 2011). This study uses similar variables to explain the adoption of GlobalGAP by small-scale pineapple farmers in Ghana and measures them at levels relevant at the time GlobalGAP was introduced. The adoption model is expressed as

$$T_i = \alpha + \beta_k X_{ki} + u_i, \tag{1}$$

where T_i is a dummy variable that scores 1 if the ith farmer is an adopter, and 0 otherwise; X_{ki} is a vector of k independent variables influencing the decision of the ith farmer to adopt GlobalGAP; α and the β_k are parameters to be estimated, and u_i is random error. Equation (1) is often estimated as a probit model to account for the binary nature of the dependent variable.

Following Khandker et al. (2009), the general impact (i.e., outcome) model is specified as

$$Y_i = \alpha' + \beta_j' X_{ji} + \lambda T_i + \varepsilon_i, \tag{2}$$

where Y_i is the outcome, X_{ji} is a vector of j exogenous explanatory variables, T_i is as previously defined, $\acute{\alpha}$, λ, and the $\acute{\beta}_j$ are parameters to be estimated, and ε_i is an error term. Estimating the outcome model using ordinary least squares (OLS) is prone to endogeneity bias because unobserved characteristics will likely affect both Y and T. To address this problem, T_i is first regressed on variables influencing the decision to adopt GlobalGAP and one or more instrumental variables (Z)

$$T_i = \alpha + \beta_k X_{ki} + \gamma Z_i + u_i. \tag{3}$$

This model is identical to the model defined by Equation (1), with the exception that it now includes instrumental variables (IVs). Like Equation (1), Equation (3) is often estimated as a probit model to account for its binary dependent variable. The probability of adoption predicted by this model ($\hat{T}_i$) accounts for observed X_i that influence adoption, and excludes the effects of unobserved characteristics u_i that may influence both adoption and net income. This suggests that $\hat{T}_i$ embodies only the exogenous variation in T_i.

In the second stage, $\hat{T}_i$ is substituted for T_i in Equation (2), and the outcome model is estimated using OLS regression. The impact of adoption (or average treatment effect [ATE]) after controlling for other variables affecting the outcome is measured by the regression coefficient estimated for λ. Standard errors obtained from this second stage regression are biased estimates of the true standard errors as the model is estimated using $\hat{T}$ rather than T. We adjusted the standard errors following the procedure described by Gujarati (2003, p. 791). We also estimated λ

using subsets of the data to identify a breakpoint in enterprise size beyond which the impact of GlobalGAP on net farm income changed.

The reliability of this two-stage regression approach to impact evaluation depends heavily on the validity of its IVs (Ravallion, 2007). IVs should correlate strongly with *T* (i.e., cov[*Z*, *T*] ≠ 0) but not with the residual term in Equation 3 (i.e., cov[*Z*, ε] = 0). We selected farmer's access to the export market before the introduction of GlobalGAP as a suitable IV for the study. It was anticipated that farmers who were already selling pineapples into export markets when GlobalGAP was introduced would be more inclined to certify than those who did not engage with the export market at that time. However, historical exposure to the export market was not expected to influence current net incomes. Section 4.3 presents evidence confirming the validity of the IV.

4 | RESULTS AND DISCUSSION

4.1 | Descriptive statistics

Table 1 presents summary statistics of the sample farmers. Most households are male-headed, with only 13% headed by females. The mean age of sample farmers is 46 years, with an average of 7 years of formal education.

TABLE 1 Variable definitions and summary statistics.

Variable	*n*	Definition	Mean	SE
Explanatory variables				
Gender household head	546	Gender of household head (1 = male, 0 = female)	0.87	0.01
Age household head	540	Age of de-facto household head (years)	46.34	0.46
Formal education	541	Formal education (years)	7.34	0.16
Household size	541	Household size (number of people)	5.84	0.09
Farmland endowment	512	Farmland endowment (ha per adult equivalent)[a]	0.40	0.02
Cooperative membership	537	Cooperative member before adoption (1 = yes, 0 = no)	0.39	0.02
Extension service	534	Access to extension service (1 = yes, 0 = no)	0.55	0.02
Distance district capital	546	Distance from household to district capital (km)	5.57	0.16
Export market access	523	Export market access before adoption (1 = yes, 0 = no)	0.41	0.02
MD2 pineapple variety	546	MD2 pineapple variety (1 = yes, 0 = other)	0.32	0.02
Pineapple farm size	530	Area planted to pineapples (ha)	0.88	0.07
Outcome/dependent variables				
GlobalGAP adopter	546	GlobalGAP adopter (1 = yes, 0 = no)	0.43	0.00
Pineapple yield	521	Pineapple yield (kg/ha)	57,145	751.78
Pineapple revenue	521	Pineapple gross revenue (GH₵/ha)[b]	58,109	933.61
Pineapple production costs	521	Cost of pineapple production (GH₵/ha)	31,949	344.23
Pineapple net income	521	Net income from pineapple production (GH₵/ha)	26,160	929.12

