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Impact of Production Support on Farm Performance: A Case of Ghana's Agricultural Support Programme

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Submitted by

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In

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Declaration

I hereby declare that I have done this dissertation entitled Impact of Production Support on Farm Performance: A Case of Ghana's Agricultural Support Programme, independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to the citation rules of the Faculty of Tropical AgriSciences.

In Prague 17th December 2021 ....

Ing. Sylvester Amoako Agyemang

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Abstract

Although production support policies have been shown to have significant positive effects on input use and food production, they are identified as a threat to agroecosystems through increased use of external inputs (mainly nitrogen fertiliser and pesticides). Moreover, studies on production support programmes have focused on their causal effect on food production without recourse to their effect on production in relation to the level of production support. This research seeks to analyse the effect of increasing levels of production support on farmers' adoption of sustainable agricultural practices (SAPs), farm performance (i.e., input use and productivity) and the heterogeneity of the effect on farm performance in relation to farm size. Quantitative data from 540 sampled beneficiaries (285) and non-beneficiaries (255) of Ghana's Planting for Food and Jobs (PFJ) programme, were analysed using logistic regression, Poisson regression, and generalized propensity score matching techniques. The latter helps to address potential self-selection bias due to farmers' decisions to participate in the production support programme. Our findings show that farmers' awareness of production and environmental risks, their perceived competence to control these risks, corruption perception and overall attitudes towards the programme had the strongest effect on their participation in the PFJ programme. Further, the participation in the PFJ support, integrated with extension and technical advisory services, increased farmers' SAP adoption intensity. Besides, higher levels of the PFJ support, decoupled from SAP adoption, increased farmers' SAP adoption intensity. Also, input use (i.e., hybrid seeds and fertiliser) and productivity increased as the level of the PFJ support per farmer increases. However, the estimated effect on farm performance was higher for small-scale farmers compared to large-scale farmers. Nonetheless, a minimum level of support was required for small-scale farmers to achieve positive effects. Higher input use and productivity can be achieved if the support is targeted and disbursed in relation to farm size rather than the "one rate for all" disbursement approach often used in Sub-Saharan Africa.

Keywords: Production support, agricultural productivity, planting for food and jobs, sustainable agricultural practices, generalized propensity score matching, Northern Ghana.

Abstrakt

I když politiky podpory produkce mají významný pozitivní vliv na využívání vstupů a produkci potravin, často představují hrozbu pro agro-ekosystémy prostřednictvím zvýšeného využívání intenzifikačních vstupů (zejména dusíkatého hnojení a pesticidů). Studie o programech podpory produkce se obvykle zaměřují jen na její účinek na produkci potravin, aniž by se zabývaly její relací k úrovni podpory. Tento výzkum se snaží analyzovat dopad výše podpory produkce na výkonnost farmy (tj. využití vstupů a produktivitu) a ochotu zemědělců zavádět udržitelné zemědělské postupy. Současně bere v úvahu heterogenitu vlivu podpor na výkonnost farmy ve vztahu k velikosti farmy. Kvantitativní údaje od 540 Ghanských zemědělců (285 účastníků a 255 stojících mimo program Planting for Food and Jobs (PFJ)) byly analyzovány pomocí logistické regrese, Poissonovy regrese a technik generalized propensity score matching. Posledně jmenovaná metoda pomáhá řešit potenciální zkreslení v důsledku sebevolby dané rozhodnutím zemědělců zapojit se do programu podpory produkce. Naše zjištění ukazují, že největší vliv na jejich účast v programu PFJ mělo povědomí zemědělců o produkčních a ekologických rizicích, vnímaná kompetence tato rizika kontrolovat, vnímání korupce v systému poskytování podpor a celkový postoj k programu. Dále účast v PFJ, jež zahrnoval dostupnost poradenské a vzdělávací služby, zvýšila intenzitu používání udržitelných zemědělských postupů zemědělci. Kromě toho vyšší úrovně podpory PFJ, která nezahrnovala podmínku přijetí udržitelných zemědělských postupů, zvyšují intenzitu jejich přijetí. Také využití vstupů (tj. hybridní osivo a hnojivo) a produktivita se zvýšily s rostoucí úrovní podpory PFJ na zemědělce. Odhadovaný vliv na výkonnost farmy se ukázal vyšší u malých farmářů ve srovnání s velkými farmáři. K dosažení pozitivních účinků však byla u drobných zemědělců potřeba určitá minimální úroveň podpory. Vyššího využití vstupů a vyšší produktivity lze dosáhnout, pokud je podpora zacílena a vyplácena úměrně ve vztahu k velikosti zemědělského podniku oproti přístupu „jedna sazba pro všechny“, který se často používá v subsaharské Africe.

Klíčová slova: Podpora produkce, zemědělská produktivita, pěstování pro potraviny a pracovní místa, udržitelné zemědělské postupy, generalized propensity score matching, severní Ghany.

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List of Acronyms

AMEs	Average Marginal Effects
CA	Conservation Agriculture
FAO	Food and Agricultural Organization of the United Nations
FBOs	Farmer-Based Organisations
GES	Growth Enhancement Support
GPS	Generalized Propensity Score
IFDC	International Fertilizer Development Centre
MEMs	Marginal Effects at Means
MERs	Marginal Effects at Representative Values
MoFA	Ministry of Food and Agriculture
NAAIAP	National Accelerated Agricultural Input Access Programme
NABCO	Nation Builders Corps
NGOs	Non-governmental Organisations
NPK	Nitrogen Phosphorus Potassium
NPP	New Patriotic Party
PFJ	Planting for Food and Jobs
R&D	Research and Development
SAP	Sustainable Agricultural Practice
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa

1. Introduction

Global agriculture requires intensive use of inputs and technology to increase production to cover the growing demand for food due to population growth (FAO 2011; Foresight 2011; Matsumoto & Yamano 2011; Raut & Sitaula 2012). Agriculture in Sub-Saharan Africa (SSA), is dominated by smallholder farms using low-input technologies resulting in low productivity (Nwaobiala & Ubor 2016; Obayelu 2016). This creates what is described as the "low-productivity poverty trap" – low input use and productivity, hindering food sufficiency aims and income diversification (Dorward et al. 2008). To increase productivity, countries have introduced production support programmes, ranging from subsidies on inputs to long-term technological interventions.

Production support programmes in SSA are one of the continent's most remarkable agricultural policy developments in recent years (Mason et al. 2017b; Lambongang et al. 2019). Several empirical studies in SSA show that production support can enhance farmer adoption of better technology and input, increase productivity and subsequently enhance food supply and food security (Jayne et al. 2015b; Ricker-Gilbert & Jayne 2017; Hemming et al. 2018; Walls et al. 2018; Novignon et al. 2020; Kuntashula 2021). Although Jayne et al. (2018) questioned the significance of the positive effect of production support on food production, empirical studies in Ghana (Tanko et al. 2019), Kenya (Mason et al. 2017b), Malawi (Schiesari et al. 2017) and Zambia (Ricker-Gilbert & Jayne 2012) found positive significant effects of access to production support, that is technology driven and private sector led, on agricultural productivity. Only a few studies in SSA found no or negative effects of production support on production outcomes (Zinnbauer et al. 2017; Azumah & Zakaria 2019).

Despite the above economic benefits of production support, most smallholder farmers in SSA still do not see the need to participate in support programmes (Habtewold 2018; Tanko et al. 2019), mostly due to corruption and pollical favouritism (Banful & Olayide 2010; Druilhe & Barreiro-hurlé 2012; Mweninguwe 2020). A large proportion of subsidised inputs go to undeserving persons (Fearon et al. 2015), and preferential treatment is usually given to political allies and geographical regions of political interest to the ruling government (Banful 2011; Kato & Greeley 2016). Pervasive corruption and political manipulation (Chirwa & Dorward 2013; Jayne & Rashid 2013) tend to demotivate vulnerable smallholders with no political networks from participating in production support programmes, although they are the primary target of such programmes.

Moreover, intensive "monocultural" crop production with the removal and burning of stubble leads to nutritional degradation of the soil, physical erosion, loss of organic matter and easier spread of pests (Vale et al. 2019; Gopel et al. 2020). These destroy soil fertility and weaken its long-term productivity (Gomiero et al. 2011; Kotu et al. 2017) that is crucial in achieving sustainable growth in crop productivity (Wagstaff & Harty 2010). To achieve food security – the first Sustainable Development Goal (SDG) – amid the growing population, food production in SSA has to be increased through intensification programmes (Pretty et al. 2011; The Montpellier Panel 2013; Jayne et. al. 2014). However, the intensive use of agrochemicals (i.e. synthetic fertilisers and pesticides) to replace mising nutrients may affect negatively the agroecosystem (José-María et al. 2010; Campos et al. 2019). Thus, at the same time, there is a need to address the negative effects of intensifying agriculture, like land degradation and desertification and biodiversity loss (referring to SDG 15).

Sustainable agricultural practices (SAPs) are increasingly used worldwide to reduce the adverse effects of agricultural intensification and to maintain soil fertility (Senayah et al. 2005; Lovo 2016). However, the challenge is how to successfully promote agricultural intensification and productivity growth under SAPs in order to increase food production. External motivators (e.g., production support) are considered by policymakers to promote SAP adoption (Ryan &

Deci, 2000a), particularly among less motivated farmers (Bopp et al. 2019). But external governmental support may reduce which can reduce farmers' intrinsic motivation in the end. As a result, farmers may stop SAP use once the support terminates (Deci 1971; Ryan & Deci 2000b). Yet, very few studies have investigated the effect of external governmental support (e.g., production support) on farmers' SAP adoption so far (exemptions are Polomé 2016; Bopp et al. 2019).

The second-generation (i.e., first-generation – 1960s to 1980s and second-generation – early 2000s till date) production support programmes in SSA are based on improved targeting – "who is eligible and who gets what". Gender, landholding size and wealth or ex-ante poverty are often used as eligibility criteria (Dionne & Horowitz 2016; Sibande et al. 2017) but most production support programmes in SSA place a flat cap on the level of support received per farmer regardless of farm size. For instance, Nigeria's Growth Enhancement Support (GES) scheme offers a 50% subsidy on two 50-kg bags of NPK (nitrogen phosphorus potassium) and urea fertilisers and a 90% subsidy on 50-kg hybrid maize and rice seeds to all beneficiaries (Wossen et al. 2017). But the impact of public support programmes can be heterogeneous in relation to firm (farm) size (Bia & Mattei 2007; Ratinger et al. 2020) – the probability of receiving more or less support is highly influenced by firm/farm size. However, no study has empirically estimated the effect of the level of production support on agricultural production outcomes and the potential heterogeneity of production support effects in relation to farm size.

This study therefore analyses the impact of agricultural production support on farm performance (i.e., input use and productivity) and its subsequent role in the sustainable development of agriculture, using Ghana's planting for food and jobs programme, integrated with extension services and SAP adoption. Logistic regression, Poisson regression and generalized propensity score (GPS) matching techniques were used to analyse the quantitative survey data of 502 farmers (after data cleaning and outlier removal from the 540 surveyed) collected in Northern Ghana in 2018-19. The study extends the literature by testing the effect of corruption perception and other drivers on farmers' decisions to participate in production support programmes. The research helps to bridge the literature gap on the effect of production support, even if decoupled from SAP adoption, on farmers' SAP adoption intensity. It also estimates the impact of rising levels of production support on farmers' combination of hybrid seeds and fertilisers to maximise agricultural productivity and the heterogeneity of the impact in relation to farm size. Thus, the study offers an insight into the policy puzzle of whether every farmer should be given the same level of support and whether any level of support can substantially increase productivity. It also enriches the policy-relevant literature since farmers globally operate within agricultural regimes where production support is used as a policy instrument to enhance long-term agricultural productivity.

The rest of this thesis presents a literature review (Section 2), and a description of the study background (Section 3), followed by the study objectives and hypotheses (Section 4). Subsequent sections present the methodology, results, discussion, and the conclusions and policy recommendations.

2. Literature Review

2.1. Production support programmes

2.1.1. History of production support programmes in Sub-Saharan Africa

Production support or input support programmes are among the most contentious development subjects, yet one of the most remarkable agricultural policy developments in Sub-Saharan Africa (SSA) in recent years. They are programmes that provide farmers, especially smallholders, with inputs (mostly fertilisers and improved seeds) and technical advice, in some cases, either free or below market prices. In the 1960s, production support was widely recognised as a tool to address input access constraints in the agrarian sector. However, with the advent of the millennium, it was phased out in all but a few countries in SSA, on the basis that it weakly contributes to agricultural productivity growth, food security and poverty reduction, while creating fiscal rigidities in national budgets and crowding out the commercial input market (Kherallah et al. 2002; Morris et al. 2007; World Bank 2008). Production support programmes resurfaced in the 2000s after African governments committed in Maputo (2003) and subsequently in Abuja (2006) to raise expenditure on agriculture to 10% of the total national budgets (African Union 2003; 2006). Subsequently, annual expenditures on production support in SSA rose to $1.05 billion (i.e., 28.6 percent of public expenditures on agriculture) in 2011 (Jayne & Rashid 2013). The reintroduction of support programmes was backed by the argument that a new genre of "smart" subsidies could be designed to correct the flaws of past production support programmes with careful targeting and private-sector participation (Morris et al. 2007). The goal of the new genre of production support is to improve productivity and break the food insecurity and poverty trap faced by smallholders through intensive use of subsidised inorganic fertilisers and improved seeds (Dorward et al. 2004; Denning et al. 2009; Sachs 2012).

Records show that fertiliser consumption (measured as the quantity of fertiliser used per hectare of arable land) has increased steadily in SSA since the Maputo declaration in 2003, with about 3% average annual increase in fertiliser consumption (Minton 2021). Nonetheless, average rates of fertiliser application is still low in some countries in SSA – less than the application rates of 50 kg/ha agreed at the Abuja declaration in 2006 (Minton 2021). Application rates are significantly lower in SSA countries without fertiliser support programmes due to high fertiliser prices (Cedrez et al. 2020).

2.1.2. Merits and demerits of production support programmes

According to Schultz (1964), farmers are rational beings and profit-maximisers who choose optimal input (i.e., seeds, fertiliser, pesticides, etc.) usage; hence the introduction of production support only distorts and reduces social welfare. Others point to negative environmental externalities (World Bank 2008) and the regressive nature of support programmes resulting from political influence and elite capture (Pan & Christiaensen 2012; Lunduka et al. 2013; Chibwana et al. 2014). Production support programmes also inhibit private sector investment in the agriculture by displacing smallholder demand for commercial inputs (Ricker-Gilbert et al. 2011). Trade liberalists therefore argue for the role of governments to be curtailed in the market as countries transition into market economies (Tanzi & Tsibouris 1999; Nsouli & Havrylyshyn 2001). However, it has been argued that the transition to a market economy in agriculture does not mean a total extinction of the state's role in the credit market but rather a redefinition of governments' role to intervene in agricultural credit markets through subsidies, guarantees and credit schemes to credit-constrained farmers and food industries (Ellis 1992; Swinnen & Gow 1999; Jansson et al. 2013). Such interventions ensure credit availability (i.e., cash or in-kind such as fertiliser, seeds, machinery, etc.) to smallholder farmers who are often rationed from the market due to poor infrastructure and lack of market institutions.

Furthermore, production support has been recognised as a potentially useful tool when the benefits to a given society exceed its private benefits (Gautam 2015). Market constraints, for instance, may undermine a farmer's motivation to use a specific input although the economic and societal benefit of improved productivity could render the added expenditure worthwhile. Again, production support or "subsidies can be justified; for example, when there are potential economies of scale, strong learning-by-doing effects, potential for innovations with large transformative impacts, strategic trade intervention opportunities, or environmental benefits, as well as for social equity considerations." (Gautam 2015, p. 87).

Dorward et al. (2008) conceptualised African rural economies as being caught in a low-productivity poverty trap, from which risk-averse farm households are incapable of escaping. The use of improved inputs and productivities remain low, underpinning staple crop self-sufficiency goals whilst impeding crop and income diversification. This creates a vicious cycle of unstable prices of food, impedes surplus staple production reducing consumers' enthusiasm to rely on staple foods, and limits routes to escape from low productivity subsistence staple cultivation (Jayne et al. 2018). Intervening through production support cannot only help to empower risk-averse farmers but can also potentially release "strong dynamic general equilibrium impacts – boosting agricultural productivity, nutrition, and incomes; lowering food prices; raising real wages, employment and broader economic growth through forward and backward linkages; promoting structural transformation; and strongly contributing to poverty reduction" (Gautam 2015, p. 88).

In addition, production support programmes have beneficial learning effects (Carter et al. 2014). Support programmes can be used to whip up farmers' interest as well as gaining useful information about the benefits of fertiliser application without risking major capital outlay, in areas where fertiliser use is low due to low farmer experience of fertilisers (Carter et al. 2014).

2.2. Determinants of farmers' participation in production support programmes

2.2.1. Drivers of production support participation – the classical approach

Despite its economic benefits, some farmers still do not find the need to participate in production support programmes (Tanko et al. 2019; Habtewold 2018). Therefore, understanding the drivers of farmer participation is essential (Duram 2000; Macé et al. 2007), especially in comprehending how farmers adjust to changes in agricultural policy (Long & van der Ploeg 1994; Darnhofer et al. 2005). The classical approach, mostly premised on socio-economic variables, has been used to explain the drivers of farmers' agricultural technology adoption behaviours (Bopp et al. 2019). For instance, farmers' age, gender, experience, education level, household size, farm size, farm income, non-farm income, access to credit, association membership, extension visits, distance from farm to input stores/markets, access to road, access to remittances, social safety nets, per capita income, wealth, ownership of livestock, per capita landholding, access to credit, and the use of hired labour have all been found to have statistically significant effects on farmers' participation in agricultural programmes (Ohene 2013; Pedzisa et al. 2015; Santeramo et al. 2016; Mango et al. 2017; Uduji & Okolo-Obasi 2018; Ansah et al. 2020).

Theoretical and empirical studies also point to farm size, often used as a proxy for scale economies, and years of education, as variables both with positive statistical significance on farmers' participation in agricultural programmes (Boz & Akbay 2005; Bayard et al. 2006; Isgin et al. 2008; Mlenga & Maseko 2016). It is also argued that female farmers are less likely to participate in new agricultural programmes due to resource limitations and gender discrimination (Langyintuo & Mungoma 2008; Abdul-Hanan 2017). In Kenya, Odendo et al. (2011) examined the drivers of soil fertility management practices and found that farmers' education level, cattle ownership, location of farm, access to extension services, and off-farm income enhanced adoption, whereas age of household head and market liberalisation impeded adoption of mineral fertiliser. Supporting earlier findings by Shiferaw et al. (2008), Odendo et al. argued that slow adoption of mineral fertiliser in Kenya is highly affected by high cost of fertiliser due to market liberalisation and poor input-out price ratios. This has regulated a large number of smallholder farmers from benefiting from the liberalised market.

However, the above studies focused on structural variables (mostly socioeconomic characteristics and geographic conditions) to explain farmers' agricultural programme participation decisions. Such research fails to consider the psychological and risk drivers of technology adoption (Meijer et al. 2015). Hence, we discuss in the next sub-section theoretical and empirical studies on the effect of psychological factors on farmers' decision to participate in production support programmes.

2.2.2. Risk awareness and perceived control over the risk, and participation in support programmes

Threats and coping appraisals are crucial factors that drive intentions to engage in self-protective behaviour amid hazards, according to Rogers' (1975) protection motivation theory. Farmers' realisation of threats such as soil infertility due to erosion and pest invasion promote cognitive actions to repair or prevent further damage to the soil and its long-term productivity (Traore et. al. 1998; Prokopy et al. 2008). Hence, supportive measures like production support programmes which help to improve soil fertility productivity through the provision of subsidised fertilisers, high-yielding and disease-resistant seedlings, and free extension services, might be appealing to farmers.

Risk realisation is significantly related to a primary desire to act, which is capable of outweighing other motives such as intrinsic motivation and beliefs (Kollmuss & Agyeman 2002). For example, climate change literature shows that farmers will adopt adaptation strategies if they believe that climate change variability possess a real threat to, or affect, their livelihood (Kibue et al. 2016; Aryal et al. 2020; Nguyen et al. 2021). On the contrary, individuals who do not perceive climate change as a potential threat to their farming do not take steps to adapt (Dang et al. 2014). However, the realisation of the threat alone does not guarantee taking corrective actions (Prokopy et al. 2008). According to Wilson et al. (2014), persons with low perceived competence or coping appraisal deny a threat and do not attempt to control it. As such, awareness of risk must be in tandem with the knowledge and self-confident feeling about how to perform protective measures (Kaiser et al. 1999).

Individuals are not motivated to act if they are not confident of being capable of achieving desired effects (Bandura 2000). Thus, the commitment to take corrective actions to protect oneself is dependent on the realisation of threat and coping appraisals (Rogers 1975). Furthermore, perceptive assessments of environmental issues are key to the development of more sentimental judgements, such as attitudes towards corrective actions (Kaiser et. al. 1999; Prokopy et al. 2008). For instance, in a study to access farmers' attitudes towards nutrient loss prevention practices, Wilson et al. (2014) observed that risk and coping perceptions positively influence a person's formation of attitudes. Moreover, positive beliefs, or values towards conservation practices, regarding economic and soil quality outcomes, have been found to influence the adoption decision (Ramírez-López et al. 2013). Hence, farmers are less likely to participate in production support programmes if they feel incapacitated to effectively apply inputs such as fertilisers, pesticides and other technologies provided under programmes to mitigate the effects of impending threat (e.g., soil erosion and pest invasion) even if they are aware of it.

2.2.3. *Attitude and corruption perception about production support, and participation in support programmes*

An attitude is a positive or negative assessment of an activity or object. It has aspects of liking or disliking, preferring or not preferring. Psychological studies show that attitudes can be developed out of psychological needs (motivational foundations) and sociological needs (social foundation) (Eagly & Chaiken 1993). The inherent reward of an activity, also known as intrinsic motivation (Skinner 1953; Ryan & Deci 2018), can create positive attitudes towards the activity (Bopp et al. 2019). Attitude formations also occur through individuals' direct experience, relationship with people or activities, and knowledge gained through word of mouth or mass media (Bem & McConnell 1970; Zanna & Rempel 1988). Aside from direct experience, the cognitive foundation of attitudes, known as beliefs, develops through thinking about an activity (Bem 1970; Petty & Cacioppo 1996). For instance, if extension agents advertise that participation in production support helps to access affordable inputs, enhance soil fertility, and increase long-term productivity, and the farmer believes that extension agents are trustworthy experts, then the farmer will believe that participation in production support is beneficial to farmers.

Studies have focused on those conditions that elicit, sustain, and enhance positive attitudes versus those that restrain or diminish them (Ryan & Deci 2000b). Key among such factors related to government policy is corruption. Corruption is generally recognised as the abuse of public office for personal gains (Asante & Mullard 2021). Others contextualise corruption as rent-seeking behaviour and activities in the absence of rule of law (Khan et al. 2019). Governments generate rents when they introduce agricultural production support programmes. For instance, political rent-seeking ruling governments in SSA often use production support as a tool to seek for re-election by giving preferential treatment to geographic areas of political interest (Kato & Greeley 2016; Mweninguwe 2020). In some cases, politically connected farmers are given more than the threshold quantity of subsidised inputs (Dionne & Horowitz 2016). In addition, subsidised input vouchers often end up in the hands of non-targeted people who cash them in (Mweninguwe 2020). Some managers of support programmes smuggle the subsidised inputs to neighbouring countries for resale (Olomola 2015). Also, some unscrupulous input suppliers and retailers receive sums of monies from governments through dubious means without delivering the inputs to the farmers (Mweninguwe 2020). These illegal rent-seeking activities (corruption) affect production support efficiency and effectiveness which tend to hurt vulnerable smallholders and threatens hunger in SSA (Mweninguwe 2020).

Political corruption (i.e., perpetrated at the highest levels by elected politicians and high-ranking public officials) and bureaucratic corruption (i.e., occurring at the implementation end of political systems by middle- and lower-ranking officials) are pervasive in SSA (Amundsen 2019; Asante & Mullard 2021). Huge amounts of resources have been committed and legal reforms (e.g., the whistle-blowers act and the special prosecutor's office) have been undertaken in fighting corruption in Ghana (Asante & Mullard 2021). In his description of the political economy of corruption in Ghana, Ninsin (2018, p. 2) points out that the nation:

...lives under the tyranny of this canker called corruption…. It has become a cancerous tumour eating into various parts of the social fabric…. It subverts and weakens the institutions of the nation-state and dissipates public resources for social development. Clearly, this is a dangerous tumour and must be attacked and uprooted.

Yet, conventional approaches of fighting corruption through formal state institutions (i.e., effective legislature and judicial systems, establishment of anti-corruption institutions, and civil service reforms) have been underwhelming to an extent. Although Ghana's score for Transparency International's corruption perception index, CPI, (the leading global indicator of public corruption) is often above 40%, available data shows that the country has not scored above 50% in the past decade (see Fig. 1).

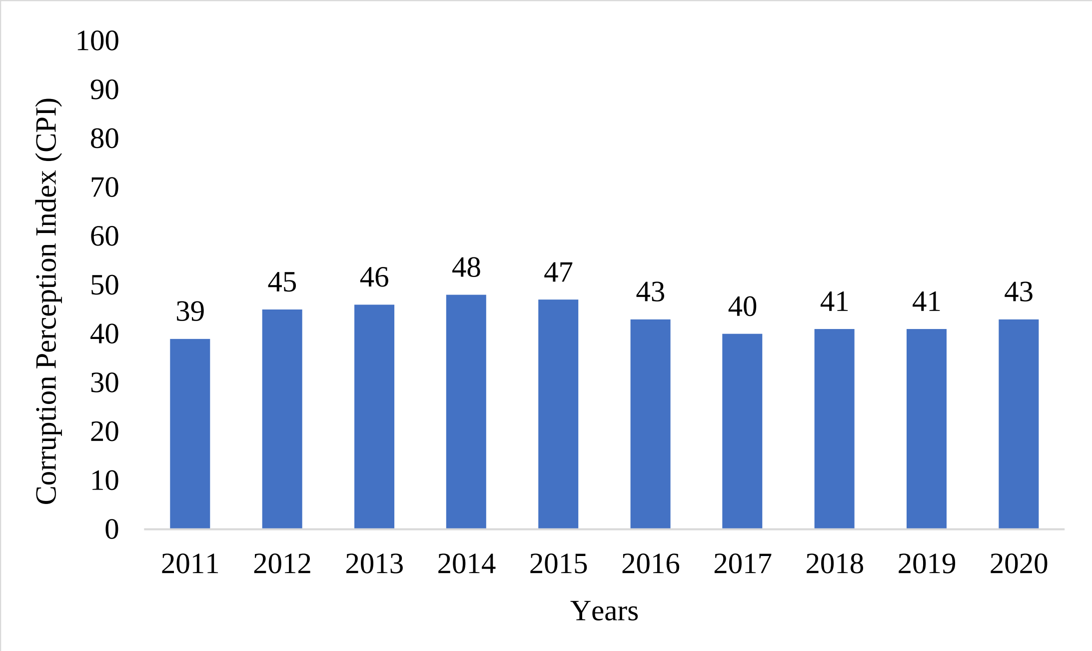

Fig. 1: Corruption perception indices of Ghana, 2011 to 2020

Source: Transparency International (2021)

The high rate of bureaucratic and political corruption in Ghana has affected past and present production support programmes (Fearon et al. 2015; International Fertilizer Development Centre – IFDC 2019). Smuggling of subsidised inputs to neighbouring countries, diversion of subsidised inputs by distributors, retailers, and public officials for resale is threatening the sustainability of Ghana's Planting for Food and Jobs (PFJ) programme (IFDC 2019; Daily Guide 2020; GhanaWeb 2020). These corrupt practices, coupled with the use of the subsidised inputs to seek for political capital in some cases, regulate most smallholders from the programme, although they are the target beneficiaries (Asante & Mullard 2021).

Corruption corrodes trust in government and weakens its social contract with citizens (World Bank 2020). Corruption dents organisational reputation, reduces positive attitudes towards it (Preston 2004; Gaines-Ross 2008), and drives away customers and investors

(Fombrun 1996). Therefore, most farmers may not be motivated to participate in support programmes if they perceive high level of discrimination due to corruption. Thus, farmers may develop negative attitudes toward production support participation if they have a strong perception that the inherent benefits of the programme could be eroded by corrupt practices such as smuggling, elite capture, and political favouritism.

2.2.4. Effects of social-psychological factors on farmers' participation in support programmes

Social-psychological variables permit a more comprehensive assessment of technology adoption (Akbari et. al. 2015; Meijer et al. 2015; Nguyen & Drakou 2021). According to Bopp et al. (2019), technology adoption behavioural appraisals based on psychological approaches present additional entry points to policymakers for bolstering existing policy programmes and recommending new ones. Therefore, evaluation approaches aimed at understanding the complex behaviours of farmers towards production support participation should be multifaceted and expand the classical approach of technology adoption to include psychological drivers (Toma & Mathijs 2007).

Akbari et al. (2015) applied the theory of planned behaviour and found attitudes and subjective norms as the best predictors of adoption behaviour. The authors argued that positive attitudes alone are not enough to inspire farmers' participation in agricultural education. Positive attitudes are affected by individuals' perceived inability to successfully convert their intensions to join agricultural education programmes into actions (termed as coping appraisal by Rogers' (1975)) and by social pressures from important reference groups. Bopp et al. (2019) investigated the role of monetary incentives in promoting farmers' sustainable behaviours, given the psychological context of their decision-making. The study found farmers' attitudes, perceived risk of soil erosion, and perceived behavioural control over risk to be key in explaining farmers' technology adoption. Similarly, Nguyen and Drakou (2021) examined the effect of behavioural factors such as attitude, social norms, perceived behavioural control and past behaviour on farmers' adoption of sustainable agricultural practices and found that farmers' intentions to adopt sustainable practices are influenced by their perception of social pressure and their abilities to perform sustainable agricultural practices. In addition, Toma and Mathijs (2007) found environmental risk perception as the strongest determinant of farmers' propensity to participate in organic farming programmes. These findings show the relevance of social-psychological factors in farmers' decisions to participate in agricultural support programmes.

2.3. Effect of production support on adoption of sustainable agricultural practices

2.3.1. Effects of agricultural production support on the agroecosystem

Conventional crop production, with the intensive cultivation of cropland for example, leads to loss of soil nutrients, physical erosion and loss of organic matter (Altieri & Nicholls 2005; Foley et al. 2011). These destroy soil fertility and weaken the long-term productivity of the soil (Gomiero et al. 2011; Kotu et al. 2017) that is crucial in achieving sustainable growth in crop productivity (Wagstaff & Harty 2010).

Agricultural intensification endangers agroecosystems through increased use of external inputs (mainly nitrogen fertilisers and pesticides) decrease in biodiversity (Garcia 2020: Sud 2020). Increased fertilisation, pesticides and cropland expansion are key factors of rapid biodiversity loss and decreased ecosystem services (WHO-FAO 2019; 2020; European Union 2021). Intensive use of chemical inputs affect insects differently due to the asymmetric reactions of various species to changing hosts (Zhao et al. 2015), and damages arable weed communities (Andreasen et. al. 1996; Sutcliffe & Kay 2000; Hyvönen et al. 2003). Sustainable agricultural practices (SAPs) are increasingly used to reduce the adverse effects of agricultural intensification, maintain soil fertility and increase agricultural productivity (Senayah et al. 2005; Lovo 2016). It is argued that sustainable intensification is the best way to simultanously increase food production and maintain the agroecosystem (Kotu et al. 2017). The question is, how do policymakers promote SAP adoption together with intensification since moving from conventional farming to sustainable agriculture is a complex transformation of farming methods and behavioural change to farmers? (Ward et al. 2018). We discuss in the next sub-section 2.3.2 the meaning of sustainable agricultural practices and the role of production support programmes and extension services in promoting sustainable farm practices.

2.3.2. Sustainable agricultural practices

The Food and Agriculture Organization of the United Nations (FAO 1989) defines sustainable agricultural practice (SAP) as a farming practice that: i) conserves resource, and is ii) environmentally non-degrading, iii) technically appropriate, iv) economically viable, and v) socially acceptable. SAPs are farming activities that have environmental, societal, and economic dimensions (Zeweld et al. 2017). Such practices include, but are not limited to, conservation tillage, crop diversification, composting, improved varieties (crop/animal), agroforestry, biological control, local seed conservation, rainfall harvesting, area enclosure, animal manure, water conservation, soil and water conservation, organic fertiliser, improved fallow management and forage management (Teklewold et al. 2013; Mbow et al. 2014; Paracchini 2020). Sustainable practices play a key role in enhancing productivity and improving economic growth (Zeweld et al. 2017; Foguesatto et al. 2020). SAPs involve a reduction in the use of inputs that are potentially harmful to the environment and a shift towards locally available resources whilst sustaining the competitiveness and economic viability of agriculture (Yazdanpanah et al. 2014). Evidence shows that the introduction of SAPs and improved technologies in some Asian and Latin American countries has considerably increased agricultural productivity and decreased food insecurity and poverty (Abebe et al. 2013; FAO 2014; Qaim 2020). Hence, the promotion of SAP adoption has been considered as a key component of policy developments in SSA countries, yet adoption of SAPs and improved technologies has remained below expectations in SSA (Kassie et al. 2015; Foguesatto et al. 2020). Understanding the drivers of SAP adoption behaviour is key in the selection of appropriate measures for promoting adoption among farmers.

2.3.3. Promoting SAP adoption: can production support programmes be a solution?

Several measures have been launched by countries to promote SAP adoption among farmers to cope with the adverse effects of agricultural intensification (Pretty et al. 2011; Calabi-Floody et al. 2018), ranging from monetary incentives to long-term technological programmes (Bopp et al. 2019). However, adoption and retention rates remain low (Green et al. 2013; Arslan et al. 2014). The decision to change from conventional to sustainable farming is complex (Ward et al. 2018), influenced by economic, sociological and psychological factors (Foguesatto et al. 2020; Nguyen et al. 2021). As such, attempts have been made to understand the drivers behind farmers' SAP adoption behaviour. However, there is no consensus on why/how farmers adopt sustainable practices and improved agricultural technologies (Wauters et al. 2010; Yazdanpanah et al. 2014). Like participation in production support programmes, socioeconomic and demographic factors such as farmers' age, gender, farming experience, education level, family size, farm income are commonly used in literature to explain SAP adoption behaviour (Fernandez 2017; Foguesatto et al. 2020; Serebrennikov et al. 2020). Recent studies have also involved social-psychological factors to allow for more explanation of technology adoption (Meijer et al. 2015; Bopp et al. 2019). One of such studies empirically examined and found a positive effect of economic incentives, as extrinsic motivation, on farmers' SAP adoption behaviour (Bopp et al. 2019). The authors further observed that monetary incentives can be an essential driver of SAP adoption, particularly among farmers with low intrinsic motivation towards SAP.

Similarly, a qualitative examination of farmers' perceptions of climate change, attitudinal and knowledge-based drivers of conservation agriculture (CA) adoption by Nyanga et al. (2011) found a high correlation between provision of subsidised input and adoption of CA in Zambia. The authors argued that farmers' dependency on material incentives to adopt CA has developed due to previous programmes' use of incentives to promote CA adoption. This confirms previous studies by Baudron et al. (2007) which found that 50% of farmers stopped practising CA after the withdrawal of the free input subsidy package. Similarly, Arslan et al. (2014) observed that only 4% of the enrolled farmers on Zambia's CA programme were still practising after 4 years (i.e., 96% of farmers stopped practising CA). According to the authors, circumstantial evidence showed that the low retention rate of CA was mainly due to farmers' expectation of receiving free inputs, hence most of the farmers were not motivated to continue once the incentives were withdrawn. This clearly shows that economic incentives are a crucial driver and remain the preferred tool among policymakers in promoting SAP adoption (Rode et. al. 2015; Dayer et al. 2018). Economic incentives (e.g., production support) can stimulate SAP adoption without the challenge of changing farmers' beliefs and perceptions (Ryan & Deci 2000a). Conversely, evidence show that access to fertiliser subsidy reduces farmers' investment in soil and water conservation practices (Vondolia et al. 2021). The authors also found that the probability of a fertiliser subsidy beneficiary investing in soil and water conservation practices is significantly lower than for non-beneficiaries. Besides, crowding-out (Frey & Jegen 2001) may occur, and extrinsic governmental incentives such as production support may reduce farmers' intrinsic motivation, and as a result, farmers may stop SAP use once the support ceases (Deci 1971; Ryan & Deci 2000b; Frey & Jegen 2001). Thus, economic incentives can have an unintended negative effect on farmers' intrinsic motivation towards SAP adoption.

Alternatively, the realisation of risk (e.g., soil erosion, pest invasion, flooding, etc.) stimulates taking cognitive actions to repair or prevent further damage to the environment and its subsequent effect on long-term productivity (Rogers 1975; Traore et.al. 1998; Prokopy et al. 2008). Consequently, several studies found a positive effect of farmers' risk awareness on their SA and conservation behaviour (Knowler & Bradshaw 2007; Greiner et al. 2009; Pilarova et al. 2018). Besides, generating behavioral changes among farmers through extension education and training tends to be a complex exercise, although its effects could be more lasting and robust (Bopp et al. 2019). Farmers' knowledge of the adverse consequences of erosion and soil degradation, for example, helps them to understand better its impact on their long-term productivity (Mengstie 2009; Darkwah et al. 2019). Moreover, farmers tend to have high self-efficacy of climate change adaptation, when trained in new methods of production (Truelove et al. 2015).

Understanding the effect of farmers' awareness of environmental and production risks, access to extension services and SAP training as well as external material motivators (e.g., production support) on farmers' SAP adoption behaviour is essential in the design and implementation of future sustainable agricultural policies. Hence, farmers' awareness of environmental and production risks, knowledge of SAP and access to economic incentives such as production support can influence their SAP adoption intensity.

2.4. Effect of production support on farm performance

We discuss the mixed empirical findings on the impacts of production support on farm performance, of selected studies in this sub-section. The literature review focuses on the impact of production support on input use, productivity and food production, and poverty reduction.

2.4.1. *Effect of production support on input use and production efficiency*

The literature has generally related the effect of production support on input use to the impact of the support on the demand for inputs from the commercial market. Thus, to assess the extent to which subsidised fertiliser and hybrid seeds "crowds in" or "crowds out" the commercial input market (Xu et al. 2009a; b). For clarity, crowding in (out) implies that a 1-kg increase in subsidised fertiliser or seeds acquired by a household leads to a more (less) than 1-kg increase in total fertiliser or seed demand (Jayne et al. 2018).

Production support helps farmers to acquire more improved varieties of seeds and technologies at commercial prices due to the effect of the support on their financial constraints (Omotilewa et al. 2019; Kumar et al. 2020). Farmers can therefore make extra investment and create efficiency through the combination of once-unreachable inputs (Mason and Jayne 2013). Moreover, farmers often use more of technologies associated with production support due to income and substitution effects, which tend to increase production efficiency and output (Seck 2017). Thus, so far as output rises faster than input, output-oriented efficiency will increase. Input-oriented efficiency gains could also be realised even if production technique remains unchanged, since the farmer can attain the same output level at a reduced cost, *ceteris paribus* (Seck 2017).

Malawi's Farm Input Subsidy Programme (FISP) has been found to have a positive statistically significant effect on farmers' adoption of inorganic fertiliser and improved maize seeds (Koppmair et al. 2017). The findings of Koppmair et al. confirms earlier findings by that access to the FISP increases farmers' probability of adopting new maize varieties. Production support strengthens weak input demand by providing quality inputs to inexperienced farmers and farmers who may not have bought the inputs, thereby providing these farmers experience and quality input as well as stimulating commercial input demand at the end (Harrigan 2008).

Production support can enhance farmers' short and long-term demand for new inputs and technologies through the creation of learning effects (Dupas 2014; Omotilewa et al. 2019).

Furthermore, studies in Kano State, Nigeria (Liverpool-Tasie 2014) and Zambia (Xu et al. 2009b) found evidence of crowding-in effect of receiving subsidised fertilisers on commercial fertiliser demand especially in rural areas in Zambia with inactive private sector. Similarly, Omotilewa et al. (2019) found access to subsidised bags of fertiliser to have increased the demand (i.e., crowd-in) for commercial market fertilisers by beneficiaries. Their result is consistent with the findings of Amankwah et al. (2016) found a positive effect of production support on farmers' demand for improved commercial inputs in Kenya.

On the contrary, the bulk of the literature in SSA has found that production support programmes crowd-out commercial inputs (mainly fertiliser and hybrid seeds) demand and reduce farmers' use of improved commercial inputs (Ricker-Gilbert et al. 2011; Takeshima et al. 2012; Jayne et al. 2013; Mason & Jayne 2013; Mason & Ricker-Gilbert 2013; Takeshima & Nkonya 2014; Mather & Jayne 2018). Other studies have also estimated the size of production support effect on the demand for commercial inputs and found that an additional 100 kg of subsidised fertiliser crowds-out commercial fertiliser by up to 50 kg in Kenya, 35 kg in Nigeria, 18 kg in Malawi, and 13 kg in Zambia (Takeshima et al. 2012; Jayne et al. 2013; Mather & Jayne 2018). Higher negative effect was recorded in Kenya because the private input market in the country was developed with higher demand for commercial fertilisers and seeds prior to the introduction of production support (Sheahan et al. 2014; Mather & Jayne 2018). Also, subsidised fertilisers have a low response rate to total fertiliser usage (Jayne et al. 2013). The authors, based on earlier work by Ricker-Gilbert et al. (2011) and Mason and Jayne (2013), found that an additional kilogram of subsidised fertiliser increases total fertiliser use by only 0.58 kg, 0.55 kg and 0.57 kg in Zambia, Malawi and Kenya, respectively. Such low response rates can be linked to inefficiencies of production support programmes and their crowding-out effect on commercial input use.

Critics also argue that production support programmes distort the market by encouraging abuse of fertiliser use and smuggling (Banful & Olayide 2010; Druilhe & Barreiro-hurlé 2012) and create incentives for farmers to resell, at higher prices, inputs acquired at lower prices (Mason & Jayne 2013). Support programmes are criticised for widespread leakages and uneven rollout, although such programmes are designed to target vulnerable farmers (Dorward et al. 2008; Ricker-Gilbert & Jayne 2008; Holden & Lunduka 2010a). The concern across SSA is, what proportion of the support ends up with the farmers, and what rate gets to the underserved people through input diversion (Fearon et al. 2015)?

2.4.2. Effect of production support programmes on agricultural productivity

Empirical micro-level studies have focused on the impact of production support on aggregate measures such as national food production or broad measures such as total food production or yields (Jayne & Rashid 2013). However, there is no consensus on the programme effects, especially in terms of magnitude, as well as the methods and indicators used to estimating the effects (Dorward et al. 2008; Toenniessen et al. 2008; Ricker-Gilbert & Jayne 2010; Wossen et al. 2017; Jayne et al. 2018).

A limited number of studies in Ghana found no or negative impact of production support on crop production. For instance, Fearon et al. (2015) found no significant relationship between state budget spending on production support and crop output. They found Ghana's previous fertiliser support programme ineffective, and that growth in output was associated with land area expansion rather than yield increases. Likewise, approximately 57% of farm households in Northern Ghana showed no positive effect of fertiliser support on their fertiliser usage and crop yield (Imoru & Ayamga 2015). Using a counterfactual approach, Azumah and Zakaria

(2019) found that the treated group of Ghana's fertiliser support programme could have produced 8.69 bags (747.34 kg) of rice more if they had not benefited from the programme. However, these studies are based on Ghana's previous production support programme (2008 – 2016) which focused only on fertiliser subsidy for a limited number of farmers. Besides, Kwao (2014) shows that Ghana's past production support was ineffective due to its poor design and implementation. A recent study however has found a positive significant impact of Ghana's current production support programme (i.e., the PFJ programme) on rice and maize production (Lambongang et al. 2019; Tanko et al. 2019).

On the contrary, positive significant effects of production support on agricultural productivity and production have been found in the body empirical literature (Abubakari & Abubakari 2015; Mason et al. 2017b; Lambongang et al. 2019; Pauw 2021). The contention however has been the extent of the effect. It is estimated that approximately 50% of agricultural productivity growth in SSA can be linked to increased fertiliser application (Toenniessen et al. 2008), which subsequently increases productivity and farmers' income. Likewise, evidence from Nigeria show that the Growth Enhancement Support (GES) scheme positive effects on maize yield and income (Wossen et al. 2017). Their study found similar effects of GES on maize yield in terms of magnitude and direction. Specifically, GES beneficiaries' maize yield increased by 28.1% when the study controlled for only state-level fixed effects, 26.1% given standard controls and state-level fixed effects, and by 26.3% when potential endogeneity of beneficiaries of GES were controlled.

