Propensity score matching approach to intervention evaluation: the case of the crop production intervention in the USDA Ghana poultry project

by

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Abstract

USDA used its Food for Progress mechanism to support two projects aimed at enhancing productivity in Ghana's poultry industry. The projects were the Ghana Poultry Project (GPP) implemented by ACDI/VOCA and Assisting in the Management of Poultry and Layer Industries by Feed Improvement and Efficiency Strategies (AMPLIFIES), implemented by the American Soybean Association's WISHH (World Initiative for Soy in Human Health). While GPP focused on enhancing the capacity of poultry farmers, AMPLIFIES' focus was on improving poultry feed quantity and quality. As part of AMPLIFIES's efforts, the project invested in increasing maize and soybean production and post-harvest management in Ghana. Maize and soybean account for the majority of poultry feed ingredients. This research sought to evaluate the impact of AMPLIFIES project on the beneficiary maize and soybean farmers.

The study was done using secondary data from the final evaluation of the AMPLIFIES project conducted by METSS Research, a research group led by the Department of Agricultural Economics at Kansas State University. The data were collected using a farm-level survey in the three principal maize and soybean-producing regions: Northern, Brong Ahafo, and Ashanti. The results show that the gross margin of maize beneficiaries of the AMPLIFIES was 50% compared to 40% for non-beneficiaries. Similarly, the gross margin for soybean beneficiaries was 56% compared to 55% for non-beneficiaries. While the beneficiaries' gross margins were both positive, the maize gross margin difference was statistically significant at the 1 percent level and the soybean gross margin difference was not statistically different.

The propensity score matching approach was used to evaluate the extent to which AMPLIFIES's intervention could allocate the differences between the financial performance of

beneficiaries and non-beneficiaries. The study explores two treatment effects: Average Treatment Effect (ATE) and Average Treatment Effect on the Treated (ATT). ATE measures the average treatment effect in the entire population while ATT measures the treatment effect on the treated population. Thus, ATT explores the effect of the treatment on beneficiaries and compares it to a "hypothetical" condition of the same being non-beneficiaries. Generating the "hypothetical "group is achieved through the propensity score matching process. The matching of beneficiaries and non-beneficiaries was based on gender, region, and maize and soybean production experience of producers. Using gross margin as the indicator of interest, the results show that the ATE of the AMPLIFIES intervention was 6.6% ($p < 0.10$) for maize producers and 7.2% ($p < 0.10$) for soybean producers. However, the average treatment effect on the treated (comparing beneficiaries to a situation where they were not beneficiaries) was negative for maize and positive for soybean. Neither of the ATT statistics was statistically significant, suggesting that the financial performance of beneficiary producers was not different from their state had they not been beneficiaries, but the intervention produced a positive impact on beneficiaries compared to non-beneficiaries across the population.

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Acknowledgments

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To my family and friends, your love, encouragement, and sacrifices have made this possible. I appreciate you.

Dedication

I dedicate this to my late grandmothers (Mama Esther Ntow and Akosua Duku).

1 Introduction

1.1 Background

In Ghana, poultry is an essential animal protein source. Although poultry demand in Ghana has been increasing over the years, domestic production has lagged (Amanor-Boadu et al., 2016). The difference between demand and supply has been addressed with the increasing importation of poultry meat. The low production of domestic poultry meat can be attributed primarily to the increasing poultry feed prices, which account for between 60% and 75% of total production costs(American Soybean Association/WISHH, 2016; Andam et al., 2017). The competitiveness of poultry production in Brazil and the United States is closely tied to their low cost of the primary ingredients in poultry feed, i.e., maize and soybean (Davis et al., 2013).

The United States Department of Agriculture (USDA) funded two five-year projects in Ghana using its Food for Progress mechanism, which aims to help "developing countries and emerging democracies modernize and strengthen their agricultural sectors." The specific purpose of the projects was to strengthen the efficiency and the competitiveness of the poultry production in Ghana. The projects, Ghana Poultry Project (GPP) was implemented by ACDI/VOCA and the Assisting in the Management of the Poultry and Layer Industries by Feed Improvement and Efficiency Strategies (AMPLIFIES) was implemented by the American Soybean Association (ASA)/World Initiative for Soy in Human Health (WISHH). This research focuses on the AMPLIFIES project.

The AMPLIFIES project was initiated in 2015 and spanned five years. Its primary objective was to address challenges within Ghana's poultry value chain. The project sought to specifically strengthen the market linkages for locally produced maize and soybean commodities utilized in feed and poultry production(American Soybean Association/WISHH, 2016).

ASA/WISHH partnered with the Adventist Development and Relief Agency (ADRA) and Kansas State University (KSU) to implement the core of its activities (American Soybean Association/WISHH, 2016). By targeting feed producers and feed production, poultry farmers, and consumers of poultry products, AMPLIFIES aimed to strengthen the production, marketing, and financial performance of Ghana's poultry value chain.

AMPLIFIES's interest in enhancing feed availability, accessibility, and affordability for poultry farmers, and the challenges maize and soybean present to the competitiveness of Ghana's poultry farmers motivated its investment in the capacity of farmers producing these crops. The success of these farmers from this intervention could provide insights into what future programs could do to enhance the competitiveness of Ghana's poultry industry, which is the overall objective of the Food for Progress initiative.

1.2 Problem Statement

Maize and soybean production holds significant potential to advance Ghana's poultry sector. Adequate access to available and affordable maize and soybean enables farmers to produce or purchase cost-effective feed, which improves their competitiveness in poultry meat and egg markets. Ghana's maize and soybean production levels are inadequate to meet the country's human food and animal feed needs (Scheiterle & Birner, 2018). Because feed cost accounts for between 60% and 70% of the total production cost of poultry, any attempt to address affordability of these feed inputs is laudable. Although the challenges farmers face in producing maize and soybeans are numerous, these crops also are major food crops, meaning poultry farmers compete with the food market for their primary feed inputs. An evaluation of how the performance of AMPLIFIES beneficiaries differed from non-beneficiaries could provide insights into how the project's efforts may be scaled to contribute to a broad solution to the feed availability, accessibility, and affordability challenges facing the industry.

1.3 Research Questions

The research question motivating this research was this: How did the interventions undertaken by AMPLIFIES in the maize and soybean production industries in Ghana enhance farmers' performance in those two crop industries? The importance of the answer to this question is that it allows future research to investigate the potential translation of the crop industries' performance on the primary purpose of the USDA investment, i.e., improving the competitiveness of Ghana's poultry industry.

1.4 Objectives of Study

The overall objective of this study is to evaluate the extent to which AMPLIFIES interventions in maize and soybean production in Ghana improved the beneficiaries' performance compared to their contemporaries who were non-beneficiaries. The specific objectives emanating from this overall objective are as follows:

1. To estimate and test yield differences between beneficiaries and non-beneficiaries of the interventions presented by AMPLIFIES.
2. To assess the relative economic outcomes from the interventions, assumed to accrue only to beneficiaries, and compare them with the prevailing economic outcomes accruing to non-beneficiaries.
3. To focus specifically on the gross margin as a critical indicator for assessing the overall impact of the AMPLIFIES interventions on beneficiary crop farmers and the extent to which it differed from non-beneficiary crop farmers.

1.5 Organization of the thesis

The rest of the study is organized as follows. Chapter 2 reviews relevant literature related to the research. Chapter 3 provides a description of the data and methods used in the study. Chapter 4 presents the findings and discusses the results to address the study's objectives. The final chapter summarizes the study, provides conclusions, and discusses the policy implications of the main findings. Recommendations for future studies are also presented.

2 Literature Review

2.1 Introduction

The purpose of this chapter is to provide an overview of the relevant literature for the study. The chapter is divided into four main sections. The first provides an overview of the motivation problem for the interventions. It presents the production and uses for maize and soybean exploring both available secondary statistics from organizations, such as FAO, and analyses and reports from the literature. The second section presents an overview of the AMPLIFIES project. It presents the objectives and activities carried out. The third section provides an overview of project evaluation literature, zeroing in on the approach that was selected for use in this study. The final section discusses the literature on the metrics used in assessing projects and explores the foundations for the ones chosen for the study.

2.2 Maize Production and Uses in Ghana

In developed countries, like the U.S., maize (Zea mays L.) is used primarily for animal feed. For example, only about 1% of the 90 million acres planted to maize are used for direct human consumption (USDA ERS, 2023). The remainder goes to livestock feed and industrial products, such as ethanol and sweeteners. In developing countries, such as Ghana and most West African and Southern African countries as well as Latin American countries, maize is a staple food and a major food security crop (Cherniwchan & Moreno-Cruz, 2019; Guzzon et al., 2021; O Awata et al., 2019).

Maize accounts for more than 50 percent of the total cereals production in Ghana (Asante et. al., 2017). It is the most widely produced and consumed cereal and a major source of calories in Ghana (Darfour & Rosentrater, 2016; Mensah et al., 2021; Ntiamoah et al., 2022; Wongnaa et al., 2019). In addition to being a major human food crop, maize is also a crucial component in the formulation of animal feed, particularly for poultry and livestock (Ntiamoah et al., 2022). Therefore, the development and productivity of the livestock and poultry sectors in Ghana are closely linked to the growth and productivity in the maize value chain.

