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Featured Article

Informing Food Security and Nutrition Strategies in Sub-Saharan African Countries: An Overview and Empirical Analysis

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Abstract *This article presents a systematic review of the literature on policy options to improve food security and nutrition in developing countries, and an empirical analysis of the impact of smallholder market participation on food security and nutrition in Ghana. The review focuses on the impacts of policy strategies such as structural changes in relative prices, agricultural infrastructure, economic incentives, and agricultural technologies. To account for threats of selection bias and omitted variable problem, the empirical analysis uses an ordered probit selection model to jointly estimate households' market orientation decisions and food and nutrients consumption. The empirical results show that transitioning from one market orientation to another significantly increase households' food and nutrients consumption.*

Key words: Food security, Nutrition, Market orientation, Crop commercialization, Treatment effects.

JEL codes: D12, Q13, Q18.

Food insecurity in sub-Saharan Africa remains a major developmental challenge, despite several interventions to improve food security and nutrition in many developing regions. Recent official estimates suggest that hunger and malnutrition appear to be increasing in most sub-Saharan African countries, a situation that is in contrast to the rest of the world (FAO, ECA, and AUC 2020).[1] The increasing food insecurity in Africa, combined with the fact that persistent food insecurity contributed to the failure of countries in the region in meeting the Millennium Development Goal (MDG) of halving the

[1]*Whereas there was no increase in the prevalence of undernourishment in the rest of world between 2014–2018, growth in prevalence for the whole of Africa and sub-Saharan Africa was 1.7% and 2.0%, respectively, over the same period (FAO, ECA, and AUC 2020).*

number of hungry people by 2015 (Abdulai and Kuhlgatz 2012), suggest the need for continuous efforts in supporting and promoting measures to improve food security in the region. While the worsening food situation can partly be attributed to climate change (Abdulai 2018; FAO, ECA, and AUC 2020), as well as poor and weakening market conditions, the impact of agricultural markets on food security and nutrition appears to be far from being conclusive (Carletto, Corral, and Guelfi 2017; Linderhof, Janssen, and Achterbosch 2019; Ehui 2020).

Many authors have emphasized the role of new agricultural technologies, specialization, and commercialization in increasing farm productivity and household welfare through enhanced efficiency, competitiveness, and gains from comparative advantage (Govereh and Jayne 2003; Ochieng et al. 2019). However, prohibitive transaction costs imposed by underdeveloped market systems and infrastructure, market failures, and inadequate access to finance and technologies in most developing countries have often hindered the efficiency of food market systems, and limited the potentials of agricultural marketing in these areas (Fafchamps 1992; Abdulai and Birachi 2009; Abdul-Rahaman and Abdulai 2020). Notwithstanding these constraints, smallholder marketing has been shown to increase farmers' access to improved crop inputs, productivity, and income (Ashraf, Giné, and Karlan 2009; Abdul-Rahaman and Abdulai 2020).

Despite the widespread agreement on the role of smallholder marketing in improving food security and nutrition, the empirical evidence on this issue remain scanty, with mixed findings (Carletto, Corral, and Guelfi 2017; Kuma et al. 2018; Linderhof, Janssen, and Achterbosch 2019). While studies such as Ochieng et al. (2019) analyzed the impact of commercialization of bananas and legumes on dietary diversity in central Africa, and Kuma et al. (2018), who examined the effects of coffee production on household food security in Ethiopia show that commercialization improved household dietary diversity and food security, other authors report that the impacts of commercialization on food consumption and nutrition is either negative or nonexistent (e.g., Carletto, Corral, and Guelfi 2017; Linderhof, Janssen, and Achterbosch 2019).

Moreover, most of these studies have often failed to consider the possible market orientation[2] of smallholders' crop sales, which may mask the extent and pattern of gains from crop sales, given that smallholders' crop sales are driven by profit and nonprofit motives (Pingali and Rosegrant 1995; Jacoby and Minten 2009). Production and marketing decisions of smallholders in Africa are often fragmented and characterized by a blend of subsistence, surplus, commercial and distress[3] motives, which may have various implications on the gains and impacts of commercialization across farmers (Pingali and Rosegrant 1995). For instance, if households are subsistence-oriented or surplus-oriented, they may choose to produce different crop mix in order to secure food self-sufficiency, and to spread market-related risks due to market

[2]*Households' market orientation in developing countries have been classified into three (FAO 1989; Pingali and Rosegrant 1995). (i)* **Subsistence farmer** *where the farmer's objective is food self-sufficiency, produces wide range of products and/or sells not more than 25% of the output; (ii)* **Transitional or surplus farmer** *where the farmer produces for household consumption and sale of surplus, but sells at least 25% and less than 50% of the output; and (iii)* **Commercial farmer** *where the farmer is profit oriented, highly specialized and with high market engagement, and sells more than 50% of the output.*

[3]*Distress sales usually arise when farmers are forced to sell their harvest to meet immediate financial requirements (such as servicing of debts or meeting other household needs) (Jacoby and Minten 2009).*

imperfections and lack of risk mitigating mechanisms such as insurance and credit markets (Zanello 2012; Ecker 2018). If, however, farm households are commercial-oriented, then production and marketing decisions could be based on profit and some market intelligence, which can result in higher "gains" from trade, increased household income, and improved food security and nutrition (Pingali and Rosegrant 1995; Abdulai and Huffman 2000).