The effect of production support on food production was affirmed when the scaling-down of Malawi's support programme coupled with poor weather in 2005/2006 led to food shortages and high maize prices (Dorward et al. 2008). In line with an earlier study (Ricker-Gilbert & Jayne 2008), Ricker-Gilbert and Jayne (2010) found a positive correlation between fertiliser subsidy and maize production in Malawi, with important dynamic effects. The authors found significant gains in the first season with indications of positive impacts in the subsequent seasons. Besides, the combined effects of subsidised fertiliser and hybrid seeds on maize productivity were found to be higher in Malawi than subsidised fertilisers only (Dorward & Chirwa 2011). Subsequent counterfactual studies also confirmed the findings of Dorward and Chirwa that access to subsidised fertiliser and maize seeds increases productivity, by up to 447kg/ha (Chibwana et al. 2014). The latter recorded higher yields even for farmers producing traditional varieties of maize with subsidised fertiliser, although the impact of fertiliser support was higher for farmers cultivating improved varieties of maize seeds.

Notwithstanding the positive correlation, empirical evidence of production support on productivity increases is surprisingly minimal generally (Jayne et al. 2018). Estimates from Kenya, Malawi, Nigeria, and Zambia suggest limited positive impacts on maize yield (Holden & Lunduka 2010b; Mason et al. 2013; Chibwana et al. 2014; Karamba & Winters 2015; Mason et al. 2017a; Wossen et al. 2017). Far lower maize production responses to subsidised inorganic fertiliser (2 kg of maize per kg of subsidised fertiliser based on recent available data) have been recorded in Zambia and Malawi (Lunduka et al. 2013; Mason et al. 2013), relative to the already low response rates of inorganic fertiliser recorded in these countries (i.e., 3 - 4 kg of maize per kg of fertiliser) (Jayne & Rashid 2013). Besides, programme inefficiencies and crowding out effects are likely to further reduce these effects (Xu et al. 2009a; b; Namonje-kapembwa et al. 2015; Burke et al. 2019), as are poor soil quality and limited use of complementary farm practices to raise crop yield to fertiliser response (Marenya & Barrett 2009).

Available evidence again shows limited positive impact of production support subsidies on household-level maize production in SSA. Mason et al. (2017b) found Kenya's National Accelerated Agricultural Input Access Programme (NAAIAP) to have raised beneficiary households' maize production by 361 kg on average. A smaller increase was also recorded in Zambia (188 kg of maize per 100-kg of subsidised fertiliser) and Malawi (165 kg of maize per a 100-kg of subsidised fertiliser) (Ricker-Gilbert & Jayne 2012; Mason et al. 2013). The Kenyan estimate is for a 100-kg fertiliser and a 10-kg of improved maize seeds, whereas the estimates for Malawi and Zambia are for subsidised fertiliser only. However, substantial (89%) positive effects on maize production, due to higher yield (50%), have been recorded in Zambia (World Bank 2010). Recent evidence also shows that Ghana's PFJ (i.e., access to subsidised seeds, fertilisers and free extension services) increased beneficiaries' average rice productivity by 55.15 metric tonnes (Mt) (Tanko et al. 2019).

In summary, the diverse levels of impacts of the programmes discussed above can be associated with the different design and implementation of production support programmes in each country (Jayne et al. 2018). Programmes that are based on subsidised seeds, fertilisers, and other inputs (e.g., mechanisation centres in Ghana) are likely to record better impacts, relative to those solely based on subsidised inorganic fertilisers. Programmes that successfully target resource-poor farmers and distribute inputs through vouchers redeemable at private retailers as well as provide free extension services (e.g., Kenya's NAAIAP and Ghana's PFJ) are likely to have higher impacts on input use and productivity (Jayne et al. 2018; Tanko et al. 2019).

2.4.3. Effect of production support on poverty reduction and farmer welfare

Unlike input use and food production, the empirical literature on the effect of production support on farm earnings and farmer welfare in SSA is generally positive, with a few diverging studies. Although fertiliser subsidy has been suggested to have positive effects on maize production (Jayne et al. 2013) and maize retail prices in Malawi and Zambia, these effects were low (Ricker-Gilbert et al. 2013). Likewise, Ricker-Gilbert (2014) found a minimal effect of production support on wage rate, indicating a very low spill-over effect of production support on non-beneficiary households. Critics also argue that the two largest support programmes in SSA (Malawi and Zambia) have had little or no impact on rural poverty since rural poverty rates in these countries remain unchanged despite years of production support implementation (Jayne et al. 2011; Lunduka et al. 2013; Mason et al. 2013). Perhaps, what the critics failed to consider is the counterfactual: what would have been the status of rural poverty rates without production support? (Mason & Tembo 2015).

However, using a randomized control trial technique, Awotide et al. (2013b) found a positive significant effect of Nigeria's seed voucher system on rice income per hectare, output and yield. The authors further observed that, although the non-beneficiaries cultivated large farm sizes than the beneficiaries, the latter recorded higher output, yield, and rice income per hectare than their non-beneficiary counterparts. Using a Gini index, the authors found a 13% decline in income inequality among production support beneficiary farmers after the intervention, whereas income inequality only decreased marginally (4%) among non-beneficiaries over the same period. The programme was considered to be a pro-poor one since its impact on rice income and income inequality was higher for poor farming households than for relatively wealthy ones. Moreover, a significant spill-over effect from the increases in rice income on incomes of other cultivated crops for beneficiaries was found by (Awotide et al. 2013b). Their findings indicate combined positive effects of production support on food production, household income and farmer welfare.

The findings of Awotide et al. (2013b) are consistent with Awotide et al. (2013a) who found a positive impact of the certified improved rice seed voucher programme (which entitles beneficiaries to up to 20 kg of subsidised rice seeds) on farmer's annual household income and per capita consumption expenditure while contributing to 24 percentage points reduction in overall poverty. Subsequently, Wossen et al. (2017) found that participation in Nigeria's voucher-based production support programme significantly increased farmers' average per capita total expenditure and per capita food consumption expenditure by 30.7% and 39.4%, respectively.

Furthermore, Chirwa (2010) found access to a 100-kg subsidised fertiliser coupon increases the annual per capita expenditure of beneficiary households by US$11.19 (8%) in Malawi. Ricker-Gilbert et. al. (2011) later found that a kilogram increase in subsidised fertiliser increased Malawian smallholders' net crop income by US$1.16, although their study found no statistically significant impact of fertiliser subsidy on total income, off-farm income, or asset wealth.

In addition, using an estimated nation-wide model, Arndt et al. (2015), in reaction to suggestions by Chirwa and Dorward (2013) that the general equilibrium effects of production support could be substantial, observed that Malawi's support programme in 2006/07 reduced the national, rural, and urban poverty rates by 1.5 – 3.0 percentage points. In a macroeconomic study, Pauw et al. (2014) attempted to solve Malawi's 'poverty puzzle' (i.e., the lack of reduction in the country's rural poverty rate in spite of Malawi's nation-wide production support programme) (Mason & Tembo 2015), by estimating new regional poverty lines using a cost-of-basic-needs approach. The authors observed that rural poverty rates reduced by 6.8 percentage points during the implementation of Malawi's production programme. Mason and Smale (2013) analysed the effect of the seed subsidy component of Zambia's production support programme on the incomes and poverty status of smallholder beneficiaries and found that an additional 10 kg of subsidised hybrid maize seeds increases the maize income of smallholders by 1.1% and reduces their poverty severity by 0.7 percentage points.

Wossen et al. (2017) estimated the benefit-cost ratios (BCRs) of Nigeria's GES at market value without accounting for nation-wide effects. Using the increases in maize incomes as a measure of economic benefits, the authors found an estimated benefit-cost ratio of 1.11, implying that a dollar spent on production support by the state produces US$1.11 worth of maize income. Dorward and Chirwa (2011) found a BCR of 1.06 using the same production-based technique. Unlike the studies above, Arndt et al. (2015) accounted for nation-wide effects and reported a higher BCR (1.62) for the same support programme. The authors argued that neglecting nation-wide effects can have great consequences on the estimated benefits of large-scale production support programmes.

2.4.4. Heterogeneity of production support effects in relation to farm size

Several studies have produced mixed findings on the effect of production support on farm performance using different performance indicators (e.g., productivity, yield, technical efficiency, output, production, per capita income, farm profitability, per capita expenditure) and various analytical methods. However, no agricultural study, based on our search, has answered the question: are effects of production support homogeneous in relation to farm size? Evidence from a non-agricultural study, show that the likelihood of receiving lower or higher support in state intervention programmes is highly influenced by firm size (Bia & Mattei, 2007). Hence, effects of production support on output increases are more likely to be heterogeneous in relation to farm size.

In a counterfactual design with generalized propensity score (GPS) matching, (Bia & Mattei (2007) evaluated the effect of state support to firms on employment and found that additional support of 50,000 euros equivalent does not generate any significant effects on employment for large enterprises but an additional support of the same amount (50,000 euros) given to small and medium size enterprises creates significant positive effects on employment.

Similarly, Ratinger et al. (2020) analysed the economic impacts of public business research and development (R&D) support on firms in the Czech Republic using the GPS matching approach. The authors also found positive substantial effects of public R&D support on the output (i.e., profit, productivity and gross value added) of small and medium firms whereas no such effects could be confirmed for large firms. The authors argue that small firms only realise positive effects on their output after receiving a certain minimum threshold of support whereas output decreases after a point of saturation. These findings confirm that treatment effects are heterogeneous in relation to farm size, hence different amounts of support may be required for small-scale and large-scale farmers to realise positive effects on their productivity. In summary, although higher levels of production support enhance a farmer's combination of inputs, at given level of technology, to maximise productivity and increase food production, these effects can be heterogeneous in relation to farm size since the probability of receiving low or high support can be influenced by farm size.

3. Study Background

3.1. Historical perspective of production support programmes in Ghana

Ghana's soils are naturally deficient in nitrogen (N) and phosphorus (P) (i.e., the two main soil nutrients enhancing yield besides potassium (K)) because they are derived from completely weathered parental materials (Jayne et al. 2015a; Antwi et al. 2016). Intensive cultivation without replenishing soil nutrients further depletes the soil at a rate of 35 kg (N), 4 kg (P) and 20 kg (K) per hectare per year because nutrients consumed by plants are often not restored through the use of sufficient rates of plant nutrients in the form of organic and inorganic fertilisers (Jayne et al. 2015a). This widespread loss of soil nutrients across agroecological zones would require the use of artificial NPK fertilisers at a considerable rate (Ministry of Food and Agriculture – MoFA 2017).

The replacement of soil nutrients by artificial NPK fertilisers was supported in Ghana in the 1960s and 1970s (Benin et al. 2013). However, the support was abolished in the 1980s with the introduction of the Economic Recovery Programme (ERP) in 1983 and the creation of a liberalised economy (Asante & Mullard 2021). This rendered the entire agricultural inputs supply chain private sector-led without state interference until 2008 (Banful 2009; Azumah & Zakaria 2019). After market liberalisation, fertiliser application reduced significantly from 21.9 kg/ha in 1978 to 8 kg/ha in 2006 (MoFA 2017; Anang & Kudadze 2019) – far below the 13 kg/ha average application rate in SSA as at 2008 (Minot & Benson 2009). According to Morris et al. (2007) the low level of agricultural productivity in SSA is partially due to the abysmal rate of fertility application. The low application of fertiliser led to the Abuja Declaration on Fertiliser for African Green Revolution, where member countries pledged to remove taxes on fertilisers and raw materials for fertiliser production and allocate 10% of their national budget to agriculture by 2008 (African Union 2006; Anang & Kudadze 2019).

Consequently, the government of Ghana in 2008 reintroduced production support as a food security strategy amid the global food crisis, 2007 – 2008 (Vondolia et al. 2012). The programme was expected to increase fertiliser application to 50 kg/ha by 2015, per the Abuja declaration (Fearon et al. 2015). Hence, the subsidy programme started with initial supply of 600,000 bags of 50 kg fertilisers, with a budget cost of US$15 million (Fearon et al. 2015). In the first two phases of the new support programme, the government adopted the voucher distribution system (2008 to 2009) and the waybill system (2010 to 2014) to distribute the subsidised inputs to farmers (Benin et al. 2013; MoFA 2017). Under the voucher system, vouchers were distributed to regional and district offices of the ministry of food and agriculture based on the country's regional and districts fertiliser consumption data (Benin et al. 2013). At the district level, the vouchers were distributed to registered farmers by the district agricultural extension agents. Upon receipt of the voucher, the farmer used the face value of the voucher to purchase the fertiliser from the nearest participating retail outlet (MoFA 2010). The approach was reported to be associated with high overhead and administrative cost, lack of personnel to police the disbursement process, delays at the national, regional and district ministry of food and agriculture offices, and diversion of fertiliser from the intended beneficiaries (MoFA 2010).

Following these critiques, the voucher system was replaced with the waybill system in 2010. The government, based on the annual budgetary allocation towards the support programme, absorbed part of the overhead cost (i.e., port tariffs, loading and transportation cost and agents' commissions and margins) of fertiliser importation and distribution, to reduce fertiliser prices to smallholder farmers in the country. The MoFA, the implementing agency, invited interested suppliers to raise a bid. Then the bidders provided indicative prices for distributing the fertilisers to the regional government warehouses and to district agents and distribution centres. This helped the MoFA to estimate the price build-up from the port to the district agents in order to negotiate, with selected bidders, the retail price per a 50-kg bag to farmers. The waybills, indicating deliveries and sales, were submitted to the government by the selected importers for payment. The submitted waybills were certified by the regional and district directors of agriculture to confirm the delivery of the fertilisers. The aim of this approach was to ensure that all farmers across the country get the fertiliser at a uniform agreed price. This approach was regarded as a clear public-private partnership in which the government involved fertiliser importers in the programme design and depended on the existing private distribution chain to get fertilisers to farmers at a lower cost (Benin et al. 2013). However, existing evidence show that fertiliser prices kept increasing in Ghana during the period of the waybill system. This distribution approach was also associated with fertiliser diversion to neighbouring countries (Ghana News Agency 2011), although no evidence exist on the magnitude of fertiliser diversion compared to the voucher system for objective assessment. To limit the leakage, farmers were issued passbooks to purchase inputs and only fertilisers and seeds reordered in the passbook as bought by farmers were paid for, yet this could not stop the input diversion. Evidence show that beneficiaries saw the waybill system as an improvement over the voucher system (Benin et al. 2013). However, the waybill system, like the voucher system, was associated with delayed input distribution (Benin et al. 2013). Hence, the two distribution approaches adopted by the previous support programme (i.e., from 2008 to 2014) did not benefit farmers in areas with early cultivation seasons (Banful 2009; Benin et al. 2013).

The existing evidence show that both the voucher and waybill systems failed due to poor implementation, input diversion and lack of financial commitment from the government (Kwao 2014; Fearon et al. 2015; Anang & Kudadze 2019). For instance, government kept providing conflicting figures on the disbursed quantity of fertilisers and funds dedicated for the programme. According to Fearon et al. (2015), though government officials claimed that 9% of the 2012 budget was dedicated to agriculture, evidence showed that only GH₵ 292.479 million out of a total national budget of GH₵ 20.58 billion (representing 1.4%, far less than the 10%

pledged at the Abuja summit) was dedicated to the ministry of food and agriculture. Benin et al. (2013) found that fertiliser application rate remained low at 13.4 kg/ha in 2010, while Jama et al. (2013) found a much higher usage rate of 20 kg/ha in 2009. Besides, the lack of data on fertiliser application from the MoFA (the implementing agency) at the time echoes how poorly the programme was designed and implemented. The support programme terminated in 2014 due to these implementation challenges but was reintroduced a year after, with about 50% less quantity of subsidised inputs distributed compared to 2013, i.e., from 166,800 Mt to 89,200 Mt of subsidised fertilisers (Azumah & Zakaria 2019).

3.2. The Planting for Food and Jobs (PFJ) programme

In 2017, the government reviewed and extended the scope of Ghana's production support, under the flagship programme Planting for Food and Jobs (PFJ). The objective of the PFJ programme is to modernise the agricultural sector and structurally transform the national economy by providing food security, employment opportunities and poverty reduction. The programme seeks to achieve its objectives through sustainable increases in the productivity levels of selected crops, namely maize, rice, soybeans, cowpea, sorghum, and other vegetables (MoFA 2017). It also creates awareness for public and private non-agricultural workers to grow the selected crops or create backyard gardens in urban communities where land is scarce for large farms.

Participation in the PFJ programme is voluntary for farmers cultivating the selected crops (i.e., self-selection criteria). However, peculiar attention is given to farmers who are willing to raise their productivity levels (productive poor) and to farmers whose land, water, labour, and capital limit productivity (resource poor). The programme mainly targets beneficiaries through registered 'nucleus farms[1]' and farmer-based organisations (FBOs) (MoFA 2017). The PFJ programme also targets at least 40% female participation (Pauw 2021) and the teeming unemployed youth as part of the government's effort to empower women and youth in agriculture.

3.2.1. Pillars of the PFJ programme

The six pillars of the PFJ programme launched in 2017 included the distribution of subsidised inputs (i.e., seeds, fertiliser), free extension services, a platform for marketing farm produce and e-agriculture – a technology to provide vital farming information to farmers and monitor the activities and progress of beneficiaries through a database (refer to Fig. 2) (MoFA 2017; Tanko et al. 2019). The e-agriculture platform helps to collect and validate beneficiaries' data to discourage smuggling and properly target beneficiaries. The platform also helps to disseminate information on weather, price, demand and supply situation in the market, and other vital agricultural production aspects to

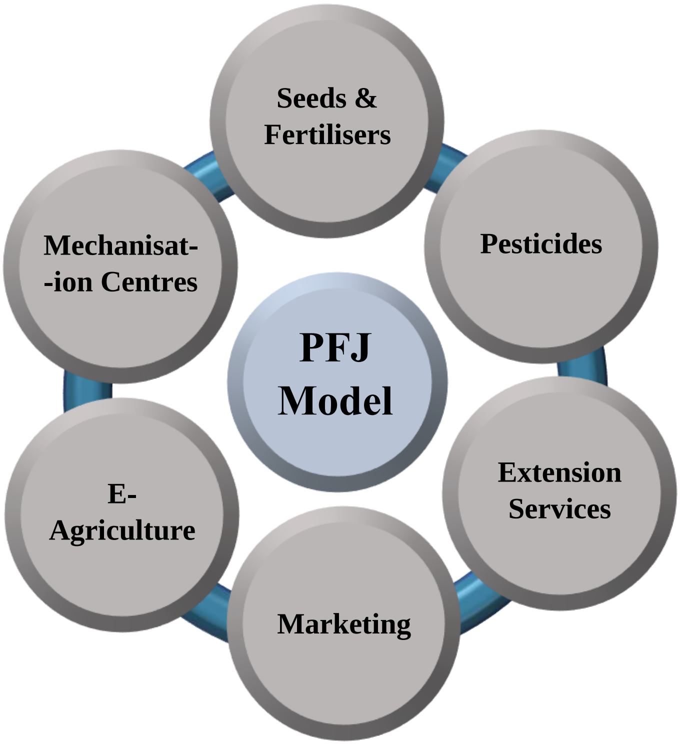

Fig. 2: Updated strategic pillars of the PFJ programme.

[1] An arrangement where a primary farm operator provides support to smallholder farmers in purchasing inputs and marketing their crop outputs (MoFA 2017). Thus, the smallholders either cultivate on their own lands or on a large piece of land owned by the primary operator but divided into smaller sizes for small-scale cultivation by the smallholders.

beneficiaries. The information is distributed through web portals, mobile text services and internet-based services (Abugri et al. 2020).

The seeds pillar helps beneficiaries to access quality seeds and improved varieties, acquired from certified seed companies, to improve the quality and quantity of production. The seeds are produced in Ghana by seed producers in partnership with the research institutes that developed the varieties. The distributed seeds are packaged in small to medium weight packs (i.e., 5 kg, 10 kg, and 20 kg) to encourage patronage by smallholder farmers. Seeds distributed under the PFJ programme are high-yielding, climate-resilient and resistant to biotic and abiotic stress (MoFA 2017).

The fertilisers pillar helps to increase usage of commonly used fertilisers in Ghana (i.e., NPK (15:15:15), urea and sulphate of ammonia) through price incentives. Ghana's previous support programme provided beneficiaries with up to 10 bags of 50 kg NPK and/or 5 bags of 50 kg urea. However, fertiliser distribution under the PFJ programme is based on the national fertiliser requirement per hectare of each targeted crop in (see Table 1). The selection of fertilisers for the districts is also based on a laboratory analysis of the soil nutrient deficiencies of each agroecological zone in Ghana. Fertilisers provided under the PFJ programme include NPK, urea and/or sulphate ammonia and bio-fertiliser for soya bean farmers (see Table 1).

Table 1: Recommended fertilisers for distribution under the PFJ programme (1 bag = 50 kg)

Fertilisers	**Crops**						
	Maize	Rice	Sorghum	Soya bean	Tomato	Chilli pepper	Onion
NPK (bags/ha)	5	5	5	-	5	5	5
Urea or Sulphate Ammonia (bags/ha)	2.5	2.5	3	-	2.5	2.5	2.5
Bio-fertiliser	-	-	-	3	-	-	-

Source: MoFA (2017)

A distinct feature of the PFJ programme, relative to Ghana's previous support programmes and other similar programmes across SSA, is the provision of technical advisory services to beneficiaries under the free extension pillar. The extension agents provide training to beneficiaries on appropriate application of fertilisers, to achieve the best results and avoid potential environmental and health risks. As part of the training, farmers are encouraged to complement the (subsidised) inorganic fertilisers with organic fertilisers to enhance the sustainability of their cropping systems. The extension agents also train beneficiaries on how to optimise input use, with sustainable agricultural practices (SAPs), i.e., crop rotation, intercropping, cover cropping, zero/minimal tillage, row planting, mulching, composting, and manure application. The training is done using various extension approaches such as demonstrations, field days, group meetings of FBOs, mass media and exchange visits. To sum up, the PFJ programme promotes SAP adoption, but farmers are not mandated to adopt SAP under the programme.

Since 2018, the programme has added to its initial five pillars (i.e., subsidised seeds and fertilisers, free extension services, output marketing, and e-agriculture platform) the provision of free pesticides to farmers to combat the upsurge in fall armyworm *(Spodoptera frugiperda)* infestation in Ghana. It has also created mechanisation centres to rent machinery at subsidised prices to farmers across the country to improve mechanised farming among farmers who have not hitherto been able to afford the services of such machinery (refer to Fig. 2). New warehouses are being constructed in each district and old ones rehabilitated to ensure adequate storage space for the recent rise in maize and rice production following the introduction of the PFJ programme (Lambongang et al. 2019).

3.2.2. Supply chain of subsidised inputs under the PFJ programme

Support allocation under the PFJ programme is determined by historical data of fertiliser and seed consumption of each region (MoFA 2017). Out of the sixteen regions, the five regions of Northern Ghana[2] have the highest fertiliser demand and receive 45% of the subsidised fertilisers (IFDC 2019). Furthermore, farmers in Northern Ghana cultivate more cereals than vegetables, hence regions at the north receive higher quantities of subsidised maize, rice, and sorghum seeds than regions in the middle and costal zones (IFDC 2019).

The MoFA selects private seed and fertiliser producers and suppliers through public procurement processes. The MoFA, based on the annual budgetary allocation for the PFJ programme, procures the quantity of seeds and fertilisers for onward distribution to farmers by the selected suppliers. The prevailing supply chain of subsidised fertiliser starts at the country's ports and proceed to blending and processing warehouses after import tariff support from the government through the MoFA (IFDC 2019; Andani et al. 2020), while the improved hybrid seeds are produced locally. The subsidised fertilisers are packaged in 25 kg and 50 kg bags whilst the improved hybrid seeds are packaged in 5 kg, 10 kg, and 20 kg bags. The inputs are distributed by the suppliers to regional warehouses, along with a waybill for endorsement at regional offices of the MoFA (see Fig. 3). The inputs are further distributed to the local retailers of the selected suppliers and public distribution centres at the district and community level, along with invoices indicating the type and quantity of inputs and a record sheet to record daily sales to farmers. The input retailers must also present their invoices to district offices of the MoFA for approval.

[2] Northern Ghana is made of 5 regions out of the 16 administrative regions in Ghana since the December 2018 referendum.

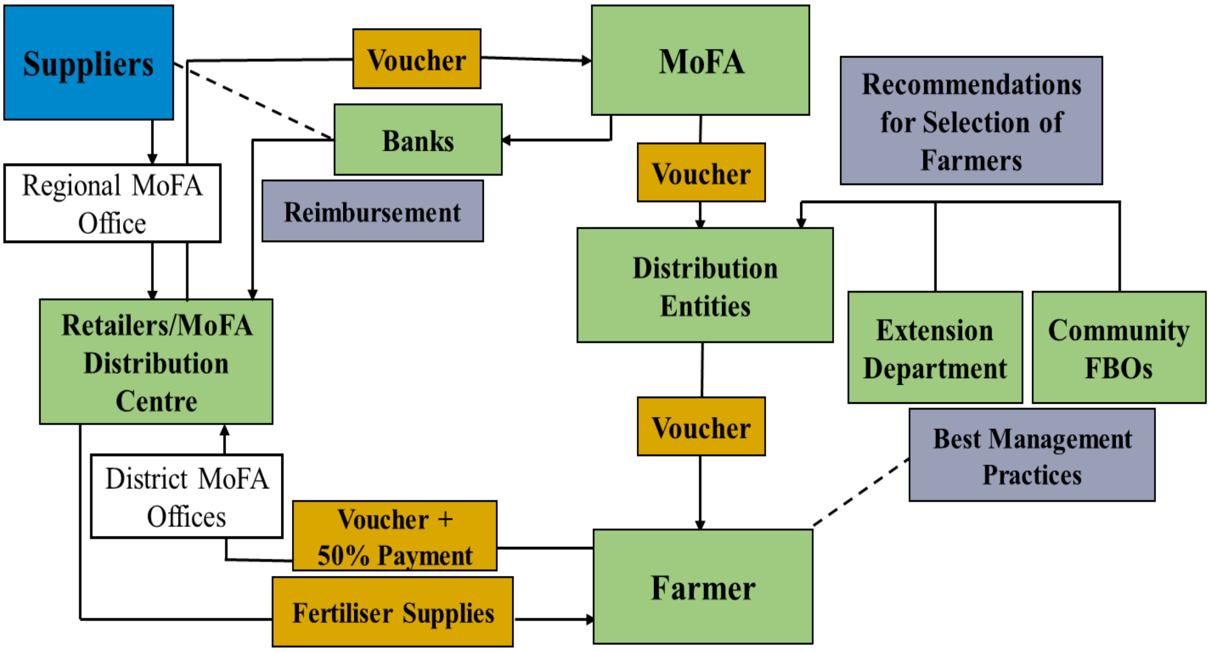

Fig. 3: Schematic illustration of the PFJ programme

Source: MoFA (2017)

To access the subsidised inputs, registered farmers receive vouchers from district offices of the MoFA through extension agents. Farmers then go to the retail point to present the vouchers to redeem their subsidised inputs (see Fig. 3). The participating suppliers must submit the endorsed waybills and invoices received from their distributers and retailers to the PFJ secretariat at the national MoFA office upon which they are reimbursed (MoFA 2019).

3.2.3. The PFJ support and payment structure

The PFJ programme offers 50% subsidy to farmers based on the prevailing market prices of the inputs distributed under the programme – the highest rate of production support in West Africa (Asante & Mullard 2021). The programme also encourages farmers to participate with a flexible payment structure for the subsidised seeds and fertilisers. Unlike Ghana's previous support programme which required an upfront payment of the total subsidised price, the PFJ programme enables beneficiaries to pay only 25% of the market price (i.e., 50% of the subsidised price) of the acquired input upfront. The remaining 25% is paid after harvesting either in cash or in-kind (i.e., farm produce). The remaining 50% is the subsidy covered by the government (MoFA 2017). Farmers who default the 25% after harvesting forfeit the opportunity to participate subsequently until all debts are paid.

The quantity of subsidised input allocated per farmer is limited to a maximum of 2 ha (MoFA 2017). Farmers cultivating more than 2 ha are supposed to acquire the rest of the needed fertilisers at market price. Thus, the subsidy distribution refers to the farm, rather than to the cropland area (refer to Fig. A 1, Appendix 4). Nevertheless, this plan for fair distribution relation to the 2 ha threshold, as enshrined in the policy document, has not been fully achieved due to corruption and political influence (Ghana Business News 2018). The quantity of subsidised inputs received per farmer is further limited by farmers' capacity to afford the 25% pre-financing of their allocated inputs.

3.2.4. Best practices under the PFJ programme

Input distribution efficiency under the PFJ programme has been enhanced by the involvement of the private sector in the aid (subsidised inputs) and service delivery along the value chains (MoFA 2017). To strengthen the PFJ programme and ensure accountability, Nation Builders Corps (NABCO)[3] beneficiaries are used to monitor the distribution of the subsidised inputs at retail and public distribution points. Monitoring mechanisms such as inspection of supplied inputs and endorsement of waybills and invoices by regional and district MoFA offices also help to reduce diversion of the subsidised inputs. The distribution of subsidised inputs based on the historical regional demand of seeds and fertiliser also helps to

[3] NABCO is a government flagship programme that signs on unemployed university graduates to various sectors of the economy for three years. The aim is to help unemployed graduates earn a living and working experience whilst searching for permanent jobs.

reduce the probability of favouring geographic regions of political interest to the ruling party. For instance, the presidential and parliamentary votes of the ruling New Patriotic Party (NPP) in general elections are often low in Northern Ghana (PeaceFM Online 2020), yet the area is the highest beneficiary of the PFJ programme (IFDC 2019) introduced by the NPP government. Furthermore, registered farmers are recommended for selection unto the programme by extension agents and community FBOs to reduced input diversion and default payments. Furthermore, fertilisers and seeds distributed under the PFJ programme are packaged in smaller sizes to distinguish them from commercial seeds and fertilisers and to make them attractive to smallholders. For instance, whereas commercial fertilisers are packaged in only 50 kg bags, PFJ fertilisers are packaged in both 25 kg and 50 kg bags to encourage patronage by smallholder who do not use up to 50 kg of fertiliser. The subsidised inputs are also branded with the PFJ programme's label as part of the mechanisms to prevent diversions.

3.2.5. Challenges and successes of the PFJ programme

Ghana's PFJ programme has generally been regarded as successful by the MoFA and some empirical studies (Tanko et al. 2019; Abugri et al. 2020; Tanko 2020). However, the programme faces some implementation challenges, such as lack of information about the programme, difficult registration processes, long distances to distribution centres, late distribution of inputs, and poor quality of inputs (Ghana Business News 2018). Besides, the 25% pre-financing requirement remains a challenge to some farmers. Despite the safeguarding measures put in place under the PFJ programme, input smuggling remains a concern. Though it is difficult to determine the scale and cost of input smuggling under the programme, estimates from International Fertiliser Development Centre (IFDC) show that Ghana lost 50,000 Mt of fertiliser through smuggling to neighbouring countries, costing the country US$ 12 million, in 2018 alone (IFDC 2019). The MoFA officials have expressed concerns about the cost of smuggling and have requested the support of security agencies at the country's borders (CitiNewsroom 2020) to ensure the sustainability of the programme.

On the other hand, the number of beneficiaries has increased fivefold (300,000 to 1.7 million) during the first four years of the PFJ programme's implementation, i.e., from 2017 to 2020 (Pauw 2021), with significant female participation (SEND GHANA 2019; Graphic Online 2020). Over 3,000 extension agents have been hired to provide technical assistance and train farmers on SAP. The increase in the number of extension agents has improved the country's extension-farmer ratio from 1:1,900 in 2016 to 1:709 in 2020 (MoFA 2021). Although the impact the PFJ programme on SAP adoption has not been empirically evaluated, a preliminary study by Darkwah et al. (2019) found an average of 4.30 SAPs per farmer, far exceeding the 1.81 (Nkegbe & Shankar 2014) and 1.30 SAP adoptions (Abdul-Hanan 2017) recorded before the programme's implementation. Records also show a significant reduction in fall armyworm invasion in 2018 (Bariw et al. 2020). Similarly, Koffi et al. (2020), in a 3-year experimental study, found a reduction in fall armyworm infestation rate from 68% in 2016 to 18% per hectare in 2018. The authors further argued that level of invasion and leavers per hectare were higher in neighbouring countries such as Togo than in Ghana. In addition, the programme's 2020 target of 49% and 30% increase in maize and rice yields, respectively, were exceeded in 2018, with over 50% rise in average yield of maize and rice (Lambongang et al. 2019). Available data from the ministry of food and agriculture shows that maize, rice, and sorghum yield per hectare in 2020 increased by 94%, 67% and 82%, respectively, compared to the 2016 yields of these crops (refer to Table 2).

Table 2: Yield of major cereals under PFJ (Mt/ha)

Crop	2016	2017	2018	2019	2020	% Change in Yield (2020/2016)	Target yield
Maize	1.7	3.5	3.5	3.8	3.3**	94%	5.5
Rice	2.7	4	4	4.3	4.5	67%	6
Sorghum	1.1	1.24	1.39	1.57	2	82%	2

**Yield affected by severe drought

Source: MoFA (2021)

The increased maize and rice yield since 2017 (i.e., since the introduction of the PFJ programme) made Ghana a net exporter of maize to neighbouring West African countries in 2018, after 11 years of importation (Business and Financial Times 2019; Graphic Online 2021).

4. Objectives and Hypotheses

4.1. Objectives of the study

The aim of this thesis is to analyse the impact of agricultural production support on farm performance and its subsequent role in the sustainable development of agriculture, using Ghana's Planting for Food and Jobs (PFJ) programme, integrated with extension services and Sustainable Agricultural Practices (SAP) adoption. The specific objectives are to:

a. analyse the determinants of farmers' decisions to participate in production support programmes.
b. assess the impact of production support on farmers' SAP adoption intensity (i.e., number of SAPs adopted).
c. estimate the effect of increased agricultural production support on farm performance, using input use (i.e., hybrid seeds and fertiliser) and productivity as performance indicators.

4.2. Research hypotheses

Empirical evidence on the impact of the level of support on food production and the heterogeneity of these impacts in relation to farm size is under-researched. Many national governments have expressed their optimism that agricultural production support is a sure way to address market failure and transfer improved technologies to farmers to increase agricultural productivity and enhance food security (Tanzi & Tsibouris 1999; Shiferaw et al. 2008). Yet, it has been argued that intensive crop cultivation and/or increased use of chemical inputs such as pesticides and nitrogen fertilisers affect the agroecological system and reduce the long-term productivity of the soil (Xie & Huang 2021). Sustainable agricultural practices have emerged as alternatives to mitigate the effects of agricultural intensification (Foguesatto et al. 2020).

Thus far, empirical evidence on the synergy between intensification programmes such as production support and SAP adoption is limited. As such, the research estimates the effect of participation in a production support programme and increasing levels of the production support on farmers' SAP adoption intensity and farm performance using the following hypotheses.

1) H1: Farmer participation in a production support programme is affected by their: i) awareness of environmental and production risk (i.e., soil erosion and pest invasion) (H1a); ii) perceived competence to control these risks (H1b); iii) attitudes towards the production support, measured as farmers' expected productivity and benefits (H1c); iv) corruption perception about the production support programme (H1d); while v) farmers' positive attitudes towards production support increase with low levels of corruption perception about the programme (H1e).
2) H2: Participation in the production support programme, integrated with SAP training and technical advisory services, increase farmers' SAP adoption intensity. Farmers' SAP adoption intensity is influenced by their: i) awareness of environmental and production risks (i.e., soil erosion, flood, and pest invasion) (H2a); ii) provision of SAP training and extension services to farmers (proxies for farmer knowledge on SAP) (H2b:) iii) participation in production support (H2c); iv) increased levels of production support (H2d).
3) H3: Increased levels of production support can sustainably: i) increase farmers' adoption of hybrid seed and fertiliser (H3a); and ii) increase their productivity levels (H3b).
4) H4: The effects of the production support on farm performance are heterogenous in relation to farm size, ceteris paribus.

5. Methodology

5.1. Conceptual framework

Figure 4 illustrates the effect of participation in production support (e.g., the PFJ support) and increased levels of the support on farmers' SAP adoption intensity (i.e., number of SAPs adopted) and their farm performance (i.e., input use and productivity).

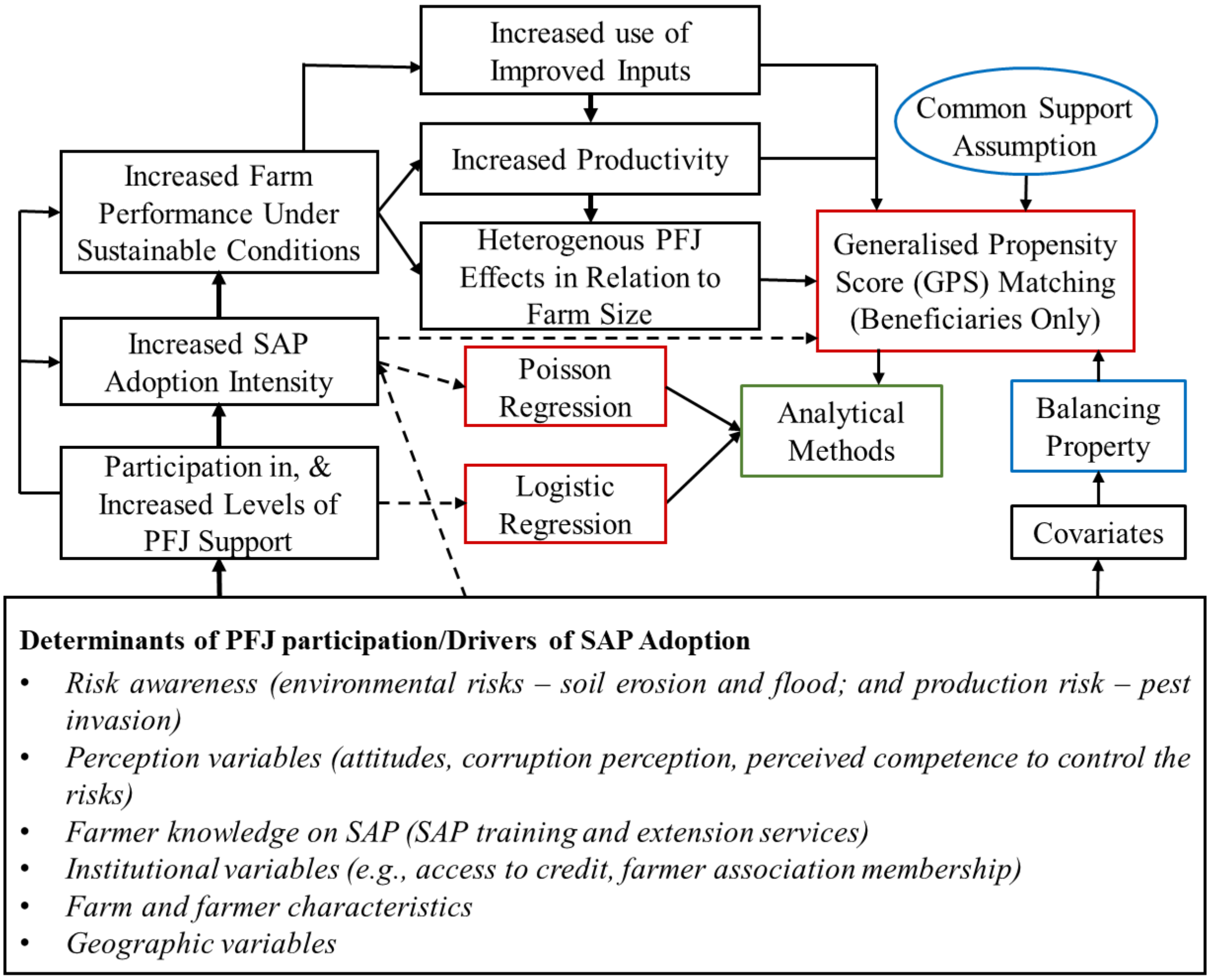

Fig. 4: Graphical representation of the conceptual and empirical framework

Higher level of production support increases farmers' use of improved inputs and technologies (Mason & Jayne 2013) which consequently increases their productivity (Seck 2017). Production support can also be used to motivate farmers' adoption of sustainable agricultural practices (Arslan et al. 2014; Kumar et al. 2020) to mitigate the negative environmental effects of crop cultivation (e.g., soil erosion) and intensive use of inputs (e.g., soil and water pollution) (Gomiero et al. 2011; Kotu et al. 2017).

This study conceptualises that participation in agricultural production support programme, integrated with SAP training and technical advisory services (e.g., the PFJ programme), will stimulate farmers' SAP adoption. Likewise, increased levels of support and technical advisory services, can sustainably boost farm performance and food production, ceteris paribus (Fig. 4). However, the expected output increase due to production support is likely to be heterogenous in relation to firm/farm size (Bia & Mattei 2007). Besides, the PFJ programme limits the allocation of subsidised inputs per farmer to the proportional inputs requirement for cultivating 2 ha (MoFA 2017). We therefore assume that the effect of farm performance is not homogenous in relation to farm size. Thus, large-scale farmers are likely to record lower production increases relative to small-scale farmers if the former are unable to afford the additional inputs at market price to raise yield on their entire farm area.

We adopted three econometric methods: i) logistic regression ii) Poisson regression and iii) generalized propensity score matching (see Fig. 4), to test the four hypotheses in sub-section 4.2. First, we tested the effect farmers' risk awareness, attitudes towards the production support, corruption perception about the support programme and other factors on their participation in the production support programme with a logistic regression model. Secondly, we used a Poisson regression model to analyse the second hypothesis, i.e., that participation in production support, integrated with SAP training and technical advisory services, will increase farmers' SAP adoption intensity. To remind the reader, the aim of the PFJ programme is to increase productivity through the provision of support to farmers. Adoption of SAP is neither an entry requirement of the programme nor a condition for the PFJ support. Rather, the programme encourages farmers to adopt SAP through training and technical advisory services. According to Darkwah et al. (2019) farmers in Ghana (i.e., both PFJ beneficiaries and non-beneficiaries) have high knowledge about SAP and receive training on SAP from MoFA extension officers and NGOs. These therefore make PFJ participation and SAP adoption independent processes in the second model (i.e., Poisson regression). Thirdly, the study adopted a counterfactual approach, proposed by Hirano and Imbens (2004) (i.e., a generalized propensity score (GPS) matching), to estimate the effect of increased levels of production support on farmer performance (i.e., H3), using additional input use (i.e., hybrid seed and fertiliser) and productivity as performance indicators.

The Resource-Based Theory suggests that differences in the performance of firms are determined by the heterogeneity of their resource availability (Barney et al. 2011; Fernández et al. 2019). Empirical literature also show that different firm types (i.e., in relation to size) respond heterogeneously (i.e., in terms of productivity and growth) to public support and protection measures (Reyes et al. 2021). Our fourth hypothesis is premised on the assumption that farmers with different farm sizes are likely to receive different levels of support (i.e., resource availability), and hence are likely to have different farm performance. We tested the fourth hypothesis, whether effects of production support are heterogenous in relation to farm size, with the GPS matching. Institutional, farm and farmer characteristics, and geographic variables empirically shown to have influence on farmers' participation in production support programmes and SAPs adoption intensity (Chirwa et al. 2011; Nahayo et al. 2017; Lambongang et al. 2019), were added to account for the structural aspect, and socioeconomic and environmental conditions in the two regression models (i.e., logistic and Poisson regressions). These covariates were also used to test the balancing property and common support assumption of the GPS matching technique (see Fig. 4), which helps to eliminate potential bias due to differences in the pre-treatment (i.e., before PFJ support) characteristics of the sampled farmers.

5.2. Study area

Northern Ghana occupies about 7 million hectares of land, of which 70 percent is used for agricultural production, and is inhabited by 4,603,986 people (Ghana Statistical Service 2019) who are predominantly farmers. The study area was originally made up of 3 administrative regions (i.e., Upper West, Upper East, and Northern regions) until early 2019 when the formal Northern region was divided into 3 regions (i.e., North-East, Savanah and the Northern regions). The resulting five administrative regions (refer to Fig. 5) are currently divided into 55 districts – 16 administrative districts in Northern region, 6 in North-East, 7 in Savannah, 15 in Upper East and 11 in Upper West regions.