Maize crop in Ghana covers approximately one million hectares (MoFA-SRID, 2021). It is cultivated across all agro-ecological zones in Ghana and is primarily produced by smallholder resource-poor farmers using rain-fed farming methods (Darfour & Rosentrater, 2016; Scheiterle & Birner, 2018). Maize production in Ghana follows different cropping systems depending on the geographic or agroecological region. In the higher rainfall areas of the southern forest zone, maize is typically grown in annual single-crop systems. In the forest/savannah transitional zone, annual double-crop systems are commonly practiced. These double-crop systems involve mixed cropping, such as maize-maize, maize-cowpea, maize-soybean, and groundnut-maize. In the three northern regions, sorghum, and millet are frequently intercropped with soybean, cowpea and/or maize. In the southern forest zone, maize is often intercropped with other crops like cassava, cocoyam, and plantain. Eastern, Brong Ahafo, Ashanti, Northern and Central region produces majority of the country's maize, (MoFA, 2019).

Between 2016 and 2018, the average output of maize in Ghana was 2,013,600 metric tons (MoFA, 2019). Though production has been upward trending, maize yield in Ghana is still one of the lowest worldwide. There is a significant gap between the national average maize yield of 2.48 metric tons per hectare and the potential yield of 5.50 metric tons per hectare (MoFA-SRID, 2021). This indicates that there is room for productivity improvement for maize production in Ghana. Closing this yield gap could contribute to enhanced food security, provide lower feed cost, increased feed availability, and improve the competitiveness of the poultry industry.

Post-harvest losses are a major problem in maize production, particularly in developing countries. Several studies have examined the impact of different post-harvest management practices on maize quality and losses. For instance, Odoi et al. (2020) found that using hermetic storage bags can significantly reduce post-harvest losses and improve maize quality. Similarly, (Akowuah & Mensah, 2022) found that using improved drying methods can reduce post-harvest losses and improve maize quality.

2.3 Soybean Production and Uses in Ghana

Soybean (Glycine max L.) is an important legume crop cultivated in many countries around the world. It is used for human food, animal feed, and industrial input (Gresshoff, 2017). Soybean is a relatively new crop in Ghana and mainly used by farmers for crop rotation with maize. Increasing economic value of soybean has created a growing market with an increase in domestic demand exceeding domestic supply in Ghana. Soybeans are predominantly cultivated in the northern regions of Ghana and are transported to the southern regions for processing (Ntiamoah et al., 2022). The demand for soybean grains is high, not only for household consumption but also for industrial purposes such as the production of cooking oil and animal feed. Soybean meal, an important component of animal feed, is widely used in Ghana's agriculture and aquaculture sectors. The poultry industry, in particular, accounts for approximately 75% of the total annual consumption of soybeans in Ghana (Ntiamoah et al., 2022).

Soybean production has increased from 112,800 metric tons in 2009 to 176,670 metric tons in 2018 (MoFA, 2019). This indicates that Ghana's soybean production experienced a significant growth of 36.2% during this period. The crop is grown mainly in the Northern, Upper East, and Upper West Regions of Ghana, with an estimated 200,000 hectares of land used for its cultivation

(FAO, 2022; Mahama et al., 2020). Ghana's domestic demand for soybean grains surpasses 300,000 metric tons per year, and the industrial sector accounts for 91% of this demand (Ntiamoah et al., 2022). However, the domestic supply of soybeans is only at 176,672 metric tons in 2018 (MoFA, 2019) , resulting in a shortfall of over 120,000 metric tons. To meet the demand, Ghana often relies on imports from countries like Brazil and China. Several factors contribute to the poor soybean yield of 1.72 metric tons per hectare, which is significantly below its feasible average yield of 3.00 metric tons per hectare (MoFA, 2019). Countries like Turkey, Italy, the USA, and Brazil have significantly higher productivity levels, with yields ranging from 3.39 to 4.26 metric tons per hectare (Ntiamoah et. al., 2022).

Several studies have examined the impact of different crop management practices on soybean yields. For instance, Cao et al. (2020) found that applying suitable micro sprinkler fertigation at the right time and in the right amount can boost soybean yields. Similarly, Pereyra et al. (2022) found that using improved planting techniques, such as row spacing and plant density, can increase soybean yields. A study by Wang et al. (2016) found that the application of biochar can boost and improve the growth of soybean plants thereby leading to increased productivity. Several studies have examined the impact of different pest management practices on soybean yields. Bueno et al. (2021) found that using integrated pest management (IPM) practices, such as crop rotation and biological control, can significantly reduce soybean yield losses due to pests.

2.4 The AMPLIFIES Project

Assisting in the Management of Poultry and Layer Industries by Feed Improvement and Efficiency Strategies (AMPLIFIES) aimed at increasing the poultry industry’s productivity and expanding the trade in egg products and by-products. It sought to strengthen the use of locally produced maize and soybeans in poultry feed production. The AMPLIFIES project was implemented in three different regions in Ghana, namely: Ashanti, Brong Ahafo, and Northern. The project was developed with three key strategic objectives, all aimed at enhancing the agricultural productivity of the poultry value chain:

- To increase the quality and lower the cost of poultry feed through the reduction of post-harvest loss and procurement inefficiencies of primary feed ingredients.
- To improve poultry feed quality by boosting feed testing capacity and demonstrating the benefits of quality feed
- To increase the trade of eggs through awareness campaigns and the trade of commercialized poultry feed through improved distribution networks and marketing.

To accomplish these objectives, the AMPLIFIES project implemented several key activities, which are detailed in appendix table A.1. The AMPLIFIES activities included.

- Training: Harvesting, Post-harvest Handling, and Storage of Feed Inputs
- Infrastructure: Post-harvest Storage and Aggregation of Feed Inputs
- Capacity Building: Increased Efficiency in the Procurement of Feed Ingredients and Adoption of Improved Poultry Feed
- Capacity Building: Improvements in Quality and Consistency of Feed Formulations
- Capacity Building: Increased Feed Testing Capacity
- Capacity Building: Increased Efficiency in Feed Processing and Marketing: Expansion of Poultry Feed Distribution Network
- Financial Services: Loans for Investments in Feed Processing
- Organize National Awareness Campaign to Promote Egg Consumption

Training played a crucial role in the implementation of the key activities. The training methods employed included seminars, small group meetings, practical field demonstrations, durbars, and a "training of trainers". Crop farmers were provided with hands-on demonstrations and practical guidance on various techniques related to planning and organizing their farming activities. These included training on proper harvesting techniques, post-harvest handling, and effective storage methods. Similarly, poultry farmers and feed millers were given training sessions on feed formulation and testing, with a focus on improving the quality and nutritional value of the feed. Awareness campaigns on eggs were mainly done through durbars where different members of society gathered. The campaign mainly used informal discussions and drama to educate the public about consuming eggs. The project's activities primarily focused on improving feed quality, quantity, and cost.

2.5 Evaluating the Impact of Interventions

Impact evaluations generally aim to estimate the average impacts of a program, its modalities or design innovations. It is important for evidence-based policymaking. By rigorously evaluating the outcomes and effects of a project, impact evaluation provides valuable insights into whether the intended objectives have been achieved, the extent of the program's success, and the factors contributing to its outcomes. The robust evidence generated by impact evaluations is increasingly serving as a foundation for greater accountability, innovation, and learning (Gertler et al., 2016)

Evaluation methods are widely applied in economics to assess the effects of policy interventions and other treatments of interest (Abadie & Cattaneo, 2018). Impact evaluation may be conducted using various approaches. The most common methods used are randomized control trials, quasi-experimental designs, difference-in-difference, and propensity score matching.

Randomized control trials are regarded as the gold standard for estimating causal effects (West et al., 2008) due to their ability to control both observed and unobserved confounding variables. In a randomized control trials, individuals are assigned to receive specific treatment interventions by chance mechanisms (Gopalan et al., 2020; Stanley, 2007). When structural or policy interventions are being examined, it is not easily feasible or practical to conduct randomized control trials (Ali et al., 2019). Quasi-experimental research designs utilize nonexperimental variation in the main independent variable of interest (Gopalan et al., 2020). This approach essentially replicates experimental conditions by exposing some subjects to the treatment while others are not, without the researcher actively manipulating the assignment on a random basis. The use of experimental designs such as random assignment of treatment and control groups allows for the clear identification of causal effects. The reliability of causal claims and estimates differs among these designs and relies on the degree to which the study conditions resemble an actual experiment. The difference-in-difference estimate quantifies the disparities in outcome changes between a treatment group and a control group before and after implementation of a particular treatment (Goodman-Bacon, 2021). Casual inference methods based on propensity scores are ranked among the most advanced strategies utilized (West et al., 2008). Studies have evaluated the impacts of different interventions or policies using different frameworks. Scheiterle and Birner (2018) evaluated the impact of the impact of a fertilizer subsidy program on the private and social profitability of maize production using the Policy Analysis Matrix (PAM) Tsiboe et al. (Tsiboe et al., 2021) assessed the impact of the Ghana fertilizer subsidy program on crop yields using matching methods.

Matching is an invaluable technique in impact analysis because it allows the impact of a program or event to be estimated when randomization is neither ethically nor logistically possible.