In this paper, our goal is twofold: First, to provide an overview of the literature on food security and nutrition strategies in developing countries. While food security and nutrition are of interest in their own rights, we focus on the survey of the literature on economic policies and microstrategies of promoting smallholder food security and nutrition in sub-Saharan Africa. Second is to provide an empirical example of how smallholder market orientation impacts on food security and nutrition in Ghana. The empirical analysis builds on the review by showing how commercially/profit-oriented market engagement by smallholders can serve as a food security and nutrition enhancing strategy in the area. While previous studies have considered the role of smallholder market participation and commercialization on food security and nutrition, there is almost no study on how smallholder market orientation affects the impacts of commercialization on food security and nutrition[4]. The empirical analysis is partly justified by the fact that the extent of smallholder market integration is closely associated with the motive of production, which tends to have varied impacts on household welfare (Abdulai and Huffman 2000; Ecker 2018). This, therefore, allows us to delineate smallholder market participation effects on household food security and nutrition under different motives of market engagement by smallholders.

Second, the empirical analysis allows us to highlight the impact of smallholder transition from subsistence to commercial on the consumption of specific nutrient-rich foods. The analysis on specific nutrients intake is significant in this setting for at least two reasons: First, unlike most previous studies that focused on calorie and/or food consumption (Kuma et al. 2018; Ochieng et al. 2019), which do not enhance the understanding of individual nutrients intake patterns, analysis of the consumption of nutrient-rich foods provide insights into specific nutrients intake and therefore, serve as a wedge between food patterns and food quality (Freisling et al. 2010). Second, the distinction between food/calorie and specific nutrient-rich foods is important, because many African countries, including the study country, face deficiencies in specific nutrients such as vitamins, protein and iron, in spite of appreciable or relatively normal levels of food and calorie intake (Abdulai and Kuhlgatz 2012; Colen et al. 2018). This, coupled with the fact that the recent deteriorating food security and nutrition situation in Africa has been partly attributed to adverse food market conditions, underscore the need to further understand how smallholder market orientation affects the impact of commercialization on household food security and nutrition.

[4]*Some studies examine the impacts of smallholder market participation and commercialization by focusing on market participation decisions, cultivation and sale of cash crops, as well as the value of total crop harvest sold. Strasberg et al. (1999), Govereh and Jayne (2003), Zanello (2012) and Kuma et al. (2018), for instance, focus on smallholder marketing decisions, and cultivation and sales of cash crops, and Carletto, Corral, and Guelfi (2017) and Linderhof, Janssen, and Achterbosch (2019) focus on the value of crops sold. Notable exceptions are Ochieng et al. (2019) who focus on the effect of households moving from noncommercialized to commercialized, and Ogutu, Godecke, and Qaim (2019) who emphasis the effects of commercialization in a continuum (i.e., continuous treatment effects), but not on how market orientation affects food security and nutrition.*

The rest of the paper is organized into three main sections as follows: The first section presents an overview of food security research in Africa, with particular emphasis on food security and nutrition promotion strategies in the literature. The second section, "Empirical Analysis," shows the empirical example of smallholder market participation as a food security and nutrition enhancing strategy. The third section, "Conclusions and Policy Implications," concludes and highlights some policy and future research implications.

Food Security in Africa

The recent increase in the incidence of food insecurity and malnutrition in sub-Saharan African (SSA) countries calls for the need to seriously assess and find ways to promote food security in the subregion. Evidence shows that the prevalence of food insecurity and malnutrition have risen from 18.2% in 2014 to 20% in 2018 in Africa, with that of sub-Saharan Africa, increasing from 20.8% to 22.8% over the same period (FAO, ECA, and AUC 2020). Estimates from the FAO, ECA, and AUC (2020) reveal that about 239 million in the region were undernourished in 2018. The number of undernourished people in Nigeria, which is the most populated country in the region, was estimated to be over 25 million in 2018, which is about 180% increase over the past decade (FAO, ECA, and AUC 2020). This development suggests that, as was in the case of the failure to achieve the Millennium Development Goal of halving the incidence of hunger by 2015, the realization of the Sustainable Development Goal Two of eradicating hunger and improving nutrition by 2030 may not be realized if concerted efforts are not made to overcome the barriers to improving food security and nutrition in the region (OECD 2016).

The state of food security and nutrition in developing countries has been a consequence of environmental and economic factors including climate shocks; conflicts; unemployment; low wages and food price inflation; lack of access to and adoption of improved technologies; and lack of institutions, structures, and markets for farmers and consumers (Weber et al. 1988; Abdulai and Kuhlgatz 2012; Abdulai and Huffman 2014; FAO, ECA, and AUC 2020). In this section, we provide an overview of the literature on how these factors have impacted food security and nutrition, as well as general household welfare.

Economic Policies and Food Security

In most African countries, the fundamental agricultural policy objectives have been to increase productivity and private sector engagement in agriculture, reduce state involvement, improve innovation and technology, opening up markets and allowing prices to determine the allocation of factors of production (Abdulai and Huffman 2000). Food security policies in many of these economies have also focused on improving food trade and market integration through enhanced infrastructure, private and state trade support policies, and public buffer stocks. These policies have resulted in key policy initiatives such as the Comprehensive Africa Agricultural Development Programme (CAADP) and the African Regional Nutrition Strategy (ARSN) aimed at increasing investment in research and development; agricultural infrastructure; extension services; and the subsidization of farm inputs to increase productivity, trade, and food security (Sheahan and Barrett 2017; FAO, ECA, and AUC 2020). Also, in the wake of the COVID-19 pandemic, which has resulted in border closures, lockdowns, and curfews, and the consequent disruption in

supply chains as well as projected contraction of agricultural production, ministers for agriculture of African Union members have publicly committed to implementing measures to minimize food system disruptions and ensure food security and nutrition for their citizens (Ehui 2020).