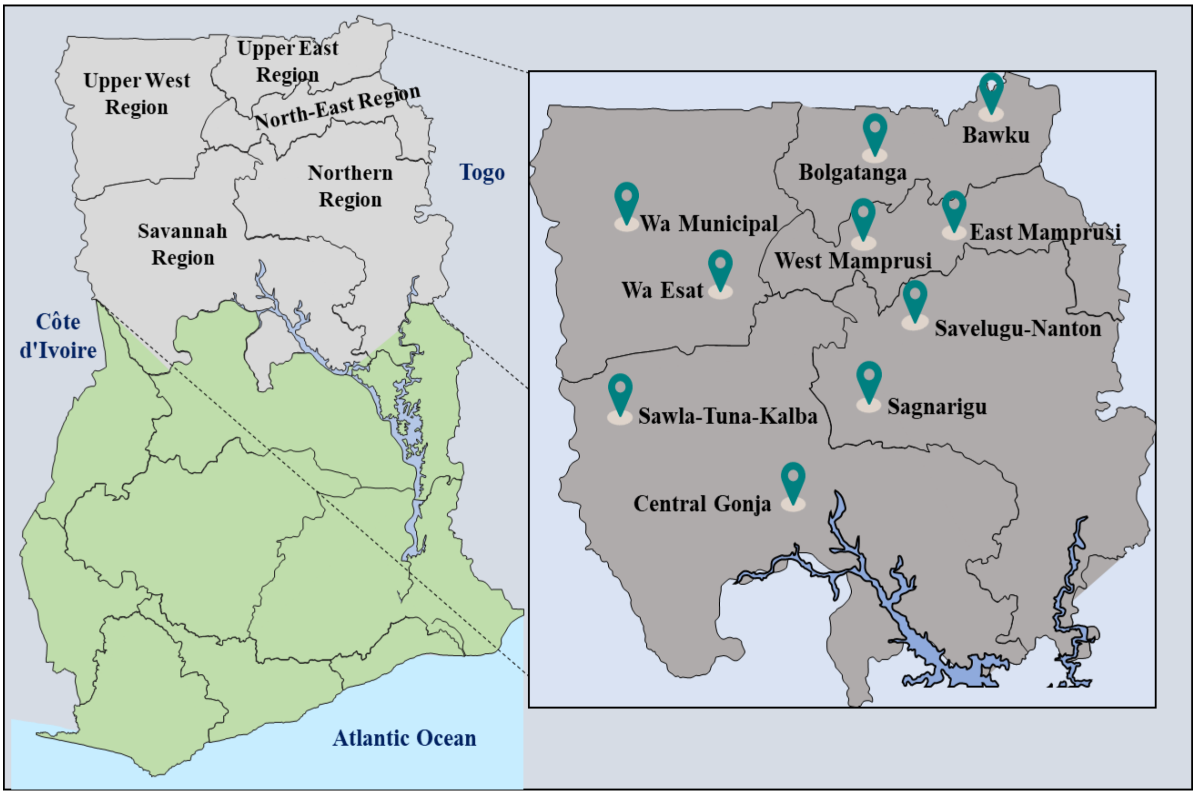

Fig. 5: Map of Northern Ghana indicating the sampled districts

Source: Author’s design

The area is characterised by a monomodal rainfall pattern, from May to June, with an annual average of 1000 mm and over seven months of dry spells (Kotu et al. 2017; Nkegbe 2018). The land is flat, and the soil is mainly lateritic with less than 0.5 percent organic matter, thus the soil fertility is low. In Ghana, about 69% of arable lands are prone to erosion, and 35% is estimated to be vulnerable to desertification, the majority of these lands to be found in Northern Ghana (MoFA 2007; Nkegbe 2018). The soil infertility problem in Northern Ghana is worsened by the annual burning and removal of crop residues (Nkegbe 2018). The high incidence of soil erosion coupled with harsh climatic conditions, loss of vegetation cover and erratic rainfall pattern have contributed to a continuous fall in agricultural productivity, making the Northern Ghana the poorest and most food-insecure zone in Ghana (MoFA 2011; Nkegbe 2013).

The incidence of poverty in the five regions of Northern Ghana (Upper West, Upper East, Savanah, North-east and Northern regions) is high (44.4 – 70.7 %) relative to the national average of 24.2 % (World Bank 2011; Ghana Statistical Service 2014). The efforts of the government and non-governmental organisations (NGOs) to address food security and poverty have focused on improving the productivity of locally produced and consumed food crops, especially cereals, through production support. Northern Ghana has exhibited the highest fertiliser demand and receives about 45% of PFJ subsidies (IFDC 2019: 47). The study area has the highest number of beneficiaries of the previous and current government support programmes. Moreover, over 28% of the 2018 PFJ beneficiaries were from the two Upper regions (GhanaWeb 2018; Smith 2020). However, the study area has also been a major source of input smuggling (for the previous and current support programmes) to neighbouring West African countries (Benin et al. 2013; Daily Guide 2020; GhanaWeb 2020) since the five regions at the north share borders with Togo to the East, Côte d'Ivoire to the West and Burkina Faso to the North (refer to Fig. 5).

Cereals and legumes are the most cultivated crops in Northern Ghana whilst root crops, vegetables and fruits are grown only to some extent (Amanor-Boadu et al. 2015; USAID 2012). Usually, farmers intercrop cereals with grain legumes (among these, cowpea is the most common). First, they use maize which is followed by sorghum in the next season. The cowpea is harvested first while sorghum remains in the field. Intercropping, crop rotation and cover cropping are farming systems practised in the study area as a weed control mechanism and to make more nitrogen and phosphorus available for the next cultivation. Zero or minimum tillage practices rest in lower frequency and intensity of tillage and vertical movement of the surface, which reduces soil and water loss (Bopp et al. 2019). Minimum tillage practices, like beds and ridges, are used to prevent soil erosion and improve soil moisture due to the low water-holding capacity of soils of Northern Ghana relative to soils of the tropical rainforest zones of the country. Row planting has been a major SAP propagated by the ministry of food and agriculture in Ghana. Practised by cereal farmers, row planting ensures adequate spacing of crops for a better yield. Although the crop-livestock integration is limited in Northern Ghana, oxen are often used as draught power for land preparation in all the five regions and for weeding in parts of the Upper East region (Houssou et al. 2013). The dung of livestock housed on or close to croplands is often used as manure. Compost, resulting from the decomposition of food waste such as yam peels, 'pito' (indigenous beer brewed from sorghum) waste, and other organic waste, are also used to enrich the soil. Mulching, covering the soil between plants with a layer of material to protect the soil from wind, rain, and sun, and composting, is rare in Northern Ghana.

Northern Ghana is therefore suitable for studies such as this one, aimed at understanding the economic effects of state production support programmes on sustainable agriculture, farm performance and the general wellbeing of farmers. Besides, the prevalence of production and environmental risk (i.e., soil erosion, pest invasion and flooding), and the harsh climatic conditions, have prompted efforts from government and NGOs to promote sustainable agriculture among farmers. These reasons make Northern Ghana suitable for a study that aims at testing the possibility of achieving sustainable increases in food production through a production support programme.

5.3. Sampling and data collection

A quantitative questionnaire survey was conducted among cereal farmers in Northern Ghana from December 2018 to April 2019. The study targeted cereal farmers who benefitted from the PFJ programme in its first two years of implementation (2017 and 2018). A multi-stage sampling technique was used to select the respondents from the target population (i.e., PFJ beneficiary = 2 years, and non-beneficiary). Farmers who have benefited for only one year were excluded from the sample to prevent potential bias in estimates due to differences in the period the sampled farmers have benefited from the programme. First, two districts were randomly selected (i.e., by lottery) from each of the five regions of the area, i.e., Northern, Upper East, Upper West, Savanna and North-East regions (see Fig. 5). Then three communities were purposively selected from each sampled district (based on their level of production of the selected cereals, i.e., maize, rice, and sorghum), in each of the regions, except for the Upper West region where five communities were selected per district, making a total of 34 communities. Five communities were selected from the Upper West region because it had the highest number of PFJ beneficiaries as at the period of the data collection. The 2018 district registers for PFJ beneficiaries were accessed from the ministry of food and agriculture offices of the selected districts), and a representative sample of 285 PFJ beneficiary farmers were randomly (i.e., by lottery) selected from these 34 communities. A total of 64, 73, 116, 117, and 170 PFJ beneficiaries were sampled from the Upper East, North-East, Savannah, Northern and Upper West regions, respectively (see Table 3). The regional sample sizes of the beneficiaries were estimated based on the registered PFJ farmers at 5% level of significance. Random sampling could not be used for the selection of the non-beneficiaries of PFJ due to lack of data on staple crop farmers in Ghana. In the absence of a register, a total of 255 non-beneficiaries of PFJ were selected through purposive sampling (i.e., non-beneficiaries cultivating the selected cereals without support) from the non-beneficiary farmer groups in the 34 sampled communities, making a total of 540 respondents (refer to Table 3). However, sampled beneficiaries who received less than GH₵ 100 and above GH₵ 4,000 were removed as outliers.

Table 3: Regional and district distribution of sampled respondents

Region	District	Respondents
Northern	Savelugu-Nanton	61
	Sagnarigu	56
	Total	**117**
Upper East	Bawku	33
	Bolgatanga Municipal	31
	Total	**64**
Upper West	Wa Municipal	92
	Wa East	78
	Total	**170**
Savannah	Central Gonja	59
	Sawla-Tuna-Kalba	57
	Total	**116**
North-East	West Mamprusi	40
	East Mamprusi	33
	Total	**73**
Total sample		**540**

In addition, observations with no response on the performance variables (i.e., quantity of hybrid seeds, fertiliser and total production) and the number of SAPs adopted were removed. Data cleaning and outlier removal reduced the sample size to 502 (252 PFJ beneficiaries and 250 non-beneficiaries) which were used for the analysis.

A semi-structured questionnaire (see Appendix 5) was pretested with 20 farmers, and revised before the main survey was conducted – the pre-test data were not included in the main analysis. Twelve enumerators, including the author, were used to conduct face-to-face interviews with the selected farmers. The enumerators were trained and involved in the pre-testing of the questionnaire. The questionnaire was written in English but was administered in the local languages of the area by the enumerators who were students and extension agents from the study area. The questionnaire was divided into 7 main sections. Section A gathered basic information about the respondent location, and sections B – D on the production systems, asset base of the farmer and farm management practices. Section E captured data on farm performance (input use and production) whereas information on the planting for food and jobs programme was captured in section F. The questionnaire captured data on farm performance and SAP adoption for the year before PFJ implementation (i.e., 2016) and the first two years after the implementation of the PFJ programme (i.e., 2017 and 2018). The final section (G) covered the socio-economic characteristics of the farmer (refer to Appendix 5 for details).

With the help of the district PFJ registers, appointments were scheduled by phone with some of the sampled PFJ beneficiaries by enumerators before the face-to-face interviews. Other beneficiaries were interviewed by enumerators during their community PFJ farmers association meetings since they could not be reached on phone for a prior appointment. The 255 non-beneficiaries were either selected and interviewed during the meetings of community FBOs or interviewed individually at their homes based on the criteria for the purposive sampling (i.e., non-beneficiaries cultivating maize, rice and sorghum without any support or subsidy and did not benefit from the previous support programme). The questionnaire was mainly administered on smartphones and tablets with the help of an offline survey application (i.e., Kobo Toolbox). Printed copies were used in cases where enumerators encountered technical challenges with their smartphones.

The survey encountered some challenges. Key among the challenges was the difficulty in finding non-beneficiaries who were producing the selected cereals and were not beneficiaries of any public or private support programme (previous or current). The use of the community FBOs was key in overcoming this challenge. However, to prevent possible sampling bias arising from the selection of only members of FBO organisations with similar features, 138 out of the 255 non-beneficiaries were selected through the community FBOs meeting approach whereas the remaining 117 were selected individual farmers interviewed at their homes and farmers.

The collected data was first entered in Excel and then analysed with Stata 14. Out of the 252 beneficiaries, 115 were small-scale (farm size ≤ 5 acres or 2 hectares) with the remaining 137 ranging from medium to large-scale (farm size > 5 acres). For this study, farmers with farm size greater than 5 acres were classified as large-scale. The small-scale and large-scale subsamples were used to test the heterogeneity of production support effects in relation to farm size.

5.4. Model specification

5.4.1. Logistic regression model

Participation in agricultural support programmes is generally understood as a dichotomous decision, i.e., participate or not (Chirwa et al. 2011; Nkomoki et al. 2018; Zeweld et al. 2020). Binary logistic regression (i.e., logit) and probability regression (i.e., probit) approaches are commonly used methods in modelling dichotomous decisions. Logit and probit models yield similar, although not identical, inferences. They both take a number and rescale it to lie between 0 and 1 (Adekanmbi 2017; Klieštik et al. 2015). Thus, the coefficients of both logit and probit models are transformed by these techniques to yield predicted probabilities. Despite their mutual similarity, the distribution of a logistic function is simple relative to probit models. The inverse transformation of a logit function can be directly interpreted as the logarithm of probabilities, while the inverse transformation of probit has no direct interpretation (Klieštik et al. 2015). Moreover, logit is popular and commonly used in literature to estimate a farmer's dichotomous decision in the adoption production support and related programmes (Chirwa et al. 2011; Nahayo et al. 2017).

This research adopts the binary logistic regression to estimate the drivers behind farmers' decisions to participate in production support. The outcome variable, production support participation, is dichotomous, taking the value of 1 if a farmer participates in the production support programme, and 0 otherwise. The model assumes that individual farmers faced two alternatives, and that their choice was conditional upon a set of independent variables made up of risk, social-psychological, institutional, and structural variables. The logit model is mathematically specified as follows (Gujarati 1995):

$$\frac{prob(y_i=1)}{prob(y_i=0)} = \frac{\rho_i}{1-\rho_i} = e^{(\beta_0+\beta_1 X_{1i}+\beta_2 X_{2i}+\cdots+\beta_k X_{ki})}$$

=

$$L_i = \ln\left(\frac{\rho_i}{1-\rho_i}\right) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots + \beta_k X_{ki} \qquad \text{Eq. (1)}$$

where ρ_i is the probability of participation, $(y_i = 1)$; $1 - \rho_i$ is the probability of non-participation, $(y_i = 0)$; X_i denotes the covariates; β_0 is the intercept; $\beta_1, \beta_2, \dots, \beta_k$ are coefficients of the covariates X.

For this study, the empirical model is as follows:

$$L_i = \alpha + \theta R_i + \gamma C_i + \beta M_i + \delta P_i + \mu(M_i * P_i) + \vartheta Z_i + \varepsilon_i, \qquad i = 1, 2, 3, \dots, N \quad \text{Eq. (2)}$$

The dependent variable L_i represents $ln\left(\frac{\rho_i}{1-\rho_i}\right)$ where ρ_i is the probability of PFJ participation. R_i is a vector of farmer awareness of environmental and production risk (i.e., if a farmer has experienced or experiences soil erosion and pest invasion on farm); C_i represents a vector of farmer perceived competence to control the aforementioned risks given the production support (PFJ) technologies; M_i denotes farmer attitude towards the PFJ programme (measured as perceived productivity and benefits using a 5-point Likert scale); P_i represents farmer level of corruption perception (measured with a 5-point Likert scale) about the support programme; $(M_i * P_i)$ denotes the interaction of corruption perception and attitude toward the production support programme. A vector of farmer and farm characteristics Z_i was added to capture other structural variables that can influence participation. Lastly, ε_i is the random error with assumed independence and standard logistic distribution. According to Stoltzfus (2011), logistic regressions must fulfil four basic assumptions, i.e., independence of errors, linearity in the logit for continuous variables, absence of multicollinearity, and lack of strongly influential outliers. The model was checked for these assumptions during data analyses to ensure the appropriateness of the estimates.

Coefficient estimates of logistic regression models lose their direct interpretation as unconditional marginal effects to avoid interpretation errors (Leeper 2021). Marginal effects are useful quantities because they express the marginal contributions of the covariates (i.e., $R_i, C_i, M_i, P_i, M_i * P_i, Z_i$) to the probability of participation (ρ_i). Marginal effects at representative values (MERs), marginal effects at means (MEMs) or average marginal effects (AMEs) can be used to derive marginal effects. According to Leeper (2021), AMEs are superior to MEMs and MERs because they can provide a significant amount of information about the impact of each covariate on the outcome. AMEs also provide a true summary measure that appreciates both the distribution of the original data and does not rely on summarising a substantively unobserved covariate value. This study used AMEs to calculate the marginal effect of each covariate in Eq. (2) by numerical approximation using the *"margins"* command of STATA.

5.4.2. Poisson regression model

Adoption of technologies is often understood as a dichotomous decision (Asaaga et al. 2020; Nkomoki et al. 2018; Zeweld et al. 2020). However, estimating adoption as the number of pro-environmental practices adopted can enrich measurement in cases where the number of adopters are higher than non-adopters in the sampled respondents (Imrey 2000). A count model also helps to deal with potential bias since some of the treated units (PFJ beneficiaries) might have adopted SAP before the treatment. The count data models offer some useful insight as they focus on adoption intensity (Darkwah et al. 2019; Sharma et al. 2011).

Studies using count data models typically employ parametric specifications such as the Poisson or Negative Binomial (Lohr & Park 2002; Isgin et al. 2008; Nkegbe 2018; Nkegbe & Shankar 2014). The Poisson model is argued to be a suitable count data estimator than the Negative Binomial model in the literature, except when the data suffer from overdispersion (Abdul-Hanan et al. 2014; Bopp et al. 2019; Darkwah et al. 2019). It deals with fixed threshold data in which the responses of the dependent variable are independent of one another, and each y is a non-negative integer following a Poisson distribution (Yu & Phillips 2018). Using a count dependent variable (i.e., the number of SAPs adopted) and a set of individual, institutional, risk and geographic characteristics as explanatory variables, the Poisson model is specified as:

$$Prob\ [Y_i = n_i | x_i] = \frac{e^{-\lambda_i} \lambda_i{}^{n_i}}{n_i}, n_i = 0, 1, 2, 3, \ldots\ldots, 10 \qquad \text{Eq. (3)}$$

where the number of conservation practices adopted by the *i*th farmer is dependent on a vector of covariates x_i, (i.e., farmer and farm characteristics, geographic, risk awareness and institutional variables). The parameter λ_i is normally formulated as a log-linear model according to Greene (2003):

$$ln\lambda_i = x_i'\beta$$

According to Bopp et al. (2019), this is expressed as the expected number of counts in the sample (of sustainable agricultural practices in our study), resulting in:

$$E[n_i|x_i] = \lambda_i = e^{x_i{}'\beta}$$

Hence, the effect of the covariates (partial effects) on farmers' SAP adoption intensity can be modelled as:

$$\partial E \frac{[n_i|x_i]}{\partial x_i} = \lambda_i \beta$$

For this research, the empirical model is specified as:

$$Y = \alpha + \beta_1 D_i + \beta_2 M_i + \beta_3 R_i + \beta_4 G_i + \varepsilon_i, \qquad i = 1, 2, 3, \dots., N \qquad \text{Eq. (4a)}$$

where Y is the number of SAP adopted by a farmer, α denotes the constant term, D_i represents the farmer and farm characteristics, M_I denotes the institutional variables (including participation in PFJ support, extension, and SAP training), R_I corresponds to farmer's awareness of the risk of soil erosion, flood, and pest, and G_I denotes the geographic or regional location of the farmer. Lastly, $\beta_{1,2,3,4}$ represent the parameter estimates of the explanatory variables whereas ε_i denotes the random error associated with SAP adoption intensity which are independent of each other; ε_i is Poisson distributed about $E(Y)$ with a variance equal to $E(Y)$.

The Poisson model assumes that the distribution of the variance and mean is the same (over-dispersion) (Greene 2003). The negative binomial specification becomes appropriate if this assumption is violated. So, we test for over-dispersion before performing Poisson regression analyses since over-dispersion causes the standard deviation to exceed the mean. Both the deviance and Pearson chi-square statistics can be used to check for over-dispersion (Coxe et al. 2009). An index of dispersion is given as the total chi-square divided by the corresponding degrees of freedom. An equidispersion is represented by an index of one (1) for the ratio of mean to standard deviation. The deviance also helps to estimate a pseudo R^2, falling between 0 and 1, which increases when more covariates are added to the model (Coxe et al. 2009; Darkwah et al. 2019).

$$R^2_{deviance} = 1 - \frac{deviance\ (fitted\ model)}{deviance\ (intercept\ alone)} \qquad \text{Eq. (4b)}$$

5.4.3. *Generalized propensity score matching*

Hypothetically, farmers receiving more production support will be more productive than farmers receiving less support (this is the intention of the PFJ programme). To confirm this, random assignment of low and high production support to farmers and measuring which farmer had better performance (i.e., input use, productivity), in an on-farm trial, would have been an appropriate approach. However, estimates of production support under a research-managed farm trial can be overstated since the favourable conditions under such trials are not representative of the reality smallholders face (Snapp et al. 2014). Again, such experiments would be expensive and particularly difficult. Hence, we have to rely on the data collected from current practice. However, the observed relationship between production support and farm performance could be highly affected by selection bias. We attempt to solve this problem by balancing the treatment and control groups (farmers who received more production support and those who received lesser support) based on known farmers' and farm characteristics. The impact of the production support on input use and productivity is estimated via a dose-response function which provides estimated outcomes for every level of the production support on a balanced distribution of known covariates (Doyle 2011).

We utilise the generalized propensity score (GPS) matching approach as described by Imbens (2000) and Hirano and Imbens (2004). This technique originates in the standard counterfactual approach introduced by Rosenbaum and Rubin (1983). Assuming a random sample of units, indexed by $i = 1, \ldots, N$, there exist, for each unit of i, a set of potential outcomes $Y_i(t)$ for $t \in T$, known as the unit-level dose-response function. For binary treatment $(t \in \{0, 1\})$, the standard counterfactual using an estimated propensity score $p(t = 1)$ would have been appropriate. However, the standard propensity score matching is not applicable in this study since the objective is to estimate the causal effect of increased production support on farm performance – the sampled target population for the objective are PFJ beneficiaries only. This study therefore adopts the approach developed by Hirano and Imbens (2004) who suggested estimating the entire dose-response function of a continuous treatment. The approach suits our third objective perfectly since we are interested in estimating the response – i.e., the post-treatment input use and productivity – associated with each level of continuous dose – amount of production support received.

With the GPS, the continuous treatment (i.e., amount of support received per farmer) takes an interval $[t_0, t_1]$, where $t_0 > 0$. The goal is to estimate the average dose-response function (ADRF) $\mu = E[Y_i(t)]$. The ADRF evaluates to what extent a higher treatment level (i.e., PFJ support) results in stronger or weaker effects than a lower treatment level does (Liu & Florax 2014). A vector of covariates X_i, is observed for each unit of i, at T_i level of treatment that unit i receives, with $T_i \in [t_0, t_1]$, and the expected outcome (i.e., input use and productivity) corresponding to the level of treatment received, $Y_i = Y_i(T_i)$. For the remainder of this chapter, the subscript i will be dropped for purposes of notational simplification.

Key GPS Assumption and Property

The functionality of the GPS matching is premised on the *weak unconfoundedness* assumption and the *balancing property* according to Hirano and Imbens (2004).

(i) *Weak unconfoundedness*

The unconfoundedness assumption developed by Rosenbaum and Rubin (1983) for binary treatments were generalised by Hirano and Imbens (2004) to cases of continuous treatment, i.e.,

$$Y(t) \perp T|X, \forall\, t \in T \qquad \text{Eq. (5)}$$

Hirano and Imbens referred to this assumption as weak unconfoundedness which requires only pairwise conditional independence to hold for each value of the treatment, rather than joint independence of all potential outcomes. Thus, any treatment intensity T across units is not dependent on the potential outcomes $Y(t)$ after controlling for observable characteristics X. The random variable treatment T assumes conditional independence from the random variable outcome Y, measured at an arbitrarily chosen level t (Liu & Florax 2014).

(ii) The balancing property

With $r(t,x) = f_{T|X}\,(t|x)$ being the conditional density of the treatment given the covariates, the generalized propensity score can be defined as

$$R = r(T,X) \qquad \text{Eq. (6)}$$

Similar to binary treatment (i.e., binary propensity scores matching approach), it is important to assess how well adjustment for the GPS balances the covariates in continuous treatment (i.e., GPS matching). To fulfil the balancing property, the likelihood that $T = t$ should be independent of the value of X, within strata with the same value of GPS, $r(t,X)$, i.e., the GPS posses $X \perp = 1\{T = t\}|\, r\,(t,X)$ property. This is a mechanical implication of the definition of GPS matching according to Hirano and Imbens (2004) and does not necessitate unconfoundedness. The implication, therefore, is that assignment to treatment is unconfounded given the GPS. Once this condition is achieved, we can be confident that the GPS summarises the adequate information in the multi-dimensional vector X and is randomly assigned within that specific GPS strata.

Given these results, Hirano and Imbens (2004) and Kluve et al. (2007) shows that bias associated with differences in covariates can be removed with two steps. First, is to compute the conditional expectation of the outcome (i.e., input use and productivity) as a function of the treatment level T and the GPS R scalar variables, i.e.,

$$\beta(t, r) = E[Y|T = t, R = r] \qquad \text{Eq. (7)}$$

Second, is to estimate the dose-response function at each level of treatment by averaging the conditional expectation function over the GPS at every level of the treatment of interest.

$$\mu(t) = E[\beta(t, r(t, X))] \qquad \text{Eq. (8)}$$

The technique averages over the score evaluated at the treatment level of interest, $r(t, X)$ instead of the GPS (Kluve et al. 2007). The regression function $\beta(t, r)$ does not have a causal interpretation (Hirano & Imbens 2004). However, the $\mu(t)$ corresponds to the value of the dose-response function for treatment level t, which has a causal interpretation when compared to another treatment level, t'.

Whilst in binary propensity score matching the covariate means of the treated and control groups are compared before and after matching, testing for the covariate balance is cumbersome for continuous treatments. Hirano and Imbens (2004) suggest *blocking* on both the treatment, i.e., the PFJ support in this case, and the estimated GPS. Details of the balancing property is provided in the results chapter (i.e., sub-section 6.3.1) where we compare balances in covariates before and after adjusting for the GPS.

(iii) The common support assumption

The common support assumption holds when, for every treatment-level group, there are sampled respondents within that particular treatment-level group (e.g., group 1) and sampled respondents outside that treatment group (e.g., groups 2 and 3) with the same (or a similar) GPS. The common support assumption ensures that there is sufficient overlap in the characteristics of the sampled respondents across different treatment levels to find adequate matches (Lechner & Strittmatter 2017). This study therefore tested for common support following the procedure proposed by Kluve et al. (2007). The procedure for testing common support[4] will be described in the results chapter (refer to sub-section 6.3.1).

Estimation of average dose-response function

Following closely the Hirano and Imbens (2004) approach, we assumed a normal distribution of the conditional level of treatment (i.e., production support) as modelled below:

$$T_i|X_i \sim N(\beta_0 + \beta_1' X_i, \sigma^2) \qquad \text{Eq. (9)}$$

where (β_0, β_1) and σ^2 are the coefficients and the variance, estimated using ordinary least squares (OLS) methods[5]. The GPS can be estimated given the predicted level of treatment as $(\hat{\beta}_0 + \hat{\beta}'_1 X_i)$:

$$\hat{R}_i = \frac{1}{\sqrt{2\pi\sigma^2}} exp\left(-\frac{1}{2\sigma^2}\left(T_i - \hat{\beta}_0 - \hat{\beta}_1' X_i\right)^2\right) \qquad \text{Eq. (10)}$$

[4] Refer to Kluve et al. (2007), evaluating continuous training programmes by using the generalized propensity score, for details of the procedure.

[5] Hirano and Imbens (2004) argue that other assumptions, either than the normal distribution and other model specifications (e.g., maximum likelihood), can be used to estimate the GPS. In this situation, OLS is the best estimator since the dependent variable, while not normally distributed, is continuous, and the OLS properties are well-known, and the estimates are easy to replicate. Key in the model specification is the achievement of balanced covariates after adjusting for the GPS with the remaining being of secondary importance.

The conditional expectation of the function of Y_i, given T_i, and the GPS R_i, can be modelled in a quadratic functional form, to account for possible non-linearity in the relationship between Y_i, farm performance (i.e., input use productivity) and T_i, PFJ support. The empirical model is approximated as:

$$E[Y_i | T_i, \hat{R}_i] = \alpha_0 + \alpha_1 T_i + \alpha_2 {T_i}^2 + \alpha_3 \hat{R}_i + \alpha_4 \hat{R}_i^2 + \alpha_5 T_i \hat{R}_i \qquad \text{Eq. (11)}$$

The observed level of treatment T_i and the estimated GPS $\hat{R}_i$ are used for each unit to estimate the equation via ordinary least squares. Based on the estimated parameters in equation (11), we compute the average potential outcome at treatment level t as,

$$E[\hat{Y}(t)] = \sum_{i=1}^{N} \left(\hat{\alpha}_0 + \hat{\alpha}_1 t + \hat{\alpha}_2 t^2 + \hat{\alpha}_3 \hat{r}(t, X_i) + \hat{\alpha}_4 \hat{r}(t, X_i)^2 + \hat{\alpha}_5 t * \hat{r}(t, X_i) \right) \qquad \text{Eq. (12)}$$

The dose–response function evaluates the average impact of each level of the treatment (i.e., PFJ support) for every observed level of the GPS given the covariates. If the above assumptions hold, the impact of this is to eliminate bias from comparisons in the treatment status by balancing on the covariates. We estimate the standard errors via bootstrapping which considers the estimation of the GPS and the α parameters (Kluve et al. 2012).

The GPS matching technique as a suitable method for attaining unbiased estimates has been applied to understand the effect of different durations of job training programmes on increasing wages (Flores-lagunes et al. 2007; Kluve et al. 2012); the impact of increased academic momentum on the probability of transfer from community colleges to four-year institutions (Doyle 2011); and the economic impact of public support to private enterprises (Bia & Mattei 2007). To the best of our knowledge, there are no empirical studies on the application of this technique to understand the effect of production support on various agricultural production outcomes. Using the GPS matching technique in this study is therefore novel (relative to agricultural research) and enriches the scarce literature on the analytical method.

5.5. Definition of variables

5.5.1. Treatment variable

The treatment variable is measured alternatively as a dichotomous variable (i.e., participation in PFJ support) and as a continuous variable (amount of PFJ support) due to differences in the analytical methods used for the specific objectives. Participation in the PFJ support is measured as a dummy variable (i.e., 1 = if a farmer receives PFJ support and free pesticides and 0 = otherwise) in the Poisson regression because the data includes both beneficiaries and non-beneficiaries of the PFJ support. For the counterfactual method (i.e., GPS matching), we measure the treatment (PFJ support) as the amount of support received per beneficiary (i.e., a continuous variable), defined as the average market price of inputs (i.e., received under the PFJ programme minus their subsidised price, in Ghana Cedi (GH₵), for every sampled farmer, over the 2017 – 2018 programme period.

5.5.2. Dependent variables

The main dependent variables for the research are PFJ participation, SAP adoption intensity and farm performance. First, participation in PFJ, the dependent variable for the first objective (determinants of farmer participation in production support programmes), is measured as a dichotomous variable (i.e., 1 = participation in the PFJ programme; 0 = otherwise). The dependent variable for the second objective, SAP adoption intensity, is expressed as the number of SAPs adopted (Sap_Adopt) per farmer. Sustainable agricultural practices involve farming activities that environmentally and socially acceptable without sacrificing agricultural competitiveness and economic viability (FAO 1989; Zeweld et al. 2017). SAPs enhance soil fertility, decrease the risk of drought and water shortage, reduce erosion, preserve biodiversity, and strengthens agroecosystem (Price & Leviston 2014; Wauters & Mathijs 2014;

Yazdanpanah et al. 2014). In this study, sustainable agricultural practices refer to crop rotation, intercropping, cover cropping, zero/reduced tillage, row planting, composting, mulching, manure application. The selected practices are SAPs promoted by Ghana's ministry of food and agriculture (Nkegbe 2018; Darkwah et al. 2019) which fall within FAO's definition of sustainable agricultural practices[6], i.e. socially acceptable practices that are seek to protect soils and improve economic viability of agriculture.

Table 4 presents a list of the selected practices with the number and percentage of adopter for each practice.

Table 4: Adoption of SAP and descriptive statistics of production support

SA Practices†	Description	Adopters	Percentage of Adopters
Crop rotation	Dummy: 1 = adopter; 0 = non-adopter	366	67.78
Intercropping	Dummy: 1 = adopter; 0 = non-adopter	289	59.10
Cover cropping	Dummy: 1 = adopter; 0 = non-adopter	141	26.31
Zero tillage	Dummy: 1 = adopter; 0 = non-adopter	282	57.67
Row planting	Dummy: 1 = adopter; 0 = non-adopter	158	30.92
Mulching	Dummy: 1 = adopter; 0 = non-adopter	48	10.53
Composting	Dummy: 1 = adopter; 0 = non-adopter	75	14.56
Manure application	Dummy: 1 = adopter; 0 = non-adopter	148	28.96

Variable	Mean	Std. Dev.	Min.	Max.
Sap_Adopt (N = 502)	2.63	1.78	0	8

† Sustainable agricultural practices

Source: Author's estimation from survey data

The average number of adopted SAPs per farmer was 2.63 (with a range of 0–8), although there was a substantial level of deviation (1.78) around the mean (see Table 4). Further checks of multicollinearity show that there is no correlation between the adoptions of individual SAPs (see Table A 1, Appendix 1).

[6]http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/soil-biodiversity/agriculture-and-soil-biodiversity/sustainable-agricultunoral-practices/en/

Farm performance, the dependent variable for the third objective and counterfactual model (i.e., GPS matching), is measured by additional hybrid seed and fertiliser usage (i.e., Add_seed and Add_fertiliser – increase in commercial and subsidised inputs use after PFJ), as well as average and marginal productivities of land and labour. Specifically, average productivity (AP) is measured as the average production (i.e., yields of cereals in kg) per acre or labour unit (farmer/worker), over the first two years of implementation of the PFJ programme (2017 and 2018). To measure the additional effect of the PFJ support and to deal with the time-invariant *"fixed effects"* that can influence the outcome levels (Bia & Mattei 2007), we took the difference between average production for the first two years of PFJ's implementation (2017 and 2018) and the year before implementation (2016) for each sample respondent observed. The additional hybrid seed and fertiliser usage were treated in the same way. Importantly, only sampled beneficiaries are considered under the GPS matching technique. The sampled respondents (i.e., non-beneficiaries and beneficiaries of the PFJ programme) of the study were non-beneficiaries of Ghana's previous support programme due to its poor implementation; this is an advantage for our analysis, since it reduces the misrepresentation of the base year (2016) input use and production figures.

5.5.3. Covariates

The research used several carefully selected covariates to balance the sample across treatment levels, for the GPS matching technique (see Table 5). These variables were used as covariates for the logistic and Poisson regression models to analyse the first and second objectives. Because of the peculiarity of each objective, not all covariates were used in each model, though most of the variables run across the three models.

Table 5: Definition and measurement of covariates

Variables	Description
Risk awareness variables	
Soil erosion	Dummy: 1 = experienced before; 0 = otherwise
Pest invasion	Dummy: 1 = experienced before; 0 = otherwise
Flood	Dummy: 1 = experienced before; 0 = otherwise
Soil infertility	Dummy: 1 = experienced before; 0 = otherwise
Perceptual/social-psychological variables	
Perc_comp_erosion†	Perceived ability to control soil erosion under PFJ technologies (1–5)
Perc_comp_pest†	Perceived ability to control pest invasion under PFJ technologies (1–5)
Attitudes	Attitudes towards PFJ (1 = strongly disagree; 5 = strongly agree)
Corruption_perc†	Corruption perception – input smuggling, political influence, and elite capture (1 = strongly disagree; 5 = strongly agree)
Interaction term	Corruption perception (1 = strongly agree; 5 strongly disagree) * attitudes (= strongly disagree; 5 = strongly agree)
Institutional variables	
Extension services	Dummy: 1 = receives extension services; 0 = otherwise
SAP training	Dummy: 1 = trained on SAP; 0 = otherwise
PFJ participation	Dummy: 1 = participates in the PFJ; 0 = otherwise
Credit	Dummy: 1 = takes credit; 0 = other
Farmer association	Dummy: 1 = a member of a farmer association; 0 = otherwise
Level of information	Level of information about PFJ (1-5)
Pre-financing	Ability to afford PFJ's pre-financing arrangement (1-5)
Distance to centre	Distance from input collection centre to farm (km)
Farmer and farm characteristics	
Household size	Number (head count)
Age	Farmers age (years)
Gender	Dummy: 1 = male; 0 = female
Experience	Years of experience
Education	Farmer's years of schooling
Farm size	Acres
Livestock production	Dummy: 1 = yes; 0 = no
Use of family labour	Dummy: 1 = yes; 0 = no
Use of hired labour	Dummy: 1 = yes; 0 = no
Use of chemicals	Dummy: 1 = yes; 0 = no

Table 5. continued

Variables	Description
Irrigation	Dummy: 1 = use irrigation for cultivation; 0 = otherwise
Non-farm income	Dummy: 1 = earns other income(s) either than farm income; 0 = otherwise
Other crops	Dummy: 1 = cultivates non-cereal crop(s); 0 = otherwise
Sorghum	Dummy: 1 = cultivates sorghum; 0 = otherwise
Maize	Dummy: 1 = cultivates maize; 0 = otherwise
Rice	Dummy: 1 = cultivates rice; 0 = otherwise
No._cultivation‡	Dummy: 1 = ones per year; 0 = otherwise
CMSIFH§	Dummy: 1 = yes; 0 = no
Geographic variables	
Northern region	Dummy: 1 = yes; 0 = no
Savannah region	Dummy: 1 = yes; 0 = no
Upper East region	Dummy: 1 = yes; 0 = no
Upper West region	Dummy: 1 = yes; 0 = no
North-East region	Dummy: 1 = yes; 0 = no

† Perceived competence to control pest invasion and soil erosion; corruption perception about PFJ

‡ No._cultivation: Number of cultivation times per year

§ CMSIFH: Cultivation of cereal as the main source of income for farmer household

Source: Author’s estimation from survey data

In all, 28 covariates were used as controls in the GPS matching technique (the assessment of the programme effects) whilst 21 and 18 covariates were used in the logit (the assessment of the factors affecting PFJ participation) and Poisson regression models (the assessment of factors affecting the intensity of SAP adoption), respectively. More covariates were used in the GPS models to control for potential bias in the estimated outcome associated with differences in characteristics of selected respondents. We describe below the risks and social-psychological variables (the main variables for the first objective), followed by the structural variables (i.e., risk awareness, perceptual, institutional, farmer and fam characteristics, and geographic variables) (see Table 5 for details).

Firstly, the dichotomous treatment variable, PFJ participation, was used as a covariate to estimate the effect of the PFJ support on farmers' SAP adoption intensity. Secondly, farmers' awareness of production and environmental risks were measured as dichotomous variables. In particular, awareness of risk of soil erosion, pest invasion and flooding were measured by the questions: *'Have you been experiencing/experienced soil erosion on your cropland since 2016?'* and *'Have you experienced/experiencing fall armyworm and any other crop pest invasion on your farm since 2016?'*. Farmers' perceived competence to control soil erosion and pest infestation given the production support (PFJ) technologies, attitudes toward the production support programme, were measured with a 5-point Likert scale ranging from strongly disagree to strongly agree using specific statements. Specifically, perceived competence to control the risk of soil erosion and pest invasion were measured as: *'I am able to effectively apply fertiliser to mitigate the effect of soil erosion on my cropland and farm output'* and *'I am able to effectively apply pesticides to control the effect of pest invasion on my farm output'*. Attitude towards the PFJ programme was measured by the average of the 5-point Likert scale of these statements: '*PFJ participation help farmers to acquire better inputs at affordable price'* and *'PFJ participation help farmers to increase yield and income'*.

Corrupt actors tend to hide corruption activities due to its illegality. Therefore, regular, and direct observation of corrupt practices is nearly impossible. Citizens of developing countries therefore lack accurate information about corruption. Hence, academic research (Treisman 2000; Rose-Ackerman 2004) and international institutions (Lambsdorff 2003; Kaufmann et al. 2005) often use corruption perception (rather than corruption reality) to measure the average level of corruption in a country. Likewise, farmers are less likely to have accurate data on corruption reality. This study uses corruption perception to capture the effect of illegal rent-seeking behaviours in the PFJ programme (i.e., input smuggling, elite capture and pollical favouritism) on farmers probability to participate in the support programme. We therefore measured farmers' perception about corruption in the PFJ programme using the average of the 5-point Likert scale of the following two questions: *'PFJ's input distribution favours political affiliates of the governing party'* and *'PFJ implementation is clouded with input smuggling and elite capture'*. Similarly, 5-point Likert scale was used to measure farmers' level of information about the PFJ programme and their ability to afford the 25% of the market price (or 50% of the subsidised price) pre-financing before input collection under the programme (Table 5). According to Williams (2021), ordinal variables with Likert scale (e.g., strongly disagree, disagree, neutral, agree, strongly agree) can be used as explanatory variables in logistic regression if they are treated as interval-level measurement effects (continuous variables). Hence, we treated the 5-point Likert scale variables as continuous variables in the logistic regression model.

Socioeconomic variables such as household size, age, gender, years of education and farming experience were used to measure the effect of farmer characteristics (Table 5). Resource-poor farmers are reluctant to invest in untried inputs and technologies due to perceived high risks and limited resource availability (Langyintuo & Mungoma 2008). Therefore, farm size, use of hired labour, livestock production, access to irrigation, use of agro-chemicals, cultivation of other crops and access to non-farm income were included to capture farmers' resource capacity. Literature shows that these variables have statistically significant effects on adoption of agricultural technologies (i.e., SAP adoption intensity and PFJ participation) (Mazvimavi & Twomlow 2009; Nkegbe & Shankar 2014) as well as input use and productivity (Kausar et al. 2011; Abdul-Hanan et al. 2014; Sereda 2014; Abebe 2018). Livestock are essential farm assets for generating income and producing manure to improve soil fertility, in terms of SAPs. Moreover, large livestock such as oxen provide power for tillage activities in Northern Ghana (Abdul-Hanan 2017). Production of livestock is therefore expected to relate to SAP adoption intensity. Institutional variables such as access to credit, farmer association membership, access to extension services and formal training on SAP are shown in the literature to have statistically significant effects on adoption of agricultural technologies and farm performance (Boz & Akbay 2005; Mango et al. 2017; Abdul-Hanan et al. 2014). We also considered geographic variables, i.e. the administrative regions of the farmers, as proxies to capture soil and weather differences following Bopp et al. (2019).

5.6. Description of variables

5.6.1. The covariates

Table 6 presents the descriptive statistics of the covariates, categorising the respondents into beneficiaries and non-beneficiaries of the PFJ programme. Of the sampled farmers, 50.2% (252) were beneficiaries and 49.8% (250) non-beneficiaries of the programme after outlier elimination and data cleaning. This provides a relatively balanced sample for estimation purposes. The results show that more PFJ beneficiaries were affected by pest invasion (62% vs 50%) and soil erosion (69% vs 32%) than non-beneficiaries. Perhaps, most of the farmers joined the programme due to the subsidised fertiliser and free pesticides given to beneficiaries under the programme to mitigate the adverse effects of these risks.

Turning to the perceptual indicators, the beneficiary group had higher perceived competence to cope with the risk of soil erosion (3.45 vs 2.42) and pest invasion (3.36 vs 2.18). This indicates that most of the farmers joined the PFJ programme because they are confident of being able to effectively apply the subsidised fertiliser to mitigate loss of soil nutrient due to soil erosion and the free pesticides provided under the PFJ programme to control pest (fall armyworm) infestation.