The Matching Method is a non-parametric method for estimating treatment effects when controlled randomization is impossible and observable data are available (Thibbotuwawa et. al., 2012). The primary challenge with every evaluation study is the selection bias risk (Caliendo, & Kopeinig, 2008). This challenge arises because of the need to estimate the difference in outcome between participants with and without treatment when it is impossible to have people who are beneficiaries and at the same time non-beneficiaries. The motivating hypothesis is that beneficiaries of an intervention will differ in the expected outcomes from the intervention from non-beneficiaries. The beneficiaries are described as being in the treatment group while the non-beneficiaries are described as the control group. It is important to have beneficiaries and non-beneficiaries express similar or comparable baseline characteristics (Benedetto et. al.; 2018). It is developing the similarity of beneficiaries and non-beneficiaries that is the essence of matching, and it has been presented as a tedious and complex process. There are numerous matching approaches or methods. They include propensity score matching nearest neighbor matching, optimal pair matching, and optimal full matching. Others are generalized full matching, exact matching, and coarsened exact matching. Several fields have used propensity score matching. For example, (Benedetto et al., 2018; Haukoos & Lewis, 2015) discussed the usage of propensity score matching in clinical treatments to assess the impact of treatments on patients. It is also used to evaluate labor market policies (Caliendo & Kopeinig, 2008).

In relevant cases, researchers have used propensity score methods to reduce bias in estimating treatment effects and to reduce the likelihood of confounding when analyzing nonrandomized, observational data (Haukoos, 2015). Propensity score matching is a statistical technique in which a treatment case is matched with one or more control cases based on each case's propensity score. The key identifying assumption for propensity score matching is that there is a set of observables and that the outcomes are independent of program participation i.e., conditional independence (Thibbotuwawa et. al., 2012). The purpose of estimating the propensity score is to simplify the match process by collapsing all confounders into a single value. Weights are applied only to make the control group's outcomes represent the counterfactual outcomes of the treatment group by making the groups similar concerning observable characteristics (Nichols 2008). The reweighting makes the mean of each variable in the matrix (i.e., those variables included in the propensity-score model) approximately equal across the treatment and control groups.

Searching EconLit, a database published by the American Economic Association and providing bibliographic coverage of a wide range of economics-related literature, using the keywords "Propensity Score Matching," and limiting the search to only peer-reviewed studies produced 1,508 studies between 2000 and 2023. Removing the limitation produced 2,130 scholarly articles, 12 books, 86 dissertations, and 344 working papers between 1880 and 2023, with articles first appearing in 1998. On the other hand, searching the Health and Medicine database maintained by GALE Onefile produced nearly 20,000 academic articles, 581 magazine articles, and seven books. From this, it is obvious that propensity score matching has been used primarily in medicine and related fields and has only recently been borrowed into economics.

There are four general ways propensity scores are used. This involves matching one or more control cases with a propensity score that is (nearly) equal to the propensity score for each treatment case. That is, assembling two groups of study participants, one group that received the treatment of interest and the other did not while matching individuals with similar or identical propensity scores. This may approximate that of a randomized trial by directly comparing outcomes between individuals who received the treatment of interest and those who did not, using methods that account for the paired nature of the data (Haukoos, 2018). Another approach is stratification on the propensity score. This involves dividing or separating the study participants into distinct groups or strata based on rank-ordered propensity score and comparisons between groups are performed within each stratum. Although five strata are commonly used, increasing the number reduces the likelihood of bias. The relationship between treatment and outcome is estimated within each stratum or pooled across strata to provide an overall estimate of the treatment-outcome relationship. This method is based on the idea that people within each stratum are more similar to one another than people in general, so their outcomes can be directly compared (Haukoos, 2018). A third approach is weighting using propensity score (weight by inverse probability of treatment). Propensity scores are used to calculate statistical weights for each individual in order to create a sample with a distribution of potential confounding factors that is independent of exposure, allowing for an unbiased estimate of the relationship between treatment and outcome. This approach is similar to that of survey sampling where weights are used to ensure that samples are representative of specific populations (Benedettyo et. al., 2018). The final approach is regression or covariate adjustment. This includes propensity scores as a covariate in a regression model used to estimate the treatment effect. Following the propensity score model, a separate multivariable model is developed in which the study outcome serves as the dependent variable and the treatment group and propensity score serve as predictor variables. This enables the investigator to estimate the outcome associated with the treatment of interest while controlling for the likelihood of receiving that treatment (Haukoos, 2018).

2.6 Profitability of Maize and Soybean Production in Ghana

Studies have explored various measures of profitability. Common measures of profitability include, but are not limited to, the benefit-cost ratio (BCR), return on investment (ROI), gross profit, profit margin, net profit. The benefit-cost ratio provides a measure of the economic value generated by the project's value relative to the costs incurred. The value of the classification of project impacts as benefits or costs can vary, making it unable to fulfill its objectives of selecting an economically preferred design or ranking projects for limited budget funding; furthermore, it is logically possible to have an economically desirable project with a BCR less than one, zero, or even negative in terms of net present value (Lund, 1992). The profitability of maize production has been studied extensively (Darko et al., 2020; Ntiamoah et al., 2022) because of its importance in Ghana's agriculture These studies have used different approaches to assess the profitability of maize production, including cost-benefit analysis, partial budgeting, and gross margin analysis.

Mensah at al. (2021) examined the impact of adopted maize seed technology on farm profitability. Their study showed that maize farmers do not base their adoption decisions solely on farm output and revenue indicators, but also on the return on investment and the cost of the maize seed technology adopted. A recent study by Wongnaa et al. (2019) found maize production in Ghana to be profitable, providing a gross margin of GHS510/Ha with a Return on Investment (ROI) of 41.3%. Similarly, Scheiterle and Birner (2018) found that maize production in Ghana is profitable and is a significant contributor to economic growth.

Kankam-Boadu et al. (2018) found that the profitability (total value cost ratio) of maize production was highest at 4.79 due to the application of poultry manure and synthetic fertilizer in the Northern Region of Ghana. Although numerous studies have found maize production to be profitable, the profitability of maize production in Ghana varies depending on several factors such as the use of improved varieties, access to credit, and the availability of inputs. Abdulai et al. (2017) reported the economic efficiency of maize production in Northern Ghana showed increasing returns to scale. Gershon et al. (2014) found that the profit efficiency of maize farmers ranges between 47% and 96.7%. Similarly, Gad et al., (2019) assessing the profitability of small-scale farmers in the Brong Ahafo region of Ghana found that farmers in the region had an average profit efficiency of 58%, with estimated minimum and maximum profit efficiency of 19% and 83% respectively. Sarfo, (2018) on the effect of credit use on the profitability among smallholder maize farmers in the Brong Ahafo Region of Ghana using gross margin analysis found that farmers who use credit had a higher average total revenue than non-credit users.

Given the growing significance of soybean production, numerous studies have been undertaken to assess the profitability of soybean cultivation in Ghana. These studies have used different approaches to assess the profitability of soybean production, including cost-benefit analysis, partial budgeting, and gross margin analysis.

A study by Asodina et al. (2021) on the performance of soybean farmers in Ghana found that soybean farmers in the Upper West region had a technical efficiency of 59%. Similarly, Amesimeku and Anang, (2021) on the profit efficiency of smallholder soybean farmers in the Tolon District of the Northern Region of Ghana found that smallholder farmers who produced soybean had an average profit efficiency of 0.70. The profitability of soybean production in Ghana varies depending on several factors such as the use of improved varieties, access to credit, and the availability of inputs. While some studies have found soybean production to be profitable, others have found it to be unprofitable. This is evident in Dogbe et al., (2013) who estimated the profitability of soybean production in the Saboba and Chereponi Districts of the Northern Region of Ghana. They found that soybean production was profitable for male farmers in the Saboba

District while in Chereponi District, soybean production was found not to be profitable for both males and females. Akramov, K., & Malek, (2012) in analyzing the profitability of maize, rice, and soybean production in Ghana found that efficient farmers make substantial positive profits, and the society also makes welfare gains from resources allocated to maize and soybean production. They combined the policy analysis matrix (PAM) and data envelopment analysis (DEA) techniques to evaluate profitability.

2.7 Gross margin analysis

Gross margin analysis is one of the oldest and simplest analytical tools used in economic studies to evaluate profitability. There are numerous examples of research using gross margin analysis to conduct profitability analysis. Perdersen et. al. (2005) used gross margins to compare different cropping practices and their cost structures in the production of conventional table potatoes in six countries within the European Union. The study found that potato cropping practices vary significantly between the countries based on the different gross margin estimates and with that produced major differences in costs and yields. According to Adu-Gyamfi et al. (2019), maize production in Ghana is profitable, providing a gross margin of 0.46 under 100%-Briquette treatment. Their study explored different treatments of fertilizer applications and farm practices on maize farmers' profitability.

The gross margin of maize and soybean production in Ghana varies across regions and is influenced by factors such as farm size, quantity of fertilizer used, access to credit, and variable cost components. Overall, the studies reviewed suggest that maize and soybean production in Ghana is profitable, although the gross margin varies by region and may be influenced by various factors (Osei Danquah et al., 2020).

3 Methods and Data

3.1 Introduction

This section presents the methods and data used in this study. It provides further insights into theories and concepts of impact evaluations using propensity score matching, and profitability analysis using gross margin. It also discusses the models and statistical techniques that were employed in order to achieve the study objectives. The final segment of this section focuses on the description of the data utilized and provides insights into the study area. Detailed information about the data sources employed in the research is presented, including the types of data collected. Additionally, a comprehensive overview of the study area is provided, outlining its geographical scope, relevant characteristics, and any distinctive features that may have influenced the study outcomes.