The issue of food prices has been a key focus of interest in food security policies in many developing countries. Such policies aim at improving food access through lower market prices and stabilization of consumption in times of high food price inflation (Barrett 2002; OECD 2016). Two main approaches have been widely used to implement these policies in the past. These included universal price subsidies that benefit net buyers of food, and limited access subsidies that provide rationed quantities at reduced prices (Byerlee, Jayne, and Myers 2006; Abdulai and Kuhlgatz 2012). However, the limitations of these policies have been the lack of sustainability and exit mechanisms, and the accruals of greater shares of rationed food gains to political actors and groups at the expense of the poor. Moreover, a number of these price policies did not sufficiently incorporate country specific price and production risk factors. This resulted in the failure of several food price policies to produce the desired results with respect to food security and nutrition measures (Barrett 2002; Byerlee, Jayne, and Myers 2006).

Similarly, the Structural Adjustment Programs that were implemented by many African governments in the 1980s also contributed to food security dynamics in many of these countries. Available evidence shows that the response of the agriculture sector in Africa to these policy reforms was encouraging, because output and productivity increased in the countries that pursued reforms compared to countries that failed to implement these reforms (Byerlee, Jayne, and Myers 2006; Abdulai and Kuhlgatz 2012). However, the reduction or removal of subsidies on farm inputs following the structural reforms also led to increased input prices, which later led to reduced farm output and productivity, and increased food insecurity and malnutrition (Abdulai and Huffman 2000). This suggests the need for policymakers and researchers to put particular emphasis on how long-term policies and interventions can ensure a balance between state efficiency and productivity, without compromising food security and nutrition goals.

Climate Change and Food Security

Climate change and shocks continue to have serious adverse effects on agricultural production and food security, particularly in developing countries (Abdulai 2018; Eastin 2018; FAO, ECA, and AUC 2020; Shahzad and Abdulai 2020). In particular, high temperatures, heat, water stress, and related weather extremes tend to affect poor people in developing countries the most, because of their heavy reliance on agriculture for their livelihoods, low economic diversification, and their inability to cope with food price inflation and income shocks (Abdulai and CroleRees 2001; Eastin 2018). Several attempts have been made to address or mitigate the adverse impacts of climate change in Africa, with some prominent strategies being the development of irrigation systems and the adoption of climate-smart agricultural practices (Lipper et al. 2014; Abdulai 2018). Climate-smart agriculture is an embodiment of practices that seek to promote the reliance on agricultural systems and livelihoods to promote production, and reduce risks of food insecurity and malnutrition for the current and future generations (Lipper et al. 2014; Issahaku and Abdulai 2020).

The literature has shown a variety of climate-smart practices that include conservation agriculture, use of improved and drought-tolerant crop varieties, adoption of improved technologies, crop rotation and mixed cropping, matching livestock to supply of grazing land, as well as crop diversification and economic diversification into nonfarm income activities (Abdulai and CroleRees 2001; Di Falco and Veronesi 2013; FAO 2016; Shahzad and Abdulai 2020). Earlier studies on the impact of climate change focused on crop productivity at the country, regional, and global levels, and only provided insights into the impacts of climate change in aggregate terms (Di Falco, Veronesi, and Yesuf 2011). However, the need to promote resilience of the poorest and vulnerable segments of rural population in developing countries (Eastin 2018), resulted in the need to understand smallholder adaptation strategies (Di Falco, Veronesi, and Yesuf 2011; Issahaku and Abdulai 2020). Thus, recent studies have focused on understanding the drivers of smallholder adaptation to climate change in developing countries, and also quantifying the effects of adaptation strategies on farm performance and household welfare measures such as yields, net returns, poverty reduction, and food security and nutrition (FAO 2016; Eastin 2018; Issahaku and Abdulai 2020; Shahzad and Abdulai 2020).

Promotion of drought resistant crop varieties, and conservation agriculture remain top of the list of climate change adaptation practices, since these have been shown to have substantial impacts on household resilience to climate change and on household welfare in Africa (Di Falco, Veronesi, and Yesuf 2011; Abdulai 2018). Many studies have shown positive effects of climate change adaptation practices such as changing crop varieties, soil and water conservation practices, water harvesting and irrigation, tree planting, matching livestock to supply of grazing land, and economic diversification on household welfare in Africa and Asia (e.g., Di Falco, Veronesi, and Yesuf 2011; FAO 2016; Issahaku and Abdulai 2020; Shahzad and Abdulai 2020). For instance, Issahaku and Abdulai (2020) show that smallholder adaptation to climate change increases household dietary diversity and reduces household food insecurity by about 15% and 35%, respectively in Ghana.