Table 6: Summary statistics of the covariates for PFJ beneficiaries and non-beneficiaries of Northern Ghana (2017 – 2018)

	Beneficiaries		Non-beneficiaries		
Variables	Mean (n = 252)	Std. Dev.	Mean (n = 250)	Std. Dev.	Diff.†
Risk awareness variables					
Soil erosion	0.69	0.45	0.32	0.42	***
Pest invasion	0.53	0.49	0.63	0.49	**
Flood	0.23	0.43	0.22	0.42	
Soil infertility	0.95	0.20	0.92	0.26	
Perceptual variables					
Perc_comp_erosion	3.45	0.98	2.42	0.99	***
Perc_comp_pest	3.36	1.31	2.18	1.28	***
Attitudes	3.75	0.73	2.15	0.67	***
Corruption_perc	2.27	1.43	3.43	1.73	***
Institutional variables					
Extension services	0.68	0.48	0.26	0.32	***
SAP training	0.86	0.49	0.42	0.40	***
PFJ participation	0.50	0.50	–		–
Credit	0.34	0.47	0.29	0.45	*
Farmer association	0.37	0.48	0.17	0.37	***
Level of information	3.41	1.52	2.68	1.76	***
Pre-financing	3.77	1.90	3.24	1.64	
Distance to centres	8.25	9.45	10.50	12.46	***
Farmer and farm characteristics					
Household size	7.46	4.91	7.94	4.57	
Age	43.83	10.06	44.70	11.04	
Gender	0.76	0.38	0.79	0.45	
Experience	15.48	10.93	19.78	11.31	***
Education	6.42	5.54	6.25	5.91	
Farm size	5.84	5.43	3.40	4.37	***
Livestock production	0.72	0.43	0.52	0.46	***
Use of family labour	0.80	0.45	0.80	0.45	
Use of hired labour	0.47	0.50	0.34	0.41	**
Use of chemicals	0.62	0.49	0.58	0.43	

Table 6. continued

Variables	Beneficiaries Mean (n = 252)	Std. Dev.	Non-beneficiaries Mean (n = 250)	Std. Dev.	Diff.†
Irrigation	0.14	0.35	0.11	0.31	
Non-farm income	0.44	50	0.47	0.50	
Other crops	0.70	0.46	0.64	0.48	*
Sorghum	0.14	0.35	0.08	0.24	***
Maize	0.97	0.22	0.98	0.14	
Rice	0.25	0.44	0.16	0.35	***
No._cultivation	0.84	0.11	0.82	0.47	
CMSIFH	0.65	0.48	0.61	0.49	
Geographic variables					
Northern region	0.27	0.38	0.30	0.41	
Savannah region	0 .15	0.36	0 .21	0.38	
Upper East region	0.08	0.22	0.08	0.31	
Upper West region	0.36	0.44	0.37	0.50	
North-East region	0.14	0.37	0.05	0.13	***

† Difference: Welch's t-test for comparison of means; *** p < 0.01, ** p < 0.05, * p < 0.1

Source: Author's estimation from survey data

The beneficiaries also had higher levels of positive attitudes towards the support programme (3.75 vs 2.15). But non-beneficiaries had higher levels of perceived corruption (2.27 beneficiaries vs 3.43 non-beneficiaries) within the programme (Table 6). Thus, the non-beneficiaries had higher perception that PFJ's implementation is clouded with input smuggling, political favouritism, and elite capture.

In addition, the institutional variables show that more of the PFJ beneficiaries took credit from financial and non-financial institutions, participated in SAP training, and extension services and were members of farmer associations than the sampled non-beneficiaries. Moreover, the beneficiary group had high average level of information about the support programme (3.41 vs 2.68). In terms of resources, more beneficiaries used hired labour (47% vs

34%), produced livestock (72% vs 52%), cultivated other crops (70% vs 64%), produced rice and sorghum more as well as cultivated larger farm sizes (5.84 vs 3.40 acres) than the sampled non-beneficiaries. On the other hand, the sampled non-beneficiaries, on the average, had longer distances from the nearest PFJ registration and input collection points to their farms (8.25 vs 10.50 km) and were older (43.83 vs 44.70 years) than the beneficiaries, although the latter comparison is not statistically significant. There are no statistically significant differences between beneficiaries and non-beneficiaries for the remaining covariates (refer to Table 6).

Summary statistics of the covariates relative to farm size (see Table A 3, Appendix 2) indicate that the sampled small-scale farmers had larger household size and more years of farming experience. Most of the small-scale farmers also used family labour and cultivated other crops aside cereals, relative to the large-scale farmers. In addition, 11% more of the small-scale farmers (71%) cultivated cereals as their main source of income than the large-scale farmers (60%). This implies that most of the sampled small-scale farmers depended on cereal cultivation for their household income. The large-scale farmers on the other hand had higher means in the remaining covariates (refer to Table A 3, Appendix 2).

5.6.2. Descriptive statistics of SAP adopters before and after PFJ implementation

Table 7 presents the mean comparison of adopters of the selected practices before and after the implementation of the PFJ programme. The result shows that the number of adopters increased among farmers who accessed the support programme in all the selected SAPs after PFJ implementation. Whereas the number of beneficiaries practising crop rotation, intercropping and zero tillage increased by 15% (from 53% to 68%), 13% (from 53% to 66%) and 25% (from 42% to 67%) before (i.e., 2016) and after the PFJ programme's implementation (i.e., 2017 and 2018), the number of non-beneficiaries practising these SAPs only increased by 2% (from 62% to 68%), 5% (from 43% to 45%) and 1% (from 41% to 42%), respectively.

Table 7: Adoption of selected SAPs by PFJ beneficiaries and non-beneficiaries

	Adopters before support (2016)					Adopters after support (2018)				
SAPs†	Benefit.‡ (n =252)		Non-benefi‡ (n = 250)		Diff§	Benefit.‡ (n =252)		Non-benefit.‡ (n = 250)		Diff§
	Mean	SD⁂	Mean	SD		Mean	SD	Mean	SD	
Crop rotation	0.53	0.50	0.62	0.49	**	0.68	0.48	0.68	0.45	
Intercropping	0.53	0.50	0.43	0.50	***	0.66	0.49	0.48	0.50	***
Cover cropping	0.25	0.43	0.26	0.44		0.27	0.45	0.26	0.45	
Zero tillage	0.42	0.49	0.41	0.49		0.67	0.47	0.42	0.44	***
Row planting	0.16	0.37	0.16	0.37		0.40	0.48	0.16	0.35	***
Mulching	0.06	0.24	0.06	0.24		0.12	0.32	0.08	0.29	
Composting	0.06	0.23	0.05	0.23		0.20	0.39	0.06	0.29	***
Manure application	0.15	0.36	0.19	0.39		0.32	0.48	0.24	0.43	**
Sap_Adopt¶	2.16	1.62	2.18	1.64		3.08	1.81	2.06	1.55	***

† SAPs measured as dummy variables: 1 = adopters; 0 = non-adopters

‡ Beneficiaries and non-beneficiaries of the PFJ programme

§ Difference: Welch's t-test for comparison of means; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

⁂ Standard deviation

¶ Dependent variable: Average number of SAPs adopted per farmer

Source: Author's estimation from survey data

The PFJ programme gives special attention to the promotion of row planting over broadcasting among cereal farmers. It is therefore not surprising that the rate of beneficiary adoption of row planting doubled (from 16% to 40%) relative to the non-beneficiaries which remained constant (16%) over the programme period.

On average, SAP adoption among beneficiaries of the programme increased by 43% (2.16 to 3.08) whereas SAP adoption among non-beneficiaries marginally reduced by 6% over the programme period (Table 7). The average number of adopted SAPs among the entire sample is 2.63, in a range from 0 to 8 (refer to Table 4). Though the average adoption rate is slightly below the 4.30 found in Techiman, a middle zone area, by Darkwah et al. (2019), it is more than the 1.81 found in Northern Ghana before the intervention (Nkegbe & Shankar 2014).

5.6.3. Performance indicators in relation to farm size and level of support.

Table 8 presents summary statistics of the performance indicators (i.e., input use and productivity) and the treatment variable for the sampled beneficiaries (of the PFJ programme).

Table 8: Descriptive statistics of farm performance indicators and treatment variable for beneficiaries

	Total Sample (n = 252)		**Small-Scale Farmers (n = 115)**		**Large-Scale Farmers (n = 137)**	
Variables	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Add_seed (kg/acre)	2.03	3.44	1.83	2.08	2.22	3.98
Add_fertiliser (kg/acre)	24.31	33.72	27.24	36.31	21.38	31.88
AP land (kg/acre)	682.65	398.21	725.23	475.43	647.22	317.63
AP labour (kg/worker)	373.65	342.27	250.47	227.44	476.76	386.26
MP land (kg/acre)	220.23	340.99	198.83	366.97	238.04	318.03
MP labour (kg/worker)	122.63	248.76	65.84	161.50	170.16	295.41
Treatment variable						
PFJ support (GH₵)†	551.59	587.90	671.67	719.68	437.53	417.22

† PFJ support in Ghana Cedi (GH₵): USD 1.00 = GH₵ 4.90 – December 31, 2018 exchange rate

Source: Author’s estimation from survey data

The results in Table 8 show that the PFJ programme increased the input use and productivities of both small-scale and large-scale farmers, though the increase in fertiliser use were slightly higher for the small-scale farmers. On average, the small-scale farmers used 1.83 kg/acre and 27.24 kg/acre additional hybrid seeds and fertiliser whilst the large-scale farmers used 2.22 kg/acre and 21.38 kg/acre more hybrid seeds and fertiliser, respectively, over the programme period (2017 and 2018). The results imply that the small-scale farmers used more local seeds per acre than the large-scale farmers although the PFJ programme provides small-scale farmers the opportunity to use varieties of hybrid seeds to cover their entire farm size since most of them cultivates less than 2 ha. Perhaps, the small-scale farmers prefer to access more fertilisers compared to hybrid seeds due to resource constraints caused by the 25% pre-financing under PFJ.

Furthermore, addition to productivity, i.e., the marginal productivity (MP)[7] of land, increased more for the large-scale farmers (198.83 kg/acre) than small-scale farmers (65.84 kg/acre). However, the small-scale farmers recorded higher average productivity (AP)[8] of land (725.23 kg/acre) relative to the large-scale farmers (647.22 kg/acre). The small-scale farmers, on average, received more of the PFJ support (GH₵ 671.67) than the large-scale farmers (GH₵ 437.53) – on average, the large-scale farmers received GH₵ 234.14 (US$ 47.78) less support, although they cultivated averagely 3.50 acres (see Table A 3, Appendix 2) more than the small-scale farmers. The average PFJ support received per farmer was GH₵ 551.59 (US$ 112.57), with a range of GH₵ 100 to GH₵ 4,085.

Table 9 presents descriptive statistics of the dependent variables at various levels of support received. The results show that the additionality effect of the support programme on input usage and productivity are not linear. Add_seed, Add_fertiliser as well as marginal productivity (MP) of land and MP of labour first fall and then increase as the level of the PFJ support increases.

[7] Marginal productivity was measured as the difference between average production for the first two years of PFJ's implementation (i.e., 2017 and 2018) and production for the year before PFJ implementation (i.e., 2016) for each sample respondent observed.

[8] Average productivity (AP) was measured as the average production (i.e., yields of cereals in kg) of the programme period (i.e., 2017 and 2018) per acre or labour unit (farmer/worker).

Table 9: Summary statistics of the farm performance indicators given the PFJ support

	Treat.† 1 (PS‡: ≤ 250)		Treat. 2 (PS: 250–500)		Treat. 3 (PS: 500+)	
Variables	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Add_seed (kg/acre)	1.90	1.74	1.40	5.21	2.84	2.07
Add_fertiliser (kg/acre)	19.29	29.69	13.05	34.64	14.68	36.19
AP land (kg/acre)	686.27	358.20	702.18	426.99	661.33	406.19
AP labour (kg/worker)	400.46	305.49	381.92	414.47	343.48	297.55
MP land (kg/acre)	282.00	356.93	183.56	313.06	201.61	348.56
MP labour (kg/worker)	187.48	312.78	91.31	206.49	96.40	212.82

†Treatment interval of the level of the PFJ support received by a farmer

‡ PFJ support in Ghana Cedi (GH₵)

Source: Author's estimation from survey data

For instance, farmers who received not more than GH₵ 250 PFJ support had 35% (i.e., 282 – 183.56 kg/acre) and 51% (i.e., 187.48 – 91.31 kg/worker) higher land and labour productivity than those who received GH₵ 250 – 500 whereas farmers who received above GH₵ 500 of the support had 14% (i.e., 183.06 – 201.61 kg/acre) and 6% (i.e., 91.31 – 96.40 kg/worker) lesser land and labour productivities than those who received GH₵ 250 – 500. The average productivity (AP) of land increases and falls as the level of the PFJ support increases whereas AP of labour falls directly as the level of the support increases (refer to Table 9).

The results imply that the production support increased input use by relaxing the budgetary constraints of farmers, thereby increasing their input-oriented efficiency and productivity. In addition, the rise and fall of land and labour productivity as the level of the PFJ support increases indicate somewhat heterogeneity in the PFJ support effect on farm performance (i.e., input use and productivity). Therefore, we estimate the heterogeneity of the effect of the PFJ support on farm performance empirically in sub-sections 6.3 and 6.4 using the GPS matching method.

6. Results

The results will be presented in order of the specific objectives, i.e., determinants of farmers' decisions to participate in the production support programme, effect of the PFJ support on sustainable agricultural practice adoption intensity, and the impact of the PFJ support on farm performance.

6.1. Determinants of farmers' participation in the PFJ support programme

Table 10 presents estimates of the effect of selected drivers on farmers' decision to participate in the production support programme. We checked for potential multicollinearity before the analyses. The results show that there is no correlation between the independent variables (refer to Table A 2, Appendix 2). Generally, the model is statistically significant at the 1% level with 89% (Pseudo $R^2 = 0.89$) of variation in PFJ participation dependent on changes in the covariates.13 out of the 17 variables were statistically significant at 0.01, 0.05 and 0.1 significance level.

The results show that the likelihood of farmers to participate in the PFJ programme increases by 7 and 6 percentage points (refer to Table 10) if they experience soil erosion and pest invasion, respectively, on their farm. To remind the reader, the PFJ programme offers free pesticides to beneficiaries to fight fall armyworm (i.e., crop pest) since its upsurge in 2018. The subsidised fertiliser supplied under the programme helps farmers to mitigate soil fertility loss caused by soil erosion. Moreover, the SAP training integrated in the PFJ programme helps farmers to adopt SAPs such as cover cropping and zero tillage to reduce erosion on their cropland. The results confirm our hypothesis that farmers will participate in a production support programme which provides instruments for improving soil nutrients and preventing pests if they are aware of the production and environmental risks of their farmland (H1a).

Table 10: Estimated effect of selected drivers on farmer participation in the PFJ programme

Variables	Coef.	Std. Err.	P>z †	Average Marginal Effect	Std. Err.	P>z †
Soil erosion	3.35	0.89	***	0.07	0.01	***
Pest invasion	2.99	0.90	***	0.06	0.02	***
Perc_comp_erosion‡	2.28	0.65	***	0.05	0.01	***
Perc_comp_pest‡	2.31	0.97	**	0.05	0.02	**
Attitudes	5.15	1.05	***	0.11	0.01	***
Corruption_perc‡	-9.07	2.53	***	-0.19	0.04	***
Interactive term§	5.97	1.82	***	0.12	0.03	***
Level of information	0.58	0.23	**	0.01	0.00	**
Pre-financing	1.26	0.74	*	0.03	0.01	*
Distance to centres	-0.91	0.30	***	-0.02	0.01	***
Credit	1.69	1.23		0.04	0.03	
Irrigation	1.24	0.84		0.03	0.02	
Extension services	4.34	1.26	***	0.09	0.02	***
Farmer association	0.57	0.82		0.01	0.02	
Age	-0.35	0.39		-0.01	0.01	
Gender	-2.07	0.87	***	-0.04	0.02	***
Education	-1.11	0.44	***	-0.02	0.01	***
_cons	-12.82	4.30	*			
Number of Obs.	469					
Prob > Chi^2	0.00					
Pseudo R^2	0.89					
Log-likelihood	-32.23					

† Statistical level of significance: *** p < 0.01, ** p < 0.05, * p < 0.1

‡ Perceived competence to control soil erosion pest invasion; corruption perception about PFJ

§ Attitudes*Corruption perception about PFJ

Source: Authors' estimation from survey data

Our results also show that farmers with high level of perceived competence to control soil erosion and pest invasion with the PFJ technologies were more likely to participate in the

PFJ programme. From Table 10, a point increase in perceived competence to control soil erosion and pest invasion given PFJ technologies (1 – 5), increase farmers' probability to participate by 5 percentage points each. The results imply that farmers awareness of environmental and production risks should be complemented by feeling confident of applying fertilisers and pesticides to mitigate the effect of soil erosion and pest invasion. The findings also confirm our hypothesis (H1b).

It has been argued that a more effective evaluation of behaviour such as attitude comes to play after appraisal of threat and perceived behavioural control (Prokopy et al. 2008). The results show a high relationship between the social-psychological variables and farmers' participation about the PFJ programme. Among these, attitude, represented by expected productivity and benefits, have the second highest positive marginal effect (0.11) on farmer participation. This suggests that an additional point in attitude (higher level of agreement that PFJ participation helps farmers to acquire more inputs at affordable price and to enhance productivity; scale 1 – 5) increases farmers' probability to participate in the PFJ programme by 11 percentage points (H1c).

Farmers' corruption perception about the PFJ programme has the highest negative marginal effect (-0.19) on their participation decisions. Thus, a one-point increase in corruption perception (i.e., high level of agreement that the PFJ programme is implemented based on political affiliation, clouded with input smuggling and elite capture), reduces farmers' likelihood to participate in the programme by 19 percentage points. This confirms our assumption that high level of corruption perception about a production support programme negatively affect farmers' decision to participate in the programme (H1d). As such, the corruption perception status of the PFJ programme is a crucial driver of current and future participation.

Turning to the interplay between attitude and corruption, the interaction term of the model (i.e., attitudes*corruption perception)[9] has a positive statistically significant marginal effect. Regarding the nature of the interaction, the positive sign implies that attitude toward the PFJ programme and corruption perception have a joint effect on PFJ participation. This implies that higher level of positive farmer attitude towards the PFJ and low level of corruption perception about the programme increase at higher value (i.e., at 12 percentage points) farmers probability to participate in the PFJ programme and vice versa. This confirms our study hypothesis (H1e) that low corruption perceptions about the PFJ programme, (i.e., lower level of agreement by farmers that the PFJ programme is implemented based on political favouritism, clouded with input smuggling and elite capture) increase farmers' positive attitudes toward the programme (i.e., higher level of farmers perceived enhance input use; increase yield and income under the programme), which tend to increase the probability of their participation in the PFJ programme.

Table 10 further shows that factors such as farmers' level of information, perceived capacity to afford PFJ's 25% prefinancing condition and distance from farms to registration and input collection points had statistically significant effects on farmers participation in the PFJ programme, though their marginal effects are lower compared to the perception/social-psychological factors. For instance, a one-point increase in farmers' level of information about the PFJ programme increases their likelihood of participation by only 1 percentage point. Similarly, a one-point increase in farmers' perceived ability to afford the 25% prefinancing arrangement under the PFJ programme (i.e., the percentage of the market price of the input payable by farmers before collection), increases their willingness to participate by 3 percentage

[9] **Note:** For the interaction term, corruption perception was measured on a 5-point Likert scale, i.e., 1 = high corruption perception and 5 = low corruption perception whereas attitude was measured as 1 = low positive attitude; 5 = high positive attitude towards the PFJ programme.

points. The result implies that resource-rich smallholder farmers are more likely to participate in the PFJ programme compared to resource-poor smallholders. On the contrary, distance from cropland to PFJ registration and input collection centres has a negative and statistically significant association with farmers' probability to participate, with a low (-0.02) marginal effect. Thus, the closer the registration and input collection centre, the more likely that farmers will participate in the PFJ programme.

The results show that only access to extension services has a positive significant impact on PFJ participation out of the four institutional variables; it increases farmers' likelihood to participate in the PFJ programme by 9 percentage points. Since the extension agents provide information about the PFJ programme, help with the registration and the distribution of subsidised input vouchers, the result is not surprising. The use of irrigation, taking credit and farmer association membership are not statistically significant drivers of PFJ participation (Table 10).

Furthermore, all the socio-economic variables, except age of the farmer, have statistically significant effect on farmers' probability to participate in the support programme. Gender has a significant negative effect on farmer participation in the support programme. Female farmers were 4 percentage points more likely to participate in the PFJ programme than their male counterparts. The result is important since the PFJ programme aims at least 40% female participation (Pauw 2021). Similarly, farmers' years of education had a negative statistically significant impact on PFJ participation, with a -0.02 marginal effect on farmers probability to participate in the programme. Although not anticipated a-priori, the finding implies that highly educated farmers are less likely to participate in the support programme, *ceteris paribus*.

In summary, the results clearly suggest that risk awareness and the social-psychological or perceptual factors are significant drivers of farmers' participation decisions in the agricultural production support programme relative to the socioeconomic and institutional variables. The results further show that positive attitude toward the programme drive participation, but attitude should be complemented by low corruption perception about the programme to increase PFJ participation.

6.2. Factors influencing farmers' SAP adoption intensity

Table 11 presents the Poisson regression estimates of the factors that influence farmers' SAP adoption intensity. The dependent variable (i.e., SAP adoption intensity) is the number of sustainable agricultural practices (SAPs) adopted per farmer.

According to Cameron and Trivedi (1990), the potential over-dispersion (e.g., high unpredictability around the mean) of count-dependent variable needs to be tested before choosing the best specification within data count model. We, therefore, checked for possible over-dispersion and a high rate of zeroes in the dependent variable observing the Pearson Chi^2 and the deviance goodness-of-fit. The value of the Pearson goodness-of-fit statistic is 147.81 with Prob > $Chi^2(404)$ = 1.00, while the value of the deviance goodness-of-fit is 168.62 with Prob > $Chi^2(404)$ = 1.00 (see Table 11). The Pearson and deviance goodness-of-fit statistics show that the dependent variable is neither over-dispersed nor has excess zeroes because an index of equidispersion is represented by one (1) (refer to Eq. 4b, p.59). Hence, we opted for a standard, rather than a zero-inflated, Poisson regression model. From Table 11, the estimated Pseudo R-squared value is 22% whereas the Wald Chi^2 value is 353.49. The p-value of 0.00 shows that the overall Poisson regression model used to analyse the drivers of SAP adoption intensity was statistically significant at 1% level.

Table 11: Poisson regression estimates of farmers' SAP adoption intensity.

Variables	Coef.	Std. Err.	P>z†	Av. Marg. Eff. ‡	Std. Err.	P>z†
Farmer and farm characteristics						
Experience	0.01	0.00	*	0.01	0.01	*
Education	0.01	0.01	**	0.03	0.02	**
Gender	-0.13	0.07	**	-0.36	0.18	**
Farm size	0.01	0.01	**	0.03	0.02	**
Use of hired labour	0.13	0.07	*	0.34	0.19	*
Livestock production	0.29	0.08	***	0.77	0.23	***
Geographic variables						
Northern region	0.18	0.15		0.49	0.40	
Savannah region	0.31	0.15	**	0.81	0.40	**
Upper East	0.34	0.18	*	1.74	0.38	**
Upper West	0.65	0.14	***	0.91	0.48	***
Risk awareness variables						
Pests invasion	-0.17	0.07	***	-0.45	0.18	***
Flood	0.12	0.08	*	0.32	0.20	*
Soil erosion	0.19	0.07	***	0.51	0.19	***
Institutional variables						
Extension services	0.14	0.08	*	0.37	0.22	*
SAP training	0.35	0.14	***	0.92	0.36	***
PFJ support§	0.19	0.09	***	0.50	0.24	***
Credit	0.23	0.07	***	0.62	0.19	***
Farmer association	0.03	0.07		0.09	0.19	
_cons	-0.57	0.19	***	–	–	
Number of Obs.	423					
Wald Chi^2 (17)	353.49					
Prob > Chi^2	0.00					
Pseudo R^2	0.22					
Log-likelihood	-632.96					

Deviance goodness-of-fit = 168.62; Prob > $Chi^2(404)$ = 1.00

Pearson goodness-of-fit = 147.81; Prob > $Chi^2(404)$ = 1.00

† *** p < 0.01, ** p < 0.05, * p < 0.1

‡ Average marginal effect

§ Treatment variable measured as a dummy (1 = participation in the PFJ support; 0 = otherwise)

Source: Author's estimation from survey data

The results in Table 11 show that farmers' awareness of the risk of flood, soil erosion, and pests invasion have statistically significant effects on farmers' SAP adoption intensity. Awareness of soil erosion and flood have positive significant influences on SAP adoption intensity (0.51 and 0.32 more SAPs, respectively). These findings imply that, farmers will adopt sustainable practices to prevent further damages to their cropland if they are aware of the existence of environmental and production risks on their farms; this result confirms our study hypothesis (H2a). In contrast, awareness of pest invasion has a negative impact on SAP adoption intensity. The result suggest that smallholders will spend their limited resources in fighting pest invasion due to its immediate impact on their productivity. This result is therefore not surprising since our data was collected during the peak of the fall armyworm (i.e., pest for cereals) infestation in Ghana (i.e., from 2017 to 2019).

Farmers' knowledge on SAP (approximated by the use of extension and training on SAPs) has a statistically significant effect on SAP adoption intensity. Participation in extension services and SAP training increase the number of SAPs adopted by 0.37 and 0.92 additional practices, respectively (Table 11). Thus hypothesis (H2b) is confirmed. In addition, participation in the PFJ support (subsidised inputs) has a positive significant effect on the number of SAPs adopted by a farmer (H2c). Thus, farmers receiving the support adopted 0.50 more SAPs than their non-beneficiary counterparts. As anticipated, the provision of public support, complemented with extension services and SAP training, such as the PFJ programme, can motivate farmers to adopt sustainable practices. This finding requires attention hence we will further test the results with the GPS matching in sub-section 6.3.4 before discussing it in chapter 7.

The results indicate that all the geographical dummies, except farming in northern region, have positive statistically significant effect on farmers' SAP adoption intensity. From

Table 11, farming in the Upper West, Upper East and Savannah regions is related to 1.74, 0.91 and 0.81, respectively, more SAPs adopted compared to the North-East region. This implies that the geographic location of farmers was the biggest driver (in terms of marginal effect) of farmers SAPs adoption intensity compared to receiving PFJ support and farmer knowledge on SAPs (i.e., provision of extension services and SAP training to farmers). The results imply some farmers located in the two upper regions might adopt more SAPs regardless of the PFJ support and their knowledge on SAPs. Further attention will be given to this result in the discussion section.

Table 11 further shows that all the farmer and farm characteristics are statistically significant at 5% level, except farming experience and use of hired labour that are significant at 10% level. An additional year of schooling and farming experience increase farmers' SAP adoption intensity slightly by 0.03 and 0.01, respectively, more practices. This suggest that educated and experience farmers appreciates better the benefits of SAPs and are more likely to adopt more sustainable practices to prevent soil degradation and increase their productivity. The negative interaction between SAP adoption intensity and gender indicates that female farmers adopted 0.36 more SAPs than their male counterparts. Farm size and use of hired labour have positive statistically significant effects on the number of SAPs adopted by a farmer in our sample. The result shows that an acre increase in farm size increases SAP adoption by 0.03 practices whereas the use of hired labour increases SAP adoption by 0.34. Likewise, livestock production increases farmers' number of adopted SAPs by 0.77 compared to farmers without livestock. The results further share light on the impact of farmers wealth (i.e., farm size, use of hired labour and livestock production) on their adoption of agricultural technologies.

6.3. Generalized Propensity Score (GPS) Matching

This section introduces the balancing property and the common support condition of the GPS matching technique which was used to estimate the impact of increasing levels of the production support on farmers' SAP adoption intensity (H2d) and farm performance (i.e., input use and productivity) (H3a-b). Likewise, the GPS approach was used to test if the effects of the PFJ support on farm performance is heterogenous in relation to farm size (H4). The GPS approach considers continuous treatment variables, and hence, the following estimations were done with only the 252 sampled beneficiaries of the PFJ programme.

6.3.1. Testing the balancing property[10] of the generalized propensity score

First, we estimated the conditional distribution of the PFJ support given the covariates using ordinary least squares (see Eq. 5, p. 61). The result of this estimation provides the generalized propensity scores (GPS). With the GPS estimated, we test whether GPS is capable of making treatment levels independent of the covariates. To investigate this, we first divided the treatment, the PFJ support, into 3 different levels (≤ GH₵ 250; GH₵ 250 – GH₵ 500 and GH₵ 500+). We then compared the means of every covariate for each level of support received. For instance, the mean household size of farmers receiving not more than GH₵ 250 of the support was compared to the mean for farmers receiving above GH₵ 250 (Table 12a). As the t-statistic of 2.91 indicates, farmers receiving more than GHS 250 of the PFJ support had larger households than those receiving not more than GH₵ 250. The process was repeated for all covariates for the three levels of the PFJ support.

[10] For details of the balancing property, refer to Doyle WR. 2011. Effect of increased academic momentum on transfer rates: An application of the generalized propensity score. *Economics of Education Review* 30: 191–200. https://doi.org/10.1016/j.econedurev.2010.08.004.

Table 12: a–b. (From left to right): Balance in sample of the covariates across treatment levels before and after GPS application: t-statistics for equality of means.

	Total Sample (n = 252)					
	Balances in Sample Before GPS (**a**)			Balances in Sample Given GPS (**b**)		
Covariates	IS: ≤250	IS: 250–500	IS: 500+	IS: ≤ 250	IS: 250–500	IS: 500+
Household size	**2.91**	1.40	**-3.29**	0.72	0.64	-1.17
Age	-0.46	-0.11	0.70	-0.53	0.25	0.86
Gender	1.32	-1.58	-0.18	1.43	-1.42	0.25
Experience	**-2.68**	1.67	1.76	0.17	-0.31	0.47
Education	1.30	1.09	**-2.52**	-0.07	1.36	-1.28
Farm size	1.48	-0.15	-1.15	0.16	0.54	-1.00
Livestock production	-1.10	1.46	-0.07	1.02	-0.27	-0.63
Use of family labour	0.52	0.03	-0.69	0.49	-0.12	-0.46
Use of hired labour	**2.60**	-1.62	-1.61	0.47	0.24	-0.50
Non-farm income	-0.66	0.64	0.20	-0.33	0.00	0.19
Other crops	0.71	-1.22	0.27	0.44	-1.31	0.87
Credit	1.59	-1.02	-0.95	0.68	0.29	-0.86
Soil infertility	0.59	-0.56	-0.22	-0.28	0.86	-0.76
Flood	-0.09	-0.31	0.42	-0.37	0.43	0.07
Soil erosion	-0.83	0.04	1.00	1.09	-0.18	-0.68
Pest invasion	**-2.16**	1.84	0.87	-0.54	0.82	-0.65
SAP training†	-0.08	-0.23	0.31	0.73	0.09	-0.34
Use of chemicals	1.62	-0.69	-1.36	0.88	-0.12	-0.16
Irrigation	0.64	-0.04	-0.72	-0.27	1.21	-0.96
No._cultivation‡	0.50	-0.80	0.12	-0.15	-0.24	0.30
Northern region	0.85	-0.02	-1.01	1.25	-0.46	-1.03
Upper West region	-0.35	-0.58	1.03	0.11	-0.47	0.07
Savannah region	-1.10	1.02	0.41	0.36	-0.04	0.08
Upper East region	0.02	-0.13	0.11	-0.78	-0.15	1.04
Sorghum	1.90	-0.96	-1.31	-0.43	-0.13	0.07
Maize	-1.51	0.66	1.08	-1.23	0.19	0.60
Farmer association	**4.25**	-1.38	**-3.70**	-0.13	0.53	-0.63
CMSIFH§	0.94	0.21	-1.41	-0.43	0.73	-0.56

† SAP training = Measured as a dummy (1 = trained on SAPs; 0 = not trained on SAPs)

‡ No._cultivation = Number of cultivation times per year

§ CMSIFH = Cereal as the main source of income for farmer household

The decision rule at 0.05 alpha level: Reject H0 if the $t < -1.960$ or $t > 1.960$

Source: Author's estimation from survey data

As shown by Table 12a, there are large differences in the treatment levels concerning the covariates as shown by the t-statistics. For the 28x3 = 84 possible differences, 8 have t-statistics with absolute values more than 1.96, four (4) have absolute values more than 1.64, and 3 have absolute values a little above 1.60 – there is strong evidence against the balancing property if the t-statistic is below -1.96 or above 1.96 at 0.05 probability level.

Next, we test whether the propensity score balanced the sample as detailed in Eq. (7), page 62. To investigate this, we divided the treatment variable into 3 support levels (≤ GH₵ 250; GH₵ 250 – GH₵ 500 and GH₵ 500+) following the steps in our previous paragraph. Then we estimated the GPS at the median of the PFJ support (i.e., treatment) for values of the covariates within each support level. Subsequently, we divided each support level (e.g., ≤ GH₵ 250) into five blocks of quintiles of the GPS estimated at the median. We then compared, within each quintile block of this GPS range, the mean values of the covariates for those within the estimated GPS range and those outside the range of the GPS, across each PFJ support (treatment) level. A weighted average, estimated from the mean differences in the values of the covariates in each of the five GPS blocks across the PFJ support (treatment) levels, was used to calculate the t-statistic of differences in mean between a particular support level and all other support levels with same GPS. Presented in Table 12b are the results for the t-test for the differences in means produced from this process. Table 12b shows the differences in the support levels after adjusting for the GPS. Limited differences exist among the PFJ support levels regarding the covariates after GPS adjustment. Based on the results, none of the covariates had t-statistics with absolute values exceeding 1.64. According to the test, there is *very slight* *evidence against the balancing property*[11]. The estimated GPS, therefore, satisfied the balancing property at 0.1 level.

The procedure was repeated for the subsamples of small-scale and large-scale farmers. The balancing property of the small-scale and large-scale subsamples were fulfilled at 0.05 level with *moderate evidence against the balancing property*. None of the covariates recorded absolute t-statistic values above 1.96 for both small-scale and large-scale farmers subsamples after adjusting for the GPS (see Table A 4, Appendix 3).

6.3.2. Testing the common support assumption of the GPS

In addition, we tested the common support condition following the procedure proposed by Kluve et al. (2007). As discussed in sub-section 5.4.3, we first divided the sample into three treatment (i.e., the PFJ support) groups, the same groups as the PFJ support levels for testing the balancing property (i.e., group 1 = ≤ GH₵ 250, group 2 = GH₵ 250 – GH₵ 500 and group 3 = GH₵ 500+). We then evaluated the GPS of the entire sample at the median PFJ support level of the first group. The distribution of the calculated GPS of group 1 and the distribution of the sample outside group 1 (groups 2 and 3) are plotted on the same figure (see Fig. 6). The method was repeated for groups 2 and 3 to give the second and third panels of Figure 6. We repeated this procedure for the small-scale and large-scale farmer subsamples. Similar to the binary propensity score matching, the common support condition of GPS matching is observed by the overlap of the two distributions in each group. The results indicate that the common

[11] Decision rule: There is *slight evidence against the balancing property* if none of the covariates record absolute t-statistics values above 1.64 at 0.1 level, *moderate evidence against the balancing property* $\{t > \pm 1.64\ t \leq \pm 1.96\}$ at 0.05 level, *strong evidence against the balancing property* $\{t > \pm 1.96\ t \leq \pm 2.96\}$ at 0.01 level and *decisive evidence against the balancing property* $\{t > \pm 2.96\}$ at 0.01 level. The balancing property is not satisfied if there is a strong or decisive evidence against the balancing property.

support condition is largely fulfilled. These observations are similar to the results for the small-scale and large-scale farmers subsamples (see Fig. A 2, Appendix 4).

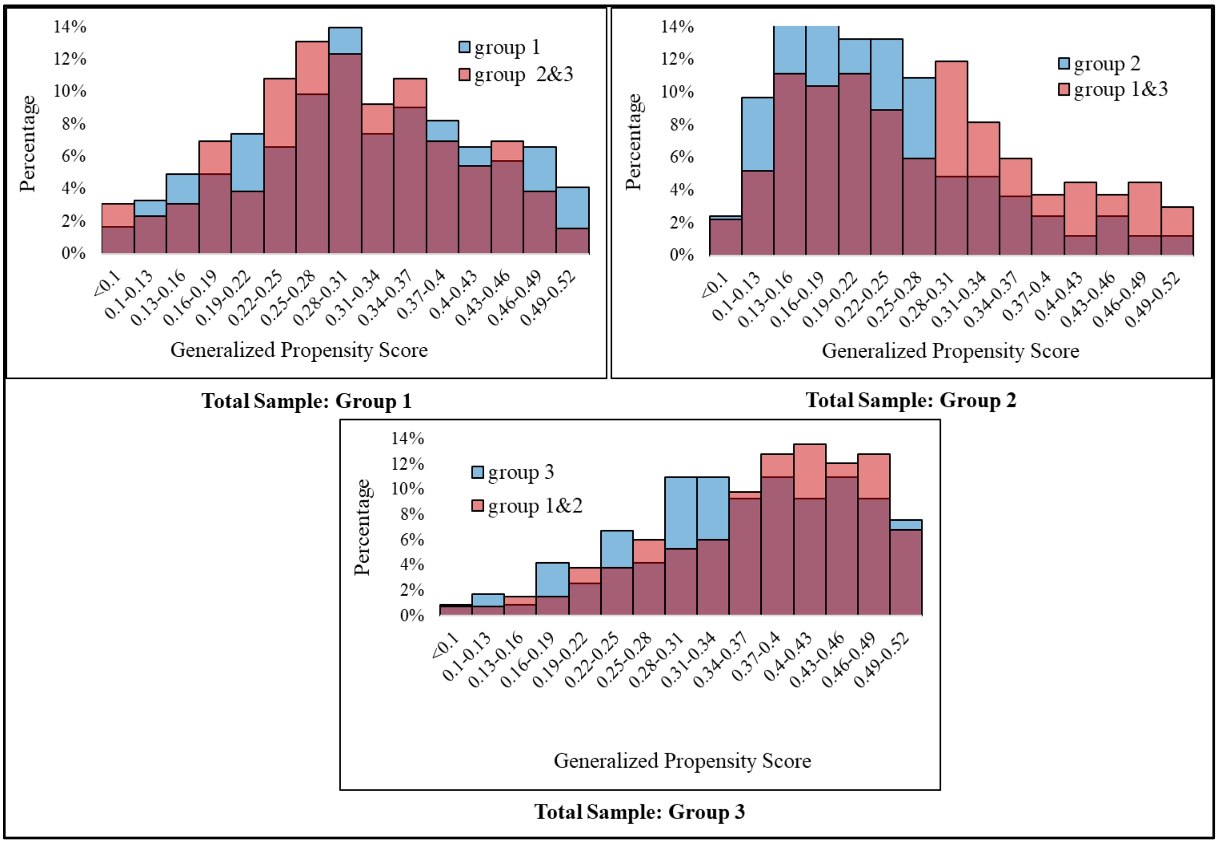

Fig. 6: Common support condition of GPS matching, total sample (n = 252)

Source: Author's estimation from survey data

6.3.3. Estimated dose-response functions

Finally, we regressed the conditional distribution of the PFJ support (treatment) given the covariates against the dependent variables, SAP adoption, input use (i.e., hybrid seed and fertiliser) and productivity (average and marginal) (see Eq. 11, p. 64). The results are presented in Table 13.

According to Hirano and Imbens (2004), these regression estimates do not have direct interpretations but are used to estimate the dose-response function. The dose-response function is estimated for each level of the PFJ support as defined in Eq. (12), page 64. It indicates the estimated impact of a given level of the support received on the likelihood of treatment, conditional on the GPS, averaged over each unit in the sample or subsample (i.e., small-scale, and large-scale). The predicted levels of SAP adoption intensity and farm performance at each level of the PFJ support, given the covariates, are shown in Figure 7 to 17. The solid/blue line represents the estimated dose-response functions whereas the red/top and green/bottom dashes represent the lower and upper bounds at 90% (for SAP adoption) and 95% (for farm performance) confidence intervals bootstrapped with 100 replications. The estimated dose-response function therefore answers what would have happened to, for example, the productivity of a farmer receiving say GH₵ 1,000 (US$ 204) of support had that farmer received GH₵ 2,000 (US$ 408), and vice versa. This is where the GPS and the dose-response functions are superior to the binary propensity score matching, which would have only shown the effect of the PFJ support on farmers productivity regardless of the level of treatment.

Table 13: Parameter estimates of the conditional distribution of SAP adoption and farm performance given the PFJ support and GPS

	SAP_Adopt (a)	**Add_Seed (b)**	**Add_Fertiliser (c)**	**Land AP† (d)**	**Labour AP (e)**	**Land MP‡ (f)**	**Labour MP (g)**
Variables	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
PFJ support	-1.2E-03	0.02***	0.01**	0.25	0.99	0.66*	0.55*
	(9.3E-04)	(0.01)	(0.01)	(1.00)	(0.76)	(0.44)	(0.39)
PFJ support^2	4.4E-07*	-3.9E-06***	1.5E-06	0.00	0.00	0.00**	0.00**
	(2.3E-07)	(1.7E-06)	(1.6E-06)	(0.00)	(0.00)	(0.00)	(0.00)
G.P. score§	2.33	-0.47	-31.11	2268.17	1596.12	799.48	661.74
	(4.60)	(34.36)	(35.16)	(1887.81)	(1427.86)	(836.08)	(756.02)
G.P. score^2	-6.64	1.14	22.38	-5753.85*	-3633.46	-1657.00	-1408.66
	(7.67)	(56.24)	(57.67)	(3627.43)	(2750.15)	(1591.97)	(1443.02)
PFJ support x G.P. score	2.3E-03	-0.02	0.00	-0.63	1.44	0.13	0.90
	(1.9E-03)	(0.01)	(0.01)	(2.05)	(1.54)	(0.89)	(0.80)
_cons	2.75***	-1.76	9.84**	1087.68***	246.89*	57.29	-16.85
	(0.61)	(4.66)	(4.77)	(213.55)	(160.73)	(96.13)	(86.52)
Number of Obs.	202	203	198	232	230	223	221
Prob. > F	0.06	0.00	0.00	0.18	0.00	0.03	0.00
R-squared	0.05	0.16	0.52	0.03	0.19	0.05	0.10
Adj. R-squared	0.03	0.14	0.51	0.01	0.17	0.03	0.08

†AP = Average productivity

‡MP = Marginal productivity.

§Generalized propensity score

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Author's estimation from survey data

6.3.4. Impact of increased levels of the PFJ support on SAP adoption intensity

We used the GPS matching to test the relationship between the PFJ support and farmers' SAP adoption intensity (H2d). Figure 7 shows the estimated dose-response function of the PFJ support and farmers' SAP adoption intensity (i.e., number of SAPs adopted). Like estimates of the Poisson regression in sub-section 6.2, the dose-response function (Fig. 7) shows that the PFJ support has a monotonically increasing relationship with farmers' SAP adoption intensity.

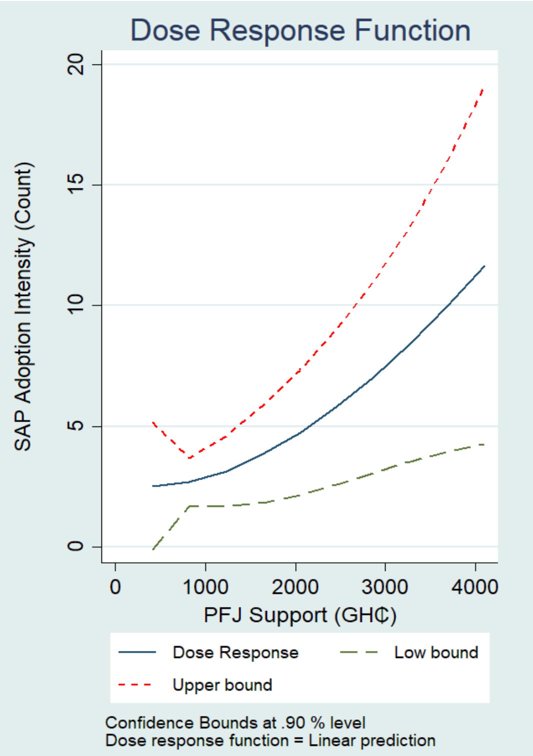

Fig. 7: Estimated effect of the level of the PFJ support on the number of SAP adopted, dose-response estimates.

Source: Author's estimation from survey data

Figure 7 indicates that the number of adopted SAP by farmers increases by 60% (i.e., from 2.90 to 4.65) when the level of support increases from GH₵ 1,000 to GH₵ 2,000 (100%) ceteris paribus. The next 50% increase in the PFJ support (GH₵ 2,000 to GH₵ 3,000) increases the number of SAPs adopted by 60% (4.65 to 7.45) whereas a further 33% (GH₵ 3,000 to GH₵

4,000) increase in the support results in the adoption of 50% (7.45 to 11.20) additional sustainable practices by farmers. This result, tied with the Poisson regression estimates, confirm that a production support programme, integrated with SAP training and extension services, can be used to encourage sustainable farming among farmers. However, the reverse of the curve also implies that a reduction in or lower levels of the PFJ support can reduce farmers' SAP adoption intensity, holding other factors constant. This confirms our hypothesis (H2d) that increased levels of production support (i.e., external incentives) to farmers will increase their SAP adoption intensity and vice versa.

6.4. Effect of the PFJ support on farm performance

6.4.1. Effect of the PFJ support on farmers' input use

Figure 8 represents the estimated dose-response functions of the PFJ support and additional input use (hybrid seed and fertiliser, respectively). The results show that farmers use more hybrid seeds and fertilisers per acre as the level of the support increases. For instance, at GH₵ 1,000 of the PFJ support, farmers used 0.8 kg/acre and 19 kg/acre of hybrid seeds and fertilisers, whereas at GH₵ 2,000 farmers use 1.90 kg/acre and 39 kg/acre more hybrid seeds and fertilisers, respectively. A further 50% (from GH₵ 2,000 to GH₵ 3,000) increase in the support to farmers increases additional hybrid seeds and fertiliser usage (i.e., commercial and subsidised) by 32% (1.90 – 2.5 kg/acre of seeds) and 54% (39 – 60 kg/acre of fertiliser).