3.2 Theoretical Framework

3.2.1 Impact Evaluation Using Propensity Score Match

In estimating the causal effect of a treatment (intervention) on an individual with absolute certainty, one would have to observe the same individual receiving and not receiving the intervention at the same point in time (Garrido et al., 2016). It is impossible to observe more than one treatment state at a given time for an individual, so a plausible counterfactual must be identified (an estimation of the individual's outcome in the unobserved state). Comparing treatment and control individuals in a non-randomized setting can be challenging due to the potentially significant differences in observables between the two groups. Matching is an excellent method for comparing treatment and control groups based on similar covariates.

The propensity score match is used in diverse fields of studies. It applies to all situations where one has a treatment group and an untreated group of individuals. The nature of treatment may be diverse. The propensity score matching (PSM) method compares the observed characteristics of a "Treatment Group" and a "Control Group" based on the similarity of their predicted probabilities (Propensity Scores) of receiving treatment (i.e., AMPLIFIES beneficiaries and non-beneficiaries).

The treatment effect for a specific individual refers to the change in outcome that occurs when that individual receives a particular treatment or intervention. It measures the impact of the treatment on the individual's outcome compared to what would have happened if they had not received the treatment. Two general treatment effects are typically considered in causal inference: the average treatment effect (ATE) and the average treatment effect on the treated (ATT) (Garrido et al., 2016). The ATE is the average treatment effect across the entire population or the target group (beneficiaries and non-beneficiaries). The ATT is the treatment effect for those in the treatment group (beneficiaries). ATE is particularly relevant when there is a possibility that the treatment can be provided to all individuals, whereas ATT is more suitable when the treatment received is more likely to be determined by their individual characteristics (Benedetto et al., 2018).

3.2.1.1 Summary of Advantages and Disadvantages

Propensity score matching has several advantages that make it a popular method in observational studies. It can control observed confounding variables, reduce bias, and provide more robust estimates of treatment effects. By creating balanced comparison groups, propensity score matching helps to address selection bias. The method mimics a randomized controlled trial (RCT) setting by matching individuals with similar propensities to receive the treatment and reduces the impact of confounding variables.

Propensity score matching facilitates causal inference by reducing confounding. It aids in estimating a treatment's or intervention's causal effect by isolating the effect of interest from the influence of observed covariates. Without the need for additional data collection, propensity score matching can be performed using existing observational data. This makes it a useful tool in situations where an RCT is neither feasible nor ethical.

Despite its advantages, propensity score matching also has limitations that should be considered. Propensity score matching assumes unconfoundedness, which means that all relevant covariates are balanced between the treatment and control groups based on the propensity score. This assumption cannot be directly tested, and the results' validity is dependent on its plausibility. Estimating the propensity score necessitates fitting a logistic regression model or other models. Misspecification of the propensity score model can introduce bias into the matching process and subsequent estimates of treatment effect.

Propensity score matching can only control for variables that have been observed. Propensity score matching cannot address unobserved confounding variables that influence both treatment assignment and outcomes. Unobserved confounding can be assessed using sensitivity analyses and tests for hidden bias. Propensity score matching can result in a loss of sample size, particularly if there are few control individuals available who closely match the treated individuals. Because of the smaller sample size, the statistical power and precision of the estimated treatment effects may be limited. (Fowler, 2017; Gao et al., 2022; King & Nielsen, 2019; Narita et al., 2023)

3.2.1.2 Profitability Analysis

Profitability is one way to measure performance. One indication of profitability is gross margin. Because its estimation is limited to the variable cost of production, it is possible to measure gross margin for single or multiple enterprises.

Gross Margin is the difference between the value of production and the variable cost of the production (Djokoto & Zigah 2021). According to Pedersen et al. (2005), gross margin usually indicates revenue left for fixed costs and profits.

The revenue, R_i from the sale of output of a single product may be given as follows:

$$R_i = P_i * Q_i \quad (1)$$

where i is the type of crop, P_i is the price and Q_i is the output produced. The gross profit, GP_i, from producing Q_i, is defined as:

$$GP_i = R_i - VC_i \quad (2)$$

where GP is gross profit and VC is variable costs of production. Variable cost is also referred to as cost of goods sold. It is defined to only include costs that change with the level of production given the current production scale. All costs that do not change at the current production scale are considered fixed costs. For the production of annual crops, variable costs include the cost of land preparation, fertilizers, seed, chemicals, transportation, storage, and hired labor used for weeding, harvesting, and performing other agronomic and marketing activities.

Gross profit is not scale-independent. Therefore, it cannot be used as a comparative metric. Gross margin is one metric that may be used to compare the productivity of firms of different sizes and different enterprises, it is defined as follows:

$$GM_i = GP_i / R_i \quad (3)$$

where GM= gross margin and the other variables are as defined. Gross margin can be measured as a percentage, and this tells us what percentage of every dollar of sales revenue remains after the cost of purchasing or manufacturing a product. A higher GM means that the company is more efficient at converting sales into actual profits. If an enterprise cannot generate a large enough gross profit from its revenue, then there is pressure on the bottom line when financial reports are generated.

3.2.1.2.1 Gross Margin as an Indicator for Profitability Measures

Gross margin analysis is a simple model used to estimate the financial returns of a production process. It is used as a proxy for the profitability of a production process. In gross margin analysis, there is no need for a distribution of fixed costs to enterprise operations, which is a significant advantage (Semerci, Parlakay, & Çelik, 2014). Gross margins do not account for fixed costs such as land and assume that operating capital and labor availability does not limit crop selection. It is a useful planning tool in situations where fixed capital is a negligible portion of enterprises as in the case of small-scale subsistence agriculture.

Gross margins provide a good approximation of economic well-being (Brown & Kennedy, 2005). It is widely applied as part of the evaluation of the economic performance of smallholder agricultural production systems, where data is limited (Nkadimeng et. al., 2021).

Gross margin is mostly compared with farms with similar characteristics and production systems (Firth, 2002). The comparison gives a useful indication of the production and economic efficiency of an enterprise. Firms with low variable costs will be advantageous for them in terms of gross margin, even if the company has fixed costs. Gross margin is a great tool for farm budgeting in farm planning and management.

3.2.1.2.2 Summary of Advantages and Drawbacks

Gross Profit margin may vary across industries, so inter-industry comparisons may not always be relied upon as a good indicator (Tracy, 2012). This is a good indicator for this study because maize and soybean are in the same industry and use similar inputs for production.

Gross margin fluctuations can be influenced by various factors over time. Merely observing whether the result is increasing or decreasing is often insufficient. Instead, the initial outcome serves as a signal to delve further and assess the enterprise's market and competitive strategy for a more comprehensive understanding.

3.3 Methods of Analysis

The methods used in the analysis of the data for the study are discussed. A gross margin analysis was used to estimate the profitability of maize and soybean production. The mean comparison test was conducted to evaluate the effect of profitability and yield on beneficiaries and non-beneficiaries of AMPLIFIES. In estimating the impact on beneficiaries and non-beneficiaries. The underlying hypothesis was stated.

On the average yield of crops, we hypothesized that beneficiaries' yields and non-beneficiaries' yields are different. Our null hypothesis for profitability states that the profitability of beneficiaries is different from that of the non-beneficiaries.

The study further measured the treatment effect to estimate the causal effect of the treatment outcome using the propensity score match. The propensity score matching (PSM) method compares the observed characteristics of a "Treatment Group" and a "Control Group" based on the similarity of their predicted probabilities (Propensity Scores) of receiving treatment (i.e., AMPLIFIES beneficiaries and non-beneficiaries). In the analysis, beneficiaries of AMPLIFIES (treated) were matched with farmers with the same observable characteristics as the non-beneficiaries of AMPLIFIES to isolate the impact of the project on performance. The first step was to estimate the propensity score or the probability that the respondent is a beneficiary. *Bij* is a binary indicator of being a beneficiary of AMPLIFIES; that is *Bi*=1 if the ith subject is a beneficiary and *Bi*=0 if the i^{th} subject is a non-beneficiary, j represents the type of crop that is maize or soybean. The potential outcome of profitability (using gross margin as an indicator for profitability). The propensity score is estimated with a logit model as the conditional probability of a beneficiary modeled on observable characteristics that are independent of the measured outcomes.

$$log \frac{P}{1-p} = \propto + \beta X\_ij + \varepsilon \quad (4)$$

Where P is the estimated propensity score for the ith respondent on the jth crop, β is the estimated coefficients, X are covariates of observed characteristics (Table 3.1) and ε is a random error term that is logistically distributed. These covariates may simultaneously influence the outcomes (profits or yields) and the beneficiary status. Thus, estimating propensity scores for each subject is conditional probability of being a beneficiary given the observed covariates. The resulting effect of a treatment is known as the treatment effect. The treatment effect for a specific individual refers to the change in outcome that occurs when that individual receives a particular treatment or intervention. It measures the impact of the treatment on the individual's outcome compared to what would have happened if they had not received the treatment.

Table 3.1. Covariates employed in the logistic model for propensity score match

Variables	Definition and Measurement
Gender of farmer	Dummy variable, male =1, female =0)
Region	region where the farm is located (Ashanti =1 Brong Ahafo = 2 and Northern= 3)
Experience	Frequency of maize or soybean production in the last five years (years)

Table 3.2. Outcomes and their a prior expectation

Variables	A priori Expectation
Yield (metric tonnes per hectare)	+
Profit (Ghana cedis per hectare)	+
Gross Margin	+

The distribution of the propensity scores must also be checked for balance, that is, whether the means of the treated and controls are statistically different after matching for each covariate. Once the propensity score is calculated, it is used to match treated and untreated farmers with similar closing probabilities.