Despite the benefits of these practices, adoption of specific climate-smart practices remains low in many African countries (Abdulai and Huffman 2014; Walker et al. 2014; Issahaku and Abdulai 2020). Whereas available evidence estimates the average adoption of climate-smart practices at about 66% (Di Falco, Veronesi, and Yesuf 2011; Issahaku and Abdulai 2020), the incidence of adoption of specific strategies have been quite low. For instance, Di Falco and Veronesi (2013) show that farmers' adoption of water strategies ranges from 4% to 16%, while their adoption of other strategies such as the use of new technologies and diversification into off-farm jobs stand at 1.35% and 6.83%, respectively. Also, in spite of the burgeoning literature on impact of adaptation to climate change, discourse between adaptation and food security and nutrition in developing countries is quite limited (Di Falco, Veronesi, and Yesuf 2011; Di Falco and Veronesi 2013; Issahaku and Abdulai 2020).

Adoption of Technology and Food Security

In addition to the issues of climate-smart and sustainable agriculture, the association between adoption of improved agricultural technologies and household welfare has received considerable attention among policymakers

and researchers (Abdulai and Huffman 2005; Foster and Rosenzweig 2010). This is due to the long recognition that productivity growth in agriculture partly depends on the availability of improved technologies and the adoption of these technologies (Foster and Rosenzweig 2010; Pannell and Zilberman 2020). Studies on this front can be broadly categorized into those that focus on understanding the drivers of technology adoption and diffusion in developing countries, and those that examine the impacts of adoption on household welfare (Foster and Rosenzweig 2010; Abdulai and Huffman 2014; Wossen et al. 2019; Huffman 2020).

In the case of the former, many factors have been found to be associated with the lack of adoption of improved technologies, particularly in sub-Saharan Africa. Prominent among these factors are credit constraints, absence of insurance and other risk mitigating schemes, high transaction costs due to lack of market infrastructure and efficient markets, lack of access to extension services and some behavioral limitations (Foster and Rosenzweig 2010; Pannell and Zilberman 2020). Information failure has also been identified as an important factor that limits farmers' awareness, understanding and adoption of improved technologies in many developing countries. This contributed to increased interest in understanding the role of social learning and other peer effects in the adoption and diffusion of improved technologies in Africa (Abdulai and Huffman 2005; Foster and Rosenzweig 2010; Huffman 2020).

The other strand of adoption studies focused on understanding the impacts of adoption on household welfare (e.g., Becerril and Abdulai 2010; Abdulai and Huffman 2014; Kassie et al. 2017; Wossen et al. 2019). Most of these studies show that adoption of improved technologies tends to increase household productivity, income and consumption, with some of the studies reporting impacts of 24% and 16% increase in smallholder crop yields and farm net returns, respectively (Abdulai and Huffman 2014; Kassie et al. 2017; Wossen et al. 2019). Unfortunately, despite the significance of improved technologies for farm productivity and income, Africa has lagged behind in the use of improved and modern technologies, and as such has not been able to reap the productivity and welfare benefits of the so-called Green revolution (Sheahan and Barrett 2017). For instance, Walker et al. (2014) estimate the mean level of adoption across 20 improved crop varieties at 35% in Africa, with two-thirds of these crops having adoption rates lower than this mean level.

Similarly, in spite of the high interest in understanding the impact of agricultural technologies on household welfare, not much has been done on the impacts of adoption of improved crop varieties on food security and, in particular, on the consumption of specific nutrient-rich foods in Africa. Previous studies mostly focused on adoption, farm returns, and to a lesser extent on food security (Abdulai and Huffman 2014; Kassie et al. 2017; Wossen et al. 2019), and when attempts are made in the realm of specific nutrients consumption, the focus has been on calorie-income and price elasticities (Abdulai and Aubert 2004; Colen et al. 2018). There is therefore the need for an in-depth examination and understanding of the impacts of specific food security promotion strategies such as adoption of new technologies, smallholder diversification and marketing, as well as the associated impact mechanisms on specific food nutrients intake. Such information would be relevant in informing the design and implementation of propoor policies in Africa, and in increasing the effectiveness of food security and nutrition policies in realizing the Sustainable Development Goal of eradicating hunger, achieving food

security and improved nutrition, and promoting sustainable agriculture (Abdulai 2018; Colen et al. 2018).

Thus, the empirical analysis considers the role of smallholder market engagement as a diversification strategy that can enhance the resilience of smallholders to food and nutrition insecurity. Smallholder farmer market engagement generally includes nonfarm employment, diversification into cash cropping, selling of harvest, and purchases of food to minimize seasonal variation in food availability (Abdulai and CroleRees 2001; Wiggins et al. 2011; Di Falco and Veronesi 2013; Kuma et al. 2018), and these have been recognized as food insecurity coping mechanisms (Di Falco and Veronesi 2013; Shahzad and Abdulai 2020). Also, the integration of smallholders into output and input markets can result in increased motivation of smallholders to produce for profit maximization, which may lead to increased household welfare (Abdulai and Huffman 2000). Thus, the next section focuses on the issues of agricultural commercialization and household food security and nutrition.