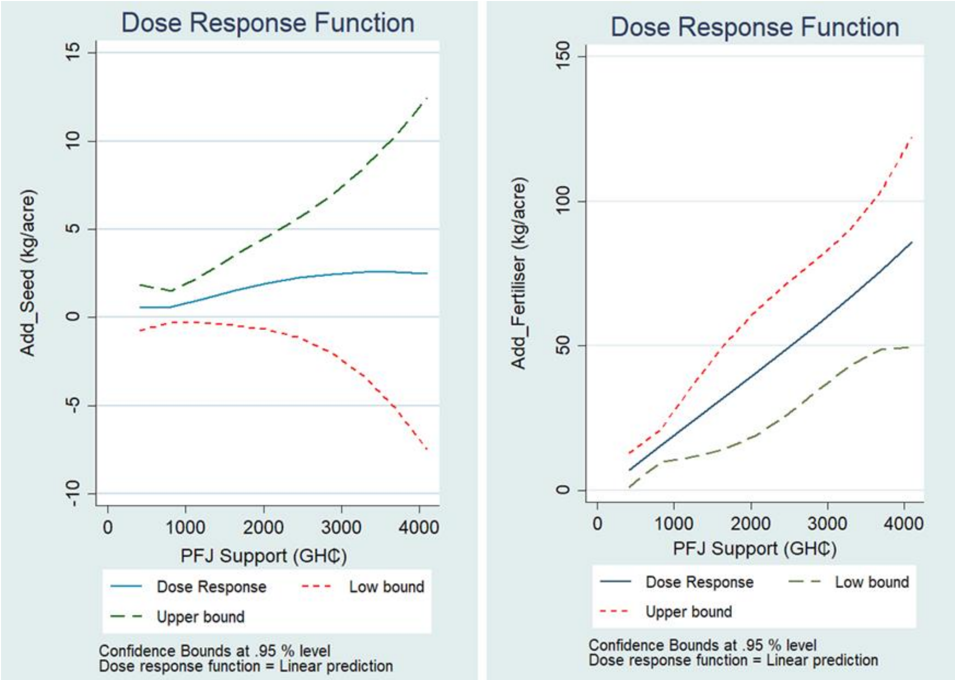

Fig. 8: a–b. (From left to right): Estimated effect of the PFJ support on hybrid seed and fertiliser use, dose-response estimates.

Source: Author's estimation from survey data

Figure 8a shows that additional hybrid seeds usage attains a saturation point at GHȻ 3,000. Hence, any additional support received after GHȻ 3,000 yields no additionality effect on hybrid seeds usage, whilst further increase in PFJ support levels (GHȻ 4,000), results in 39% (60 – 83.50 kg/acre) additional use of fertiliser (refer to Fig. 8b). These findings confirm our a priori assumption that increasing levels of production support increases farmers' usage of modern inputs (i.e., hybrid seed and fertiliser) (H3a). Furthermore, the results indicate a higher additionality effect of increasing levels of PFJ support on commercial and subsidised fertiliser usage than hybrid seed. Perhaps the farmers are accustomed to the use of local seeds since they are cheaper than hybrid seed.

6.4.2. *Impact of the PFJ support on average and marginal productivity*[12]

Figures 9 and 10 show the estimated dose-response functions of average and marginal land and labour cereal productivity, respectively.

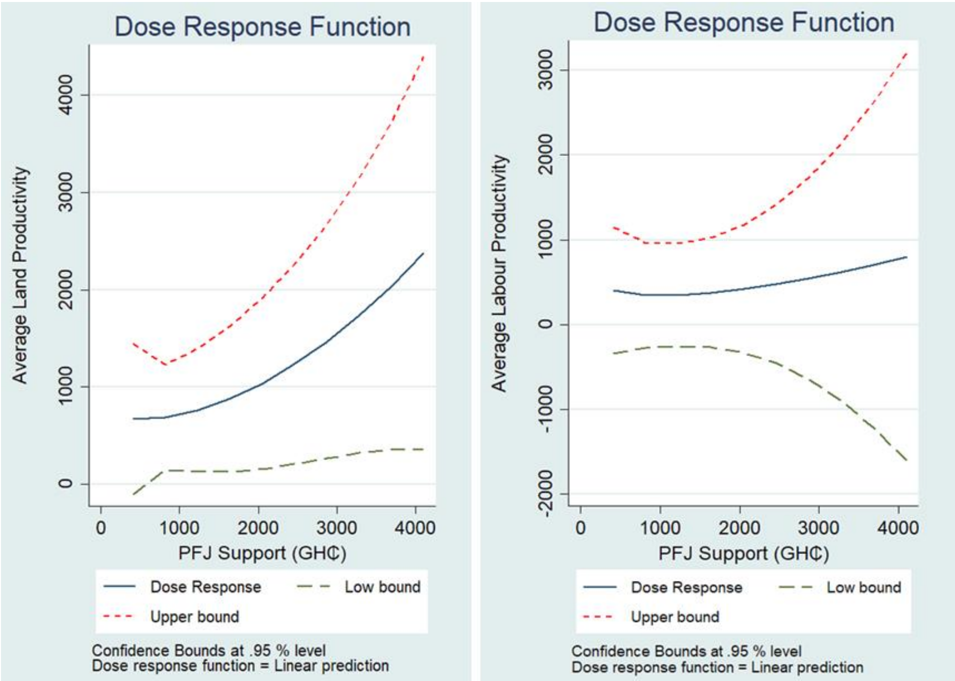

Fig. 9: a–b. (From left to right): Estimated effect of the PFJ support on average land and labour productivity, dose-response estimates.

Source: Author's estimation from survey data

As indicated by both figures, average and marginal productivities of land and labour increase in a linear fashion with the level of PFJ support. Increasing the support from GHȻ 1,000 to GHȻ 2,000, for instance, increases the average labour productivity from 350 to 420 kg/worker, respectively (Fig. 9). On the other hand, increasing the support from GHȻ 3,000 to GHȻ 4,000

[12] Average productivity was measured as the average production (i.e., yields of cereals in kg) of the programme period (i.e., 2017 and 2018) per acre or labour unit (farmer/worker) whereas marginal productivity was measured as the difference between average production for the first two years of PFJ's implementation (i.e., 2017 and 2018) and production for the year before PFJ implementation (i.e., 2016).

increases marginal land and labour productivities from 950 to 1,500 kg/acre and from 500 to 830 kg/worker (see Fig. 10). Thus, increasing levels of the support increases average labour productivity (H3b). The estimated effect of the PFJ support on average land productivity was not statistically significant (refer to Table 13d).

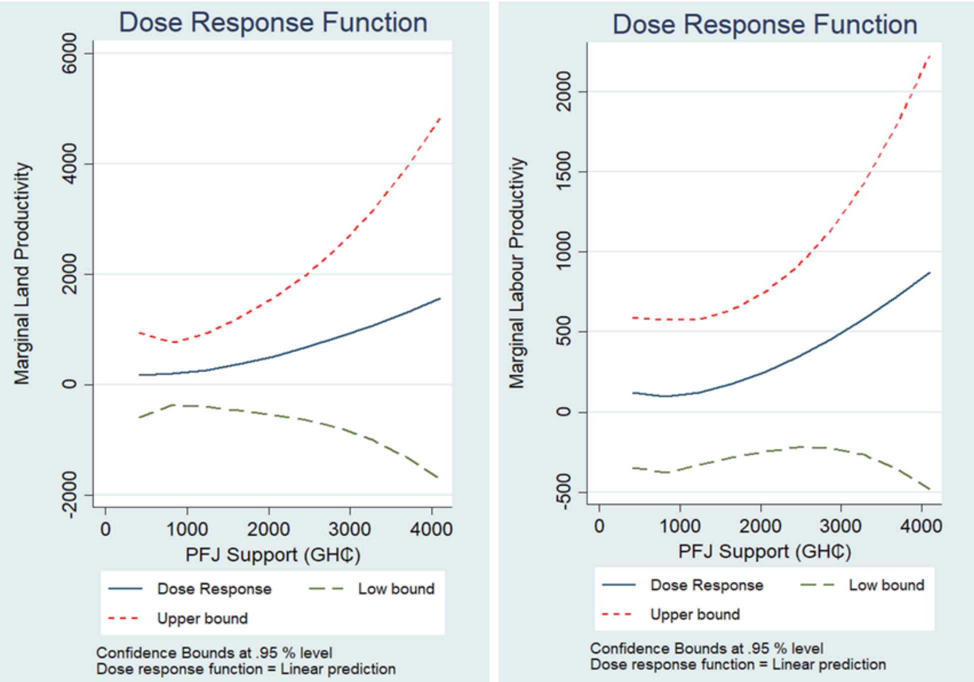

Fig. 10: a–b. (From left to right): Estimated effect of the PFJ support on marginal land and labour productivity, dose-response estimates.

Source: Author's estimation from survey data

The predicted additional effect of the PFJ support on productivity (i.e., marginal productivity) is higher compared to its effect on average productivity. For instance, an increase in PFJ support, from GH₵ 2,000 to GH₵ 3,000 (50%), increases average land and labour productivities by 55% (from 1000 to 1550 kg/acre) and 35.14% (from 420 to 570 kg/worker) (Fig. 9) whereas the same level of rising in the PFJ support increases marginal land and labour productivities by 90% (500 – 950 kg/acre) and 108% (240 – 500 kg/worker), respectively (Fig. 10). This implies that the effect of the production support on farmers' marginal productivity (i.e., additionality effect of the PF support) is higher than its impact on average productivity.

Nonetheless, the general effect of support on both average and marginal productivities is substantial.

6.5. Effect of the PFJ support on farm performance in relation to farm size

Although results in sub-sections 6.4.1 and 6.4.2 show substantial additionality effects of the production support on farmers' input use and productivity, these effects are likely to be heterogeneous in relation to farm size since the support received per farmer is likely to differ relative to farm size. To test the heterogeneity of the effect of the PFJ support on farmers' cereal productivity, we divide the sampled farmers into two groups, small-scale (farm size ≤ 5 acres/2 ha) and large-scale (farm size > 5 acres/2 ha) farms. We repeated the procedure for testing the balancing property of the GPS and estimating the dose response function for both subsamples (see Table A 4, Table A 5 and Table A 6, Appendix 3). The estimated dose-response functions of input (i.e., hybrid seed and fertiliser) use and average and marginal cereal productivities (land and labour) for the two subsamples are presented in Figures 11 to 17.

6.5.1. Impact of the PFJ support on farmers' input use in relation to farms size

Figures 11 and 12 show that the PFJ support has a positive additionality effect on the input use of both small-scale and large-scale farmers, though the magnitude of the effect is dissimilar for both farmer groups at different levels of the support. For instance, at GH₵ 1,000 of the support, small-scale and large-scale farmers used 0.5 kg/acre and 0.2 kg/acre, respectively, more of hybrid seeds. However, small-scale farmers use 1.05 kg/acre whereas large-scale farmers use 2.25 kg/acre additional hybrid seeds when the support is increased to GH₵ 2,000 per farmer. A further 25% (GH₵ 2,000 to GH₵ 2,500) increase in the support for large-scale farmers result in 76% (2.25 to 3.95 kg/acre) additional use of hybrid seeds whilst the next 50% (GH₵ 2,000 to GH₵ 3,000) increase in PFJ support only increases hybrid seeds use by 52% (1.05 to 1.6 kg/acre) for small-scale farmers (refer to Fig. 11a and Fig. 12a).

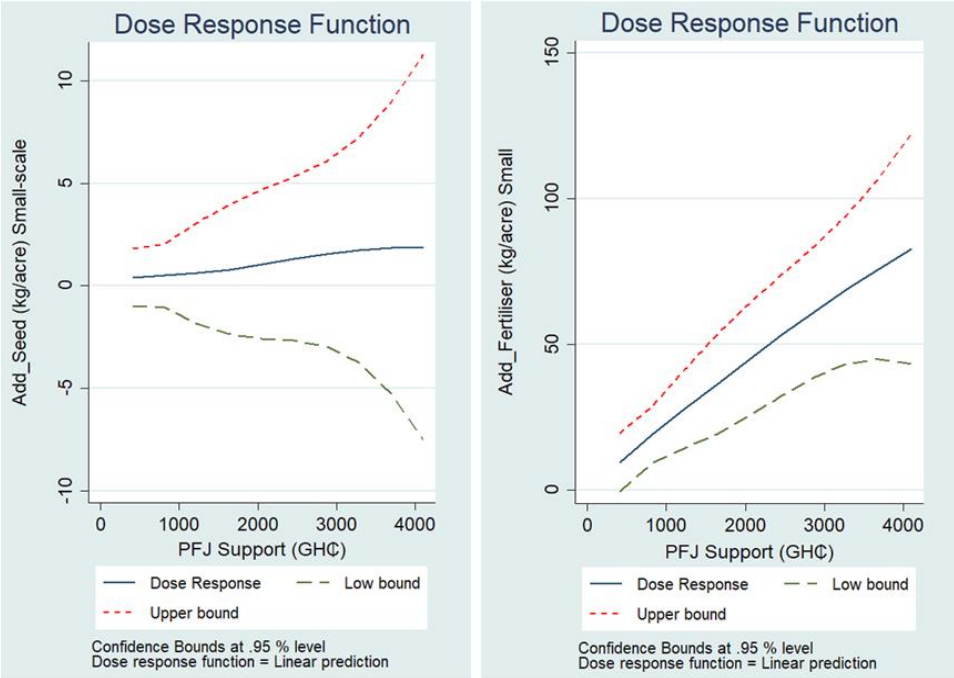

Fig. 11: a–b. (From left to right): Estimated effect of the PFJ support on hybrid seed and fertiliser use of small-scale farmers.

Source: Author's estimation from survey data

On the other hand, small-scale farmers use more (22.50 kg/acre) fertilisers than large-scale farmers (13.50 kg/acre) at GH₵ 1,000 (Fig. 11b and Fig. 12b). But increasing the PFJ support from GH₵ 1,000 to GH₵ 2,000 results in 43 kg/acre and 46 kg/acre more fertiliser usage for small-scale and large-scale farmers, respectively. Similarly, the next 25% (GH₵ 2,000 to GH₵ 2,500) increase in the support increases fertiliser usage by 52% (65 to 100 kg/acre) for large-scale farmers whilst the next 50% (GH₵ 2,000 to GH₵ 3,000) rise in the support results in 47% (43 to 63 kg/acre) additional use of fertiliser by small-scale farmers.

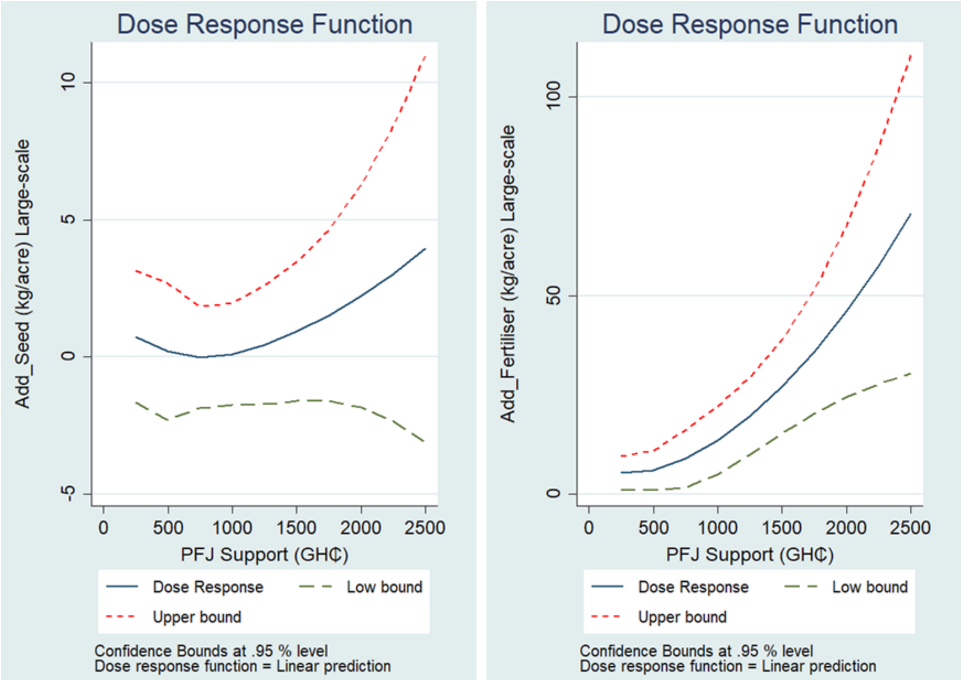

Fig. 12: a–b. (From left to right): Estimated effect of the PFJ support on hybrid seed and fertiliser use of large-scale farmers.

Source: Author's estimation from survey data

These findings imply that relatively low levels of the support have a greater additionality effect on the input use of small-scale farmers whereas higher levels of the support results in a greater additionality effect on the input use of large-scale farmers. The result confirms the theory of production. Small-scale farmers are expected to reduce the rate at which they add to fertiliser and hybrid seeds use per acre compared to large-scale farmers due to the small size of their cropland. With a smaller average farm size, i.e., 2.57 acres or 1 ha, (refer to Table A 3, Appendix 2), small-scale farmers might not be able to expand their area of cultivation at a point due to land constraints relative to large-scale farmers (i.e., average farm size 8.27 acres or 3.35 ha), holding other factors constant. Hence, increasing levels of PFJ support might not result in a corresponding higher use of the variable input (i.e., hybrid seeds and fertiliser) on small farms.

6.5.2. *Impact of PFJ support on farmers' productivity in relation to farm size*

Figures 13 and 14 show estimated dose-response functions of the average and marginal land and labour productivities of both farmer groups.

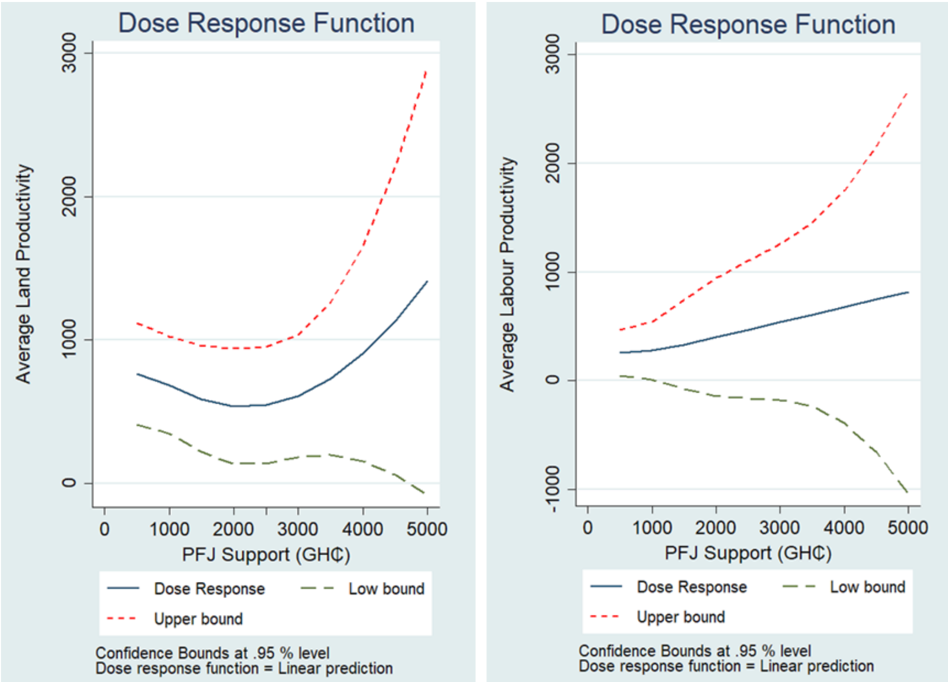

Fig. 13: a–b. (From left to right): Estimated effect of the PFJ support on average land and labour productivity of small-scale farmers.

Source: Author's estimation from survey data

The result indicates that small-scale and large-scale farmers' average productivities of land reduce to a minimum when the PFJ support is GH₵ 2,000 and GH₵ 2,500, respectively, and then rise thereafter with each cedi (GH₵) of the support received (Fig. 13a and Fig. 14a). However, derivatives of the dose-response functions (refer to Fig. A 3, Appendix 4) show that the treatment effect function of the small-scale farmers' is steeper than the treatment effect function of the large-scale farmers. Thus, each cedi (GH₵) increase in the PFJ support, has a high impact on the average productivity (AP) of for small-scale farmers than large-scale farmers.

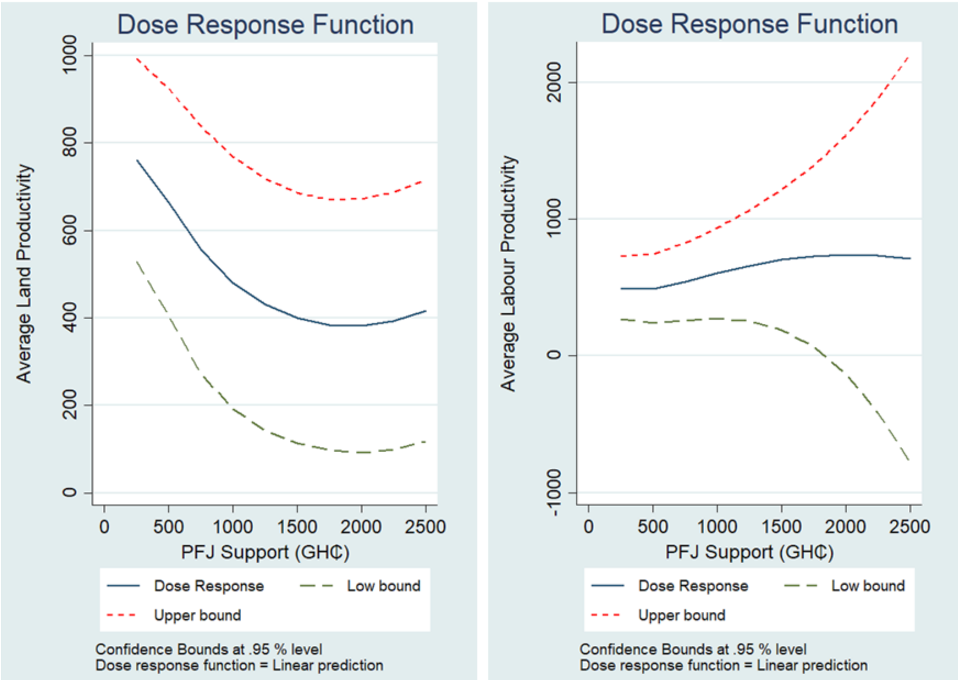

Fig. 14: a–b. (From left to right): Estimated effect of the PFJ support on average land and labour productivity of large-scale farmers.

Source: Author's estimation from survey data

Turning to the rate of increase, a 100% increase in the support for small-scale farmers (GH₵ 1,000 – GH₵ 2,000) (Fig. 13a) and large-scale farmers (GH₵ 500 – GH₵ 1,000) (Fig. 14a) reduces the average land productivity of small-scale farmers by 19% (680 – 550 kg/acre) whilst reducing the average land productivity of large-scale farmers by 28% (668 – 480 kg/acre). A further 25% increase in the PFJ support (i.e., GH₵ 4,000 – GH₵ 5,000 and GH₵ 2,000 – GH₵ 2,500 for small and large farms respectively), when both curves are rising, showing once that the average land productivity of small-scale farmers is higher 56% (900 – 1,400 kg/acre) than large-scale farmers 4% (400 – 415 kg/acre).

On the other hand, Figures 13b and 14b show that an increase in the PFJ support increases the average labour productivity of small-scale farmers whilst reducing the average labour productivity of large-scale farmers. This result imply that the production support has a higher impact on the average productivity of small-scale farmers relative to large-scale farmers.

Furthermore, Figure 15 and Figure 16 indicate that an increase in the level of the support slightly increases the marginal productivity of large-scale farmers whilst substantially increasing the marginal productivity of small-scale farmers only after receiving above GH₵ 2,500 of the PFJ support.

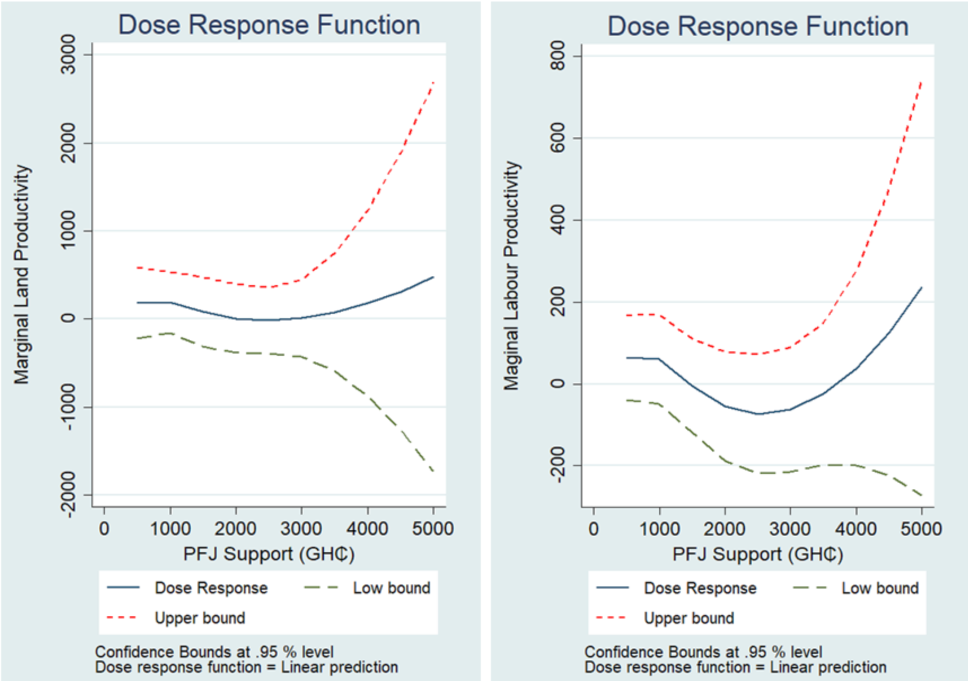

Fig. 15: a–b. (From left to right): Estimated effect of the PFJ support on marginal land and labour productivity of small-scale farmers.

Source: Author's estimation from survey data

For instance, after the minimum points of Figures 15b and 16b, a 25% (GH₵ 4,000 – GH₵ 5,000 and GH₵ 2,000 – GH₵ 2,500 for small-scale and large-scale farmers, respectively), increase in the PFJ support increases the marginal labour productivity of small-scale farmers by 539%, more than five times, (36 – 230 kg/worker) but increases the marginal labour productivity of large-scale farmers by 24% (250 – 310 kg/worker) – a higher additionality effect of the production support on the productivity of small-scale farmers than large-scale farmers.

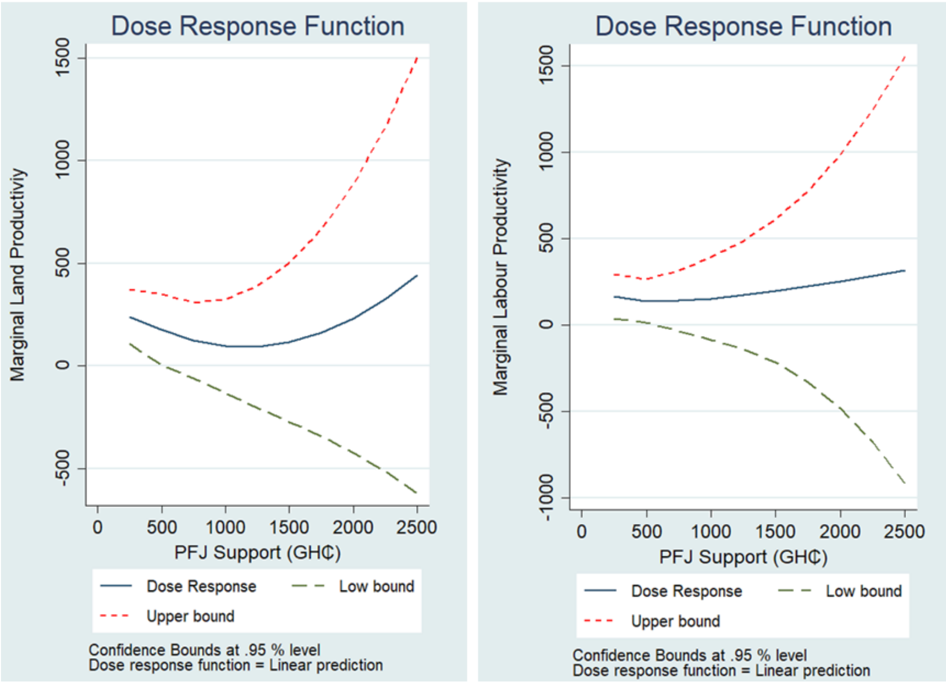

Fig. 16: a–b. (From left to right): Estimated effect of the PFJ support on marginal land and labour productivity of large-scale farmers.

Source: Author's estimation from survey data

Likewise, whereas the PFJ support has a near-convex relationship with the marginal productivity of land for both small-scale and large-scale farmers, the rate of increase of marginal productivity is higher for small-scale farmers than for large-scale farmers (refer to Fig. 15a and Fig. 16a). However, the effect of the PFJ support on the marginal productivity of land of large-scale farmers is statistically not significant (see Table A 6, Appendix 3). These results therefore confirm our hypothesis (H4) that the effect of the PFJ support on farm performance is heterogenous in relation to farm size, with higher effects for small-scale farmers.

6.5.3. *Expected effect of higher the PFJ support threshold on the productivity of large-scale farmers*

Findings from sub-sections 6.5.1 and 6.5.2 show that the impact of the PFJ support is heterogenous with greater positive effects for small-scale farmers. Yet, a minimum level of the support (GH₵ 2,500) is required for a small-scale farmer to produce positive productivity.

Table 14: A scenario of increasing the PFJ support threshold from the current 2 ha to 3 ha for large-scale farmers

- ❖ Current average PFJ support for small-scale = 671.67 and large-scale =437.53 (refer to Table 8)
- ❖ Holding hybrid seeds constant, the average support for large-scale farmers could purchase 6.25 fertiliser bags (50 kg/bag) as of 2018 at a subsidised price per bag of GH₵ 70.
    - 6.25 bags = 6.25*50 = 312 kg
- ❖ According to Ragasa et al. (2013), the recommended fertiliser application rate for a continuously cropped land in Northern Ghana by MoFA is 4 bags/ha (200 kg/ha).
- ❖ Using the application rate of 200 kg/ha: 312 kg/ 200 kg/ha = 1.6 ha
- ❖ The average support per large-scale farmer can therefore purchase fertilisers for 1.6 ha.
- ❖ If the PFJ programme increases the maximum support per large-scale farmer from 2 ha to 3 ha, holding other factors constant,
    - It means the increase of the maximum from 2*4 to 3*4 50kg fertiliser bags,
    - the subsidised price of GH₵ 70 per 50 kg bag of fertiliser (i.e., the subsidised price for the 2018 farming season)
    - thus, (3*4 bags) = (12 bags * GH₵ 70) = GH₵ 840
    - then a large-scale farmer will get the support of GH₵ 840 at maximum comparing the current maximum of GH₵ 560 for fertilisers only.
- ❖ Large-scale farmer therefore requires 92% increase in their current support to cover 3 ha,
    - (840 – 437.53) = (402.5/437.53*100) = 92%.

This implies that the support provided to the large-scale farmer might not be enough to have higher positive impact on their productivity since lower levels of the PFJ support reduced the productivity of small-scale farmers (refer to Fig. 13 and Fig. 15). Perhaps, the fact that the (implementation of) PFJ programme limits the support per farmer to a maximum of 2 ha for all farmers regardless of farm size could be the reason for the low performance of large-scale farmers. In this sub-section, we estimate the potential impact of the PFJ support on the average land productivity of large-scale farmers if their PFJ support threshold is increased to 3 ha following the scenario described in Table 14 and compare it to the current support threshold of 2 ha. The scenario was based on the prices of subsidised fertilisers holding subsidised seeds constant.

Figure 17a–b presents the actual estimated effect of the PFJ support on the average land productivity of large-scale farmers (Fig. 17a is the same as Fig. 14a) and the potential impact of the PFJ support on large-scale farmers' productivity if their support threshold is increased by 1 ha (i.e., an increase in the quantity of supported inputs equivalent to the normative need for 2 ha to 3 ha). Thus, Figure 17b is the expected extension of Figure 17a if the PFJ support threshold of large-scale farmers is capped at 3 ha rather than 2 ha.

A comparison of both curves shows that average productivity (AP) of land reduces at lower levels of the PFJ support, attain a minimum at GH₵ 2,000 and then rises thereafter. However, the rate of reduction is lower for the 3-ha threshold (Fig. 17b) than the 2-ha support threshold (Fig. 17a). For instance, at the support threshold of 2 ha per large-scale farmer, an increase in the PFJ support from GH₵ 500 to GH₵ 2,000 reduces AP of land by 42% (i.e., from 670 kg/care to 390 kg/acre) (Fig. 17a).

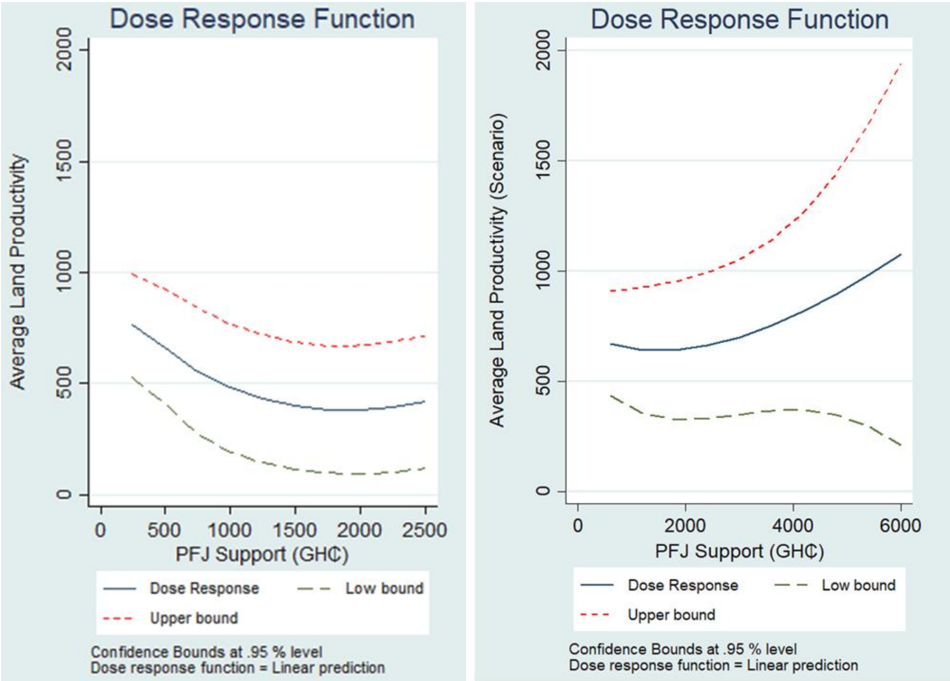

Fig. 17: a–b. (From left to right): Estimated effect of the PFJ support on average land productivities before and after the increase productivity of large-scale farmers.

Source: Author's estimation from survey data

On the other hand, AP of land reduces by 5% (i.e., from 670 kg/acre to 630 kg/acre) with the same level of increase in support (i.e., from GH₵ 500 to GH₵ 2,000) (Fig. 17b) at the support threshold of 3 ha. However, further increases in the PFJ support after GH₵ 2,000 increase AP of land, though the rate of increase is higher at higher levels of the support. For example, the first 100% (i.e., from GH₵ 2,000 to GH₵ 4,000) increase in the PFJ support after the minimum point of Figure 17b, increases AP of land by 27% (i.e., from 630 kg/acre to 800 kg/acre) whereas the next 50% (i.e., from GH₵ 4,000 to GH₵ 6,000) increase in the PFJ support increases productivity by 38% (i.e., from 800 kg/acre to 1100 kg/acre). This confirms our assumption that higher productivity increases can be achieved by large-scale farmers if they receive high level of support than small-scale farmers.

7. Discussion

The aim of this study was to understand how participation in a production support programme integrated with technical and advisory services and SAP training affects farmers' SAP adoption and farm performance. We expanded the common approach of technology adoption based on structural variables, with the inclusion of social-psychological variables such as farmers' corruption perception and attitudes. The study also included external incentives such as production support among the explanation factors of SAP adoption. The research also estimated the impact of increased levels of production support on farm performance and the heterogeneity of the effects in relation to farm size.

Our results on the determinants of farmers' participation in the production support programme (refer to sub-section 6.1) show that farmers' perception towards the PFJ programme plays a key role in explaining their decision to participate in the support programme. The estimates of the logistic regression indicate that farmers' risk awareness and perceived own competence to control effects of pest invasion and soil erosion positively influence their probability to participate in the PFJ programme. According to Kollmuss and Agyeman (2002), risk realisation (experience with its impact) is significantly related with a primary instinct to take action, which has the potential to override intrinsic motivation. Therefore, farmers will take cognitive steps to participate in the PFJ programme in order to improve their soil fertility and control pests if they realise the existence of soil erosion and pest invasion on their farmland. Perhaps this is the key reason why PFJ participation quadrupled (300,000 to 1.2 million) from 2017 to 2019 (Graphic Online 2020). Wossen et al. (2017) found that farmers who experienced drought shocks were more likely to register in Nigeria's e-wallet. On the other hand, Prokopy et al. (2008) argued that awareness of threat alone does not guarantee taking remedial actions. Farmers' awareness of environmental and production risks should be complemented by the knowledge and confidence to perform the self-protective behaviour (Kaiser et. al. 1999). Thus, farmers are more likely to participate in the PFJ programme if they are aware of the existence of soil erosion and pest invasion on their cropland and are capable of effectively applying the fertiliser and pesticides provided under the programme to fight pest invasion, improve soil fertility, and increase their long-term productivity. This confirms the earlier finding of Nguyen and Drakou (2021) that farmers' intention to adopt sustainable agricultural practices is influenced by their perceived abilities to perform the sustainable practices. Hence, not considering risk awareness and perceived competence to control the risk as complementary factors biases prediction of actual behaviour (Wilson et al. (2014).

Attitudes are behavioural tendencies built on an individual's beliefs, which come from favourable or unfavourable assessments of behaviour (Ajzen 1991). In this study, we approximated expected benefits (i.e., improved access to inputs, increase yield and income) from the support programme as attitude, and found a positive effect on farmers' participation in the PFJ programme. Also, attitudes towards the support programme had the second highest positive impact, in terms of marginal effect, on PFJ participation. According to Piñeiro et al. (2020), one of the strongest drivers of farmer participation in agricultural programmes in the long run is the perceived benefits of the programme for the farm. Moreover, it has been argued that successful agricultural programmes are designed based on people's attitudes and socioeconomic conditions (Cao et al. 2009).

In addition, the results show that farmers' perception of corruption in the PFJ programme, represented by perceived input smuggling, elite capture, and political favouritism, reduces their likelihood to participate in the support programme. In fact, corruption perception was the strongest negative driver of participation in terms of magnitude. Despite the measures introduced to check corruption in the PFJ programme, such as approvals of waybills at national, regional and district offices of the ministry of food and agriculture, IFDC (2019) reports that there are still alleged cases of input smuggling to neighbouring countries, elite capture, and diversion of subsidised inputs for resale by unscrupulous distributors and retailers at the periphery of vulnerable smallholder farmers. Asante and Mullard (2021) also found that discrimination against some farmers based on their political affiliation in the distribution of input vouchers, inhibited some farmers from participating in the PFJ programme.

Beside analysing the impact of attitude and corruption perception on farmers' participation decisions, our goal was to also understand the interplay of these two perceptual drivers. The study found a complementary relationship between high positive attitudes towards the PFJ programme and low corruption perception. Specifically, the effect of positive attitudes towards the PFJ programme on farmers' participation decisions is highly increased as the level of corruption perception about the programme reduces. On the other hand, a higher level of perceived corruption offsets the positive attitudes (perceived expected benefits) towards the PFJ programme, discouraging farmers' participation. It has been argued, in non-agricultural studies, that higher levels of corruption increase the risks and costs of doing business, which might discourage positive entrepreneurial intentions (Griffiths et al. 2009; Heuer & Liñán 2013). On the other hand, Traikova et al. (2017) contended that positive attitudes partially offset the negative effect of corruption perception on entrepreneurial intentions. Our result therefore conforms with the finding of Traikova et al. since positive attitudes towards the PFJ programme complemented by low corruption perception about the PFJ programme substantially enhance/increase the probability of farmer participation.

The results show that farmers' level of information about the PFJ programme has a positive effect on their likelihood to participate in the programme, but the magnitude of the effect is low. Since the introduction of the PFJ programme, the ministry of food and agriculture has done a lot of education on the programme, especially in Northern Ghana. The reported initial success of the PFJ programme coupled with intensive promotion of the programme by top government officials, has also made it popular in the media landscape. Chiefs and other opinion leaders have also been involved in the promotion of the PFJ programme due to the respect they command in rural Ghana. Hence, there is a high level of information on the programme among farmers (beneficiaries and non-beneficiaries, refer to Table 6). This could be why farmers' level of information about the PFJ programme is only a moderate driver of participation. The results however conform with studies that used various proxies for information level and found that informed farmers are more likely to take part in agricultural support programmes (Jara-Rojas et al. 2012; Lemessa et al. 2019; Serebrennikov et al. 2020). Similarly, farmers' capacity to afford the 25% pre-financing arrangement positively affects participation. Resource-rich farmers have high financial capacity to afford the pre-financing, and hence they are more likely to participate and acquire more of subsidised inputs than their resource-poor counterparts. They are also more prone to accept some risk and costs associated with new agricultural technologies. Various proxies of wealth have been used in the literature and have shown that resource-poor farmers are less likely to participate in new agricultural technologies due to the initial investment cost (Chirwa et al. 2011; Nkegbe & Shankar 2014; Abdul-Hanan 2017; Darkwah et al. 2019).

Long distances from farms to input collection centres reduced farmers' probability to participate in the PFJ programme. According to Abdul-Hanan et al. (2014), proximity to the input collection points of support programmes motivates farmer participation since it reduces the cost of transporting the inputs. However, the low marginal effect of distance to registration and input collection centres on participation means that proximity is not an issue in the farmer's decision to participate in the PFJ programme. The use of community private input retailers to distribute the subsidised inputs may have helped to weaken the proximity challenge.

The findings indicate that the provision of extension services to farmers had a positive high impact on their probability to participate in the support programme. Extension agents are a key source of technical advice and information to rural farmers (Donkoh & Awuni 2011;

Abdul-Hanan et al. 2014).The PFJ programme uses extension agents to inform farmers about the programme and distribute input vouchers (refer to Fig. 3). Therefore, extension agents can influence participation by explaining the benefits of the production support programme to farmers, which can enhance positive attitudes (relating to perceived benefits and increased productivity) towards the PFJ programme. The result conform with findings in the literature that farmers with no extension contacts or access are less likely to adopt modern agricultural technologies (Odendo et. al. 2011; Ali & Rahut 2013; Anang et al. 2020).

Gender had a statistically significant effect on PFJ participation, with female farmers more likely to be attracted by the PFJ programme than male farmers. The result is in line with a report (SEND GHANA 2019) that indicates that female participation in the PFJ programme has substantially increased in some districts of the study area. The high likelihood of female participation was anticipated due to the PFJ programme's objective to engage more females and unemployed youth in agriculture (MoFA 2017). If Abdul-Hanan et al. (2014) and Abdul-Hanan (2017) findings that male farmers are more likely to adopt new agricultural production technologies in Northern Ghana since they control most of the production resources like land, labour and capital are correct, then we can admit that the PFJ contributed to minimising the advantage of the male farmers and succeeded in its gender objective.

Although the negative effect of education on PFJ participation was not anticipated a-priori, the result confirms the findings of Abdul-Hanan et al. (2014) on the adoption of conservation technologies in Northern Ghana. A large body of literature argues that farmers with higher education are able to read and appreciate information about new agricultural technologies, and hence are more likely to participate than farmers with no or a low level of education (Mwangi & Kariuki 2015; Mango et al. 2017; Anang & Kudadze 2019; Xie & Huang 2021). The issue needs more investigation to provide satisfactory answers on the role of general education in farmers' decisions to participate in support programmes.