[a]Adult equivalent measures household size, with children (below 16) and older adults (above 65) assigned 0.5 of an adult, while adults 16–65 are assigned 1 unit.
[b]GH₵ is Ghanaian currency (US1 = GH₵6.01 in 2020).

Household sizes are relatively large with an average of almost six persons per household, suggesting ready access to farm labor. When GlobalGAP was introduced in 2007, 41% of the farmers were accessing export markets, and 39% were members of farmer cooperatives. More than half (55%) of the farmers used extension services. On average, households are reasonably close (5.6 km) to their district capital, but there is significant variation in this estimate.

Although the mean area planted to pineapples (0.88 ha) comprised only one-half of the average household's farmland, revenue earned from pineapple sales accounted for almost three-quarters of total farm revenue, emphasizing the importance of pineapple production to these small-scale farmers. Approximately 43% of the farmers were GlobalGAP certified. Pineapple yields averaged 57,145 kg per hectare, generating revenue of GH₵58,109 per hectare at a cost of GH₵31,949 per hectare.

Tests for differences in mean values computed for GlobalGAP adopters and nonadopters are presented in Table 2. Adopters had more farmland, cultivated larger areas of pineapples, and lived closer to the district capital. At the time GlobalGAP was introduced, adopters made better use of extension services, cooperatives, and export markets than did nonadopters. On the other hand, adopters and nonadopters were similar in respect of age, formal education, and household size. They also achieved similar pineapple yields. This finding appears to contradict expectations of higher yields on certified farms, but the explanation lies mainly in varietal differences. Most adopters (66%) cultivate the exotic MD2 variety, whilst almost all nonadopters grow the traditional Sugar Loaf variety. MD2 produces lower yields than Sugar Loaf (Kleemann, 2016). Although adopters and nonadopters average similar yields, adopters earn substantially higher revenue per hectare (GH₵71,191) than nonadopters (GH₵47,607)

TABLE 2 Differences in characteristics of GlobalGAP adopters and nonadopters.

	Adopters			Nonadopters			
Variable	*n*	Mean	SE	*n*	Mean	SE	Difference in group means
Explanatory variables							
Male headed household	236	0.80	0.03	310	0.93	0.01	−0.13***
Age household head	235	46.41	0.67	305	46.28	0.62	0.13
Formal education	235	7.28	0.24	306	7.39	0.21	−0.11
Household size	235	5.73	0.13	306	5.93	0.12	−0.20
Farmland endowment	231	0.47	0.04	281	0.34	0.01	0.13***
Cooperative membership	232	0.48	0.03	305	0.32	0.03	0.16***
Extension service	228	0.65	0.03	306	0.48	0.03	0.16***
Distance district capital	236	5.19	0.26	310	5.86	0.20	−0.67***
Export market access	227	0.59	0.03	296	0.27	0.03	0.32***
MD2 pineapple variety	236	0.66	0.31	310	0.07	0.14	0.59***
Pineapple farm size	232	0.98	0.04	298	0.81	0.03	0.17***
Outcome variables							
Pineapple yield (kg/ha)	232	58,507	1139	289	56,051	997	2456
Pineapple revenue (GH₵/ha)	232	71,191	1364	289	47,607	883	23,584***
Pineapple production cost (GH₵/ha)	232	36,859	518	289	28,008	303	8851***
Pineapple net income (GH₵/ha)	232	34,332	1532	289	19,599	981	14,733***

***Statistical significance at the 1% level.

as they receive higher prices for pineapples sold to the export market. These gains in revenue more than offset higher production costs on certified farms, leaving the average adopter better off (net income of GH₵34,332 per hectare) than the average nonadopter (net income of GH₵19,599 per hectare). The difference in per hectare pineapple net income (GH₵14,733) is, of course, a biased estimate of GlobalGAP impact as it does not account for pre-existing differences between adopters and nonadopters, nor does it account for other factors that may have contributed to this difference in 2020.