Market Engagement and Food Security

Agricultural marketing or commercialization has been conceived in the literature as involving smallholder participation in nonfarm economic activities, participation in output and input markets, and the profit motive or orientation of the farm business (Pingali and Rosegrant 1995; Abdulai and Delgado 1999; Wiggins et al. 2011; Dithmer and Abdulai 2017; Carletto, Corral, and Guelfi 2017). A considerable body of empirical research has focused on understanding the role of smallholder nonfarm work and market participation on household welfare (Abdulai and Delgado 1999; Abdulai and CroleRees 2001; Zanello 2012; Carletto, Corral, and Guelfi 2017). This is due to the fact that nonfarm engagement or marketing has long been recognized as a means by which smallholders can move from subsistence farming to a more commercialized one, and also minimize agricultural risks, given the failure or absence of consumption and insurance markets in developing countries (Pingali and Rosegrant 1995; Reardon et al. 2006). These studies place more emphasis on understanding the determinants of smallholder participation in nonfarm work or marketing, and the impact of such participation on smallholder welfare indicators such as productivity, net returns, and income (Abdulai and Delgado 1999; Abdulai and CroleRees 2001; Wiggins et al. 2011; Zanello 2012).

Many factors such as education, availability of markets and other infrastructure, household access to credit, income and capital have been reported as influencing smallholders' decisions to participate in nonfarm work or economic diversification, since the lack of access to these factors appears to make it difficult for smallholders in many developing countries to diversify away from subsistence agriculture (Abdulai and CroleRees 2001; Wiggins et al. 2011). Also, studies have shown that transaction costs, wealth and assets, and contractual and cooperative marketing substantially affect smallholders' marketing decisions and the quantities of inputs and outputs traded (Abdulai and Birachi 2008; Zanello 2012; Abdul-Rahaman and Abdulai 2020). In particular, recent studies show that smallholder contract and cooperative marketing tend to reduce market risks; increase smallholders' bargaining power; and contribute to increasing farm productivity, income, and household welfare in some Asian and African countries (Abdulai and Birachi 2008;Ma, Abdulai, and Goetz 2018; Abdul-Rahaman and Abdulai 2020).

In addition, several studies have examined the impacts of nonfarm work and diversification (Holden, Shiferaw, and Pender 2004; Owusu, Abdulai, and Abdul-Rahman 2011; Ecker 2018), sale and purchase of food (Zanello 2012; Ogutu, Godecke, and Qaim 2019), and contracting or cooperative marketing (Ma, Abdulai, and Goetz 2018; Abdul-Rahaman and Abdulai 2020) on household welfare. Smallholder marketing has contributed to increased household productivity and farm returns in Asia and Africa (Ma, Abdulai, and Goetz 2018; Ochieng et al. 2019; Ogutu, Godecke, and Qaim 2019; Abdul-Rahaman and Abdulai 2020), although its impacts on food security and particularly nutrients intake remain inconclusive (Zanello 2012; Carletto, Corral, and Guelfi 2017; Ogutu, Godecke, and Qaim 2019).

One possibility of resolving the mixed and inconclusive findings on the impacts of smallholder marketing on food security and nutrition is to consider the fact that consumption gains from commercialization could be heterogeneously distributed among households, and also within household members (Carletto, Corral, and Guelfi 2017; Ogutu, Godecke, and Qaim 2019). However, studies have mostly failed to consider these dimensions in examining the impacts of commercialization on household welfare (Carletto, Corral, and Guelfi 2017). In addition, existing studies have completely neglected smallholder profit or market orientation on welfare gains, in spite of the fact that smallholders' production and marketing decisions in developing countries are characterized by different motives, including "distress sales" (Pingali and Rosegrant 1995; Reardon et al. 2006; Jacoby and Minten 2009). A notable exception is Ogutu, Godecke, and Qaim (2019), who examined the heterogeneity in the impacts of agricultural commercialization on household calorie and micronutrients consumption, but did not consider the profit motive or market-orientation of smallholders.

The empirical analysis builds on these previous studies, by examining the impact of smallholder market orientation on household food and nutrient-rich food consumption. This is partly justified by the fact that the extent of smallholder market integration is closely associated with the motive of production, which has been argued as having varied impacts on household welfare (Abdulai and Huffman 2000; Ecker 2018). Another motivation for the analysis is the fact that, the recent upsurge in malnutrition in Africa has been attributed to the adverse impact of climate change and worsening food markets' conditions in the region (FAO, ECA, and AUC 2020).

Empirical Analysis

This section presents the empirical analysis of the impact of smallholder market participation as household food security and nutrition strategy. The section consists of the conceptual framework, the study area and data, analytical and empirical strategies, as well as the results of the analysis.

Conceptual Framework

In this section, we outline three pathways highlighting the conditions under which smallholder market orientation may lead to different levels of food and nutrients consumption among households.

The first is the pure income effect. The underlying premise of this pathway is that agricultural commercialization and specialization through high value crops, or selling higher quantities at higher prices for current crops can lead to increased farm incomes and consequently increased household

consumption possibilities of food and other essential household needs (Carletto, Corral, and Guelfi 2017; Kuma et al. 2018). Increased household income from commercialization can also enhance the household's ability to purchase food items that are not produced by the household through cash purchases from the market (Abdulai and Aubert 2004; Ecker 2018). However, increased specialization in cash crops and sale of output may lead to reduced production of diverse foods and availability of staples for home consumption, which can predispose commercially oriented households to food insecurity and malnutrition, especially if the additional income is not spent on food, or if output prices are low (Von Braun, Kennedy, and Bouis 1989; Carletto, Corral, and Guelfi 2017).