Secondly, we analysed the drivers of farmers' intensity of SAP adoption in relation to the PFJ support in terms of external motivation. The results from the Poisson regression, in sub-section 6.2, show that farmers' awareness of soil erosion and flood had a positive impact on their SAP adoption intensity whereas pest invasion had a negative impact. Although not anticipated, the negative effect of awareness of pest invasion on SAP adoption could be due to the surge in fall armyworm infestation (i.e., the main pest) on cereals in the study area in 2018. Smallholder farmers, upon the realisation of pest invasion, might invest in pest prevention technologies with immediate effect rather than invest their limited resources in other SAPs. Conversely, the positive effects of soil erosion and flood awareness/experience on SAP adoption are consistent with the literature on the effect of farmers' risk awareness on their adoption of sustainable agricultural practices, soil and water conservation practices and agri-environmental technologies (Pilarova et al. 2018; Lemessa et al. 2019; Zeweld et al. 2020; Wąs et al. 2021). Farmers' realisation of threats such as soil erosion promotes taking cognitive actions to repair or prevent further damage to their farmland and the effect of soil degradation on their long-term productivity (Rogers 1975; Traore et.al. 1998; Prokopy et al. 2008). Moreover, it has been argued that the realisation of climate change and climate variability on people's livelihoods promotes adaptation strategies among farmers (Esham & Garforth 2013; Nguyen et al. 2021).

The findings also show that the geographical location of the farmers had the highest positive effect on their number of SAPs adopted. However, farming in the Upper West and Upper East regions was associated with higher effects than farming in the Savannah region. According to Nkegbe (2018), climate conditions and soil fertility worsen as one moves further north in Ghana. This explains why farming in regions closer to the desert areas of Burkina Faso, i.e., Upper West and Upper East (refer to Fig. 5), with erratic rainfall patterns and poor soil fertility (Adu-Boahen et al. 2019), are associated with higher SAP adoption intensity. Nkegbe and Shankar (2014) and Sharma et al. (2011) employed count data models and found regional effects in the adoption of SAPs in Ghana and the adoption of pest control technologies among UK farmers.

Farmers' knowledge of SAP, approximated by the provision of extension services and SAP training to farmers, had the second highest positive effect on farmers' SAP adoption intensity. This result confirms our a-priori assumptions and existing evidence that the provision of information and technical assistance on sustainable practices to farmers increases their adoption and retention rate of SAPs (Himberg et al. 2009; Reid 2009; Green et al. 2013). Zeweld et al. (2018) and Kumar et al. (2020) found that participatory capacity building training and the provision of extension services to farmers promote their adoption of more land management practices and improved technologies aimed at improving productivity. Farmers' knowledge of the adverse consequences of soil erosion and soil degradation, for example, helps them to understand better its impact on their farm performance (Mengstie 2009; Darkwah et al. 2019).

Participation in the PFJ support (refer to Table 11) increases the number of SAPs adopted by a farmer. The PFJ support ecourages farmers to join the programme and come in touch with the extension services. The extension contacts help resource-poor farmers to get information, advice and training which change their SAP adoption behaviour. The findings conform with the conclusions of Koppmair et al. (2017) and Bopp et al. (2019) that access to production subsidies (described as extrinsic motivation by Bopp et al.) increases farmer adoption of natural resource management technologies and SAP adoption intensity. However, results from the Poisson regression show that the geographical location of a farmer and farmers' knowledge on SAP had higher impacts on their SAP adoption intensities compared to participation in the PFJ support (refer to Table 11). This implies that farmers with high knowledge of SAP and farmers located in geographical regions with poor soil fertility and harsh weather conditions such as the two upper regions (i.e., Upper West and Upper East) of northern Ghana might adopt more SAPs regardless of the PFJ support. Estimates of the dose-response function for the impact of the production support on SAP adoption intensity (refer to Fig. 7) show that increasing levels of the PFJ support increase the SAP adoption intensity of a farmer whilst lower levels of the support indicate low SAP adoption intensity. According to Piñeiro et al. (2020), though incentives such as production support are necessary, they need to be large enough to compensate for the opportunity cost of changing from conventional farming to sustainable agriculture since the effects on outcomes take time to realize. Conversely, it has been argued that externally motivated farmers tend to condition SAP adoption on monetary incentives, and hence can stop SAP if the support ceases (Deci 1971; Ryan & Deci 2000b). However, since the support provided under the PFJ programme is decoupled from SAP adoption, the termination of the programme may not have a direct negative effect on the retention rate of SAPs.

Although all the farmer and farm characteristics had a statistically significant effect on farmer SAP adoption intensity, impact of these variables were lower (in terms of magnitude) with the exception of livestock production (refer to Table 11). Similar to the PFJ participation model, gender had a statistically significant effect on SAP adoption intensity, implying that female farmers adopted more SAPs than their male counterparts. This result is in line with findings from Ethiopia that female farmer household heads are more likely to use manure and crop residue than males (Teklewold et al. 2013; Zeweld et al. 2020). Also, more years of schooling and farming experience had positive effects on the number of SAPs adopted by a farmer. According to Engler et al. (2016), experienced farmers may be more impervious to changing to new systems since they have managed their farm in a specific way for a long period. On the other hand, experienced farmers have a better feel of the negative effect of soil degradation on productivity, and hence are more willing to adopt SAPs to mitigate their potential loss (Boz & Akbay 2005; Bayard et al. 2006; Teshome 2013).

Use of hired labour, production of livestock, large farm size and taking credit (representing farmer wealth) increased the number of SAPs adopted by a farmer. Farmers producing livestock increased availability of manure (i.e., animal dung and feed waste) which serves as a source of soil nutrients (Teklewold et al. 2013) and sources of power for tillage activities. In the same vein, large livestock such as bulls serve as a source of power for tillage activities (Abdul-Hanan 2017). The findings support the view that well-resourced farmers can meet the initial investment expenses of sustainable technologies (Abdul-Hanan 2017). Further, the results conform with Tadesse & Belay (2004) and Abdul-Hanan et al. (2014) who found large farm size to have a positive impact on farmers' SAP adoption intensity in Ethiopia and Ghana, respectively.

Findings in relation to the third objective, i.e., to estimate the impact of increased production support on farm performance using input use (i.e., hybrid seeds and fertiliser usage) and productivity as performance indicators (refer to sub-section 6.4), show that higher levels of the PFJ support increased farmers' usage of improved hybrid seeds and fertiliser (H3a), though the impact was higher on fertiliser usage than improved hybrid seeds. Differences in the literature centre on the level of impact of production support on input use. Some studies have found substantial effects of production support on input use (Nyirongo 2005; Harrigan 2008), whereas others have found production support to have a low response rate on fertiliser usage in Zambia, Malawi and Kenya (Ricker-Gilbert et al. 2011; Mason & Jayne 2013; Jayne et al. 2013) due to inherent inefficiencies in the programme implementation such as input smuggling and diversion (Banful & Olayide 2010; Druilhe & Barreiro-hurlé 2012) and crowding out effects (Takeshima et al. 2012; Takeshima & Nkonya 2014; Mather & Jayne 2018). However, the unanswered counterfactual in these studies is, can any level of support result in substantial effects on input use? Our findings answer this question since increasing levels of the production support produced significant additionality effects on input use (Fig. 8).

Consequently, the high use of improved hybrid seeds and fertilisers, due to PFJ support, increased the average and marginal productivities of farmers (H3b). The results show that both average and marginal productivities increase at higher levels of the support. However, the PFJ programme's additionality effect on productivity (i.e., marginal productivity) is higher than its impact on average productivity. Similar studies in Ghana (Benin et al. 2013; Abubakari & Abubakari 2015), Kenya (Mason et al. 2017b), Malawi (Dorward & Chirwa 2011) and Zambia (Ricker-Gilbert & Jayne 2012) have all established substantial positive impacts of production support on agricultural productivity. Past as well as recent studies have reported higher production growth due to the fertiliser subsidy on cereal cultivation in Zambia (World Bank 2010) and Ghana (Tanko et al. 2019; Pauw 2021). Similarly, Ricker-Gilbert and Jayne (2010) found Malawi's fertiliser support programme to have increased maize productivity. According to the authors, while there are already some positive effects in the first season of the support, greater positive effects are associated with subsequent seasons. Perhaps, much higher productivity levels could be reaped from the PFJ programme in subsequent years since the data used for this research is based on the first two years (2017 and 2018) of its implementation. Conversely, Jayne et al. (2018) argued that receiving production support raises grain productivity in the short term, yet the overall production and welfare effects of support programmes tend to be smaller than expected.Fearon et al. (2015) and Azumah and Zakaria (2019) found no or a negative effect of Ghana's previous fertiliser support programme on productivity. The contradiction between these findings and ours can be attributed to the fact that their analyses were based on data from Ghana's previous support programme whereas our data is based on the new programme introduced in 2017.Differences in the design and implementation of the previous and current programmes can affect the findings. Recent studies in Ghana have found a positive impact of agricultural technologies under the PFJ programme on the productivity of cereals (Lambongang et al. 2019; Tanko et al. 2019; Asante & Bawakyillenuo 2021).

Findings from sub-section 6.5 confirm our hypotheses that, although increasing levels of the support increase input use and productivity, the increase in input use and productivity are heterogeneous in relation to farm size (H_4). The estimated dose-response functions of the subsamples also expose some heterogeneity of effects of PFJ support in relation to farm size since most of the curves for the two subsamples (refer to Fig. 11 to Fig. 16) are non-linear compared to the total sample (refer to Fig. 8 to Fig. 10). Thus, better productivity effects are attained by small-scale farmers relative to large-scale farmers at higher levels of PFJ support. Moreover, small-scale farmers attained a saturation point in additional input use between GH₵ 2,000 and GH₵ 3,000 of support, and thereafter increased hybrid seed and fertiliser usage at a decreasing rate. Consequently, the small-scale farmers recorded higher increases in productivity (i.e., average, and marginal) around this level of the support (GH₵ 2,500). Using the GPS matching approach in a non-agricultural study, Ratinger et al. (2020) found that small and medium-scale firms in Czech Republic receiving research and development support performed better (in terms of productivity, gross value added and profitability) than large-scale firms.

On the other hand, the results show that the disbursed PFJ support are not enough to generate substantial productivity effects on large-scale farmers since small-scale farmers require more than GH₵ 2,500 of the support to realise productivity increases. The current PFJ support distribution approach of 2 ha for all beneficiaries, regardless of farm size, may not be favourable to large-scale farmers. Figure 12 shows that large-scale farmers increase especially hybrid seed use at an increasing rate at higher levels of support. As such, it is logical to assume that higher levels of PFJ support to large-scale farmers can increase their use of hybrid seeds and fertiliser per acre and substantially increase their productivity levels. We therefore estimated the expected impact of the PFJ support on the average productivity of large-scale farmers in relation to a higher support threshold, i.e., 3 ha. Our findings indicate that such an increase in the threshold of support for large-scale farmers substantially increases their productivity levels. These findings, coupled with the results from sub-sections 6.5.1 and 6.5.2, imply that a differentiated support threshold in relation to farm size (i.e., higher support threshold for large-scale farmers and vice versa) have greater impacts on the productivity levels of both small-scale and large-scale farmers. The results imply that the current distribution structure of the PFJ support is favourable for semi-subsistence farming compared to dominantly commercial farming. This is contrary to the programme's general objective of modernising agriculture to structurally transform the national economy through food security, employment opportunities and reduced poverty (MoFA 2017). We observed during the survey that most of the large-scale farmers are often unable to afford, at commercial prices, the remaining fertiliser and hybrid seeds required to cover their entire farm size since they are limited to inputs for only 2 ha. As a result, some of the large-scale farmers used their previous farm produce as seeds in place of the improved hybrid seeds whereas others used local seeds such as 'Obatanpa'. Studies in Ghana show that improved hybrid varieties of seeds produce twice the yield of local seeds like 'Obatanpa' (Ragasa et al. 2013). Hence, a higher support threshold for large-scale farmers can reduce their production inefficiencies caused by the use of low-yield seeds and low fertiliser application rate, and substantially increase their productivity.

8. Conclusions and Policy Recommendations

8.1. Conclusions

Governments across Sub-Saharan Africa use production support as a policy instrument to enhance agricultural productivity and thus food security. This study focused on measuring the effect of agricultural production support, integrated with technical and advisory services, on farmers' adoption of sustainable agricultural practices and the effects of increased levels of the support on farm performance and food production at the farm level, using Ghana's integrated production support programme (i.e., Planting for Food and Jobs, PFJ). We used cross-sectional data collected from 540 cereal farmers (285 beneficiaries of PFJ and 255 non-beneficiaries) from Northern Ghana.

First, the research examined the effect of farmers' awareness of environmental and production risk, perceived competence to control these risks, attitudes toward the PFJ programme, corruption perception about the programme and other factors on farmers' participation in the PFJ programme using a logistic regression model. Secondly, it analysed the effect of the production support, farmers' awareness of environmental and production risks (i.e., pest invasion, flood, and soil erosion), as well as their knowledge on sustainable agricultural practices (SAPs) (approximated by the provision of extension services and SAP training to farmers), on farmers' SAP adoption intensity applying Poisson regression and GPS matching models. Finally, we estimated the effect of increased levels of the PFJ support on farm performance (i.e., input use – hybrid seed and fertiliser; productivity – average, and marginal) using the GPS matching approach.

Our findings on the first objective of the study, i.e., determinants of farmer participation in the PFJ programme, show that attitudes, related to expected benefits (improved input use, yield and income) from the PFJ support, had a positive effect on farmers' participation in the support programme. Likewise, farmers are more likely to participate in the support programme if they are aware of existing production and environmental risks (i.e., soil erosion and pest invasion) and possess high own competence to control these risks given the production support technologies. On the other hand, higher levels of corruption perception about the PFJ programme reduced the likelihood of farmer participation. Moreover, corruption perception towards the PFJ programme was the strongest driver of farmers' decisions to participate in the support programme (see Table 10). Furthermore, the interaction term of the model shows that higher positive attitudes toward the PFJ programme and low perception of corruption in the programme significantly increase farmers' participation in the PFJ programme. This implies that positive attitudes should be complemented by low-level corruption perception to drive farmer participation in the PFJ programme. Thus, farmers with negative attitudes towards the PFJ programme are likely not to participate if the perceived corruption reputation of the programme is not improved.

The results from the Poisson regression reported in sub-section 6.2 and the GPS reported in sub-section 6.3.4 show that farmers' awareness of environmental and production risks (i.e., soil erosion and flood) increases their SAP adoption intensity. Farmers are motivated to adopt proactive measures like SAPs if they are aware of existing threats and their negative consequences on their farm. Similarly, farmers' knowledge on SAPs, approximated by SAP training and extension participation, increased the number of sustainable practices adopted by a farmer when combined with SAP training and extension participation. Educating farmers about the adverse effects of the risk of soil erosion and land degradation, caused by conventional farming practices, and training them on the remedy (i.e., SAPs), increase SAP adoption intensity. The results show that participation in the PFJ support allows farmers to adopt SAPs especially those requiring higher investment, in the context of Ghana, such as mulching. In addition, participation in, and increasing levels of, the PFJ support, increased the number of

SAPs adopted by a farmer. However, estimates of the dose-response function, reported in sub-section 6.3.4, show that lower levels of the support are related to lower SAP adoption intensity. This implies that the production support programme aimed at promoting SAP adoption require careful design and implementation since lower levels of the support can motivate farmers to reduce the number of SAPs adopted.

The findings on our third objective, i.e., to estimate the impact of increased production support on farm performance, indicate that higher levels of the PFJ support to farmers increased their input use (i.e., hybrid seed and fertiliser), which consequently increased the land and labour productivities of farmers (sub-section 6.4). However, the effect of the PFJ support on input use and productivity was heterogeneous in relation to farm size (sub-section 6.5). The results show that small-scale farmers' input use increased at a decreasing rate whilst their average and marginal productivities increased steadily after receiving a minimum level of the support (i.e., GH₵ 2,500). Although both small-scale and large-scale farmers increased productivity at higher levels of the PFJ support, higher effects were recorded by small-scale farmers compared to large-scale farmers. Perhaps the level of the support, in absolute terms, was not high enough to have substantial effects on the productivity levels of large-scale farmers since allocation of the subsidised input is limited to a maximum of 2 ha (i.e., the quantity of supported inputs equivalent to the normative need for 2 ha). To confirm the above assertion, we estimated the impact of the production support on the productivity of large-scale farmers based on a scenario of 1 ha increase in the support threshold of large-scale farmers (i.e., 3 ha for large-scale farmers, 2 ha for small-scale farmers). Results from this analysis indicate that the large-scale farmers would have recorded substantial increases in productivity if they received higher support compared to small-scale farmers.

8.2. Policy recommendations

The findings above have direct implications for future agricultural production support programmes. From the results, risk awareness complemented by individuals' perceived competence to control the identified risks, given the technologies provided by the support programme, contribute significantly to farmer participation in the PFJ programme. Hence, extension education on the effective use of the fertilisers, pesticides and other subsidised inputs received under the programme can help to shore up farmers' competence in fertiliser and pesticide applications to mitigate the effects of soil fertility loss (caused by soil erosion) and pest invasion. Furthermore, we recommend that individuals' perceptions and attitudes should be considered in addition to the traditional socioeconomic drivers in the design and implementation of agricultural support programmes, based on the magnitude of their impact on farmers' participation in the production support programme. To this end, non-beneficiary farmers with negative attitudes toward the support programme and high competence to control risks can be targeted to increase participation in the programme. In addition, since positive attitudes (a key positive driver of farmer participation in the programme) is lowered by perceptions of corruption within the support programme, it is important for managers of the programme to address crucial limitations such as political favouritism, input smuggling, and elite capture. To this end, we suggest increased involvement of private input retailers in the distribution of the subsidised inputs rather than the use of district offices of the ministry of food and agriculture. This can reduce the media reportage on alleged cases of input diversion from government warehouses in the districts, and reduce farmers' corruption perception about the support programme. On another hand, the use of private input retailers reduces the cost of transporting the subsidised inputs to the farms since the private retailers are located in the communities. Furthermore, we suggest the use of the database of registered farmers on the e-agriculture platform of the PFJ programme to develop a technology, similar to Nigeria's e-wallet, to send input vouchers directly to beneficiaries. This could reduce distribution inefficiencies and incidence of elite capture clouding the paper voucher system of the PFJ programme. It is also important to analyse the attitudes and perception of targeted and existing beneficiaries in order to design appropriate promotional messages to reorient the corruption perceptions and beliefs of non-beneficiaries as well as to promote positive attitudes towards the support programme among beneficiaries through extension education. Education and promotional courses could be organised to promote positive attitudes (i.e., educate farmers about the benefits of the PFJ) and good rapport between officers of the PFJ programme and farmers in a participatory atmosphere. Farmer groups could be used to press home the promotional messages since farmers' perception and beliefs can be shaped by peers and reference groups with whom they can share experience.

We suggest the use of a production support programme with economic incentives conditioned (coupled) by SAP adoption and integrated with SAP training and technical advisory services, in order to engage farmers in sustainable intensive agricultural production. The farmers who want to get support should be trained on the impending threat that conventional intensive farming poses to soil fertility and their long-term productivity, and should adopt SAPs as a condition for receiving the support. To this end, the training and extension services should be intensified to increase farmer awareness on the benefits of SAPs, which will consequently increase their SAP adoption retention rate if the programme is withdrawn. However, this will require a monitoring mechanism to check the actual implementation of SAP by farmers before and after the support, which inevitably adds costs to the programme. The government must therefore balance the positive effects of the programme with cost including monitoring.

Although the results show that higher levels of the PFJ support can enhance farm performance and increase food production, the potential increase in the support should be targeted in relation to farm size. First and foremost, higher productivity for small-scale and more vulnerable farmers can enhance their food and financial resource availability. This can improve food security at the household level since small-scale farmers are mostly subsistence producers. However, with a programme such as PFJ that aims at modernising agriculture to create job opportunities and produce for feed and food, it is important also to target commercial farmers (large-scale farmers). Higher support for large-scale commercial farmers could enhance their economies of scale, which means producing more for the market and enhancing national self-sufficiency. Consequently, we propose a production support disbursement targeting based on farm size (i.e., a higher support threshold for large-scale farmers compared to small-scale farmers). The support for large-scale farmers should be diverse, i.e., investments in agricultural modernisation, machinery, training on farm management, etc. A diverse support structure can help large-scale farmers to realise optimal input combination and higher productivity growth, rather than the current distribution strategy of 2 ha maximum support for all farmers, regardless of farm size. Targeting the support disbursement in relation to farm size can increase the output levels of small-scale and large-scale farmers and subsequently enhance food security at both the household and national levels.

In the broader sense, the results conform with empirical and observational literature which highlights the significance of production support programmes to food production and food security in developing countries. On the other hand, agricultural production support should also be a part of the wider agricultural development strategy, complemented by investments in technology, infrastructure, and market development.

8.3. Study limitations

Despite the contributions of this study, it has some limitations that require the attention of future research. First, the research considers only cereal production in Northern Ghana with its monomodal rainfall pattern. It is, therefore, rational to assume that the analyses might produce different results if other crops and/or bimodal rainfall regions are considered for further research. Secondly, attitudes and perceptions change over time, affecting farmers' motivation to adopt agricultural technologies (i.e., participation in production support programmes and adoption of SAPs). Future studies could consider panel data and capture how farmers' behaviour evolves over time and long-term effects, since our data is cross-sectional and based on the first two years of implementation (2017 & 2018) of the PFJ programme. Thirdly, the research investigated the effect of decoupled production support on SAP adoption intensity. It would be valuable if further studies would investigate the effect of direct support levels on SAP adoption intensity. Although the research outlines (in paragraph 3 of sub-section 5.1) the reasons that make PFJ participation and SAP adoption independent processes, the Poisson regression model is limited due to its inability to capture unobservable bias between PFJ beneficiaries and non-beneficiaries. Future studies could consider the treatment of endogeneity by instrumenting PFJ participation in the Poisson regression model. In addition, the study could not estimate the effect of the production support programme on farmers' welfare, although this was envisioned to conduct this analysis prior to the survey. However, most of the farmers were not willing to provide accurate data on their farm and household incomes which would have been used as welfare indicators. Future studies could therefore investigate the welfare effects of the support programme.

Heckman et al. (1997) postulate four factors essential for reducing bias in evaluation studies: (1) equal distribution of unobserved characteristics of the treatment and control groups; (2) equal distribution of both the control and treated groups; (3) the control and treatment groups should answer the same questionnaire; (4) same economic or social environment for both groups. In this study, the first attribute is assumed, though there are no guarantees, which is usual with observational studies, i.e. that the treatment and control group do not differ relative to the distribution of their unobserved characteristics (Heckman et al. 1997; Doyle 2011). The second and third attributes are easily fulfilled since the estimated dose-response function given the GPS ensures that treatment levels are independent of observed individuals' characteristics. Additionally, all farmers completed the same questionnaire. The farmers also faced similar climatic and economic conditions since all were sampled from a more or less homogeneous region of Northern Ghana. This helps to fulfil the fourth attribute although the homogenous climatic and economic conditions assumption might not have been entirely true. The issue of unobserved bias is reduced by the high number of covariates used and subsequent fulfilment of the balancing property of the model.

However, most of the estimated dose-response functions show some level of uncertainty in the estimates due to the wide gap between the low and upper bounds, although they were bootstrapped at 100 replications. In particular, the confidence interval reduces with higher levels of support. This is related to the higher heterogeneity of farms receiving higher support. Although large-scale farmers were meant to receive more support because of their size, they ended up getting less proportionate to their farm size. However, programme inefficiencies (e.g., political favouritism, smuggling and elite capture) and the fact that some smaller farmers could afford the subsidised inputs, led to smaller famers receiving more support on average. As such, the degree of uncertainty rises as the level of the PFJ support increases (e.g., Fig. 12 and Fig. 15). One way of solving the problem described above would be to measure the treatment variable (PFJ support) per acre (i.e., farm size). But, measuring the treatment as PFJ support per acre will not solve the problem in this case because dividing the support received per farmer by farm size will still result in higher treatment levels for the small-scale farmer than the large-scale farmer. Thus, higher support divided by smaller farm size will result in higher support per acre for small-scale farmers and vice versa.

9. References

Abdul-Hanan A, Ayamga M, Donkoh S.A. 2014. Smallholder adoption of soil and water conservation techniques in Ghana. African Journal of Agricultural Research **9**: 539–546. https://doi.org/10.5897/AJAR2013.7952.

Abdul-Hanan A. 2017. Determinants of adoption of soil and water and conservation techniques: Evidence from N orthern Ghana. International Journal of Sustainable Agricultural Management and Informatics **3**: 31–43. https://doi.org/10.1504/IJSAMI.2017.082918.

Abebe GK, Bijman J, Pascucci S, Omta O. 2013. Adoption of improved potato varieties in Ethiopia: The role of agricultural knowledge and innovation system and smallholder farmers' quality assessment. Agricultural Systems. **122**: 22–32. https://doi.org/10.1016/j.agsy.2013.07.008.

Abebe S.A. 2018. The impact of soil and water conservation for improved agricultural production in Ethiopia. Journal of Agriculture **1**: 9–12.

Abubakari F, Abubakari F. 2015. Effects of fertilizer subsidy on the yield of crops among rural farmers in Sudan Savannah and Guinea Savannah zones of Ghana. **3**: 80–85. DOI: 10.14662/ARJASR2015.008.

Abugri B, Ahenkan A, Bawole JN. 2020. The role of knowledge management in national food and agriculture policy implementation: Evidence from the planting for food and jobs agricultural policy of Ghana. International Journal of Innovative Science and Research Technology **5**: 967–998. DOI: 10.38124/ijisrt20sep637.

Adekanmbi B. 2017. Comparison of probit and logit models for binary response variable with applications to birth data in South-Western, Nigeria. American Journal of Mathematics and Statistics **7**: 199–208. DOI: 10.5923/j.ajms.20170705.02.

Adu-Boahen K, Dadson I, Halidu MA. 2019. Climatic variability and food crop production in the Bawku West District of the Upper East Region of Ghana. Ghana Journal of Geography **11**: 103–123. https://dx.doi.org/10.4314/gjg.v11i1.7.

African Union (AU). 2003. AU 2003 Maputo declaration on agriculture and food security, Maputo, Mozambique. Available from https://www.nepad.org (accessedOctober 2021).

African Union (AU). 2006. Abuja declaration on fertilizer for the African green revolution. declaration of the African Union Special Summit of the Heads of States and Governments, Abuja, Nigeria. Available from https://www.afdb.org (accessed October 2021)

Ajzen I. 1991. The theory of planned behavior. Organizational Behavior and Human Decision Process **50**: 179-211. https://doi.org/10.1016/0749-5978(91)90020-T.

Akbari M, Rostami F, Rezaei A. 2015. Determinants of farmers' participation in horticulture-based extension programs in Iran: Application of the theory of planned behavior. International Journal of Agricultural Management and Development **5**: 141–151.

Ali A, Rahut AD. 2013. Impact of agricultural extension services on technology adoption and crops yield: empirical evidence from Pakistan. Asian Journal of Agricultural and Rural Development **3**: 801–812. DOI: 10.22004/ag.econ.198306.

Altieri MA, Nicholls CI. 2005. Agroecology and the search for a truly sustainable agriculture: Basic textbooks for environmental training. United Nations Environment Programme Mexico D.F.

Amankwah A, Quagrainie KK, Preckel PV. 2016. Demand for improved fish feed in the presence of a subsidy: A double hurdle application in Kenya. Agricultural Economics **47**: 633–43. https://doi.org/10.1111/agec.12261.

Amanor-Boadu V, Zereyesus Y, Ross K. 2015. Agricultural production survey for the northern regions of Ghana: 2013–2014 results. Kansas State University Press, Manhattan, KS.

Amundsen I. 2019. Political corruption in Africa: Extraction and power preservation. Edward Elgar Publishing, Cheltenham, UK. https://doi.org/10.1002/pa.2180.

Anang BT, Bäckman S, Sipiläinen T. 2020. Adoption and income effects of agricultural extension in northern Ghana. Scientific African 7 (e00219). https://doi.org/10.1016/j.sciaf.2019.e00219.

Anang BT, Kudadze S. 2019. Ghana's fertiliser subsidy programme: Assessing farmer participation and perceptions of its effectiveness. International Journal of Agricultural Sciences **12**: 191–203. https://doi.org/10.25077/ijasc.3.1.1-11.2019.

Andani A, Moro AHB, Issahaku G. 2020. Fertilizer subsidy policy and smallholder farmers crop productivity: The case of maize production in North-Eastern Ghana. Journal of Agricultural Extension and Rural Development **12**: 18–25. https://doi.org/10.5897/JAERD2020.1138.

Andreasen C, Stryhn H, Streibig JC. 1996. Decline of the flora in Danish arable fields. Journal of Applied Ecology **33**: 619–626. https://doi.org/10.2307/2404990.

Ansah IGK, Lambongang M, Donkoh SA. 2020. Ghana's Planting for Food and Jobs Programme: A look at the role of capability in farmers' participation. Journal of Human Development and Capabilities **21**: 161–182. https://doi.org/10.1080/19452829.2020.1745162.

Antwi M, Duker AA, Fosu M, Abaidoo RC. 2016. Geospatial approach to study the spatial distribution of major soil nutrients in the Northern region of Ghana. Cogent Geoscience 2 (1201906). https://doi.org/10.1080/23312041.2016.1201906.

Arndt C, Pauw K, Thurlow J. 2015. The economy-wide impacts and risks of Malawi's farm input subsidy program. American Journal of Agricultural Economics **98**: 962–980. https://doi.org/10.1093/ajae/aav048.

Arslan A, McCarthy N, Lipper L, Aswaf S, Cattaneo A. 2014. Adoption and intensity of adoption of conservation farming practice in Zambia. Agriculture, Ecosystems and Environment **187**: 72–86. https://doi.org/10.1016/j.agee.2013.08.017.

Aryal JP, Sapkota TB, Rahut DB, Krupnik TJ, Shahrin S, Jat M, Stirling CM. 2020. Major climate risks and adaptation strategies of smallholder farmers in Coastal Bangladesh. Environmental Management **66**: 105–120. https://doi.org/10.1007/s00267-020-01291-8.

Asaaga FA, Hirons MA, Malhi Y. 2020. Questioning the link between tenure security and sustainable land management in cocoa landscapes in Ghana. World Development **130**: 104913. https://doi.org/10.1016/j.worlddev.2020.104913.

Asante F, Bawakyillenuo S. 2021. Farm-level effects of the 2019 Ghana planting for food and jobs program: An analysis of household survey data. IFPRI Working Paper 57 https://doi.org/10.2499/p15738coll2.134458.

Asante KB, Mullard S. 2021. Social accountability and anti- corruption in Ghana's fertiliser subsidy programme. U4 Anti-Corruption Resource Centre. Available from: https://www.u4.no/publications/social-accountability-and-anti-corruption-in-ghanas-fertiliser-subsidy-programme (accessed May 2021).

Awotide BA, Awoyemi TT, Salman KK. 2013a. Impact of seed voucher system on income inequality and rice income per hectare among rural households in Nigeria : A randomized control trial (RCT) Approach. Quarterly Journal of International Agriculture **52**: 95–117.

Awotide BA, Karimov A, Diagne A, Nakelse T. 2013b. The impact of seed vouchers on poverty reduction among smallholder rice farmers in Nigeria. Agricultural Economics **44**: 647–

658. https://doi.org/10.1111/agec.12079.

Azumah SB, Zakaria A. 2019. Fertilizer subsidy and rice productivity in Ghana: A microeconomic study. Journal of Agricultural Studies **7**: 82–102. https://doi.org/10.5296/jas.v7i1.14367.

Bandura A. 2000. Self-efficacy: the foundation of agency. Pages 17–33 in Perrig WJ, Grob A, editors. Control of human behaviour, mental processes and consciousness. Lawrence Erlbaum Association, New Jersey.

Banful AB, Olayide O. 2010. Perspectives of selected stakeholder groups in Nigeria on the federal and state fertilizer subsidy programmes. NSSP Report 8. Washington, DC, IFPRI, BNFT. Available from https://www.ifpri.org/publication/ (accessed March 2021).

Banful AB. 2009. Operational details of the 2008 fertilizer subsidy in Ghana–Preliminary report. IFPRI background paper 18, Washington, DC. Available from https://www.ifpri.org/ (accessed May 2021).

Banful AB. 2011. Old problems in the new solutions? Politically motivated allocation of program benefits and the “new” fertilizer subsidies. World Development **39**: 1166–1176. https://doi.org/10.1016/j.worlddev.2010.11.004.

Bariw SA, Kudadze S, Adzawla W. 2020. Prevalence, effects and management of fall army worm in the Nkoranza South Municipality, Bono East region of Ghana. Cogent Food & Agriculture **6**: 1800239. https://doi.org/10.1080/23311932.2020.1800239.

Barney JB, Ketchen DJ, Wright M. 2011. The future of resource-based theory: Revitalization or decline? Journal of Management **37**: 1299–1315. http://dx.doi.org/10.1177/0149206310391805.

Baudron F, Mwanza HM, Triomphe B, Bwalya M. 2007. Conservation agriculture in Zambia:

A case study of Southern Province. In Triomphe B, Kienzle J, Bwalya M, Damgaard-Larsen S, editors. Conservation agriculture in Africa series. African Conservation Tillage Network, Centre de Coopération Internationale de Recherche Agronomique pour le Développement and FAO, Nairobi.

Bayard B, Jolly CM, Shannon DA. 2006. The adoption and management of soil conservation practices in Haiti : The case of rock walls. Agricultural Economic Review **7**: 28–39. DOI: 10.22004/ag.econ.44111.

Bem D. 1970. Beliefs, attitudes, and human affairs. Brooks/Cole Publishing Co., California.

Bem DJ, McConnell HK. 1970. Testing the self-perception explanation of dissonance phenomena: On the salience of premanipulation attitudes. Journal of Personality and Social Psychology **14**: 23–31. https://doi.org/10.1037/h0020916.

Benin S, Johnson M, Abokyi E, Ahorbo G, Jimah K, Nasser G, Owusu V, Taabazuing J, Tenga A. 2013. Revisiting agricultural input and farm support subsidies in Africa – The case of Ghana’s mechanization, fertilizer, block farms, and marketing programs. IFPRI Discussion Paper No. 01300, Washington, DC. http://dx.doi.org/10.2139/ssrn.2373185.

Bia M, Mattei A. 2007. Application of the generalized propensity score. Evaluation of public contributions to Piedmont enterprises. POLIS Working Papers No. 89, Alessandria. Available from https://econpapers.repec.org/paper/ucaucapdv/80.htm (accessed May 2021).

Bia M, Mattei A. 2012. Assessing the effect of the amount of financial aids to Piedmont firms using the generalized propensity score. Statistical Methods and Applications **21**: 485–516. https://doi.org/10.1007/s10260-012-0193-4.

Bopp C, Engler A, Poortvliet PM, Jara-Rojas R. 2019. The role of farmers’ intrinsic motivation in the effectiveness of policy incentives to promote sustainable agricultural practices. Journal of Environmental Management **244**: 320–327. https://doi.org/10.1016/j.jenvman.2019.04.107.

Boz I, Akbay C. 2005. Factors influencing the adoption of maize in Kahramanmaras province of Turkey. Agricultural Economics **33**: 431–440. https://doi.org/10.1111/j.1574-0864.2005.00305.x.

Burke WJ, 2019. Understanding fertilizer adoption and effectiveness on maize in Zambia. Food Policy **86**: 101721. https://doi.org/10.1016/j.foodpol.2019.05.004.

Business and Financial Times. 2019. Planting for food and jobs records more successes as Ghana resumes export of maize, other foodstuffs. 8 January 2019: p1. Available from https://www.gepaghana.org/planting-for-food-and-jobs-records-more-successesas-ghana-resumes-export-of-maize-other-foodstuffs/ (accessed Febuary 2021).

Calabi-Floody M, Medina J, Rumpel C, Condron LM, Hernandez M, Dumont M, Morak LM. 2018. Smart fertilizers as a strategy for sustainable agriculture. Advances in Agronomy **147**: 119–157 https://doi.org/10.1016/bs.agron.2017.10.003.

Cameron AC, Trivedi PK. 1990. Regression-based tests for overdispersion in the Poisson model. Journal of Econometrics **46**: 347–364. https://doi.org/10.1016/0304-4076(90)90014-K.

Campos EVR, Proença PLF, Oliveira JL, Bakshi M, Abhilash PC, Fraceto LF. 2019. Use of botanical insecticides for sustainable agriculture: Future perspectives. Ecological Indicators. **105**: 483–495. https://doi.org/10.1016/j.ecolind.2018.04.038.

Cao S, Xu C, Chen L, Wang X. 2009. Attitudes of farmers in China's Northern Shaanxi Province towards the land-use changes required under the grain for green project, and implications for the project's success. Land Use Policy **26**: 1182–1194. https://doi.org/10.1016/j.landusepol.2009.02.006.

Carter MR, Laajaj R, Yang D. 2014. Subsidies and persistent technology adoption: Field experimental evidence from Mozambique. National Bureau of Economic Research Working Paper No. 20465. Vailable from http://www.nber.org/papers/w20465 (accessed November 2020).

Cedrez CB, Chamberlin J, Guo Z, Hijmans RJ. 2020. Spatial variation in fertilizer prices in Sub-Saharan Africa. PLoS ONE 15 (e0227764.). https://doi.org/10.1371/journal.pone.0227764.

Chibwana C, Fisher M, Jumbe C, Masters W, Shively G. 2014. Measuring the impacts of Malawi's farm input subsidy programme. African Journal of Agriculture and Resource Economics **9**: 132–147. DOI: 10.22004/ag.econ.176511.

Chirwa E, Dorward A. 2013. Agricultural input subsidies: The recent Malawi experience. Oxford University Press, Oxford. https://doi.org/10.1017/S0022278X15000300.

Chirwa EW, Matita M, Dorward A. 2011. Factors influencing access to agricultural input subsidy coupons in Malawi. Working Paper 027. Available from https://www.future-agricultures.org/ (accessed December 2018).

Chirwa TG. 2010. Program evaluation of agricultural input subsidies in Malawi using treatment effects: Methods and practicability based on propensity scores. MPRA Paper No. 20878. Available from https://mpra.ub.uni-muenchen.de/20878/ (accessed May 2021).

CitiNewsroom (CNR). 2020. Ghana loses GHS120m to fertilizer smuggling – PFJ secretariat. CNR, Accra. Available from https://citinewsroom.com/2020/05/ghana-loses-ghs120m-to-fertilizer-smuggling-pfj-secretariat/ (accessed October 2021).

Coxe S, West SG, Aiken LS. 2009. The analysis of count data: A gentle introduction to poisson regression and its alternatives. Journal of Personality Assessment **91**: 121–136. https://doi.org/10.1080/00223890802634175.

Daily Guide. 2020. Immigration intercepts smuggled agric items at saboba. Available from https://www.modernghana.com/news/1009610/immigration-intercepts-smuggled-agric-items-at.html (accessed October 2021).

Dang HL, Li E, Nuberg I, Bruwer J. 2014. Understanding farmers' adaptation intention to climate change: A structural equation modelling study in the Mekong Delta, Vietnam. Environmental Science and Policy **41**: 11–22. https://doi.org/10.1016/j.envsci.2014.04.002.

Darkwah KA, Kwawu DJ, Agyire-Tettey F, Sarpong BD. 2019. Assessment of the determinants that influence the adoption of sustainable soil and water conservation practices in Techiman Municipality of Ghana. International Soil and Water Conservation Research **7**: 248–257. https://doi.org/10.1016/j.iswcr.2019.04.003.

Darnhofer I, Schneeberger W, Freyer B. 2005. Converting or not converting to organic farming in Austria: Farmer types and their rationale. Agriculture and Human Values **22**: 39–52. https://doi.org/10.1007/s10460-004-7229-9.

Dayer AA, Lutter SH, Sesser AK, Hickey CM, Gardali T. 2018. Private landowner conservation behavior following participation in voluntary incentive programs: Recommendations to facilitate behavioral persistence. Conservation Letters **11**: 1–11. https://doi.org/10.1111/conl.12394.

Deci EL. 1971. Effects of externally mediated rewards on intrinsic motivation. Journal of Personality and Social Psychology **18**: 105–115. https://doi.org/10.1037/h0030644.

Denning G, Kabembe P, Sanchez P, Malik A, Flor R., Harawa R, Nkhoma P, Zamba C, Banda C, Magombo C, Keating M, Wangila J., Sachs J. 2009. Input subsidies to improve smallholder maize productivity in Malawi: Toward an African green revolution. PLOS Biolog**y** 7 (e1000023) https://doi.org/10.1371/journal.pbio.1000023.

Dionne KY, Horowitz J. 2016. The political effects of agricultural subsidies in Africa: Evidence from Malawi. World Development **87**: 215–226. https://doi.org/10.1016/j.worlddev.2016.06.011.

Donkoh SA, Awuni JA. 2011. Adoption of farm management practices in lowland rice production in Northern Ghana. Journal of Agriculture and Biological Sciences **2**:183–192.

Dorward A, Chirwa E, Kelly V, Jayne T, Boughton D, Slater R. 2008. Evaluation of the 2006/7 agricultural input subsidy program, Malawi. School of Oriental and African Studies, London. DOI: 10.22004/ag.econ.97143.

Dorward A, Chirwa E. 2011. The Malawi agricultural input subsidy programme: 2005/06 to 2008/09. International Journal of Agricultural Sustainability **9**: 232–247. https://doi.org/10.3763/ijas.2010.0567.

Dorward A, Kydd J, Morrison J, Urey I. 2004. A policy agenda for pro-poor agricultural growth. World Development **32**: 73–89. https://doi.org/10.1016/j.worlddev.2003.06.012.

Doyle WR. 2011. Effect of increased academic momentum on transfer rates: An application of the generalized propensity score. Economics of Education Review **30**: 191–200. https://doi.org/10.1016/j.econedurev.2010.08.004.

Druilhe Z, Barreiro-hurlé J. 2012. Fertilizer subsidies in sub-Saharan Africa. ESA Working paper No. 12-04. FAO, Rome. DOI: 10.22004/ag.econ.288997.

Dupas P. 2014. Short-run subsidies and long-run adoption of new health products: Evidence from a field experiment. Econometrica **82**: 197–228. https://doi.org/10.3982/ECTA9508.

Duram LA. 2000. Agents' perceptions of structure: How Illinois organic farmers view political, economic, social, and ecological factors. Agriculture and Human Values **17**: 35–48. https://doi.org/10.1023/A:1007632810301.

Eagly A, Chaiken S. 1993. The psychology of attitudes. Harcourt Brace Jovanovich College Publishers, San Diego.

Ellis F. 1992. Agricultural policies in developing countries. Cambridge University Press, New York. https://doi.org/10.2307/1242939.

Engler A, Jara-Rojas R, Bopp C. 2016. Efficient use of water resources in vineyards: A recursive joint estimation for the adoption of irrigation technology and scheduling. Water Resources Management **30**: 5369–5383. https://doi.org/10.1007/s11269-016-1493-5.

Esham M, Garforth C. 2013. Agricultural adaptation to climate change: Insights from a farming community in Sri Lanka. Mitigation and Adaptation Strategies for Global Change **18**: 535–549. DOI: 10.1007/s11027-012-9374-6.

European Union. 2021. The use of pesticides in developing countries and their impact on health and the right to food. EU Directorate-General for External Policies, Brussels. DOI: 10.2861/953921.

FAO – Food and Agricultural Organization of the United Nations. 1989. Sustainable development and natural resources management. Twenty-Fifth Conference, Paper C 89/2 Supplement 2, Rome.

FAO – Food and Agricultural Organization of the United Nations. 2014. The State of Food and Agriculture: Innovation in Family Farming. FAO, Rome.

FAO. 2011. Current world fertilizer trends and outlook to 2010/2011. pp. 1–57. FAO, Rome.

Available from http://www.rrojasdatabank.info/cwfto11.pdf (accessed October 2020).

Fearon J, Adraki PK, Boateng VF. 2015. Fertilizer subsidy programme in Ghana: Evidence of performance after six years of implementation. Journal of Biology, Agriculture and Healthcare **5**: 100–107.

Fernández E, Iglesias-Antelo S, López-López V, Rodríguez-Rey M, Fernandez-Jardon CM. 2019. Firm and industry effects on small, medium-sized and large firms' performance. Business Research Quarterly **22**: 25–35. https://doi.org/10.1016/j.brq.2018.06.005.

Fernandez MA. 2017. Adoption of erosion management practices in New Zealand. Land Use Policy **63**: 236–245. https://doi.org/10.1016/j.landusepol.2017.01.040.

Flores-lagunes A, Gonzalez A, Neumann T. 2007. Estimating the effects of length of exposure to a training program: The case of job corps. Institute for the Study of Labor (IZA) discussion paper No. 2846. Available from http://ftp.iza.org/dp2846.pdf (accessed April 2020).

Foguesatto CR, Borges JAR, Machado JAD. 2020. A review and some reflections on farmers' adoption of sustainable agricultural practices worldwide. Science of the Total Environment. **729**: 138831. https://doi.org/10.1016/j.scitotenv.2020.138831.

Foley J.A, Ramankutty N, Kate A, Brauman1 AK, Cassidy ES, Gerber1 JS, Johnston1 M, Mueller1 DN, O'Connell1 C, Ray DK, West CP, Balzer C, Bennett EM, Carpenter SR, Hill J, Monfreda C, Polasky S, Rockstrom J, Sheehan1 J, Siebert S, Tilman D, Zaks DPM. 2011. Solutions for a cultivated planet. Nature **478**: 337–342. https://doi.org/10.1038/nature10452.