4.2 | Costs of acquiring and maintaining GlobalGAP certification

Table 3 presents costs that adopters incurred to secure and maintain GlobalGAP certification. As noted earlier, some of these costs relate to fixed improvements and durable assets, others to recurring certification costs. Following Wang and Yang (2001), we conclude that these costs are largely independent of farm scale and relevant to farmers contemplating certification as there are no sunk costs at the adoption decision-making stage. Annual costs of fixed improvements and durable assets were computed using the capital recovery method with a (real) annual discount rate of 5%. Shared improvements are expected to last much longer (20 years) than on-farm improvements (5 years) owing to their more substantive structures. We consider the farmer's fixed annual cost of GlobalGAP compliance to be high as the costs listed in Table 3 sum to GH₵6,043 per hectare and account for 16% of the average adopter's production costs (GH₵36,859 per hectare) and more than 20% of the average nonadopter's production costs (GH₵28,008 per hectare). We surmise that the aggregate data presented in this and the previous section mask the heterogeneous effect of farm size given the presence of very small farms and significant fixed costs associated with the adoption and maintenance of GlobalGAP standards. This potentially heterogeneous effect is investigated in Section 4.4.

In addition to the farmer-expenses listed in Table 3, adopters reported farming-related compliance costs covered by exporters, government agencies, and donors. This support included external audit, record-keeping, and technical services sponsored by exporters, and training and information services sponsored by government and donor organizations. In total, these services were estimated to cost stakeholders GH₵3,187 per hectare of pineapples cultivated by GlobalGAP adopters. The impact assessment presented in Section 4.3 was repeated with and without these additional costs to gauge the importance of stakeholder support on the impact that GlobalGAP adoption has on pineapple net income.

TABLE 3 GlobalGAP adoption and maintenance costs incurred by adopters (n = 236).

	Item	Cost of construction /purchase (GH₵/ha)	Expected life (years)	Annual cost (GH₵/ha)
On-farm improvements and durable assets	Changing room	5366.69	5.0	1239.57
	Toilet	5370.35	5.0	1240.42
	Disposal pit	1789.39	5.0	413.30
	Disposal bin	568.77	3.0	208.85
Farmer's share of group-owned improvements	Chemical store	6665.26	20.0	520.52
	Equipment room	5526.28	20.0	415.65
Recurring costs	Soil testing and fumigation			208.63
	Quality control			1796.25
Total				6043.19

4.3 | Impact of GlobalGAP adoption on pineapple net income

A binomial probit model was used to identify time-invariant factors influencing GlobalGAP adoption. The results are presented in Table 4. Female-headed households are 18% more likely to adopt GlobalGAP than are comparable male-headed households. Engagement with cooperatives and extension services increase the probability of GlobalGAP adoption by 33% and 29%, respectively. These findings are consistent with results reported by Muriithi et al. (2011) and Gichuki et al. (2020) for small-scale French bean and vegetable growers in Kenya, and with Lemeilleur's (2013) findings for mango farmers in Peru. An additional hectare of farmland per adult equivalent is estimated to increase the probability of GlobalGAP adoption by 27%.

With a pseudo-R^2 of 0.12 and a correct classification rate of 65%, the estimated probit model suggests that adopters and nonadopters were not markedly different in respect of observed time-invariant characteristics. Factors that did not significantly influence smallholder adoption include age of household head, years of formal education, and household size. Differences in family labor and management endowments do not appear to be critical determinants of GlobalGAP adoption.

We then used Equation (2) of the two-stage regression approach described in Section 3.2 to estimate the impact of GlobalGAP adoption on pineapple net income, both with and without the stakeholder support currently afforded to adopters. The results are presented in Table 5. The key finding from this aggregate model is that GlobalGAP adoption ($\hat{T}$) has large but negative impact on net income. On average, adoption reduces pineapple net income by GH₵14,640 per hectare under prevailing conditions where adopters benefit from services sponsored by stakeholders, and this loss would increase by an estimated 15% if adopters paid for these services. On the contrary, Asfaw et al. (2009b) found that GlobalGAP improved the net income of small-scale vegetable farmers in Kenya, but important fixed costs were omitted from their estimation of net income. Likewise, Kleemann et al. (2014) concluded that GlobalGAP improved returns on investment for small-scale pineapple farmers in Ghana, yet the results of their ESR model show a negative ATE for conventional (nonorganic) producers even though costs associated with shared fixed improvements were not considered. Unlike Asfaw et al. (2009b) and Kleemann et al. (2014) this study accounts for fixed cost improvements and consequently presents conclusions that are more realistic.