Second is that cash income from crop sales can enhance households' access to and affordability of improved farm inputs and better technologies that can be used for staple crop production (Minten, Randrianarison, and Swinnen 2011). Likewise, households who diversify their crops may enjoy economies of scope, where skills, experiences, and inputs acquired to grow staple crops for domestic consumption can also be used to produce cash crops, and *vice versa* (Abdulai and CroleRees 2001; Govereh and Jayne 2003; Ecker 2018). However, missing, inefficient, or very volatile food markets can lead to high transaction costs or interrupted input supply, which may tend to limit households access to inputs and other market opportunities, and can result in reduced household income, food purchases, and consumption (Fafchamps 1992; Abdul-Rahaman and Abdulai 2020). This could present a situation where subsistence or surplus-oriented households tend to have higher food and calorie intake than commercially oriented households.

Finally, when there is considerable seasonal variation in household food availability and food prices, which is often due to climatic shocks and inadequate infrastructure, this can lead to farmers who grow more cash or high valued crops benefiting more in terms of food and nutrients consumption (WFP and GSS 2012; Kuma et al. 2018; Issahaku and Abdulai 2020). In sum, the effects of crop commercialization on household food and nutrients consumption will be higher for commercial and perhaps surplus than subsistence households, if market conditions are favorable and additional incomes from crop sales are spent on food consumption, and lower if otherwise. In addition, commercially oriented households may benefit more if seasonality of food supply tends to increase households' reliance on purchased food in times of household food deficits. Finally, the magnitude of the effects of commercialization will be much higher for the consumption of food items that are largely purchased from the market. We examine these issues based on the case of smallholder farmers in the northern region of Ghana.

Study Area

Despite the importance of agriculture as a source of livelihood of the majority of the population in Ghana, the incidence of poverty was highest among households engaged in the agriculture sector (42.7%) in 2016–2017. Also, the incidence of poverty in the northern regions have been higher than the rest of the country since 2006 (GSS 2018). Food insecurity and malnutrition have also been the highest in these regions, compared to the rest of the country, with an average of 18% of households being severely food insecure. Farm households in these regions are faced with inadequate rains, structural constraints, and poor soils, which have often led to low agricultural output,

fluctuation in food prices, and food insecurity (WFP and GSS 2012). In spite of efforts made to promote commercialization of agriculture and smallholders in the northern regions, the average marketed crop surplus across the three regions remains low, ranging from 15% in the Upper East region to 34% in the Northern region (IFAD-IFPRI 2011). The high incidence of poverty, food insecurity, and malnutrition in the Northern region amid slightly higher proportion of marketed crops than the national average of 33%, presents an apparent paradox that provides an appropriate context for the investigation of the impact of households' crop commercialization on food and nutrients consumption.

Data and Descriptive Statistics

We conducted a survey of 500 farm households in the northern region of Ghana between July and September 2017. Five districts were purposively selected based on their intensity of cultivation of both staple and cash food crops, and then 25 villages were randomly selected across these districts, with the allocation of villages done in proportion to the total households in each district. These villages are remote and small, with less than 150 households in each. Given this, we randomly selected 20 household heads in each village, and then used structured questionnaires to interview the primary decision-makers in the households. In addition, a detailed discussion using an interview guide was administered in each village to a focus group of village leaders and representatives to obtain information on village characteristics. The survey combined modules of household characteristics, agricultural production and marketing to collect household data for the 2015–2016 cropping season.

Given our interest in measuring commercialization from the output market participation side, and in terms of sales of all crops cultivated by the household in the 2015–2016 season, we use the Household Crop Commercialization Index (HCCI) suggested by Strasberg et al. (1999). The index is expressed as:

$$HCCI = \frac{\sum_{c=1}^{\bar{c}} \bar{P}_{v,c} M_{i,c}}{\sum_{c=1}^{\bar{c}} \bar{P}_{v}, c, Q_{i,c}} \times 100 \quad (1)$$

where $\bar{P}_{v,c}$ is the average village level crop c price in village v, $M_{i,\,c}$ is the quantity of crop c marketed by household i, $Q_{i,\,c}$ is total quantity of crop c produced by the household i, and c is an index of crops produced, with c=1,…, $\bar{c}$. On the basis of this measure, a household's degree of commercialization can be expressed in a continuum that ranges from pure subsistence (HCCI = 0) to completely commercialized production (HCCI = 100). In order to characterize households' market orientation, we use the categorization by FAO (1989), which categorizes households into three orientations, based on the proportion of crop output sold (see also Pingali and Rosegrant 1995). Thus, we classify our farmers into subsistence-oriented, if the farmer sells less than 25% of the output; surplus-oriented, if the farmer sells at least 25%, but less than 50% of the output; and commercial-oriented if the farmer sells more than 50% of the output.

The outcomes of interest in this study are food consumption score (food) and food consumption scores-nutrition. Given that these outcomes measure

the frequency of consumption of food and nutrient-rich foods, we asked households the question, "How many days in the last seven days your household ate the following foods?" (refer to notes under table 1 for details). We next sum all the consumption frequencies of the food and nutrient-rich food items of the same group. For the food consumption score, we multiply the value obtained for each food group by the group weight to obtain weighted food group scores, and then add the weighted food groups to generate the food consumption score for a household. With regards to the nutrient consumption, we sum the number of days that foods belonging to each nutrient subgroup (i.e., vitamin A, protein, and hem iron) were consumed in the household to obtain the food consumption score-nutrition for the household (WFP 2015).