Fombrun C. 1996. Reputation: Realizing value from the corporate image. Harvard Business School Press, Boston Mass.

Foresight. 2011. The future of food and farming: Challenges and choices for global sustainability. Final project report, The government Office for Science, London. Available from doi: 10.1016/j.anifeedsci.2011.04.036 (accessed May 2020).

Frey BS, Jegen R. 2001. Motivation crowding theory. Journal of Economic Surveys **15**: 589–611. https://doi.org/10.1111/1467-6419.00150.

Gaines-Ross L. 2008. Corporate reputation: 12 steps to safeguarding and recovering reputation. John Wiley and Sons, New Jersey.

Garcia A. 2020. The environmental impacts of agricultural intensification. Technical Note N. 9. Consortium of International Agricultural Research Centers (CGIAR), Montpellier.

Gautam M. 2015. Agricultural subsidies: Resurging interest in a perennial debate. Indian Journal of Agricultural Economics **70**: 83–105. DOI: 10.22004/ag.econ.229968.

Ghana Business News 2018. Planting for food and jobs fraught with challenges in first year – Study. 8 September 2018: pl. Available from https://www.ghanabusinessnews.com (accessed May 2021).

Ghana News Agency. 2011. Security personnel intercept 2 vehicles smuggling fertilizer to Togo. Available from https://www.myjoyonline.com/security-personnel-intercept-two-vehicles-smuggling-fertiliser-to-togo/#! (accessed October 2021).

Ghana Statistical Service 2014. Ghana living standard survey (GLSS) 6: Poverty profile in Ghana: 2005 – 2013. GSS, Accra. Available from www. statsghana.gov.gh (accessed Febuary 2021).

Ghana Statistical Service 2019. Population by regions. Available from www. statsghana.gov.gh (accessed Febuary 2021).

GhanaWeb. 2018. 71,501 Upper East farmers register for Planting for Food and Jobs. Available from https://www.ghanaweb.com/GhanaHomePage/business/71-501-Upper-East-farmers-register-for-Planting-for-Food-and-Jobs-651391 (accessed October 2020).

GhanaWeb. 2020. 10 Togolese nabbed with 16 PFJ fertilizer at Bunkpurugu. Available from https://www.ghanaweb.com/GhanaHomePage/NewsArchive/10-Togolese-nabbed-with-16-PFJ-fertilizer-at-Bunkpurugu-997825 (accessed October 2021).

Gomiero T, Pimentel D, Paoletti MG. 2011. Environmental impact of different agricultural management practices: Conventional vs. Organic agriculture. Critical Reviews in Plant Sciences **30**: 95–124. https://doi.org/10.1080/07352689.2011.554355.

Gopel J. Schungel J, Stuch B, Schaldach R. 2020. Assessing the effects of agricultural intensification on natural habitats and biodiversity in Southern Amazonia. PLoS ONE 15 (e0225914). https://doi.org/10.1371/journal.pone.0225914.

Graphic Online. 2020. Planting for Food and Jobs: A success story others seek to replicate. Graphic NewsPlus, Accra. Available from https://www.graphic.com.gh/news/general-news/planting-for-food-and-jobs-a-success-story-others-seek-to-replicate.html (accessed December 2020).

Graphic Online. 2021. 2021 State of the Nation address (SONA) by President Akufo-Addo. Available from https://www.graphic.com.gh/news/politics/ghana-news-2021-state-of-the-nation-address-by-president-akufo-addo-full-address.html (accessed on April 2021).

Green KM, DeWan A, Arias AB, Hayden D. 2013. Driving adoption of payments for ecosystem services through social marketing, Veracruz, Mexico. Conservation Evidence **10**: 48–52.

Greene WH. 2003. Econometric analysis, 5th edition. Prentice Hall, New Jersey.

Greiner R, Patterson L, Miller O. 2009. Motivations, risk perceptions and adoption of conservation practices by farmers. Agricultural Systems **99**: 86–104.

https://doi.org/10.1016/j.agsy.2008.10.003.

Griffiths MD, Kickul J, Carsrud AL. 2009. Government bureaucracy, transactional impediments and entrepreneurial intentions. International Small Business Journal **27**: 626–45. https://doi.org/10.1177/0266242609338752.

Gujarati DN. 1995. Basic econometrics. McGraw-Hill, New York.

Habtewold TM. 2018. Adoption and impact of improved agricultural technologies on rural poverty. Pages 13–38 in Heshmati A, Yoon H, editors. Economic growth and development in Ethiopia. Perspectives on development in the Middle East and North Africa (MENA) Region. Springer, Singapore. https://doi.org/10.1007/978-981-10-8126-2_2.

Harrigan J. 2008. Food insecurity, poverty and the Malawian Starter Pack: Fresh start or false start? Food Policy **33**: 237-249. https://doi.org/10.1016/j.foodpol.2007.09.001.

Heckman JJ, Ichimura H, Todd PE. 1997. Matching as an econometric evaluation estimator: Evidence from evaluating a job training programme. Review of Economic Studies **64**: 605–654. https://doi.org/10.2307/2971733.

Hemming DJ, Chirwa EW, Dorward A, Holly JR, Hill R, Osborn J, Langer L, Harman L, Asaoka H, Coffey C, Phillips D. 2018. Agricultural input subsidies for improving productivity, farm income, consumer welfare and wider growth in low- and lower-middle-income countries: a systematic review. Campbell Systematic Reviews 2018:4. https://doi.org/10.4073/csr.2018.4.

Heuer A, Liñán F. 2013. Testing alternative measures of subjective norms in entrepreneurial intention models. International Journal of Entrepreneurship and Small Business **19:** 35–50. DOI: 10.1504/IJESB.2013.054310.

Himberg N, Omoro L, Pellikka P, Luukkanen O. 2009. The benefits and constraints of participation in forest management. The case of Taita hills, Kenya. Fennia **187**: 61–76.

Hirano K, Imbens G. 2004. Applied Bayesian modelling and causal inference from incomplete-data perspectives. Pages 73–84 in Gelman A, Meng X.-L, editors. The propensity score with continuous treatments. Wiley InterScience, West Sussex. https://doi.org/10.1002/0470090456.ch7.

Holden S, Lunduka R. 2010a. Impacts of the fertilizer subsidy program in Malawi: targeting, household perceptions and preferences. NORAGRIC report 54. Norwegian University of Life Sciences, Ås. Available from https://nmbu.brage.unit.no/nmbu-xmlui/handle/11250/2646176 (accessed March 2021).

Holden S, Lunduka R. 2010b. Too poor to be efficient? Impacts of the targeted fertilizer subsidy programme in Malawi on farm plot level input use, crop choice and land productivity. NORAGRIC Report No. 55. Department of International Environment and Development Studies, Norwegian University of Life Sciences. DOI: 10.13140/RG.2.2.16252.18560.

Houssou N, Kolavalli S, Bobobee E, Owusu V. 2013. Animal traction in Ghana (Working Paper #34). International Food Policy Research Institute, Washington, DC. Available from https://www.ifpri.org (accessed January 2021).

Hyvönen T, Ketoja E, Salonen J, Jalli H, Tiainen J. 2003. Weed species diversity and community composition in organic and conventional cropping of spring cereals. Agriculture, Ecosystems and Environment **97**: 131–149. https://doi.org/10.1016/S0167-8809(03)00117-8.

IFDC – (International Fertilizer Development Centre). 2019. Ghana fertilizer value chain optimization study. Muscle Shoals, AL. Available from https://ifdc.org/resources/ghana-fertilizer-value-chain-optimization-study/ (accessed May 2021).

Imbens GW. 2000. The role of the propensity score in estimating dose-response functions. Biometrika **87**: 706–710. https://doi.org/10.1093/biomet/87.3.706.

Imoru JA, Ayamga M. 2015. Fertilizer subsidy effects on fertilizer use in the northern region of Ghana. African Journal of Agricultural Research **10**: 4926-4936. https://doi.org/10.5897/AJAR2015.10327.

Imrey PB. 2000. Poisson regression, logistic regression, and loglinear models for random counts. Pages 391-437 in Tinsley EAH, Brown DS, editors. Handbook of applied multivariate statistics and mathematical modeling. Academic Press, Califonia.

Isgin T, Bilgic A, Forster DL, Batte MT. 2008. Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. Computers and Electronics in Agriculture **62**: 231–242. https://doi.org/10.1016/j.compag.2008.01.004.

Jama B, Harawa R, Kiwia A, Rarieya M, Kimani D, Zeila A, Scarpone J. 2013. Improving soil health in Africa: Challenges and promising solutions. Pages 44–50 in von Braun A, Bwalya M, Elhaut T, Ngongi N, Osei R, Toenniessen G, editors. Africa agriculture status report: focus on staple crops. Alliance for a Green Revolution in Africa (AGRA), Nairobi, Kenya.

Jansson KH, Huisman CJ, Lagerkvist CJ, Rabinowicz E. 2013. Agricultural credit market institutions: A comparison of selected european countries. Factor Markets Working Papers No. 33. Avaliable from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2198808 (accessed May 2021).

Jara-Rojas R, Bravo-Ureta BE, Díaz J. 2012. Adoption of water conservation practices: A socioeconomic analysis of small-scale farmers in Central Chile. Agricultural Systems. **110**: 54–62. https://doi.org/10.1016/j.agsy.2012.03.008.

Jayne T, Kolavalli S, Debrah K, Ariga J, Brunache P, Kabaghe C, Nunez-Rodriguez W, Baah KO, Bationo A, Huising E, Lambrecht I, Diao X, Yeboah F, Benin S, Andam K. 2015a. Towards a sustainable soil fertility strategy in Ghana. A report submitted to the ministry of food and agriculture of government of Ghana. International Food Policy Research Institute (IFPRI), Washinton, DC.

Jayne TS, Mason MN, Burke JW, Ariga J. 2018. Review: Taking stock of Africa's second-generation agricultural input subsidy programs. Food Policy **75**: 1–14. https://doi.org/10.1016/j.foodpol.2018.01.003.

Jayne TS, Mason N, Burke W, Shipekesa A, Chapoto A, Kabaghe C. 2011. Mountains of maize, persistent poverty. Policy synthesis No. 48. Ministry Agriculture and Cooperative, Lusaka. Available from https://ageconsearch.umn.edu/record/118476/ (accessed March 26, 2021).

Jayne TS, Mather D, Mason NM, Ricker-Gilbert J, Crawford EW. 2015b. Rejoinder to the comment by Dorward A. and Chirwa E. on how do fertilizer subsidy programs affect total fertilizer use in sub-Saharan Africa? Crowding out, diversion, and benefit/cost assessments. Agricultural Economics **46**: 745–755. https://doi.org/10.1111/agec.12190.

Jayne TS, Mather D, Mason NM, Ricker-Gilbert J. 2013. How do fertilizer subsidy pro- grams affect total fertilizer use in sub-Saharan Africa? Crowding out, diversion, and benefit/ cost assessments. Agricultural Economics **44**: 687–703. https://doi.org/10.1111/agec.12082.

Jayne TS, Rashid S. 2013. Input subsidy programs in sub-Saharan Africa: A synthesis of recent evidence. Agricultural Economics **44**: 547–562. https://doi.org/10.1111/agec.12073.

José-María L, Armengot L, Blanco-Moreno JM, Bassa M, Sans FX. 2010. Effects of agricultural intensification on plant diversity in Mediterranean dryland cereal fields. Journal of Applied Ecology **47**: 832–840. https://doi.org/10.1111/j.1365-2664.2010.01822.x.

Kaiser F, Wölfing S, Fuhrer U. 1999. Environmental attitude and ecological behaviour. Journal of Environmental Psychology **19**: 1–19. https://doi.org/10.1006/jevp.1998.0107.

Karamba RW, Winters PC. 2015. Gender and agricultural productivity: Implications of the farm input subsidy program in Malawi. Agricultural Economics **46**: 357–374. https://doi.org/10.1111/agec.12169.

Kassie M, Teklewold H, Jaleta M, Marenya P, Erenstein O. 2015. Understanding the adoption ofa portfolio ofsustainable intensification practices in eastern and southern Africa. Land Use Policy **42**: 400–411. https://doi.org/10.1016/j.landusepol.2014.08.016.

Kassie M, Zikhali P, Manjur K, Edwards S. 2009. Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia. Natural Resources Forum **33**: 189–198. https://doi.org/10.1111/j.1477-8947.2009.01224.x.

Kato T, Greeley M. 2016. Agricultural input subsidies in sub-Saharan Africa. IDS Bulletin 47: 33–48. https://doi.org/10.19088/1968-2016.130.

Kaufmann D, Kraay A, Mastruzzi M. 2005. Governance Matters IV: Governance Indicators for 1996-2004. World Bank Policy Research Working Paper Series No. 3630. http://dx.doi.org/10.2139/ssrn.718081.

Kausar Y, Abbasian E, Hussain T. 2011. Impact of educated farmer on agricultural product. Journal of Public Administration and Governance **1**: 158–164. https://doi.org/10.5296/jpag.v1i2.948.

Khan M, Andreoni A, Roy P. 2019. Anti-corruption in adverse contexts: strategies for improving implementation. SOAS-ACE Working Paper No. 13. London: SOAS University of London. Available from https://eprints.soas.ac.uk/23495/ (accessed May 2021).

Kherallah M, Delgado C. Gabre-Madhin E, Minot N, Johnson M. 2002. Reforming agricultural markets in Africa. IFPRI Food Policy Statement No. 38. Available from https://www.ifpri.org (accessed May 2020). DOI: 10.2307/4107281.

Kibue GW, Liu X, Zheng J, Pan G, Li L, Han X. 2016. Farmers' perceptions of climate variability and factors influencing adaptation: Evidence from Anhui and Jiangsu, China. Environmental Management **57**: 976–986. https://doi.org/10.1007/s00267-016-0661-y.

Klieštik T, Kočišová K, Mišanková M. 2015. Logit and Probit model used for prediction of financial health of company. Procedia Economics and Finance **23**: 850–855. https://doi.org/10.1016/S2212-5671(15)00485-2.

Kluve J, Schneider H, Uhlendorff A, Zhao Z. 2007. Evaluating continuous training programs using the generalized propensity score. IZA Discussion Paper No. 3255: 587–617.

Kluve J, Schneider H, Uhlendorff A, Zhao Z. 2012. Evaluating continuous training programmes by using the generalized propensity score. Journal of the Royal Statistical Society **175**: 587–617. https://doi.org/10.1111/j.1467-985X.2011.01000.x.

Knowler D, Bradshaw B. 2007. Farmers' adoption of conservation agriculture: A review and synthesis of recent research. Food Policy **32**: 25–48. https://doi.org/10.1016/j.foodpol.2006.01.003.

Koffi D, Agboka K, Adenka DK, Osae M, Tounou AK, Adjevi AMA, Fening KO, Meagher RL. 2020. Maize infestation of fall armyworm (Lepidoptera: Noctuidae) within agro-ecological zones of Togo and Ghana in West Africa 3 yr after its invasion. Environmental Entomology **49**: 645–650. https://doi.org/10.1093/ee/nvaa048.

Kollmuss A, Agyeman J. 2002. Mind the gap: why do people behave environmentally and what are the barriers to pro-environmental behaviour. Environmental Education Research **8**:

239–260. https://doi.org/10.1080/1350462022014540.

Koppmair S, Kassie M, Qaim M. 2017. The influence of farm input subsidies on the adoption of natural resource management technologies. Australian Journal of Agricultural and Resource Economics **61**: 539–556. https://doi.org/10.1111/1467-9566.12109.

Kotu BH, Alene A, Manyong V, HoeschleZeledon I, Larbi A. 2017. Adoption and impacts of sustainable intensification practices in Ghana. International Journal of Agricultural Sustainability **15**: 539–554. https://doi.org/10.1080/14735903.2017.1369619.

Kumar A, Takeshima H, Thapa G, Adhikari N, Saroj S, Karkee M, Joshi PK. 2020. Adoption and diffusion of improved technologies and production practices in agriculture: Insights from a donor-led intervention in Nepal. Land Use Policy **95**: 104621. https://doi.org/10.1016/j.landusepol.2020.104621.

Kuntashula E. 2021. Impact of the farmer input support policy on agricultural production diversity and dietary diversity in Zambia. AERC CRA Policy Brief. Available from https://www.africaportal.org (accessed Octobr 2021).

Kwao P. 2014. Procurement challenges in the implementation of fertilizer subsidy program in Ashanti region [MSc. Thesis]. Kwame Nkrumah University of Science and Technology, Kumasi.

Lambongang M. Ansah IGK, Donkoh SA. 2019. Participation and yield effect of Ghana's Planting for Food and Jobs programme in Bunkpurugu-Yunyoo District. Ghana Journal of Agricultural Economics and Agribusiness **2**: 86–98.

Lambsdorff JG. 2003. How corruption affects productivity. Kyklos **56**: 457–474. https://doi.org/10.1046/j.0023-5962.2003.00233.x.

Langyintuo AS, Mungoma C. 2008. The effect of household wealth on the adoption of improved maize varieties in Zambia. Food policy **33**: 550-559. https://doi.org/10.1016/j.foodpol.2008.04.002.

Lechner M, Strittmatter A. 2015. Practical procedures to deal with common support problems in matching estimation. IZA Discussion Papers, No. 10532. Institute of Labor Economics (IZA), Bonn. Available from http://hdl.handle.net/10419/161155 (accessed October 2021).

Leeper TJ. 2021. Interpreting regression results using average marginal efects with R's margins. Available from https://www.semanticscholar.org/paper/Interpreting-Regression-Results-using-Average-with-Leeper/9615c76bd5d81f7ebbbdac9714619863dc3a2337 (accessed December 2021).

Lemessa SD, Yismaw MA, Watabaji MD. 2019. Risk induced farmers' participation in agricultural innovations: Evidence from a field experiment in eastern Ethiopia. Taylor & Francis Online. **6**: 106–117. https://doi.org/10.1080/21665095.2019.1629323.

Liu J, Florax R. 2014. The effectiveness of international Aid : A generalized propensity score analysis. Paper presented at AAEA 2014 Annual Meeting; 27-29 July, Minneapolis. DOI: 10.22004/ag.econ.169804.

Liverpool-Tasie LSO. 2014. Fertilizer subsidies and private market participation: The case of Kano State, Nigeria. Agricultural Economics **45**: 663–78. https://doi.org/10.1111/agec.12114.

Lohr L, Park TA. 2002. Choice of insect management portfolios by organic farmers: Lessons and comparative analysis. Ecological Economics **43**: 87–99. https://doi.org/10.1016/S0921-8009(02)00184-2.

Long N, van der Ploeg J. 1994. Heterogeneity, actor and structure: Towards a reconstitution of the concept of structure. Pages 62–89 in Booth D, editors. Rethinking social development: Theory, research and practice. Longman, London.

Lovo S. 2016. Tenure insecurity and investment in soil conservation. Evidence from Malawi. World Development 78: 219–229. https://doi.org/10.1016/j.worlddev.2015.10.023.

Lunduka R, Ricker-Gilbert J, Fisher M. 2013. What are the farm-level impacts of Malawi's farm input subsidy program? A critical review. Agricultural Economics **44**: 563–579. https://doi.org/10.1111/agec.12074.

Macé K, Morlon P, Munier-Jolain N, Quéré L. 2007. Time scales as a factor in decision-making by French farmers on weed management in annual crops. Agricultural Systems **93**: 115–142. https://doi.org/10.1016/j.agsy.2006.04.007.

Mango N, Makate C, Tamene L, Mponela P, Ndengu G. 2017. Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa. International Soil and Water Conservation Research **5**: 122–129. https://doi.org/10.1016/j.iswcr.2017.04.003.

Marenya P, Barrett C. 2009. State-Conditional fertilizer yield response on Western Kenyan farms. American Journal of Agricultural Economics **91**: 991–1006. https://doi.org/10.1111/j.1467-8276.2009.01313.x.

Mason NM, Jayne TS, Mofya-Mukuka R. 2013. Zambia's input subsidy programs. Agricultural Economics **44**: 613–628. https://doi.org/10.1111/agec.12077.

Mason NM, Jayne TS, van de Walle N. 2017a. The political economy of fertilizer subsidy programs in Africa: Evidence from Zambia. American Journal of Agricultural Economics **99**: 705–731. http://dx.doi.org/10.1093/ajae/aaw090.

Mason NM, Jayne TS. 2013. Fertiliser subsidies and smallholder commercial fertiliser purchases: Crowding out, leakage and policy implications for Zambia. Journal of Agricultural Economics **64**: 558–582. https://doi.org/10.1111/1477-9552.12025.

Mason NM, Ricker-Gilbert J. 2013. Disrupting demand for commercial seed : Input subsidies in Malawi and Zambia. World Development **45**: 75–91. http://dx.doi.org/10.1016/j.worlddev.2012.11.006.

Mason NM, Smale M. 2013. Impacts of subsidized hybrid seed on indicators of economic well-being among smallholder maize growers in Zambia. Agricultural Economics **44**: 659-70. https://doi.org/10.1111/agec.12080.

Mason NM, Tembo ST. 2015. Do input subsidy programs raise incomes and reduce poverty among smallholder farm households? Evidence from Zambia. IAPRI Working Paper 92. Lusaka. Available from https://ideas.repec.org/p/ags/midcwp/198702.html (accessed March 2021).

Mason NM, Wineman A, Kirimi L, Mather D. 2017b. The effects of Kenya's 'Smarter' input subsidy program on smallholder behavior and incomes: Do different quasi-experimental approaches lead to the same conclusions? Journal of Agricultural Economics **68**: 45–69. https://doi.org/10.1111/1477-9552.12159.

Mather DL, Jayne TS. 2018. Fertilizer subsidies and the role of targeting in crowding out: Evidence from Kenya. Food Security **10**: 397–417. https://doi.org/10.1007/s12571-018-0773-8.

Matsumoto T, Yamano T. 2011. The impacts of fertilizer credit on crop production and income in Ethiopia. Pages 59–72 in Yamano T, Otsuka K, Place F, editors. Emerging Development of Agriculture in East Africa. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-1201-0_4.

Mazvimavi K, Twomlow S. 2009. Socioeconomic and institutional factors influencing adoption of conservation farming by vulnerable households in Zimbabwe. Agricultural Systems **101**: 20–29. https://doi.org/10.1016/j.agsy.2009.02.002.

Mbow C, Smith P, Skole D, Duguma L, Bustamante M. 2014. Achieving mitigation and adaptation to climate change through sustainable agroforestry practices in Africa. Current Opinion in Environmental Sustainability **6**: 8–14. https://doi.org/10.1016/j.cosust.2013.09.002.

Meijer SS, Catacutan D, Ajayi OC, Sileshi GW, Nieuwenhuis M. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability **13**: 40–54. https://doi.org/10.1080/14735903.2014.912493.

Mengstie FA. 2009. Assessment of adoption behaviour of soil and water conservation practices in the Koga Watershed, Highlands of Ethiopia [MPS Thesis]. Cornell University, New York.

Minot N, Benson T. 2009. Fertilizer subsidies in Africa, fertilizer are vouchers the answer? IFPRI Issue Brief 60. International Food Policy Research Institute (IFPRI), Washinton, DC.

Minton L. 2021. Fertilizers in sub-Saharan Africa: What is the potential for growth? Argus Fertilizers in sub-Saharan Africa 2021. Available from https://www.argusmedia.com/en/blog/2020/december/14/fertilizers-in-subsaharan-africa-what-is-the-potential-for-growth (accessed October 2021).

Mlenga DH, Maseko S. 2016. Factors influencing adoption of conservation agriculture : A case for increasing resilience to climate change and variability in Swaziland. Journal of Environment and Earth Science **5**: 16–25.

MoFA – (Ministry of Food and Agriculture, Ghana). 2019. Implementation modalities for 2019 ‘planting for food and jobs campaign’. MoFA, Accra. Available from https://mofa.gov.gh (accessed September 2021).

MoFA – (Ministry of Food and Agriculture, Ghana) . 2010. 2010 fertilizer subsidy programme: implementation guidelines. MoFA, Accra. Available from https://mofa.gov.gh (accessed October 2021).

MoFA – (Ministry of Food and Agriculture, Ghana). 2007. Food and Agriculture Sector Development Policy (FASDEP II). FAO, Rome. Available from http://www.fao.org/faolex (accessed May 2021).

MoFA – (Ministry of Food and Agriculture, Ghana). 2011. Agriculture in Ghana: Facts and Figures (2010). Statistics, Research and Information Directorate, MoFA-Ghana. Available from http://srid-mofaghana.com (accessed May 2021).

MoFA – (Ministry of Food and Agriculture, Ghana). 2017. Planting for food and jobs strategic plan for implementation (2017–2020). Accra Ghana: Statistics, Research, and Information Directorate, MoFA-Ghana. Available from http://mofa.gov.gh (accessed October 2017).

MoFA – (Ministry of Food and Agriculture, Ghana). 2021. Minister’s press briefing; Press briefing by Hon. Dr. Owusu Afriyie Akoto minister for food and agriculture 29th August 2021. Available from https://mofa.gov.gh (accessed October 2021).

Morris M, Kelly V, Kopicki R., Byerlee, D. 2007. Fertilizer use in African agriculture: Lessons learned and good practice guidelines. World Bank, Washington, DC. Available from https://openknowledge.worldbank.org/handle/10986/6650 (accessed August 2019).

Mwangi M, Kariuki S. 2015. Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. Journal of Economics and Sustainable

Development **6**: 208–217.

Mweninguwe R. 2020. Hunger amidst plenty. Available from https://www.dandc.eu/en/article/promising-programme-subsidise-farm-inputs-falling-victim-corruption-and-mismanagement (accessed May 2021).

Nahayo A, Omondi MO, Zhang X, Li L, Pan G, Joseph S. 2017. Factors influencing farmers' participation in crop intensification program in Rwanda. Journal of Integrative Agriculture **16**: 1406–1416. https://doi.org/10.1016/S2095-3119(16)61555-1.

Namonje-Kapembwa T, Jayne TS, Black R. 2015. Does late delivery of subsidized fertilizer affect smallholder maize productivity and production? Paper presented at the AAEA and WAEA annual meeting. San Francisco, CA. DOI: 10.13140/RG.2.2.17099.18722.

Nguyen N, Drakou EG. 2021. Farmers intention to adopt sustainable agriculture hinges on climate awareness: The case of Vietnamese coffee. Journal of Cleaner Production. **303**: 126828. https://doi.org/10.1016/j.jclepro.2021.126828.

Nguyen TH, Sahin O, Howes M. 2021. Climate change adaptation influences and barriers impacting the asian agricultural industry. Sustainability **13**: 7346. https://doi.org/10.3390/su13137346.

Ninsin K. 2018. The corrupt elites: Anatomy of power and wealth in Ghana. Freedom Publications, Accra.

Nkegbe PK, Shankar B. 2014. Adoption intensity of soil and water conservation practices by smallholders: Evidence from northern Ghana. Bio-based and Applied Economics **3**: 159–174. https://doi.org/10.13128/BAE-13246.

Nkegbe PK. 2013. Soil conservation and smallholder farmer productivity: An analytical approach. Journal of Management and Sustainability **3**: 92–99. :

http://dx.doi.org/10.5539/jms.v3n2p92.

Nkegbe PK. 2018. Soil and water conservation practices and smallholder farmer multi-activity technical efficiency in northern Ghana. Ghana Journal of Development Studies **15**: 55–91. http://dx.doi.org/10.4314/gjds.v15i1.4.

Nkomoki W, Bavorová M, Banout J. 2018. Adoption of sustainable agricultural practices and food security threats: Effects of land tenure in Zambia. Land Use Policy **78**: 532–538. https://doi.org/10.1016/j.landusepol.2018.07.021.

Novignon J. Chirwa CG, Frempong BR. 2020. Bringing rigour and evidence to economic policy making in africa impact of agricultural input subsidy on nutritional outcomes in Malawi. AERC Working Paper 005.

Nsouli SM, Havrylyshyn O. 2001. A decade of transition achievements and challenges. International Monetary Fund, Washinton, D.C. https://doi.org/10.5089/9781589060135.072.

Nwaobiala CU, Ubor VU. 2016. Effectiveness of electronic wallet system of growth enhancement support scheme distribution among arable crop farmers in Imo State, south eastern Nigeria. Management, Economic Engineering in Agriculture and Rural Development **16**: 355–360.

Nyanga P, Johnsen F, Aune J, Kalinda T. 2011. Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. Journal of Sustainable Development **4**: 73–85. DOI:10.5539/jsd.v4n4p73.

Nyirongo C. 2005. Do free inputs crowd out the private sector in agricultural input markets? Pages 129-140 in Levy S, editor. Starter Packs: A strategy to fight hunger in developing countries? CABI Publishing, London. DOI: 10.1079/9780851990088.0129

Obayelu AE. 2016. Cross-country comparison of voucher-based input schemes in sub-sahara Africa agricultural transformation: Lessons learned and policy implications. Agriculturae Conspectus Scientificus **81**: 251–267.

Odendo M, Obare G, Salasya B. 2011. What factors influence the speed of adoption of soil fertility management technologies? Evidence from Western Kenya. Journal of Development and Agricultural Economics **3**: 627–637. https://doi.org/10.5897/JDAE11.090.

Ohene FV. 2013. Determinants of farmers' participation in the youth in agriculture programme in the eastern region of Ghana [MPhil Thesis]. University of Ghana, Accra. http://197.255.68.203/handle/123456789/5926.

Olomola AS. 2015. Driving agricultural transformation with the power of information and communication technology: The performance of Nigeria's Growth Enhancement Support Scheme. NSSP Working Paper 30. International Food Policy Research Institute (IFPRI). Washington, DC.

Omotilewa OJ, Ricker-Gilbert J, Ainembabazi JH. 2019. Subsidies for agricultural technology adoption: Evidence from a randomized experiment with improved grain storage bags in Uganda. American Journal of Agricultural Economics **101**: 753–772. https://doi.org/10.1093/ajae/aay108.

Pan L, Christiaensen L. 2012. Who is vouching for the input voucher? Decentralized targeting and elite capture in Tanzania. World Development **40**: 1619–1633. https://doi.org/10.1016/j.worlddev.2012.04.012.

Paracchini ML, Justes E, Wezel A, Zingari PC, Kahane R, Madsen S, Scopel E, Héraut ABP, Buckley R, Colbert E, Kapalla D, Sorge M, Adu AG, Bezner KR, Maes O, Negre T. 2020. Agroecological practices supporting food production and reducing food insecurity in developing countries. JRC121570. Publications Office of the European Union, Luxembourg. DOI:10.2760/82475.

Pauw K, Beck U, Mussa R. 2014. Did rapid smallholder-led agricultural growth fail to reduce rural poverty? Making sense of Malawi 's poverty puzzle. WIDER Working Paper 2014/123. Available from https://www.wider.unu.edu (accessed July 2020).

Pauw K. 2021. A review of the Ghana planting for food and jobs program: 2017-2020 – implementation, impact, and further analysis. IFPRI Working Paper 53. Available from https://knowledge4policy.ec.europa.eu/publication/review-ghana-planting-food-jobs-program-2017-2020_en (accessed November 2021).

PeaceFM Online. 2020. 2020 election results. Available from: https://ghanaelections.peacefmonline.com/ (accessed October 2021).

Pedzisa T, Rugube L, Winter-Nelson A, Baylis K, Mazvimavi K. 2015. The intensity of adoption of conservation agriculture by smallholder farmers in Zimbabwe. Agrekon **54**: 1–22. https://doi.org/10.1080/03031853.2015.1084939.

Petty RE, Cacioppo JT. 1996. Attitude and persuasion: classic and contemporary approaches. Routledge, New York.

Pilarova T, Bavorova M, Kandakov A. 2018. Do farmer, household and farm characteristics influence the adoption of sustainable practices? The evidence from the Republic of Moldova. International Journal of Agricultural Sustainability **16**: 367–384. https://doi.org/10.1080/14735903.2018.1499244.

Piñeiro V, Arias J, Dürr J, Elverdin P, Ibáñez AM, Kinengyere A, Opazo CM, Owoo N, Page JR, Prager DS, Torero M. 2020. A scoping review on incentives for adoption of sustainable agricultural practices and their outcomes. Nature Sustainability **3**: 809–820.

https://doi.org/10.1038/s41893-020-00617-y.

Polomé P. 2016. Private forest owners motivations for adopting biodiversity-related protection programs. Journal of Environmental Management **183**: 212–219. https://doi.org/10.1016/j.jenvman.2016.07.097.

Preston LE. 2004. Reputation as a source of corporate social capital. Journal of General Management **30**: 43–49. https://doi.org/10.1177/030630700403000204.

Pretty J, Toulmin C, Williams S. 2011. Sustainable intensification in African agriculture. International Journal of Agricultural Sustainability **9**: 5–24. https://doi.org/10.3763/ijas.2010.0583.

Price JC, Leviston Z. 2014. Predicting pro-environmental agricultural practices: the social, psychological and contextual influences on land management. Journal of Rural Studies 34: 65–78. https://doi.org/10.1016/j.jrurstud.2013.10.001.

Prokopy LS, Floress K, Klotthor-Weinkauf D, Baumgart-Getz A. 2008. Determinants of agricultural best management practice adoption: Evidence from the literature. Journal of Soil and Water Conservation **63**: 300–311. https://doi.org/10.2489/jswc.63.5.300.

Qaim M. 2020. Role of new plant breeding technologies for food security and sustainable agricultural development. Applied Economic Perspectives and Policy **42**: 129–150. https://doi.org/10.1002/aepp.13044.

Ragasa C, Dankyi A, Acheampong P, Wiredu AN, Chapoto A, Asamoah M, Tripp R. 2013. Patterns of adoption of improved rice technologies in Ghana. IFPRI Working paper No. 35. Available from https://www.ifpri.org/ (accessed October 2020).

Ramírez-López A, Désirée Beuchelt T, Velasco-Misael M. 2013. Factors for adoption and abandonment of conservation agriculture systems in the high valleys of México.

Agricultura, Sociedad y Desarrollo **10**: 195–214.

Ratinger T, Čadil V, Agyemang AS. 2020. Are there any economic impacts of business R&D Support? The case of the Czech Republic. Central European Business Review **9**: 45–62. https://doi.org/10.18267/j.cebr.251.

Raut N, Sitaula BK. 2012. Assessment of fertilizer policy, farmers' perceptions and implications for future agricultural development in Nepal. Sustainable Agriculture Research **1**:188–200. http://dx.doi.org/10.5539/sar.v1n2p188.

Reid GH. 2009. Building resilience to climate change in rain-fed agricultural enterprises: An integrated property planning tool. Agriculture and Human Values **26**: 391–397. https://doi.org/10.1007/s10460-008-9168-3.

Reyes J-D, Roberts M, Xu LC. 2021. The heterogeneous growth effects of the business environment: Firm-level evidence for a global sample of cities. China Economic Quarterly International **1**: 15–28. https://doi.org/10.1016/j.ceqi.2020.09.001.

Ricker-Gilbert J, Jayne T, Shively G. 2013. Addressing the 'wicked problem' of input subsidy programs in Africa. Applied Economic Perspectives and Policy **35**: 322–340. https://doi.org/10.1093/aepp/ppt001.

Ricker-Gilbert J, Jayne TS, Chirwa E. 2011. Subsidies and crowding out: A double-hurdle model of fertilizer demand in Malawi. American Journal of Agricultural Economics **93**: 26–42. https://doi.org/10.1093/ajae/aaq122.

Ricker-Gilbert J, Jayne TS. 2008. The impact of fertilizer subsidies on national fertilizer use: an example from Malawi. Paper presented at the American Agricultural Economics Association Annual Meeting Orlando, July 27-29, 2008. Michigan State University, Lansing, MI. DOI: 10.22004/ag.econ.6464.

Ricker-Gilbert J, Jayne TS. 2010. What are the dynamic effects of fertilizer subsidies on household wellbeing? Evidence from Malawi. Paper presented at the 3rd AAAE and 48th AEASA conference, Cape Town. Available from https://core.ac.uk/reader/6614418 (accessed March 2021).

Ricker-Gilbert J, Jayne TS. 2012. Do fertilizer subsidies boost staple crop production and reduce poverty across the distribution of smallholders in Africa? Quantile regression results from Malawi. Paper presented at the IAAE 2012 triennial conference: **18**–24 August, Foz do Iguaçu, Brazil. DOI: 10.22004/ag.econ.126742.

Ricker-Gilbert J, Jayne TS. 2017. Estimating the enduring effects of fertiliser subsidies on commercial fertiliser demand and maize production: Panel data evidence from Malawi. Journal of Agricultural Economics **68**: 70–97. https://doi.org/10.1111/1477-9552.12161.

Ricker-Gilbert J. 2014. Wage and employment effects of Malawi's fertilizer subsidy program. Agricultural Economics **45**: 337–353. https://doi.org/10.1111/agec.12069.

Rode J, Gómez-Baggethun E, Krause T. 2015. Motivation crowding by economic incentives in conservation policy: A review of the empirical evidence. Ecological Economics **117**: 270–282. http://dx.doi.org/10.1016/j.ecolecon.2014.09.029.

Rogers RW. 1975. A protection motivation theory of fear appeals and attitude change. The Journal of Psychology **91**: 93–114. https://doi.org/10.1080/00223980.1975.9915803.

Rose-Ackerman S. 2004. The challenge of poor governance and corruption. In Lomborg B, editors. Global crises, global solutions: First edition, Cambridge University Press, UK.

Rosenbaum PR, Rubin BD. 1983. The central role of the propensity score in observational studies for causal effects. Biometrika **70**: 41–55. https://doi.org/10.1093/biomet/70.1.41.

Ryan RM, Deci EL. 2000a. Intrinsic and extrinsic motivations: classic definitions and new directions. Contemporary Educational Psychology **25**: 54–67. https://doi.org/10.1006/ceps.1999.1020.

Ryan RM, Deci EL. 2000b. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist **55**: 68–78. https://doi.org/10.1037/0003-066X.55.1.68.

Ryan RM, Deci EL. 2018. Self-determination theory: Basic psychological needs in motivation, development, and wellness. Guilford Press, New York.

Sachs J. 2012. How Malawi fed its own people. The New York Times, 19 April: p1., New York Available from https://www.nytimes.com/2012/04/20/opinion/how-malawi-fed-its-own-people.html (accessed May 2019).

Santeramo FG, Goodwin BK, Adinolfi F, Capitanio F. 2016. Farmer participation, entry and exit decisions in the Italian crop insurance programme. Journal of Agricultural Economics **67**: 639–657. https://doi.org/10.1111/1477-9552.12155.

Schiesari C, Mockshell J, Zeller M. 2017. Farm input subsidy program in Malawi: the rationale behind the policy. MPRA Paper No. 81409.

Schultz TW. 1964. Transforming Traditional Agriculture. Yale University Press, New Haven. https://doi.org/10.2307/2228861.

Seck A. 2017. Fertiliser subsidy and agricultural productivity in Senegal. World Economy **40**: 1989–2006. https://doi.org/10.1111/twec.12487.

Senayah J, Kufogbe S, Dedzoe C. 2005. Land degradation in the Sudan Savanna of Ghana: A case study in the Bawku Area. West African Journal of Applied Ecology **8**: 1–9. DOI: 10.4314/wajae.v8i1.45805.

SEND Ghana. 2019. Over 1,000 percent more East Mamprusi women registered for PFJ in

2018. Available from https://sendwestafrica.org/nu/gh/over-1000-percent-more-east-mamprusi-women-registered-for-pfj-in-2018/ (accessed April 2021).

Serebrennikov D, Thorne F, Kallas Z, McCarthy SN. 2020. Factors influencing adoption of sustainable farming practices in europe: A systemic review of empirical literature. Sustainability (2020) 12: 9719. https://doi.org/10.3390/su12229719.

Sereda VL. 2014. The influence of personal and educational demographic factors on the productivity of farmers in selected geographic regions of the Ukraine [PhD Thesis]. Louisiana State University, Baton Rouge.

Sharma A, Bailey A, Fraser I. 2011. Technology adoption and pest control strategies among UK cereal farmers: Evidence from parametric and nonparametric count data models. Journal of Agricultural Economics **62**: 73–92. https://doi.org/10.1111/j.1477-9552.2010.00272.x.

Sheahan M, Olwande J, Kirimi L, Jayne TS. 2014. Targeting of subsidized fertilizer under Kenya's National Accelerated Agricultural Input Access Program (NAAIAP). Working Paper No. 52. Tegemeo Institute of Agricultural Policy and Development, Nairobi. DOI: 10.22004/ag.econ.202590.

Shiferaw B, Obare G, Muricho G. 2008. Rural market imperfections and the role of institutions in collective action to improve markets for the poor. Natural Resource Forum **32**: 25-39. https://doi.org/10.1111/j.1477-8947.2008.00167.x.

Sibande L, Bailey, A, Davidova S. 2017. The impact of farm input subsidies on maize marketing in Malawi. Food Policy **69**: 190–206. https://doi.org/10.1016/j.foodpol.2017.04.001.

Skinner BF. 1953. Science and human behavior. Macmillan, New York.

Smith M. 2020. Upper West produces over 800,000 metric tonnes of maize under PFJ. GBC-Ghana Online. Available from https://www.gbcghanaonline.com/general/upper-west-produces-over-800000-metric-tonnes-of-maize-under-pfj/2020/ (accessed October.2020).

Snapp S, Jayne TS, Mhango W, Benson T, Ricker-Gilbert J. 2014. Maize yield response to nitrogen in Malawi's smallholder production systems. Malawi strategy support program. IFPRI Working Paper No. 9. DOI: 10.22004/ag.econ.188570.

Stoltzfus JC. 2011. Logistic regression: A brief primer. Academic Emergency Medicine **18**:1099–1104. https://doi.org/10.1111/j.1553-2712.2011.01185.x.

Sud M. 2020. Managing the biodiversity impacts of fertiliser and pesticide use: Overview and insights from trends and policies across selected OECD countries – Environment Working Paper No. 155. OECD, Paris.

Sutcliffe OL, Kay QON. 2000. Changes in the arable flora of central southern England since the 1960s. Biological Conservation **93**: 1–8. https://doi.org/10.1016/S0006-3207(99)00119-6.

Swinnen JFM, Gow HR. 1999. Agricultural credit problems and policies during the transition to a market economy in Central and Eastern Europe. Food Policy **24**:21–47. https://doi.org/10.1016/S0306-9192(98)00067-0.

Tadesse M, Belay K. 2004. Factors influencing adoption of soil conservation measures in Southern Ethiopia: The case of Gununo area. Journal of Agriculture and Rural Development in the Tropics and Subtropics **105**: 49–62.

Takeshima H, Nkonya E, Deb S. 2012. Impact of fertilizer subsidies on the commercial fertilizer sector in Nigeria: Evidence from previous fertilizer subsidy schemes. Working Paper No. 23. IFPRI Nigeria Strategy Support Program II, Abuja. Available from:

https://www.ifpri.org/publication (accessed March 2021).

Takeshima H, Nkonya E. 2014. Government fertilizer subsidy and commercial sector fertilizer demand: evidence from the federal market stabilization program (FMSP) in Nigeria. Food Policy **47**: 1–12. https://doi.org/10.1016/j.foodpol.2014.04.009.

Tanko M, Ismaila S, Sadiq AS. 2019. Planting for Food and Jobs (PFJ): A panacea for productivity and welfare of rice farmers in Northern Ghana. Cogent Economics & Finance 7(e1693121). https://doi.org/10.1080/23322039.2019.1693121.

Tanko M. 2020. Planting for food and jobs (PFJ); the dream and vision of reality. MoFA, Accra. Available from: http://mofa.gov.gh (accessed October 2021).

Tanzi V, Tsibouris G. 1999. Transition and the changing role of government. Finance and Development **36**: 20–23.

Teklewold H. Kassie M, Shiferaw B. 2013. Adoption of multiple sustainable agricultural practices in rural Ethiopia. Journal of Agricultural Economics **64**: 597–623. https://doi.org/10.1111/1477-9552.12011.

Teshome A. 2013. Tenure security and soil conservation investment decisions: empirical evidence from East Gojam, Ethiopia. Journal of Development and Agricultural Economics **6**: 22–32. DOI: 10.5897/JDAE2013.0450.

The Montpellier Panel. 2013. Sustainable intensification: A new paradigm for African agriculture. London. Available from https://ag4impact.org/publications/montpellier-panel-report2013/ (accessed June 2020).

Toenniessen G, Adesina A, DeVries J. 2008. Building an alliance for a green revolution in Africa. Annals of the New York Academic Science **1136**: 233–242. https://doi.org/10.1196/annals.1425.028.

Toma L, Mathijs E. 2007. Environmental risk perception, environmental concern, and propensity to participate in organic farming programmes. Journal of Environmental Management **83**: 145–157. https://doi.org/10.1016/j.jenvman.2006.02.004.