Four of the household and farm-level attributes (i.e., a history of using extension services, distance to district capital, the MD2 variety, and pineapple farm size) impacted positively on per hectare pineapple net income. Positive

TABLE 4 Probit analysis of GlobalGAP adoption ($n = 491$).

Explanatory variable	Marginal effect	Regression coefficient	SE
Male headed household	−0.18	−0.52**	0.20
Age household head	0.02	0.06	0.05
Age squared	−0.0002	−0.0005	0.00
Formal education	0.0008	0.002	0.02
Household size	0.04	0.01	0.04
Extension service	0.29	0.85***	0.15
Cooperative membership	0.33	0.95***	0.16
Distance district capital	0.0003	0.009	0.02
Farmland endowment	0.27	0.77***	0.21
Constant		−2.46	1.15

Note: LR $\chi^2(9) = 66.30$ Prob > $\chi^2 = 0.0000$; Log likelihood = −296.98; Pseudo $R^2 = 0.12$.

*** and **Statistical significance at 1% and 5% levels, respectively.

TABLE 5 Impact of GlobalGAP adoption on pineapple net income ($n = 457$).

Explanatory variables	With current stakeholder support		Without current stakeholder support	
	Regression coefficient	SE	Regression coefficient	SE
Predicted adoption ($\hat{T}$)	−14,640.39**	5825.35	−16,838.02***	5866.60
Male headed household	3009.80	3359.94	3189.76	3383.73
Age household head	−618.49	767.26	−659.68	772.69
Age squared	5.52	7.85	6.02	7.91
Formal education	17.43	278.14	19.79	280.11
Household size	276.07	592.32	272.87	596.51
Extension service	10,084.38***	2243.33	9677.15***	2259.22
Distance district capital	636.32**	286.88	618.28**	288.91
MD2 pineapple variety	10,171.38***	2502.75	8016.10***	2520.48
Pineapple farm size	15,273.10***	1808.74	16,332.90***	1821.55
Constant	18,185.71	17,995.03	18,522.49	18,122.45
F-statistic	13.46***		13.91***	
Adjusted R^2	0.22		0.22	
IV test results	Corr (Z, T) = 0.32***			
	Corr (Z, Y) = −0.05			
	Corr (Z, ε) = 0.006			

Note: First-stage results of the 2SLS model are reported in Appendix Table A1.
*** and **Statistical significance at 1%, and 5% levels, respectively.

regression coefficients were expected for all of these attributes apart from distance to the district capital. Contrary to expectations, pineapple farmers living further away from the district capital benefit from cheaper land, labor, and plantlet costs compared to those living close to urban centers. One explanation for this apparent anomaly is that large-scale pineapple estates have been relocating to more remote rural areas where there is less competition for land, and they partner with and support smallholders to exploit size economies in their processing, transport, and marketing activities. Estate farms serve as resource centers providing agricultural inputs, production support and markets to adjacent small-scale farms in a mutually beneficial relationship.

The estimated outcome regressions presented in Table 5 are statistically significant at the 1% level of probability, but unbiased estimation of impact requires valid instruments. The IV used in this analysis, export market access (a dummy variable scoring one for respondents who engaged in export markets before the introduction of GlobalGAP, and zero otherwise), was a significant determinant of GlobalGAP adoption in the first stage regression (Equation 3 results are reported in Appendix Table A1), improving the probit model's correct classification rate from 65% to 70%. This was expected because export market access was positively correlated with adoption ($r = 0.32$***). Also as expected, the IV did not correlate with pineapple net income ($r = -0.05$) and, importantly, it did not correlate with the residual (ε) of the second stage outcome regression ($r = 0.006$). Lastly, we tested for potential endogeneity of the adoption variable using the Durbin–Wu–Hausman test for endogeneity. Based on the test results ($\chi^2 = 20.54$; $F = 21.77$; $p = 0.000$), we rejected the null hypothesis that adoption is exogenous, and concluded that the underlying two-stage model is appropriate to estimate impact because it provides consistent parameter estimates.

TABLE 6 Impact of GlobalGAP adoption on pineapple net income for smaller and larger small-scale farms.