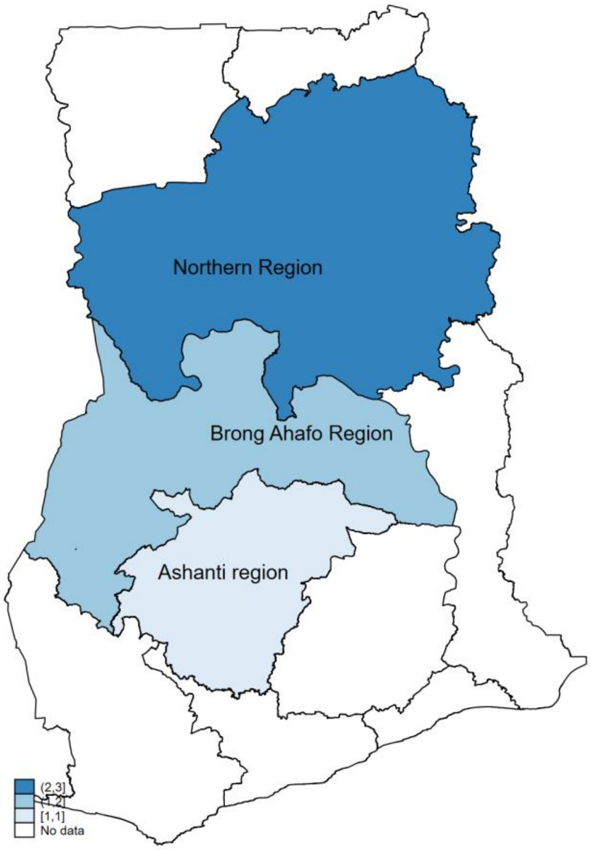
3.4 Data and Study Area

This study focuses on the production of maize and soybean in three regions of Ghana over five years under a USDA-sponsored project described as AMPLIFIES. In 2015, the USDA in collaboration with the Government of Ghana, Ghana National Association of Poultry Farmers (GNAPF), American Soybean Society/World Initiative for Soy in Human Health implemented the AMPLIFIES project. The project started with a baseline study that was conducted in 2015 to assess the agricultural situation of the country, particularly the poultry industry. The baseline study focused on accessing the technical and financial means, as well as the economic viability and sustainability of the poultry sector. The objective of AMPLIFIES was to enhance the quantity and reduce the cost of poultry feed by addressing post-harvest loss and inefficiencies in maize and soybean procurement. The final evaluation was carried out in 2021 to provide a better understanding of the benefits and limitations of the AMPLIFIES and identify strategies for further advancing the poultry value chain.

The project was implemented in three different regions in Ghana – Ashanti, Brong Ahafo, and Northern – which are counted among the top maize production regions in the country (Amanor-Boadu, 2011; MoFA, 2019). Soybeans are primarily cultivated in the northern regions and transported to southern regions for processing (Ntiamoah et. al., 2022). Ghana is a tropical country with annual average temperatures range from 26.1ºC in places near the coast to 28.9ºC in the extreme north. Daytime temperatures may rise above 40ºC in the extreme north. The Ashanti region and Brong Ahafo region are located in the middle belt, and the Northern region is in the northern belt. The middle belt is relatively hot and humid, and the north is hot and dry. There are two rainy seasons in the south from March to July and from September to October (bimodal rainfall system). The northern part of the country, on the other hand, has only one rainy season, from May to October (uni-modal rainfall system).

Prior to 2018, Ghana was divided into 10 administrative regions. However, since 2018, certain regions have been further divided, resulting in the current 16 administrative regions. For this study, the analysis was conducted based on the 10 administrative categorizations that were in place at the time when the program was implemented. These administrative regions fall into different agroecological zones. These zones include the Sudan Savannah, Guinea Savannah, Transitional zone, Deciduous Forest, Rain Forest (Evergreen), and the Coastal Savannah zone, Maize thrives well in almost every part of the country including the Northern Savannah, Transitional, Deciduous Forest and Coastal savannah zones and mostly at its peak in the transitional belt (Wongnaa et. al., 2019). Ashanti region is situated in the deciduous forest zone of Ghana, while the Brong Ahafo region is in the transitional zone. Additionally, the Northern region is positioned within the Savannah zone of the country.

Figure 3.1. The geographic scope of the study



Source: Author's computation using farm survey data

Farm-level survey data on beneficiaries and non-beneficiaries of the AMPLIFIES program were used. The data deployed for this study is secondary data from the impact evaluation of the Food for Progress Investment was used. The data was based on the final evaluation of the AMPLIFIES project, collected in the designated study area (Ashanti, Brong Ahafo, and Northern region) in 2021. The data contained information on demographic characteristics, crops produced, output, area, and yield during the period of the project. The data were imported into Stata for cleaning and analysis. All analysis was conducted using STATA 17 SE unless specified otherwise. The dataset for the crop producers survey consisted of 809 farmers, with a response rate of around 94.8%. Incomplete responses were excluded from the analysis, resulting in a total of 767 usable data points, representing approximately 99.1% of the respondents.

4 Results and Discussion

4.1 Introduction

This chapter reports the finding regarding useful demographic attributes of the study respondents as well as the designated study objectives. The demographic characteristics are presented in the first part of the chapter, providing a comprehensive overview of the population. Additionally, the section highlights the specific objectives set for the study, delineating the research questions and goals that guided the investigation.

4.2 Demographic characteristics

A total sample of 767 observations was used in the study, The study examined the socio-economic characteristics, including beneficiary status, gender, location, awareness, crop varieties produced, ownership, and role on the farm, participation in producer organizations. These characteristics were sought to gain insights into the respondents' backgrounds and their suitability for the research.

Table 4.1 presents the summary of demographic information about the respondents by their beneficiary status. There was a higher proportion of non-beneficiaries to beneficiaries in the proportion of 61% to 39%, respectively. About 44% of the respondents were aware of AMPLIFIES. On average, 96% of respondents were either owners or managers of their farms. The gender distribution of our respondents is 34% to 66% females to males. This indicates that there is a higher prevalence of male participation in Ghana's maize production compared to females. This is consistent with Wongnaa and Awunyo-Vitor (2018). It can also be deduced that both men and women have the potential to engage in maize and soybean production as a business and a source of employment. Beneficiary females to males were 16.43% to 23%. The project had a specific focus on promoting gender balance and gender equality by actively encouraging and facilitating female participation. The majority of our respondents were from the Northern Region with about 74% and about 13% each from Ashanti and Brong Ahafo regions. These regions are among the top maize-producing regions in Ghana. Additionally, soybean production is predominant in the Northern.

The majority of respondents belonged to a producer organization. About 33% of beneficiaries were members of a producer organization and only 6% were not. The respondents planted different crop varieties. The single major maize crop variety planted was the Obatampa, with approximately 26% of respondents selecting it. The remaining 73% of respondents indicated using other maize varieties, which included Pan 12 (yellow variety), Pan 53 (white variety) or Sika Aburoo, Mamaba, Etubia, Pioneer 30Y87(yellow variety), Pioneer 30Y32 (white variety), Abroahoma, Okomasa, Bihilfa, Ewul-Boyu, Sanzal Sima, and Wang Dataa. Also in this other group are farmers who used their own or uncertified seeds.

Table 4.1 Summary Statistics of Socioeconomic Characteristics by Beneficiary Status

	Non- Beneficiaries	Beneficiaries	Total
Gender			
Female	17.87%	16.43%	34.3%
Males	42.71%	23%	65.7%
Region			
Ashanti	3.52%	9.26%	12.78%
Brong Ahafo	3.65%	9.26%	12.91%
Northern	53.72%	20.6%	74.32%
Producer Organizations			
Member	20.21%	32.76%	52.97%
Non-Members	40.55%	6.47%	47.03%
Crop Varieties			
Maize -Obatampa	14.16%	11.99%	26.16%
Other maize	46.24%	27.6%	73.84%
Soy- Jeguma	42.77%	20.13%	62.89%
Other soy	27.99%	9.12%	37.11%
Beneficiary Status (frequency)	61% (467)	39% (300)	100% (767)

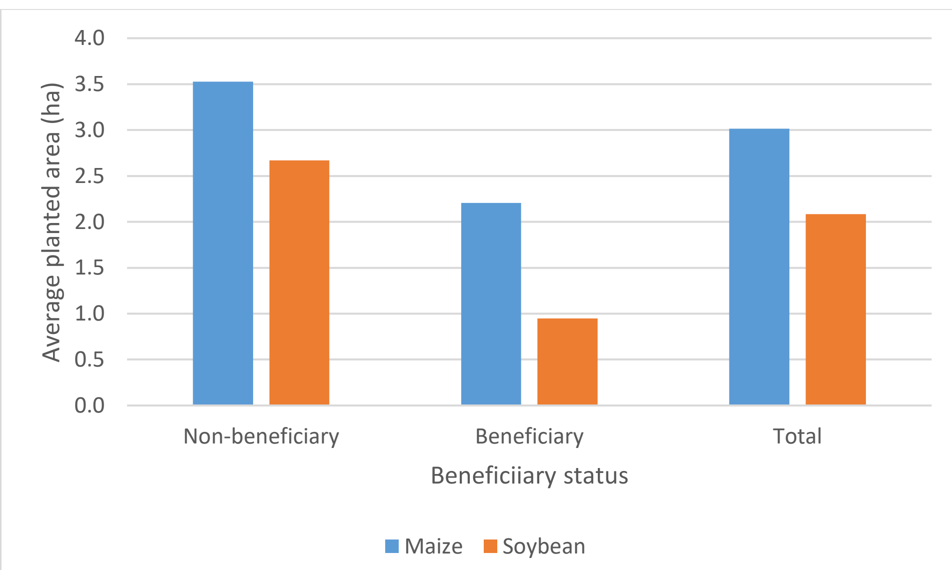
Source: Farm Survey Data, 2021

About 63% of soybean respondents indicated using the Jeguma variety. The remaining 37% were distributed among other varieties including Anidaso, Sambiba, Afayak, Songda, Soung-Pungun varieties, and their own uncertified seeds.