Traikova D, Manolova TS, Möllers J, Buchenrieder G. 2017. Corruption perceptions and entrepreneurial intentions in a transitional context–the case of rural Bulgaria. Journal of Developmental Entrepreneurship **22:** 1750018. https://doi.org/10.1142/S1084946717500182.

Transparency International. 2021. Corruption perceptions index 2011 – 2020. Available from https://www.transparency.org (accessed September 2021).

Traore N, Landry R, Amara N. 1998. On-farm adoption of conservation practices: The role of farm and farmer characteristics, perceptions, and health hazards. Land Economics **74**: 114–127. https://doi.org/10.2307/3147217.

Treisman D. 2000. The causes of corruption: A cross-national study. Journal of Public Economics **76**: 399–457. https://doi.org/10.1016/S0047-2727(99)00092-4.

Truelove HB, Carrico AR, Thabrew L. 2015. A socio-psychological model for analyzing climate change adaptation: A case study of Sri Lankan paddy farmers. Global Environmental Change **31**: 85–97. https://doi.org/10.1016/j.gloenvcha.2014.12.010.

Uduji JI, Okolo-Obasi EN. 2018. Young rural women's participation in the e-wallet programme and usage intensity of modern agricultural inputs in Nigeria. Gender, Technology and Development **22**: 59–81. https://doi.org/10.1080/09718524.2018.1445894.

USAID. 2012. The market for maize, rice, soy, and warehousing in Northern Ghana. USAID–Enabling Agricultural Trade (EAT) Project. USAID-Ghana.

Vale RL, Netto AM, de Lima Xavier BT, de Lavor Paes Barreto M, da Silva JPS. 2019.

Assessment of the gray water footprint of the pesticide mixture in a soil cultivated with sugarcane in the northern area of the State of Pernambuco, Brazil. Journal of Cleaner Production **234**: 925–932. https://doi.org/10.1016/j.jclepro.2019.06.282.

Vondolia GK, Eggert H, Stage J. 2012. Nudging Boserup? The impact of fertilizer subsidies on investment in soil and water conservation. Environment for Development discussion paper series 12–08. DOI: 10.1017/S1355770X15000364.

Vondolia GK, Eggert H, Stage J. 2021. The effect of fertilizer subsidies on investment in soil and water conservation and productivity among ghanaian farmers using mechanized irrigation. Sustainability (2021) **13**: 8242. https://doi.org/10.3390/su13158242.

Wagstaff P, Harty M. 2010. The impact of conservation agriculture on food security in three low veldt districts of Zimbabwe. Trócaire Development Review 2010: 67–84.

Walls HL, Johnston D, Tak M, Dixon J, Hanefeld J, Hull E, Smith DR. 2018. The impact of agricultural input subsidies on food and nutrition security: a systematic review. Food Security **10**: 1425–1436. https://doi.org/10.1007/s12571-018-0857-5.

Ward PS, Bell AR, Droppelmann K, Benton TG. 2018. Early adoption of conservation agriculture practices: Understanding partial compliance in programs with multiple adoption decisions. Land Use Policy **70**: 27–37. https://doi.org/10.1016/j.landusepol.2017.10.001.

Wąs A, Malak-Rawlikowska A, Zavalloni M, Viaggi D, Kobus P, Sulewski P. 2021. In search of factors determining the participation of farmers in agri-environmental schemes – Does only money matter in Poland? Land Use Policy **101**: (2021) 105190. https://doi.org/10.1016/j.landusepol.2020.105190.

Wauters E, Bielders C, Poesen J, Govers G, Mathijs E. 2010. Adoption of soil conservation practices in Belgium: An examination of the theory of planned behaviour in the agri-environmental domain. Land Use Policy **27**: 86–94. https://doi.org/10.1016/j.landusepol.2009.02.009.

Wauters E, Mathijs E. 2014. The adoption of farm level soil conservation practices in developed countries: a meta-analytic review. International Journal of Agricultural Resources, Governance and Ecology **10**: 78–102.

WHO-FAO – (Food and Agriculture Organization of the United Nations and World Health Organization). 2020. Codex alimentarius, pesticides, online publication. Available from https://www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/pestres/en/ (accesed October 2021).

WHO-FAO (Food and Agriculture Organization of the United Nations and World Health Organization). 2019. Global situation of pesticide management in agriculture and public health. Available from https://apps.who.int/iris/handle/10665/329971 (accessed October 2021).

Williams R. 2021. Ordinal independent variables. Available from https://www3.nd.edu/~rwilliam/ (accessed December 2021).

Wilson RS, Howard G, Burnett EA. 2014. Improving nutrient management practices in agriculture: The role of risk-based beliefs in understanding farmers' attitudes toward taking additional action. Water Resource Research **50**: 6735–6746. https://doi.org/10.1002/2013WR015200.

World Bank 2008. New approaches to input subsidies. Agriculture for Development policy brief No. 41390. World Bank Publications, Washington, DC. Available from http://documents1.worldbank.org (accessed November 2020).

World Bank. 2010. Zambia - Impact assessment of the fertilizer support program: analysis of effectiveness and efficiency. Public expenditure review report No. 54864. World Bank Publications, Washington, DC.

World Bank. 2011. Republic of Ghana: Tackling poverty in northern Ghana. World Bank Publications, Washington, D.C. Available from https://www.worldbank.org (accessed December 2020).

World Bank. 2020. Combating corruption. Available from https://www.worldbank.org/en/topic/governance/brief/anti-corruption (accessed May 2021).

Wossen T, Abdoulaye T, Alene A, Feleke S, Ricker-Gilbert J, Manyong V, Awotide AB. 2017 Productivity and welfare effects of Nigeria's e-voucher-based input subsidy program. World Development **97**: 251–265. https://doi.org/10.1016/j.worlddev.2017.04.021.

Xie H, Huang Y. 2021. Influencing factors of farmers' adoption of pro-environmental agricultural technologies in China : Meta-analysis. Land Use Policy 109 (105622). https://doi.org/10.1016/j.landusepol.2021.105622.

Xu Z, Burke WJ, Jayne TS, Govereh J. 2009b. Do input subsidy programs 'crowd in' or 'crowd out' commercial market development? Modelling fertilizer use decisions in a two-channel marketing system. Agricultural. Economics **40**: 79–94. https://doi.org/10.1111/j.1574-0862.2008.00361.x.

Xu Z, Guan Z, Jayne TS, Black R. 2009a. Factors influencing the profitability of fertilizer use on maize in Zambia. Agricultural Economics **40**: 437–446. https://doi.org/10.1111/j.1574-0862.2009.00384.x.

Yazdanpanah M, Hayati D, Hochrainer-Stigler S, Zaman GH. 2014. Understanding farmers' intention and behavior regarding water conservation in the Middle-East and North Africa: a case study in Iran. Journal of Environmental Management **135**: 63–72. https://doi.org/10.1016/j.jenvman.2014.01.016.

Yu P, Phillips PCB. 2018. Threshold regression asymptotics: From the compound Poisson process to two-sided Brownian motion. Economics Letters **172**: 123–126. https://doi.org/10.1016/j.econlet.2018.08.039.

Zanna MP, Rempel JK. 1988. Attitudes: A new look at an old concept. Pages 315–334 in Bar-Tal D, Kruglanski AW, editors. The social psychology of knowledge. Cambridge University Press, Cambridge.

Zeweld W, Huylenbroeck GV, Tesfay G, Azadi H, Speelman S. 2020. Sustainable agricultural practices, environmental risk mitigation and livelihood improvements: Empirical evidence from Northern Ethiopia. Land Use Policy **95**: 103799. https://doi.org/10.1016/j.landusepol.2019.01.002.

Zeweld W, Van Huylenbroeck G, Tesfay G, Azadi H, Speelman S. 2018 Impacts of socio-psychological factors on actual adoption of sustainable land management practices in dryland andwater stressed areas. Sustainability (2018) **10**: 2963. https://doi.org/10.3390/su10092963.

Zeweld W, Van Huylenbroeckb G, Tesfaya G, Azadic H, Speelmanb S. 2017. Smallholder farmers' behavioural intentions towards sustainable agricultural practices. Journal of Environmental Management. **187**: 71–81. https://doi.org/10.1016/j.jenvman.2016.11.014.

Zhao ZH, Hui C, He D-H, Li B-H. 2015. Effects of agricultural intensification on ability of natural enemies to control aphids Scientific Reports 5(8024). https://doi.org/10.1038/srep08024.

Zinnbauer M, Mockshell J, Zeller M. 2017. Effects if Fertilizer Subsidies in Zambia: A Literature Review. MPRA Paper No. 84320.

10. List of Author's Scientific Contributions

10.1. Publications

Agyemang SA, Ratinger T, Bavorová M. 2021. The impact of agricultural input subsidy on productivity – The case of Ghana. European Journal of Development Research (2021). https://doi.org/10.1057/s41287-021-00430-z.

Agyemang SA, Bavorová M. 2021. Sampling. Pages 65–83 in Bavorová M, editor. Survey design. Prague: Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague.

Agyemang SA, Ratinger T, Ahado S. 2020. Has microcredit boosted poultry production in Ghana? Agricultural Finance Review **80**: 135–152. https://doi.org/10.1108/AFR-03-2019-0030.

Ratinger T, Čadil V, **Agyemang AS**. 2020. Are there any economic impacts of business R&D support? The case of the Czech Republic. Central European Business Review **9**: 45–62. doi: 10.18267/J.CEBR.251.

10.2. Conferences

Medonos T, Ratinger T, Curtiss J, **Agyemang AS**, Hruška M. 2018. Ambiguous performance of the RDP support to modernisation of agriculture in the Czech Republic: Time to consider new options. 162nd EAAE Seminar. "The evaluation of new CAP instruments: Lessons learned and the road ahead". 26–27 April 2018, Budapest, Hungary.

Agyemang SA, Ratinger T. 2018. Agricultural efficiency and food security: Is microcredit the answer? ELLS Scientific Student Conference. "Life Sciences: Looking Across Disciplines". 9–10 November 2018, Wageningen, The Netherlands.

Ratinger T, Vladislav C, **Agyemang AS**. 2018. Evaluation of socio-economic impacts of the business R&D support in small economies. The case of the Czech Republic. Austrian Presidency of the Council of the European Union Conference. "Impact of Research and Innovation Policy at the Crossroads of Policy Design, Implementation and Evaluation". 5–6. November 2018, Wien, Austria.

Ratinger T, Čadil V, **Agyemang AS**. 2019. Are there any economic impacts of business R&D support? The case of the Czech Programme TIP. The 7th International Conference Innovation Management, Entrepreneurship and Sustainability (IMES). 30–31 May 2019, Prague, Czech Republic.

Agyemang SA, Ratinger T. 2021. Can Agricultural Input Subsidy Enhance Productivity and Food Security? – The Case of Ghana. XVI EAAR Congress. "Raising the impact of Agricultural Economics: Multidisciplinary, Stakeholder Engagement and Novel Approaches". 20–23 July 2021, Prague, Czech Republic.

11. Appendices

11.1. Appendix 1: Correlation coefficients of the SAPs and covariates of PFJ participation

Table A 1: Correlation coefficients of the sustainable agricultural practices

SAPs	Crop rotation	Intercropping	Cover cropping	Zero tillage
Crop rotation	1			
Intercropping	0.0126	1		
Cover cropping	-0.0592	0.1459	1	
Zero tillage	-0.1884	0.2061	0.0071	1
Row planting	0.1667	0.2096	0.2616	0.2966
Mulching	-0.1819	-0.1773	0.0699	0.0175
Composting	0.1153	0.1249	0.249	0.2207
Manure	0.1316	0.0863	0.2633	0.059
	Row planting	Mulching	Composting	Manure
Row planting	1			
Mulching	-0.0817	1		
Composting	0.2481	0.0237	1	
Manure	0.2192	-0.0237	0.1957	1

Source: Author’s estimation from survey data

Table A 2: Correlation coefficients of the explanatory variables of PFJ participation

	Soil erosion	Pest invasion	Perc-erosion	Perc_pest	Attitudes	Corruption	Interaction	Information	Pre-financing	Distance	Credit
Soil erosion	1.00										
Pest invasion	-0.03	1.00									
Perc_erosion	0.12	0.11	1.00								
Perc_pest	-0.05	-0.07	-0.01	1.00							
Attitudes	0.24	0.26	0.36	-0.07	1.00						
Corruption	-0.10	-0.10	-0.26	0.13	-0.26	1.00					
Interaction	0.11	0.12	0.18	-0.17	0.44	-0.50	1.00				
Information	0.03	-0.01	0.02	0.05	0.01	0.08	-0.17	1.00			
Pre-financing	0.13	0.08	0.06	-0.05	0.14	0.14	0.11	0.02	1.00		
Distance to centre	-0.08	-0.13	-0.15	0.03	-0.19	-0.23	0.24	-0.20	-0.27	1.00	
Credit	0.07	-0.03	0.04	-0.08	0.04	-0.14	0.07	0.11	-0.04	-0.02	1.00
Irrigation	0.10	0.21	0.20	-0.04	0.33	-0.17	0.13	-0.07	0.12	-0.16	0.04
Extension	0.12	0.18	0.22	0.05	0.29	-0.16	0.17	-0.09	0.10	-0.06	0.04
Farmer association	0.06	0.04	0.15	-0.08	0.16	-0.20	0.05	-0.04	0.05	0.02	0.03
Age	0.06	-0.08	-0.08	0.06	-0.08	0.11	-0.19	0.13	-0.11	0.00	0.05
Gender	-0.09	0.01	-0.07	0.12	-0.05	0.12	-0.06	-0.15	0.02	0.03	-0.08
Education	-0.01	-0.07	0.02	0.11	-0.01	-0.04	0.04	-0.11	-0.08	0.08	-0.06

	Irrigation	Extension	Farmer association	Age	Gender	Education
Irrigation	1.00					
Extension	0.31	1.00				
Farmer association	0.14	0.13	1.00			
Age	-0.04	-0.11	0.10	1.00		
Gender	-0.06	0.01	0.08	0.05	1.00	
Education	-0.02	0.06	0.04	-0.09	0.09	1.00

11.2. Appendix 2: Summary statistics of the covariates in relation to farm size

Table A 3: Summary statistics of covariates for all, small, and large-scale sampled farmers

	Total Sample (n=252)		**Small-Scale Farmers (n=115)**		**Large-Scale Farmers (n=137)**	
Variables	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Control variables						
Household size	7.46	4.72	8.69	5.39	6.45	3.81
Age	43.83	10.26	42.48	10.90	44.97	9.59
Gender	0.79	0.41	0.67	0.47	0.88	0.32
Experience	15.48	10.58	17.32	11.24	13.93	9.77
Education	6.42	5.44	5.89	5.34	6.84	5.50
Farm size	5.66	4.77	2.57	1.02	8.27	5.10
Livestock production	0.64	0.49	0.58	0.51	0.69	0.46
Use of family labour	0.79	0.41	0.82	0.39	0.77	0.42
Use of hired labour	0.47	0.50	0.37	0.48	0.56	0.50
Non-farm income	0.45	0.50	0.43	0.50	0.47	0.50
Other crops	0.70	0.46	0.80	0.40	0.61	0.49
Credit	0.33	0.47	0.21	0.41	0.43	0.50
Soil infertility	0.96	0.20	0.92	0.27	0.99	0.12
Flood	0.23	0.42	0.10	0.30	0.34	0.47
Soil erosion	0.42	0.49	0.30	0.46	0.53	0.50
Pest invasion	0.53	0.50	0.50	0.50	0.55	0.50
SAP adoption†	0.83	0.38	0.70	0.46	0.93	0.25
Use of chemicals	0.62	0.49	0.56	0.50	0.66	0.47
Irrigation	0.16	0.37	0.13	0.34	0.19	0.39
No._cultivation‡	0.84	0.37	0.78	0.41	0.89	0.31
Northern region	0.27	0.45	0.21	0.41	0.33	0.47
Savannah region	0.15	0.35	0.19	0.40	0.11	0.31
Upper East region	0.08	0.28	0.10	0.31	0.07	0.25
Upper West region	0.36	0.48	0.37	0.49	0.35	0.48
North-East region	0.13	0.34	0.12	0.33	0.15	0.35
Sorghum	0.14	0.35	0.14	0.35	0.15	0.35
Maize	0.97	0.16	0.95	0.22	0.99	0.09
Rice	0.25	0.43	0.14	0.35	0.35	0.48
Farmer association	0.37	0.48	0.33	0.47	0.40	0.49
CMSIFH§	0.65	0.48	0.71	0.45	0.60	0.49

†SAP adoption: Adoption of sustainable agricultural practices (dummy: 1 = adopted; 0 = otherwise)

‡No._cultivation = Number of cultivation times per year

§CMSIFH = Cereal as the main source of income for farmer household

Source: Author’s estimation from survey data

11.3. Appendix 3: Balancing property and regression estimates given GPS and PFJ support in relation to farm size.

Table A 4: a–b. (left to right): Balance in sample before and after GPS application in relation to farm size: t-statistics for equality of means.

	Small-Scale Farmers (n=115) (a)						**Large-Scale Farmers (n=137) (b)**					
	Balances in Sample Before GPS			Balances in Sample Given GPS			Balances in Sample Given GPS			Balances in Sample Given GPS		
Covariates	IS: ≤250	IS: 250–500	IS: 500+	IS: ≤ 270	IS: 270–470	IS: 470+	IS: ≤ 270	IS: 270–470	IS: 470+	IS: ≤ 330	IS: 330–700	IS: 700+
Household size	1.43	**2.06**	**-3.83**	1.07	0.18	-1.15	**2.14**	0.15	**-2.42**	-0.26	1.29	-1.27
Age	-0.31	1.08	-0.82	-0.55	-0.98	0.48	-0.08	-1.36	1.37	-0.21	0.64	0.13
Gender	1.22	-0.98	-0.20	-0.06	-0.51	-0.05	1.26	-0.72	-0.65	0.63	-0.90	-0.04
Experience	0.49	-0.79	0.33	0.34	-1.00	-0.22	0.52	**-2.14**	0.53	0.21	-0.68	1.22
Education	0.23	0.49	-0.77	0.60	1.48	-1.82	**1.98**	1.45	**-3.53**	-1.27	1.10	-0.85
Farm size	-0.10	0.00	0.11	0.21	0.76	-0.53	-0.53	0.11	0.46	0.19	-0.43	-0.06
Livestock prod.†	0.66	0.67	-1.38	0.31	-0.37	0.28	0.20	-0.02	-0.19	-0.18	0.19	0.17
Use of family labour	0.67	-0.48	-0.18	-0.83	1.05	-0.24	0.04	0.86	-0.85	-0.31	-0.48	1.05
Use of hired labour	-0.25	-0.42	0.70	-0.71	0.43	0.53	0.36	0.48	-0.83	-0.16	0.59	-0.23
Non-farm income	-0.55	0.23	0.32	0.90	-0.49	0.08	0.56	-0.07	-0.53	0.38	0.24	-1.11
Other crops	**-2.73**	1.09	**2.56**	1.59	-0.79	-0.38	1.05	-0.76	-0.38	-0.66	1.14	1.59
Credit	-0.98	0.69	0.26	1.14	0.17	-1.88	**2.32**	0.20	**-2.65**	-0.09	0.54	-0.30
Soil infertility	0.10	-0.29	0.21	-0.76	0.71	-0.35	-1.20	0.76	0.54	0.61	-0.83	-0.16
Flood	**3.71**	**-1.99**	0.22	-0.70	1.18	0.06	-0.31	0.44	-0.09	0.85	-1.67	0.13
Soil erosion	0.37	-0.46	0.11	1.07	-1.16	-0.19	1.02	**-1.99**	0.05	0.50	-0.58	-0.96
Pest invasion	-0.20	0.38	-0.20	-0.95	1.81	-0.15	-0.97	**3.85**	-0.70	-0.26	-0.98	0.62
SAP training‡	0.50	-0.37	-0.11	-1.02	0.18	0.80	-0.52	-0.28	0.82	0.12	-0.11	0.45

Table A4: a–b. (left to right). continued

	Small-Scale Farmers (n=115) (a)						Large-Scale Farmers (n=137) (b)					
	Balances in Sample Before GPS			Balances in Sample Given GPS			Balances in Sample Before GPS			Balances in Sample Given GPS		
Covariates	IS: ≤250	IS: 250–500	IS: 500+	IS: ≤ 270	IS: 270–470	IS: 470+	IS: ≤ 270	IS: 270–470	IS: 470+	IS: ≤ 330	IS: 330–700	IS: 700+
Use of chemicals	0.29	0.25	-0.56	0.36	0.65	-1.20	1.42	0.37	**-3.86**	0.24	0.53	-1.44
Irrigation	-0.13	0.39	-0.28	-0.37	0.98	-0.27	-0.96	0.90	0.16	0.29	1.07	-1.34
No._cultivation§	-0.47	-0.22	0.71	0.27	-0.81	0.66	0.42	**-2.20**	0.69	-0.06	0.86	-0.44
Northern region	**2.45**	**-2.12**	-0.22	0.23	-0.21	0.07	1.00	-0.48	-0.60	1.48	-1.27	-0.04
Upper West region	-0.53	0.52	-0.01	-0.52	-0.03	0.40	-0.73	-0.16	0.92	-0.49	0.34	-0.33
Savannah region	0.51	0.17	-0.70	-0.09	0.26	-0.39	0.13	0.58	-0.69	0.23	-0.76	0.93
Upper East region	-0.76	-0.28	1.07	0.63	0.27	-0.34	0.52	0.28	-0.82	-0.83	0.56	0.83
Sorghum	0.06	0.04	-0.10	-0.83	-0.33	1.41	0.16	-0.41	0.22	-0.71	0.41	0.12
Maize	**-2.73**	0.62	1.08	-0.53	1.65	-1.40	-0.84	**2.69**	-0.69	-0.99	-0.48	0.95
Farmer association	1.02	**-3.71**	0.75	1.24	0.59	-1.33	1.37	0.97	**-2.40**	0.82	-1.39	0.90
CMSIFH¶	1.54	-0.22	**-2.32**	-0.14	0.58	-0.72	0.39	-0.18	-0.25	0.48	-0.49	-0.03

† Livestock prod. = Livestock production measured as a dummy variable

‡ SAP training measured as a dummy (1 = trained on SAPs; 0 = not trained on SAPs)

§ No._cultivation = Number of cultivation times per year

¶ CMSIFH = Cereal as the main source of income for farmer household

The decision rule at 0.05 alpha level: Reject H0 if the t < -1.960 or t > 1.960

Source: Author's estimation from survey data

Table A 5: Parameter estimates of the conditional distribution of input use given the PFJ support and GPS for sampled small and large-scale farmers

	Small-Scale Farmers (n=115) a		**Large-Scale Farmers (n=137) b**	
	Add_Seed	**Add_Fertiliser**	**Add_Seed**	**Add_Fertiliser**
Variables	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
PFJ support	0.06** (0.03)	0.03*** (0.01)	-0.19* (0.06)	-0.01 (0.01)
PFJ support^2	-1.4E-05** (5.9E-06)	-1.4E-06 (2.2E-06)	1.5E-04** (8.0E-05)	1.15E-05*** (4.37E-06)
G.P. score§	20.45974 (107.00)	54.92 (49.18)	-1648.23* (992.21)	-6.27 (36.70)
G.P. score^2	-26.98 (151.01)	-82.26 (70.57)	1713.49* (946.60)	-1.41 (55.65)
PFJ support x G.P. score	-0.01 (0.03)	-0.02 (0.02)	-0.41 (0.54)	-0.01 (0.02)
_cons	-1.39 (17.28)	-5.01 (7.36)	847.22*** (269.04)	9.77* (5.58)
Number of Obs.	83	79	111	111
Prob. > F	0.01	0.00	0.02	0.00
R-squared	0.38	0.68	0.16	0.30
Adj. R-squared	0.28	0.66	0.12	0.26

†AP = Average productivity; MP = Marginal productivity

‡ SE = Standard error

§Generalized propensity score

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Author's estimation from survey data

Table A 6: Parameter estimates of the conditional distribution of productivity given the PFJ support and GPS for small and large-scale farmers

	Small-Scale Farmers (n=115) a				Large-Scale Farmers (n=137) b			
	AP† Land	**AP Labor**	**MP† Land**	**MP Labor**	**AP Land**	**AP Labor**	**MP Land**	**MP Labor**
Variables	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)	Coef. (Std. Err.)
PFJ support	-0.37* (0.26)	0.27* (0.17)	-0.29* (0.16)	-0.21** (0.08)	-0.19* (0.06)	0.31* (0.11)	-0.36 (0.34)	-0.15* (0.08)
PFJ support^2	4.7E-03*** (1.1E-03)	8.5E-05** (3.7E-05)	8.5E-05** (3.6E-05)	3.2E-05*** (1.0E-05)	1.5E-04** (8.0E-05)	-3.1E-04** (1.5E-04)	1.6E-04 (1.4E-04)	-2.5E-04* (1.2E-04)
G.P. score§	-1610.36* (843.55)	228.18 (779.96)	135.76 (572.80)	-604.85 (675.73)	-1648.23* (992.21)	-758.41 (1214.67)	-792.80 (748.09)	-1138.61* (642.96)
G.P. score^2	1820.47** (637.48)	-276.96 (1083.60)	-129.83 (604.04)	747.11 (855.25)	1713.49* (946.60)	965.69 (1810.41)	998.81 (713.10)	1087.40* (613.40)
PFJ support x G.P. score	0.49*** (3.32)	0.48* (0.26)	0.38** (0.19)	0.22** (0.11)	-0.41 (0.54)	-0.78* (0.46)	0.02 (0.41)	0.02 (0.35)
_cons	850.01 (478.67)	206.64* (127.51)	217.62* (123.52)	206.81 (126.72)	847.22*** (269.04)	635.93*** (185.63)	407.81** (203.11)	442.58*** (174.34)
Number of Obs.	87	86	86	86	111	111	113	111
Prob. > F	0.00	0.02	0.01	0.01	0.02	0.04	0.40	0.04
R-squared	0.40	0.18	0.19	0.19	0.16	0.14	0.05	0.15
Adj. R-squared	0.39	0.13	0.13	0.14	0.12	0.10	0.01	0.11

†AP = Average productivity; MP = Marginal productivity

‡ SE = Standard error

§Generalized propensity score

*** p < 0.01, ** p < 0.05, * p < 0.1.

Source: Author's estimation from survey data

11.4. Appendix 4: Graphs – the relationship between PFJ support and farm size, common support condition and treatment effect functions

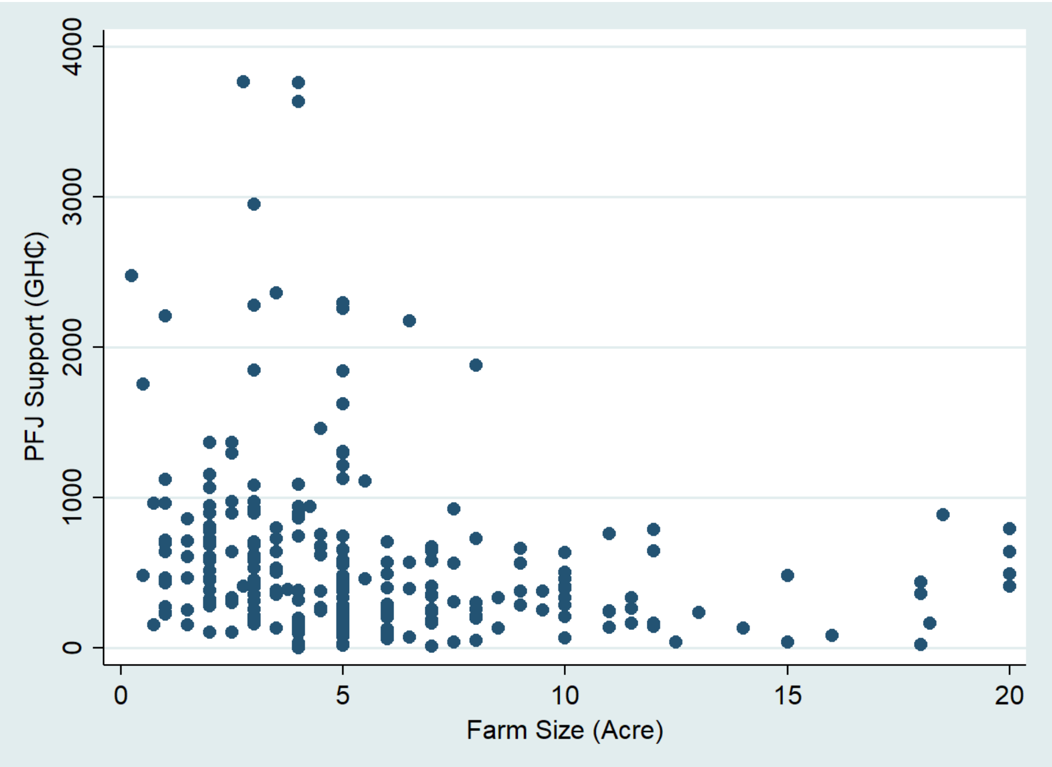

Fig. A 1: Correlation between the PFJ support and farm size

Source: Author's estimation from survey data

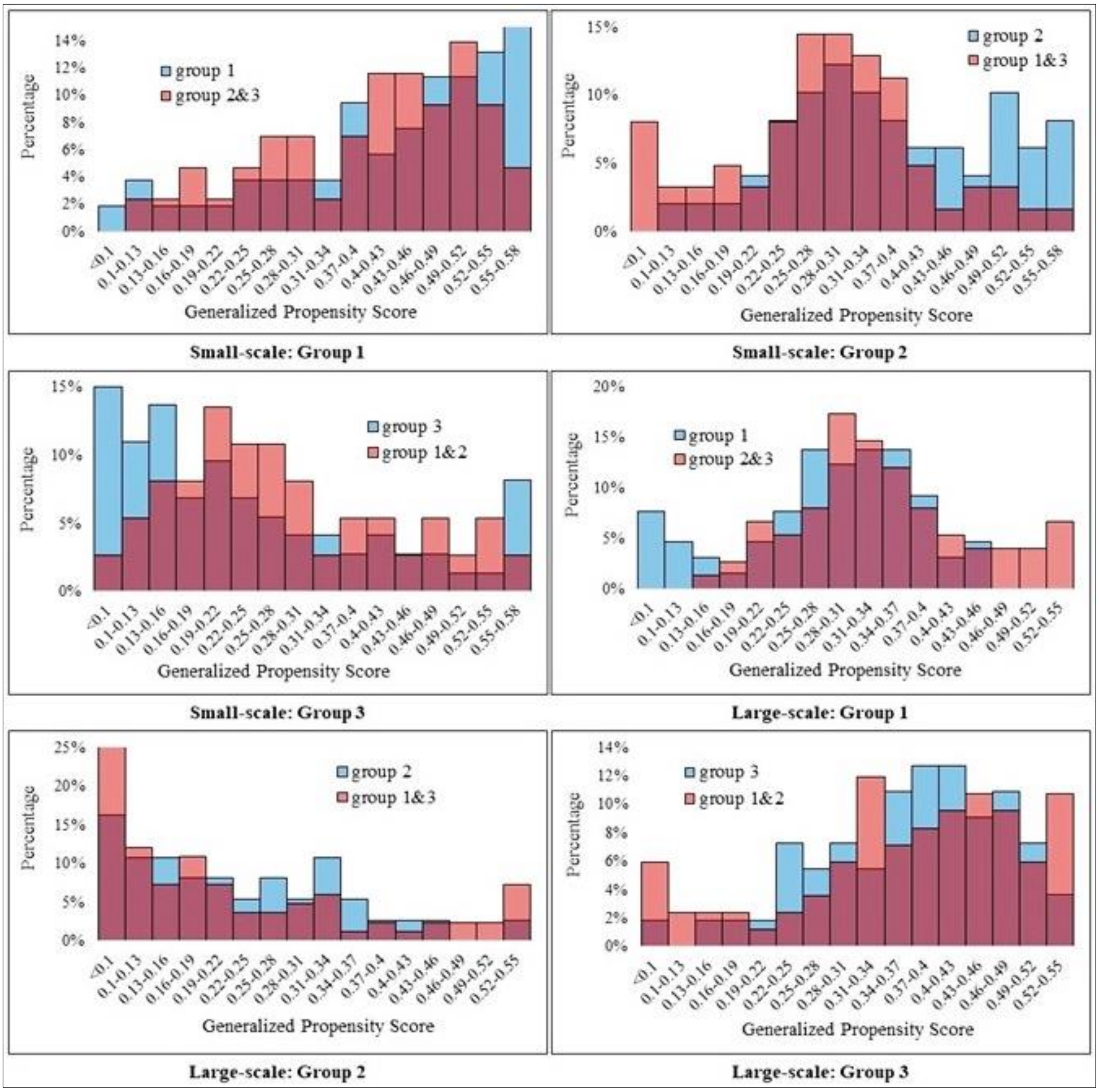

Fig. A 2: Common support condition of the small-scale and large-scale sub-samples

Source: Author’s estimation from survey data

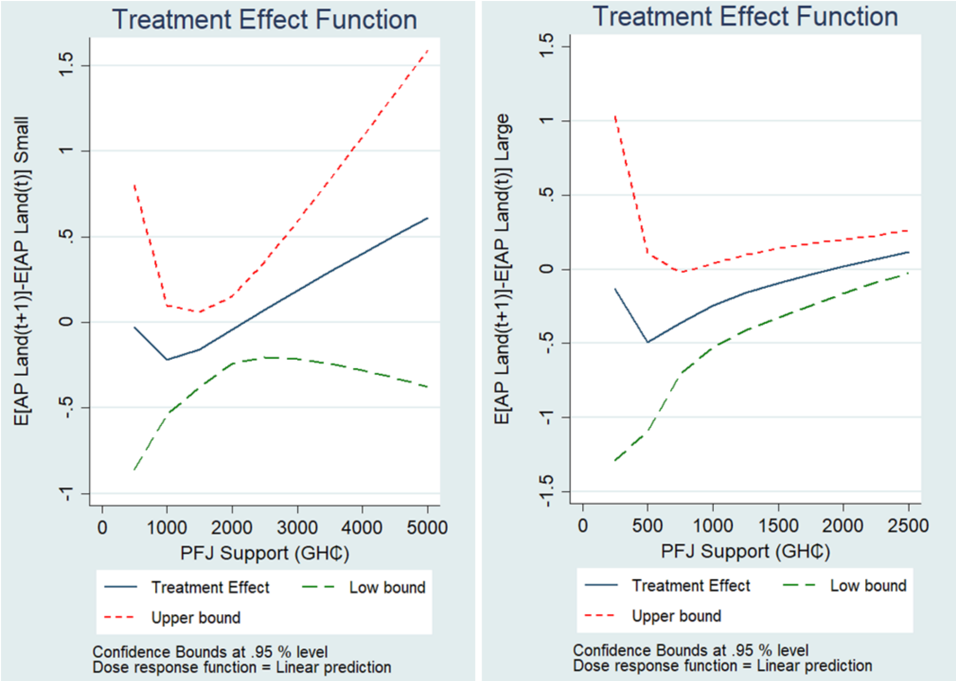

Fig. A 3: a–b. (From left to right): Estimated treatment effect functions of the average land productivities of small-scale and large-scale farmers

Source: Author's estimation from survey data

11.5. Appendix 5: Semi-structured questionnaire used for data collection

Introductory Remarks

This is an instrument for data collection on the "Impact of Production Support on Farm Performance: A Case of Ghana's Agricultural Support Programme". This forms part of a survey being conducted to fulfil an academic requirement for a PhD degree by **Sylvester Amoako Agyemang,** a student at Czech University of Life Sciences, Department of Economics and Development. The main goal of the study is to determine the impact of Planting for Food and Jobs on input use, and productivity and its subsequent role on food security. Information provided will be distinctly confidential and participation is voluntary. The interview will last for approximately 30 minutes and the respondents are kindly requested to provide honest and authentic answers.

Section A: Respondent's Information

Filled by interviewer:

Respondent's ID…………………………

Name of Community……………………………….

Name of District/Municipality……………………….

Region: ☐ Northern ☐ Upper East ☐ Upper West ☐ Savannah ☐ North-East

Filled with Respondent:

Section B: Farm Characteristics

Section B1: Crop Production

1. Which of these cereals do you produced (select as many as applied)? ☐ Maize ☐ Rice ☐ Sorghum
2. How many times do you cultivate (main cereal) in a year? ☐ Ones ☐ More than ones
3. Is cereal cultivation your main source of income? ☐ Yes ☐ No
4. Do you cultivate any other crop aside cereals? ☐ Yes ☐ No

Section A1.1: Farm Resources

Please complete the following resources indicators and its usage for these periods.

Resources Indicators	**2016**	**2017**	**2018**
Land ownership			
Total farmland (acres)			
Land used for cereals farming only (acres)			
Leased lands, % of total area (or acres)			
Labour			

Total number of workers (count)			
No. of family workers including farmer (count)			
Number of hired workers (count)			
Cost on labour *(GH₵)*			
Capital			
Total working capital *(GH₵)*			
Own share of capital *(GH₵)*			
Production inputs			
Total seeds (kg)			
Hybrid seeds (kg)			
Pesticides (litre)			
Herbicides (litre)			
Fertiliser (kg)			

Section B2: Livestock Production

5. Do you produce livestock? ☐ Yes ☐ No
6. If yes, please indicate the number of the following animals owned currently.

Animals	***Quantity***
Cattle	
Sheep	
Goats	
Pigs	
Poultry	
Fish	
Others (specify) ……………………	

Section C: Access to Extension

7. Were you visited by an extension officer this farming year? ☐ Yes ☐ No
8. If yes, how many visits, number of times?.....................................
9. From whom do you access extension services? ☐ MoFA ☐ PFJ extension ☐ NGOs extension ☐ Hired extension
10. Do you keep farm records [financial and non-financial]? ☐ Yes ☐ No

Section D: Farm Management

11. Was your farm affected by flood between 2017 and 2018? ☐ Yes ☐ No
12. If yes, please indicate the acres affected by the flood…………………
13. Have you been experiencing/experienced soil erosion on your cropland since 2016? ☐ Yes ☐ No
14. If yes, please indicate the acres affected by the fall armyworm.........................

15. Have you experienced been experiencing/experienced fall armyworm and any other crop pest invasion on your farm since 2016? ☐ Yes ☐ No
16. I am able to effectively apply fertiliser to mitigate the effect of soil erosion on your cropland and farm output. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
17. I am able to effectively apply pesticides to control the effect of pest invasion on your farm output. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
18. Have you been experiencing/experienced a continuous decline in the productivity level of your cropland? ☐ Yes ☐ No
19. Are you aware of any sustainable agricultural practice (SAPs)? ☐ Yes ☐ No
20. Have you received any SAPs and fertility management training before? ☐ Yes ☐ No
21. Do you practice any of the sustainable agricultural practices? ☐ Yes ☐ No
22. If yes, which of these SAPs did you practice by the end of 2016? [pick as many as applicable]? ☐ Crop rotation ☐ Intercropping ☐ Cover cropping ☐ Zero/minimum tillage ☐ Row planting ☐ Composting ☐ Inorganic fertilizer ☐ Manure application ☐ Mulching ☐ Drains ☐ Others (specify)……….
23. Which of these SAPs do you currently (2018) practice? [pick as many as applicable]? ☐ Crop rotation ☐ Intercropping ☐ Cover cropping ☐ Zero/minimum tillage ☐ Row planting ☐ Composting ☐ Inorganic fertilizer ☐ Manure application ☐ Mulching ☐ Drains ☐ Others (specify)……….
24. Do you allow your land to fallow after years of cultivation? ☐ Yes ☐ No
25. If yes, how long?.......................................(years).
26. Do you use pesticides or weedicides (agro-chemicals) for farming? ☐ Yes ☐ No
27. Do you use hybrid seeds from MoFA and other agro-chemical firms? ☐ Yes ☐ No
28. Do you have access to irrigation? ☐ Yes ☐ No
29. Do take any other form of credit to finance your farm [cash or in-kind]? ☐ Yes ☐ No
30. If yes, how much credit did you take for cereal farming in 2018 (GH₵) ………………….

Section E: Measuring Farm Performance

Section E.1: Productivity and Output

31. Please complete the table with information on the output and selling prices for the stipulated periods. NB: Accuracy of information is highly encouraged for these indicators.

Cereals	**2016**		**2017**		**2018**	
	Qty. (100 kg bag)	***Price GH₵***	***Qty. (100 kg bag)***	***Price GH₵***	***Qty. (100 kg bag)***	***Price GH₵***
Maize						
Millet						
Sorghum						
Rice						
Total						

Section E.2: Labour and Income

32. Were you doing another job before farming cereals? ☐ Yes ☐ No
33. Do you have access to communal labour? ☐ Yes ☐ No

Section E.3: Profitability

34. Did you make profit in 2017–2018? ☐ Yes ☐ No
35. In which these ranges will your profit fall within? ☐ Below 500 ☐ 500 – 1,000 ☐ 1,000 – 2,000 ☐ 2,000 – 5,000 ☐ 5,000 – 10,000 ☐ Above 10,000
36. Please indicate approximately the profit/loss realized for the following periods.

Periods	**Profits** ***(GH₵)***
2016	
2017	
2018	

Section E.4: Agricultural Diversity

37. Do you produce any other crop apart from cereals? ☐ Yes ☐ No
38. If yes, please indicate the types of other crops produced for the following periods.

Crops	**Qty. 2016(acre)**	**Qty. 2018(acre)**
Cash crops		
Tuber crops		
Vegetables & legumes		
Fruits		
Others (specify)……………………		

Section F: The Planting for Food & Jobs (PFJ) Programme

39. Are you aware of the planting for food and jobs programme? ☐ Yes ☐ No

40. If yes, how did you get to know about it? Through; ☐ Friends & families ☐ Farmer groups ☐ Extension/MoFA officers ☐ The media ☐ Others (specify) ………………
41. Are you registered under the Planting for Food and Jobs (PFJ)? ☐ Yes ☐ No
42. How long have you been benefiting from the PFJ programme?......................years.
43. Do you take your inputs from PFJ on credit? ☐ Yes ☐ No
44. What is the distance from the nearest PFJ input collection centre to your farm?..............km
45. Please complete the following table regarding the input support received for the following periods.

Input	**2017**			**2018**			**2019**		
	Qty.	***MP***	***CP***	***Qty.***	***MP***	***CP***	***Qty***	***MP***	***CP***
Seeds (kg)									
Fertilisers (50kg bags)									
Herbicides (litre)									
Pesticides (litre)									

NB: MP = market price, CP = coupon price (price sold to farmer by PFJ)

Section F.1: Efficiency and Sustainability of PFJ – Farmers' Perception:

To what extend do you agree with the following statements:

46. PFJ participation help farmers to acquire more better inputs at affordable price. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
47. PFJ participation help farmers to increase yield and income. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
48. PFJ's input distribution favours political affiliates of the governing party. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
49. PFJ implementation is clouded with input smuggling and elite capture. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
50. PFJ is beneficial to its participants? ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
51. Farmers feel reluctant to repay for the credited inputs to the programme office. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
52. Farmers feel reluctant to repay because the programme is operated by government. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
53. The PFJ programme will not be sustainable. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
54. It is cheaper to take PFJ inputs than to borrow from any other source to buy. ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree

Section F.2: For Beneficiaries only (Question 52 – 54)

55. How many times are you visited by PFJ extension officers in 2018? ....times
56. I can successfully run my farming activities after exiting the PFJ programme? ☐ Strongly disagree ☐ Disagree ☐ Undecided ☐ Agree ☐ Strongly agree
57. Was your decision to produce cereals informed by the PFJ programme? ☐ Yes ☐ No

Section E.3: Constraints Faced by Farmers when Accessing PFJ – All Farmers

58. Please rank the following factors as your constraints faced when accessing PFJ [assign 1 for the highest constraint and 6 for the least constraint].

Constraints	**Rank**
Lack of information	
Time consuming and bureaucratic registration processes	
Corruption by officers	
Long distance to registration centres	
Co-financing/Pre-financing	
Discrimination (politically, gender, etc.)	

Section G: Socio-Economic Characteristics of Farmers

59. Gender of respondent ☐ Male ☐ Female
60. Farmer's age………………………years old.
61. Marital status ☐ Married ☐ Single ☐ Divorced ☐ Widowed
62. How many years did you spend in school? [level of Educational] ……………. years.
63. How many years have you spent in farming?.................................... years.
64. What is your household (HH) size? [number of HH members] ………………persons.
65. How many of your HH members are below 18 and above 60 years?.........................persons.
66. Is cereal farming the main sources of you household income? ☐ Yes ☐ No
67. Do you earn any other income aside farming? ☐ Yes ☐ No
68. Do you belong to any farmers' association or group? ☐ Yes ☐ No

Thanks for your time and assistance.