	Pineapple area ≤ 1 ha		Pineapple area > 1 ha	
Explanatory variables	Regression coefficient	SE	Regression coefficient	SE
Predicted adoption ($\hat{T}$)	−26,559.04***	6865.99	28,151.28***	8632.96
Male headed household	2160.31	4116.25	4539.53	4201.32
Age household head	424.71	837.74	−453.68	1618.06
Age squared	−5.46	8.52	6.50	16.56
Formal education	−2.56	316.48	−663.06	450.28
Household size	−381.27	756.79	269.55	785.72
Extension service	12,226.18***	2558.28	3689.32	3324.81
Distance district capital	656.12**	326.74	878.45*	446.79
MD2 pineapple variety	17,047.10***	2990.55	−3298.18	3456.14
Constant	10,180.57	19,270.33	17,803.53	39,904.83
F-statistic	5.86***		2.49**	
Adjusted R^2	0.11		0.10	
n	339		118	

***, **, and *Statistical significance at 1%, 5%, and 10% levels, respectively.

4.4 | Heterogeneous impact of GlobalGAP adoption on pineapple net income

In Table 5, we observed that while pineapple farm size is a positive and important determinant of net income, GlobalGAP adoption appears to have the opposite impact. We took our cue from previous studies (e.g., Mbowa & Nieuwoudt, 1998) to investigate the possibility of size economies usually associated with small-scale farming. The discrete grid search approach[1] we applied identified a breakpoint at 1 ha beyond which the impact of GlobalGAP adoption switched from negative to positive. Table 6 presents the results of our impact analysis for the subset of farmers who grew more than 1 ha of pineapples (larger small scale) and the subset who farmed pineapples on areas smaller than or equal to the 1 ha threshold (smaller small-scale). This approach avoided collinearity problems that would likely be encountered if an interaction term between the threshold and $\hat{T}_I$ were added to the outcome model (Khandker et al., 2009). The results presented in Table 6 are for the prevailing situation where adopters benefit from services sponsored by external stakeholders.

For farmers cultivating less than 1 ha of pineapples, GlobalGAP adoption reduced pineapple net income by GH₵26,559 per hectare. However, for farmers cultivating more than 1 ha, GlobalGAP adoption increased pineapple net income by GH₵28,151 per hectare. We can therefore infer that, on average, GlobalGAP adoption improves profits for small-scale farmers who grow more than 1 ha of pineapples but is not profitable for those growing pineapples on a smaller scale. These smaller-scale pineapple farmers benefit most from extension services, support provided by neighboring estate farms, and the MD2 pineapple variety. On larger farms, the impact of MD2 variety

[1]The discrete grid search approach involved a manual search for the optimal break point by identifying different plausible breakpoints between 0.6 and 1.2 ha (not far from the 0.88 ha average) at intervals of 0.1, splitting our data at each breakpoint and estimating separate models until we found the breakpoint of 1 ha which showed that GlobalGAP adoption produced negative net income for farms less than or equal to 1 ha, and positive net income for small farms greater than 1 ha.

TABLE 7 Comparison of GlobalGAP impact estimators.

Model	(a)		(b)		(c)	
	Probit-OLS two-stage regression model		OLS-OLS two-stage regression model		Maximum likelihood extended regression model	
Explanatory variables	≤1 ha	>1 ha	≤1 ha	>1 ha	≤1 ha	>1 ha
Predicted adoption ($\hat{T}$)	−26,559.0***	28,151.3***	−26,729.1***	27,305.2***	−19,189.0**	37,074.4***
Male headed household	2160.3	4539.5	2074.0	4298.4	2945.2	4511.0
Age household head	424.7	-453.7	428.5	-513.6	324.4	78.3
Age squared	−5.5	6.5	−5.5	7.1	−4.6	0.4
Formal education	−2.6	−663.1	−18.7	−658.7	42.1	−647.1
Household size	−381.3	269.6	−406.0	288.0	−379.2	84.7
Extension service	12,226.2***	3689.3	12,177.1***	3784.8	11,325.8***	1208.3
Distance district capital	656.1**	878.5*	643.4**	848.7*	445.7	894.1*
MD2 pineapple variety	17,047.1***	−3298.2	17,043.6***	−3249.8	6898.5*	−9785.6***
Constant	10,180.6	17,803.5	10,603.3	19,968.7	14,394.7	6267.9
F-statistic	5.86***	2.49**	5.80***	2.34**		
Adjusted R^2	0.11	0.10	0.11	0.10		
N	339	118	339	118	339	118
Log likelihood					−4016.68	−1361.28
Wald χ^2					19.84**	29.71***

***, **, and *Statistical significance at 1%, 5%, and 10% levels, respectively.

is not significant. However, the adoption of GlobalGAP secures positive net income irrespective of the pineapple variety they cultivate.