4.3 Profitability of Maize and Soybean Production

The profitability of maize and soybean production was estimated. Figure 4.1 shows the average planted area for maize and soybean production by beneficiary status. The results present the average of the five years. Findings from the study indicate that Ghana's maize and soybean production is predominately done on small scale basis. On average, 3 hectares (ha) of maize were planted by the respondents. Beneficiaries planted an average of 2 ha of maize compared to 3.5 ha for non-beneficiaries. The total soybean average planted by the respondents during the period of the project was about 2.08 ha. Non-beneficiaries planted a higher average of 2.67 ha of soybeans compared to 0.95 ha by beneficiaries.

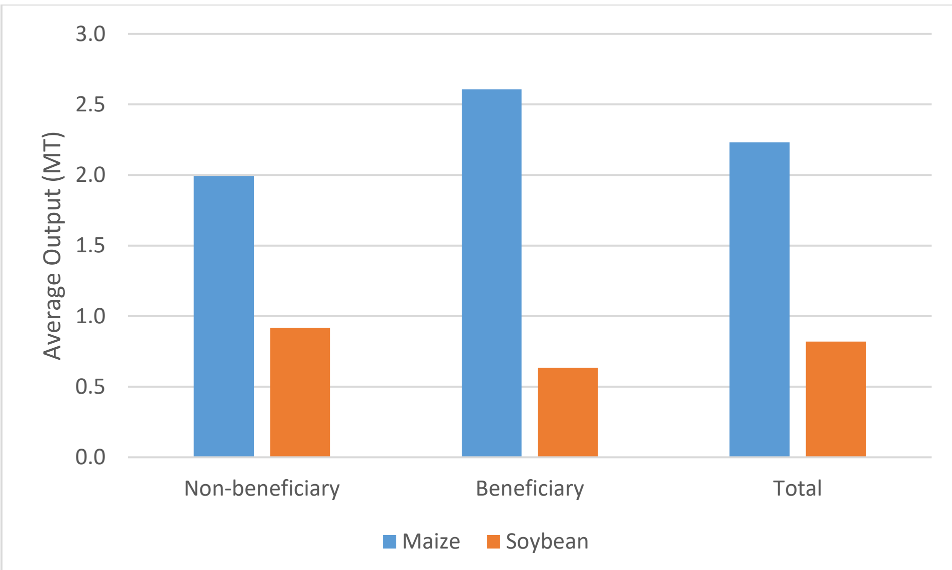
Figure 4.1. Average Maize and Soybean Planted Area by Beneficiary Status (2015-2021)



Source: Farm Survey Data, 2021

Agriculture is predominantly on a smallholder basis in Ghana. According to (MoFA-SRID, 2021), most farm holdings in Ghana are less than 2 hectares in size, though there are some large farms and plantations, particularly for rubber, oil palm, and coconut, as well as rice, maize, and pineapples to a lesser extent. Most food crops are intercropped. Monoculture is mostly done by large-scale or commercial farms.

Figure 4.2. The Average Maize and Soybean Output Produced by Beneficiary Status (2015-2021)

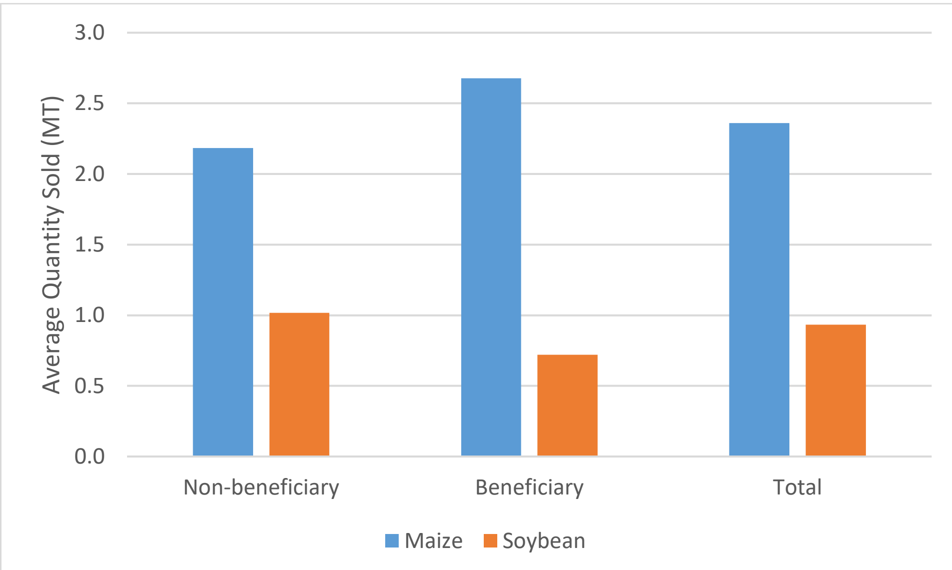


Source: Farm Survey Data, 2021

The average maize output produced by respondents was about 2.2 metric tons (MT) while the average soybean output produced was about 0.82 MT presented in Figure 4.2. Beneficiaries and non-beneficiaries produced an average maize output of 2.61 MT and 1.99 MT, respectively. Beneficiaries produced an average soybean output of 0.63 MT and non-beneficiaries produced 0.92 MT.

The average quantities of maize and soybean sold were estimated (figure 4.3). The average maize and soybean quantities sold were 2.36 MT and 0.93 MT, respectively. Beneficiaries' and non-beneficiaries' quantities of maize sold were 2.68 MT to 2.18 MT, respectively. Beneficiaries sold an average of about 0.72 MT of soybean and non-beneficiaries sold 1.02 MT of soybean.

Figure 4.3. The Average Maize and Soybean Quantity Sold (MT) by Beneficiary Status (2015-2021)



Source: Farm Survey Data, 2021

Table 4.2 presents a summary of the various costs and revenue associated with maize and soybean production. The average total revenue received for maize producers was about GHS 1187.79/ ha compared to GHS 1058.26/ ha for soybean. Beneficiaries received an average revenue of GHS 1426.45/ ha for maize and non-beneficiaries received GHS 1014.73/ha. On average, beneficiaries received revenue of GHS 1123.56 / ha for soybean, while non-beneficiaries received GHS 1023.86/ ha. The average variable cost for producing maize and soybean was GHS 565.57/ha and GHS 435.27/ ha. Beneficiaries spent an average variable cost of GHS 633.64/ ha to produce maize and non-beneficiaries spent an average of GHS 522.27/ ha. The average variable cost for soybean production was GHS 497.85 per hectare for beneficiaries and GHS 403.07 per hectare for non-beneficiaries.

The average gross profit per hectare and gross margin were also computed and presented in Table 4.2. The average gross profit per hectare for maize was GHS 595.13/ha and the average gross profit per hectare for soybean was GHS 621.08/ ha. This is consistent with (Wongnaa et al., 2019) who estimated a maize gross profit of GHS 510. Beneficiary and non-beneficiary maize producers have an average gross profit of GHS 764.40/ha and GHS 472.94/ha, respectively. The average gross profit per hectare for beneficiary soybean producers was GHS 621.82/ha, while non-beneficiary maize producers had an average gross profit of GHS 620.70 per hectare. The average gross margin for soybean production was higher than for maize production. The average gross margin for maize and soybean production was 0.45 and 0.55, respectively. The average gross margin for maize corresponds with (Adu-Gyamfi et al., 2019) who estimated an average of 0.46. The average gross margin for maize production was 0.50 for beneficiaries and 0.41 for non-beneficiaries, indicating higher profitability for beneficiaries in comparison to non-beneficiaries. Beneficiary to non-beneficiary average gross margin for soybean production was 0.56 to 0.55. Soybean beneficiaries received a slightly higher gross margin than maize beneficiaries. Soybean non-beneficiaries also received a slightly higher gross margin than maize non-beneficiaries.