In order to explore how food and nutrients consumption vary by household market orientation, we present the mean differences in food and nutrient-rich foods consumption by household market orientation in table 1. We first present the means for the whole sample in column (1). In columns (2) to (4), we compare the mean differences of households who did not report any sales and those who reported sales of $0 < HCCI < 25\%$. The table suggests that households who did not sell any of their harvest have slightly lower food and nutrient-rich food consumption than those who sold at most 25% of the harvest, albeit not statistically significant across all outcomes. This justifying our classification of households with less than 25% HCCI as subsistence-oriented.

Columns (5) to (7) present the means and the mean differences between subsistence and surplus-oriented households, while columns (8) to (10) report the comparison between commercial on the one hand and surplus and subsistence households, on the other hand. The comparison shows that both surplus and commercial-oriented households have significantly (at the 1% level) higher income, food, and nutrient consumption than subsistence-oriented households. At the same time, commercial-oriented farm households appear to have significantly higher income, food, and nutrient consumption than surplus-oriented households. These suggest the possibility of significant differences in the returns to household crop commercialization across market orientations.

Table 2 presents the definition, measurement and descriptive statistics of all the variables used in the analysis for the entire sample. Panel A shows that 36% of the farm households surveyed are subsistence-oriented, 41% are surplus-oriented, and 23% are commercial-oriented. Also, the average household head is 44 years old and with 1.27 years of schooling. The average household size and landholding are 5.63, and 2.6 hectares, respectively (panel B). The average distance from the villages to the nearest town center is about 15 kilometers, and the mean village wage rate is about 6 GHS. We also compare the differences in the main controls between market orientation in table A1 in the appendix, and this shows significant differences mostly in the household characteristics across market orientation.

Analytical Framework and Empirical Strategy

Our conceptual framework shows how smallholder food and nutrients consumption both tend to depend on household market orientation and market conditions. Given the categorization of smallholders' market orientation into subsistence-, surplus-, and commercial-oriented, based on the proportion

Table 1 Means and Differences in Means of Food and Nutrient-Rich Food Consumption Outcomes Across Market Orientation

	All sample	Sell none	Sell <25%	Difference	Subsistence-Oriented	Surplus-Oriented	Difference	Commercial-Oriented	Difference	Difference
	(1)	(2)	(3)	(4) = (3–2)	(5)	(6)	(7) = (6–5)	(8)	(9) = (8–5)	(10) = (8–6)
Food consumption score	33.55 (8.23)	27.95 (1.03)	30.08 (0.67)	2.13 (1.85)	29.83 (0.61)	33.73 (0.52)	3.90*** (0.79)	39.11 (0.59)	9.28*** (0.89)	5.38*** (0.83)
Vitamin A	12.43 (3.83)	10.18 (0.69)	10.56 (0.34)	0.38 (0.94)	10.52 (0.31)	12.55 (0.24)	2.03*** (0.38)	15.23 (0.18)	4.71*** (0.41)	2.68*** (0.34)
Protein	6.18 (3.46)	3.13 (0.57)	4.26 (0.24)	1.12 (0.69)	4.13 (0.23)	6.14 (0.22)	2.01*** (0.31)	9.52 (0.15)	5.39*** (0.31)	3.38*** (0.31)
Hem iron	3.77 (2.26)	1.91 (0.37)	2.48 (0.16)	0.57 (0.45)	2.41 (0.15)	3.75 (0.14)	1.34*** (0.21)	5.96 (0.09)	3.55*** (0.19)	2.21*** (0.20)
Log income	8.39 (0.71)	7.93 (0.14)	8.23 (0.04)	0.30*** (0.12)	8.19 (0.04)	8.33 (0.04)	0.14** (0.06)	8.83 (0.09)	0.64*** (0.09)	0.49*** (0.08)

Notes: *The table shows the descriptive statistics and the differences in means across household market orientation for the food and nutrient rich foods consumption outcomes and household annual income. Column (1) presents the means of household consumption of food and nutrients, and household income for the entire sample. Columns (2) and (3) depict the means for households who did not sell any of the output and those who sold less than 25% of the output, respectively, while column (4) shows the differences in these means. Columns (5), (6) and (8) present the means for subsistence-oriented, surplus-oriented, and commercial-oriented households. Column (7) reports the differences in means between subsistence and surplus-oriented households, while column (9) presents the differences in means between subsistence and commercial-oriented households. Column (10) shows the differences in means between surplus- and commercial-oriented households. Values in parenthesis are standard deviations in column (1) and standard errors in columns (2) to (10). The asterisks *** and ** are significance at 1% and 5% levels, respectively.*

We calculated the food consumption score by first grouping all food items consumed by households into main staple, pulses, vegetables, fruits, meat and fish, milk, sugar, oils and condiments and the food consumption score-nutrition by grouping food items into 15 food groups under vitamin A-rich foods (i.e., dairy, organ meat, eggs, orange and green vegetables; and orange fruits), protein-rich foods (pulses, dairy, flesh meat, organ meat, fish and eggs) and iron-rich foods (flesh meat, organ meat, and fish) (WFP 2015).