4.5 | Robustness of the impact model

Angrist and Pischke (2009, pp. 190–192) recommend that the first regression (Equation 3) in the two-stage regression model should be estimated as a linear probability model and not as a probit model as only OLS estimation is guaranteed to produce first-stage residuals that are uncorrelated with $\hat{T}$. Table 7 compares the results of (a) the probit-OLS two-stage model reported in Table 6 with the results of (b) an OLS–OLS two-stage model. The regression coefficients are very similar suggesting that little harm was done by estimating Equation (3) as a nonlinear function.

We then used an extended regression model (ERM) to test the robustness of the two-stage regression models. ERMs use maximum-likelihood estimation to address endogeneity bias such as that introduced by observed and unobserved variables that affect both adoption and the outcome of adoption (Jafari et al., 2022; Stata Press, 2021). Like the two-stage regression approach, ERMs require specification of a valid IV to generate an unbiased estimate of the ATE. The ERM results presented in column (c) of Table 7 are consistent with those of the two-stage regression models. GlobalGAP adopters are estimated to gain GH₵37,074 per hectare if they grow more than 1 ha of pineapples, and to lose GH₵19,189 per hectare if they cultivate smaller areas. Again, these smaller farmers are predicted to benefit most from extension services and the MD2 pineapple variety.

5 | CONCLUSIONS

Over the years, the government of Ghana, in partnership with various development agencies, has executed several interventions to enhance food quality and safety to improve the performance and competitiveness of the agri-food sector. For example, Ghana is currently implementing the Food and Agriculture Sector Development Policy (FASDEP II). FASDEP II aims to increase competitiveness in the agri-food sector and to enhance smallholder integration into domestic and international markets by promoting food quality and safety standards such as GlobalGAP and its domestic equivalent, GhanaGAP, along agri-food value chains. While GhanaGAP is still being piloted, international food standards, particularly GlobalGAP and organic certifications, are standards routinely preferred by farmers.

There are no specific criteria for selecting farmers into these food safety interventions. Farmers growing a target crop within a target area are eligible to participate regardless of their farm size but profitable adoption of GlobalGAP adoption is biased against the very small farms in Ghana's pineapple sector because significant compliance costs, particularly those associated with investments in fixed improvements, are largely independent of farm scale. Farmers operating very small farms confront a real prospect of losing income if they adopt GlobalGAP because they cannot spread these costs over sufficiently large volumes of output. The implication is that smallholders operating relatively large farms are more likely to sustain their food safety certification, especially if public and private stakeholders reduce their subsidies for compliance services over time.

The results of this study suggest that the design and implementation of policies and interventions intended to promote the adoption of GlobalGAP in Ghana's pineapple sector should consider the following: First, small-scale farming households that have a female head, are relatively well endowed with farmland, and engage with extension services and cooperatives have a higher propensity to adopt GlobalGAP standards. Second, small-scale farmers who are willing and able to cultivate more than 1 ha of pineapples are more likely to benefit from Global adoption and hence to sustain their certification. Third, small-scale pineapple farmers unable or unwilling to meet this size threshold would benefit more from quality extension services and improved varieties that appeal to high-end but less regulated domestic markets. Our results are more realistic than previous studies because our analyzes account for fixed cost improvements which other studies did not consider.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

PEER REVIEW

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APPENDIX A

TABLE A1 Impact of GlobalGAP adoption on pineapple net income—the first stage of 2SLS regression ($n = 477$).

Explanatory variable	Marginal effect	Regression coefficient	SE
Male headed household	−0.21	−0.64***	0.20
Age household head	0.02	0.06	0.05
Age squared	−0.0002	−0.001	0.00
Formal education	−0.001	−0.004	0.02
Household size	−0.007	−0.02	0.04
Extension service	0.18	0.55***	0.13
Distance district capital	−0.009	−0.03	0.02
Farmland endowment	0.21	0.64***	0.22
Export market access	0.33	0.99***	0.13
Constant		−1.681	1.09

Note: LR $\chi^2(9) = 96.87$ Prob > $\chi^2 = 0.0000$; Log likelihood = −274.31; Pseudo $R^2 = 0.16$.

*** and **Statistical significance at 1% and 5% levels, respectively.

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