Table 4.2. Summary Statistics of Average Maize and Soybean Cost and Returns by Beneficiary Status (2015-2021)

Variables	N	Mean	SD
Maize Average Revenue GHS/ha			
Non-beneficiaries	302	1,014.73	650.92
Beneficiaries	219	1,426.45	1162.69
Total	521	1,187.79	923.78
Soybean Average Revenue GHS/ha			
Non-beneficiaries	260	1,023.86	715.94
Beneficiaries	137	1,123.57	1,202.27
Total	397	1,058.27	913.20
Maize Average Variable Cost GHS/ha			
Non-beneficiaries	437	522.27	366.06
Beneficiaries	278	633.64	527.25
Total	715	565.57	438.89
Soybean Average Variable Cost GHS/ha			
Non-beneficiaries	274	403.07	274.21
Beneficiaries	141	497.85	484.60
Total	415	435.27	361.96
Maize Average Gross profit GHS/ha			
Non-beneficiaries	302	472.9436	668.45
Beneficiaries	218	764.3983	1,011.98
Total	520	595.1304	841.46
Soybean Average Gross Profit GHS/ha			
Non-beneficiaries	260	620.70	713.61
Beneficiaries	137	621.82	1,141.81
Total	397	621.09	883.63
Maize Average Gross margin			
Non-beneficiaries	291	0.41	0.40
Beneficiaries	201	0.50	0.30
Total	492	0.45	0.36
Soybean Average Gross margin			
Non-beneficiaries	248	0.55	0.30
Beneficiaries	114	0.56	0.36
Total	362	0.55	0.32

Source: Farm Survey Data, 2021 USD1 – GHS5.76 (BOG, Jan 2021 rate)

4.4 The Impact of Maize and Soybean Profitability on Beneficiaries and Non-Beneficiaries

To evaluate the impact of profitability on beneficiaries and non-beneficiaries, a mean comparison test was conducted. The analysis involved estimating the average yield, gross profit, and gross margin to assess the impact of these factors on beneficiaries and non-beneficiaries.

Table 4.3. Summary Statistics for Average Maize and Soybean Yield/ha by Beneficiary Status (2015-2021)

	N	Average Yield/ha	Std. error	t	P>|t|
Maize					
Total	722	0.94	0.03		
Beneficiary	280	1.10	0.05		
Non-Beneficiary	442	0.83	0.03		
Difference		**0.27*** **	0.05	5.06	0.0000
Soybean					
Total	415	0.72	0.03		
Beneficiary	141	0.75	0.06		
Non-Beneficiary	274	0.70	0.29		
Difference		0.05	0.06	0.88	0.20

*** Statistically significant at less than 1%.
Source: Farm Survey Data, 2021

Maize and soybean yields were estimated and presented in Table 4.3. The average maize yield per hectare was approximately 0.94, while the average soybean yield was around 0.72 per hectare. This finding is below the average maize and soybean yield of 2.48 and 1.72 metric tons per hectare respectively reported by the Ministry of Food and Agriculture (MoFA-SRID, 2021) and also the average of 1.5MT/ha reported by Scheiterle and Birner (2018) for maize. This indicates that maize and soybean yield by respondents is relatively low. On a regional basis, the Ashanti region exhibits the highest maize yield of 1.66 metric tons per hectare (Appendix). This finding aligns with the data reported by the Ministry of Food and Agriculture (MoFA-SRID, 2021), which indicates that the Ashanti region produces the highest maize yield in the country, though the yield obtained in this study is relatively low compared to the regional average. Beneficiaries obtained an average maize yield of 1.10 per hectare while non-beneficiaries obtained an average of 0.83 per hectare. The difference in maize yield between beneficiaries and non-beneficiaries, which was 0.2671/ ha, was found to be statistically significant at a level of less than 1%. On average beneficiaries achieved a soybean yield of 0.72 per hectare whereas non-beneficiaries obtained approximately 0.75 per hectare. The difference between the beneficiary and non-beneficiary soybean yield was small and insignificant.

Table 4.4. Summary Statistics for Average Maize and Soybean Gross Profit/ha by Beneficiary Status (2015-2021)

	N	Average Gross Profit GHS/ha	Std. error	t	P>|t|
Maize					
Total	520	595.13	36.90		
Beneficiary	218	764.40	68.54		
Non-Beneficiary	302	472.94	38.46		
Difference		**291.45*** **	73.75	3.95	0.0000
Soybean					
Total	397	621.09	44.35		
Beneficiary	137	621.82	97.55		
Non-Beneficiary	260	620.70	44.26		
Difference		1.12	93.40	0.01	0.50

*** Statistically significant at less than 1%.

Source: Farm Survey Data, 2021

Beneficiaries received a higher maize gross profit per hectare than non-beneficiaries. The difference of GHS 291.45 was statistically significant at a less than 1% level. For soybean production, beneficiaries received a higher gross profit compared to non-beneficiaries. However, the difference was small and not statistically significant.

Table 4.5. Summary Statistics for Average Maize and Soybean Gross Margin by Beneficiary Status (2015-2021)

	N	Average Gross Margin	Std. error	t	P>|t|
Maize					
Total	492	44.51%	0.02		
Beneficiary	201	50.22%	0.02		
Non-Beneficiary	291	40.56%	0.23		
Difference		**9.6%*** **	.033	2.92	0.001
Soybean					
Total	362	55.20%	0.02		
Beneficiary	114	55.95%	0.03		
Non-Beneficiary	248	54.85%	0.02		
Difference		1%	0.04	0.30	0.38

*** Statistically significant at less than 1%. Source: Farm Survey Data, 2021

Beneficiary maize producers receive a higher gross margin compared to non-beneficiary maize producers (table 4.5). The difference of 0.097 was statistically significant at a 1% level. In soybean production, beneficiaries obtained a higher gross margin in comparison to non-beneficiaries. However, the difference was relatively small and not statistically significant.

4.4.1 Impact Assessment of AMPLIFIES Intervention in Maize and Soybean Production

The study employed the propensity score matching estimator to evaluate the average treatment effect on the beneficiary's average yield, gross profit, and gross margin. The distribution of the propensity scores was checked for balance, that is, whether the means of the treated and controls are statistically different after matching for each covariate (table 4.6). The most commonly used statistic to examine the balance of covariate distribution between treatment groups is the standardized mean difference (SMD) (Zhang et al., 2019). Because SMD is unit-independent, it allows for the comparison of variables with different units of measurement.

Table 4.6. Characteristics of Respondents Before Matching and After Matching

Maize			Soybean		
	Standardized Differences			Standardized Differences	
	Raw	Matched		Raw	Matched
Region	-0.96	5.63e-16	Region	-0.26	3.47e-15
Gender	-0.27	0.004	Gender	-0.28	0.04
Maize production frequency	-0.004	-0.017	Maize production frequency	-0.28	0.03
Soybean production frequency	-0.51	0.03	Soybean production frequency	-0.26	0.07

Table 4.7 presents the summary statistics of our average treatment effect on maize and soybean yields. Following our hypothesis, we expect that beneficiaries receive a higher yield compared to non-beneficiaries. From Table 4.7, It was estimated that the average treatment effect (ATE) and the average treatment effect on the treated (ATT) population were all positive, but they were not statistically significant. The average treatment effect (ATE) for maize yield explains that beneficiaries received a 0.06 MT/ha yield more than non-beneficiaries who were similar to beneficiaries by visible characteristics. However, the value was not statistically significant. Similarly, for the average treatment effect of soybean yield.

Table 4.7. Summary Statistics of the Average Treatment Effect on Beneficiary Maize and Soybean Average Yield (2015-2021)

	(ATE) Maize Average Yield	(ATT) Maize Average Yield	(ATE) Soybean Average Yield	(ATT) Soybean Average Yield
Beneficiaries	0.061 (0.06)	0.015 (0.07)	0.08 (0.07)	0.10 (0.08)
N	722	722	415	415

Standard error in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The average treatment on the treated population for yields estimates the average difference in yield resulting from treatment or intervention (AMPLIFIES) calculated for only beneficiaries of the program. The estimated maize yield difference is 0.015MT/ha which was not statistically significant. The estimated yield difference for beneficiary soybean farmers was 0.1MT/ha and was not statistically significant. This indicates that the overall treatment effect on yields was insignificant.

Table 4.8. Summary Statistics of the Average Treatment Effect on Beneficiary Maize and Soybean Average Profit per Hectare (ha) (2015-2021)

	(ATE) Maize Gross Profit/ha	(ATT) Maize Gross Profit/ha	(ATE) Soy Gross Profit/ha	(ATT) Soy Gross Profit/ha
Beneficiaries	99.29 (81.55)	55.03 (98.05)	46.39 (102.52)	81.34 (112.98)
N	520	520	397	397

Standard error in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.8 presents the summary statistics of the average treatment effect on Maize and Soybean gross profit per hectare. Beneficiary maize producers received a higher profit of GHS 99.29 than non-beneficiary maize producers and this was not statistically significant. Beneficiaries of soybeans received a GHS 46.39 higher profit than non-beneficiaries. The value was not statistically significant. The treatment effect on beneficiaries estimated an average profit of GHS55.03 among beneficiary maize producers and GHS81.34 among beneficiary soybean producers and neither was statistically significant.

Table 4.9: Summary Statistics of the Average Treatment Effect on Beneficiary Maize and Soybean Gross Margin (2015-2021)

	(ATE) Maize Average Gross Margin	(ATT) Maize Average Gross Margin	(ATE) Soybean Average Gross Margin	(ATT) Soybean Average Gross Margin
Beneficiaries	0.066*	-0.017	0.072*	0.075
	(0.03)	(0.04)	(0.04)	(0.04)
N	492	492	362	362

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Based on the hypothesis, there should be a significant difference in the profit between beneficiaries and non-beneficiaries. Beneficiaries and non-beneficiaries received a positive gross margin for soybean and maize production. Beneficiaries received an average of 6% more profit for maize than non-beneficiaries, based on the estimate of the ATE. This estimate was statistically significant at less than a 5% level. Beneficiaries received an average of 7% more profit from soybeans than non-beneficiaries. This estimate was statistically significant at less than a 5% level. In estimating the treatment effect on only beneficiaries, we estimated a negative profit for maize producers. This shows the average difference in profit among beneficiary maize producers was less than 1% and the value was not statistically significant. The average treatment effect on only beneficiary soybean producers estimated 7% more profit among beneficiaries. However, this estimate was not statistically significant.

5 Summary, Conclusions, and Recommendations

5.1 Introduction

In this chapter, a summary of the study is presented, along with conclusions drawn from the findings. Additionally, practical policy recommendations are provided based on the study's outcomes. The summary provides a concise overview of the main research objectives, methodologies employed, and key findings obtained. The conclusions highlight the main insights derived from the analysis of the data and discuss their implications within the broader context of the study. Building upon these conclusions, the chapter proceeds to present practical policy recommendations that are informed by the study's outcomes.

5.2 Summary and major findings

The study used the propensity score matching approach to estimate the USDA AMPLIIES program on maize and soybean profitability. The study specifically estimated the profitability of maize and soybean and assessed the impact of the AMPLIFIES project beneficiaries and non-beneficiaries. Gross margin was used as an indicator of profitability.

Using a field survey questionnaire of the AMPLIFIES project, a total of 767 respondents were sampled from three maize-growing regions. The regions were the Ashanti region, Brong Ahafo, and the Northern region. These regions are the locations where the AMPLIFIES project was implemented. A total of 467 respondents (61% of our sample size) were non-beneficiaries of the program and 300 respondents (39% of our sample) were beneficiaries of AMPLIFIES. The majority of our respondents were in the northern region representing about 74% and about 13% each from Ashanti and Brong Ahafo regions.

Descriptive statistics such as frequencies and percentages were used to describe the demographic attributes and our study objectives. Profitability was measured using gross margin (also known as gross profit percent). A mean comparison test was used to evaluate the impact of AMPLIFIES on beneficiaries and non-beneficiaries. The propensity score match was further used to estimate the treatment effect on beneficiaries and non-beneficiaries.

The results showed that beneficiaries received a higher revenue of GHS 411.7/ha more than non-beneficiary maize farmers and soybean beneficiaries received GHS 99.7/ha more revenue than non-beneficiaries. The average area planted by our respondents for maize and soybean was 3ha and 2.08ha, respectively. The average gross profit per hectare for maize non-beneficiaries was GHS 472.94/ha and beneficiaries were GHS 764.40. Soybean non-beneficiaries had an average profit of GHS 620.70/ha and GHS 621.82/ha for beneficiaries. The Gross margin or gross profit percent for maize beneficiaries was estimated to be 0.50 and for non-beneficiaries was 0.40. Soybean beneficiaries received a slightly higher gross margin of 0.56 than maize beneficiaries. Soybean non-beneficiaries also received a slightly higher gross margin of 0.55 compared to maize non-beneficiaries.

On average, the beneficiary maize yield per hectare was estimated to be higher than non-beneficiaries. The difference of 0.26MT/ha was statistically significant. Soybean beneficiaries also received a slightly higher average yield than non-beneficiaries, their difference of 0.05 was not statistically significant. The difference between the beneficiary maize profit per hectare of GHS 291.45/ha more than non-beneficiaries was statistically significant at less than 1%. However, the difference in soybean profit per hectare was not statistically significant. The difference of 9.6% gross margin of maize beneficiaries more than non-beneficiaries was statistically significant at less than 1%. The soybean gross margin was not statistically significant.

The treatment effect (ATE and ATT) of maize and soybean yield, gross profit, and gross margin was estimated. ATE measures the statistical significance of the difference between the average impact of the intervention on beneficiaries and what the average impact would have been on the same beneficiaries if they had not been beneficiaries. ATT, on the other hand, measures the statistical significance of the average impact of the intervention on beneficiaries. The results showed that beneficiary maize producers received an average yield of 0.06/ha more than non-beneficiaries. However, the value was not statistically significant. Soybean beneficiaries also received 0.1/ha more than non-beneficiaries; however, it was also not statistically significant. Beneficiaries' maize producers received 6.6% more profit than non-beneficiaries and this value was statistically significant at less than 5%. Soybean producers also received a higher profit of 7% more than non-beneficiaries and the value was statistically significant at less than 5%.

5.3 Conclusions

The project's purpose was to provide training and capacity building to as many crop producers as possible to expand maize and soybean production. Despite this, due to the limited resources available, the proportion of respondents who were non-beneficiaries increased. The majority of respondents were in the Northern Region and there were more females than males in the sample. The gross profit per hectare estimated for beneficiary maize producers was higher than the non-beneficiaries and the average gross profit per hectare was slightly higher than for non-beneficiaries. The average gross margin estimated for maize beneficiaries was also higher than non-beneficiaries, similarly for soybean gross margin. Beneficiaries received a higher yield per hectare than non-beneficiaries and the difference for maize was statistically significant.

The above estimates did not give the causal inference of being a beneficiary. Estimating the intervention effect, we can conclude that beneficiaries received a higher profit of 6% more than non-beneficiary maize producers, and beneficiaries received 7% more than non-beneficiaries for soybean production. It can be inferred that the project interventions statistically enhanced beneficiary maize and soybeans producers' gross margins compared to the situation if they had not been beneficiaries, the interventions did not produce any difference among only those who benefited from the interventions.

5.4 Recommendations and Limitations

The project enhanced beneficiaries' gross margin, and the expansion of the AMPLIFIES project will be beneficial for increasing farmers' productivity and profitability. The USDA AMPLIFIES project was interested in improving the poultry value chain. The specific needs of crop farmers were not addressed. The study recommends that the specific needs of farmers need to be addressed. A thorough needs assessment must be conducted for each sector (e.g., Maize, soybean, poultry) and the findings should be the focus of the project.

The study focused on the average of a five-year project. Data collected was based on past information production and performances. These could have led to recollection errors where respondents overstated or understated the values. A yearly impact analysis can be conducted to see the impact of the program within each period (year) of the project.

Ghana relies on maize as a key component of both human and animal consumption, including poultry feed. Exploring alternative poultry feed sources is indeed important for the improvement and sustainability of the poultry sector. By diversifying feed sources, Ghana can reduce its dependence on maize, mitigate the impact of price fluctuations, and enhance the overall productivity and profitability of the poultry industry.

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Appendix

Appendix Table A 1. Activities carried out during the USDA GPP and AMPLIFIES project

Improving feed by introducing farmers and feed millers to strategies that would	**1. Improve feed components (maize and soybean) for poultry.** **2. Lead to cost savings in production.** **3. Encourage a sustainable way of providing feed for poultry farmers in Ghana.**
Improving the quality and consistency of feed formulations by teaching farmers and commercial feed millers to	1. Test for mycotoxin. 2. Measure the nutritional content of poultry feed. 3. Formulate the right poultry diets for each breed
Increasing feed testing capacity using quality assurance manuals that teach participants how to test the quality of feed at feed testing facilities and feed mills.	
Improving the efficiency of feed processing by training farmers and feed millers on	1. Techniques in mixing feeds to meet the nutritional requirement of the birds. 2. Standards for quantifying feed ingredients at feed testing facilities and feed milling services for other value chain players
Improving efficiency around procuring feed ingredients by building strong linkages between various players on the poultry sector value chain, including	**1. Crop farmers** **2. Poultry farmers** **3. Crop aggregators** **4. Processors** **5. GNAPF and government officials**
Building the capacity of farmers to obtain investment in feed processing by teaching them how to	**1. Carry out basic bookkeeping and record keeping.** **2. Prepare income and expenditure accounts.** **3. Manage stocks.** **4. Access loan facilities** **5. Efficiently manage given loans**
Developing infrastructure for post-harvest storage and the aggregation of feed inputs by	**1. Providing farmers with storage facilities for harvested crops needed for poultry feed.** **2. Constructing crop aggregation centers (CAC) and standalone drying platforms in the Northern, Brong Ahafo, and Ashanti Regions.**

	3. Training local committees in the beneficiary communities on how to manage the facility, store produce in the warehouse, manage the produce, and handle post-harvest materials. **4. Providing all local committees with required tools and manuals, including Grain Mate Moisture Meters, Purdue Improved crop storage (PICS) bags, and CAC operating manuals to effectively manage the facilities.** **5. Provide select local committees with Flatbed Biomass Assisted Dryers and Cleaners for crop storage.**
Expanding the poultry feed distribution network by increasing the participation of the various stakeholders and players of the poultry industry value chain in the processing and distribution of poultry feed and thereby creating employment opportunities	
Organizing a national awareness-raising campaign to promote egg consumption by educating the public on the benefits of eating eggs.	
Training farmers in harvesting and post-harvest handling techniques and storing feed inputs, mainly on topics relating to	**1. Timely harvesting** **2. Strategies to reduce pests and disease in crops.** **3. Techniques to mitigate post-harvest loss, which includes shelling, winnowing, drying, proper use of the Grain Mate Moisture Meter, bagging, and storage to reduce aflatoxin infestation and storage losses.**

*Bolded sections are specific to AMPLIFIES activities

Appendix Table A 2. Average Maize Yield by Region

Variables Region	N	Mean	SD
Ashanti	97	1.657201	1.005145
Brong Ahafo	98	1.079556	0.672543
Northern	527	0.775894	0.529056
Total	722	0.935514	0.700776