Table 2 Variable Definition, Measurement and Descriptive Statistics

Variables	Definition and measurement	Mean	S.D.
Panel A: C*ommercialization*			
HCCI	Household crop commercialization index (in percentage)	36.76	19.02
Subsistence-oriented	1 if household sells less than 25% of harvest; 0 otherwise	0.36	0.48
Surplus-oriented	1 if household sells between 25% & 49.99% of harvest; 0 otherwise	0.41	0.49
Commercial-oriented	1 if household sells at least 50% of harvest; 0 otherwise	0.23	0.41
Panel B: *Household characteristics*			
HHAge	Age of household head (years)	44.03	12.04
HHSex	1 if household head is male; 0 otherwise	0.59	0.49
HHEducation	Number of years in school by household head	1.27	3.27
HHSize	Household size (number of persons)	5.63	2.14
HHLandholding	Total land size of household (in hectares)	2.56	1.56
CB_Assoiations	Number of associations the farmer is a member in the community	1.07	1.27
Log HHIncome	Log of total household annual income	8.39	0.71
Log HHLivestock	Log value of household livestock at beginning of 2015 season	7.65	2.19
Log HHDAsset	Log value of household durable assets at beginning of 2015 season	9.11	0.88
Extension	1 if ever had extension contact; 0 otherwise	0.34	0.47
Save money	1 if household regularly save money; 0 otherwise	0.72	0.45
Save food	1 if household at least save some food surplus; 0 otherwise	0.06	0.23
Panel C: *Community variables and district FEs*			
Town distance	Distance from community to main town center in kilometers	15.46	11.86
Local wage	Local wage rate per day in GHS	6.22	1.34
Gushegu	1 if household resides in Gushegu district; 0 otherwise	0.24	0.43
Karaga	1 if household resides in Karaga district; 0 otherwise	0.15	0.36
Savelugu-Nanton	1 if household resides in Savelugu-Nanton district; 0 otherwise	0.32	0.46
Tolon	1 if household resides in Tolon district; 0 otherwise	0.19	0.39
Kumbungu	1 if household resides in Kumbungu district; 0 otherwise	0.09	0.28
Panel D: *Instruments*			
PreProductContract	1 if farmer has no pre-planting input contract in the past 5 years, 0 otherwise	0.18	0.39
HHMobileNetwork	1 if household location has a telecommunication network coverage, 0 otherwise	0.72	0.45
CMarket	1 if household resides in community with market, 0 otherwise	0.44	0.49

(Continues)

Table 2 Continued

Variables	Definition and measurement	Mean	S.D.
Farm_shock	1 if household experience any shock in farming due to weather or bush/wildfires in the past 5 years, 0 otherwise	0.59	0.49
NonEmployTravel	1 if a household member left the community for non-employment reasons (such as marriage, education, or religion) in the past year, 0 otherwise	0.23	0.42
Panel E: ***Other covariates of the first-stage household income model***			
Tractor	Tractor cost per acre in GHS	57.28	40.85
SeedUse	Quantity of crop seeds used per acre in kilograms	67.15	207.32
SeedPrice	Average seed price in GHS	32.01	177.68
Fertilizer	Cost of fertilizer applied per acre in GHS	56.94	67.01
Pesticides	Cost of pesticides applied per acre in GHS	1.47	5.98
Weedicides	Cost of weedicides applied per acre in GHS	20.65	30.28
Labor	Number of man-days per acre	22.98	10.68
Soil fertility	4 = fertile; 3 = moderately fertile; 2 = less fertile; and 1 = infertile	1.20	0.36

Notes*: the table depicts the definition, measurement, and descriptive statistics of household crop commercialization, instruments, and other controls. Panel A shows the household crop commercialization index (HCCI) and the proportion of households under each market orientation. Panels B and C consist of household, community and district controls, while panel D contains the instruments used for exclusive restriction in the first-stage market orientation model as well as the first-stage household income regression to account for potential endogeneity of household income. Panel E consists of farm inputs and soil characteristics of households. GHS is Ghana cedis, which is the Ghanaian currency.*

of output marketed, we model household market orientation as an ordered choice (Heckman, Urzua, and Vytlacil 2006). We define the latent variable C_{ij}^{*}, which denotes sorting of farm households i into the three categories of market orientation, based on an ordered probit selection rule as

$$\begin{aligned} & C_{ij}^{*} = \alpha_j' \mathbf{Z}_i + \mu_{ij}, \\ \text{where} \quad & C_{ij} = \mathbf{1}\left\{ \tau_j(w_j) < \alpha_j' \mathbf{Z}_i + \mu_{ij} \le \tau_{j+1}(w_{j+1}) \right\}, \\ & j = 1, 2 \ldots \bar{J} \end{aligned} \tag{2}$$

and the cutoffs satisfy

$$\tau_j(w_j) \le \tau_{j+1}(w_{j+1}), \quad \tau_0(w_0) = -\infty, \quad \text{and} \, \tau_{\bar{J}}\left(w_{\bar{J}}\right) = \infty$$

where C_{ij} is a multivalued observed treatment variable, $\mathbf{Z}_i$ is a vector of observed controls, $\alpha_j' \mathbf{Z}_i + \mu_{ij}$ is a latent linear index, α_j is a vector of parameters to be estimated, w_j is a vector of observed regressors, $\tau_j(w_j)$ are threshold parameters (which are allowed to depend on the regressors[5]), and μ_{ij} are error

[5]*Such a model is referred to as the generalized ordered probit model, as opposed to the classical ordered choice model which assumes the distribution of* w_j *are degenerate, and thus the thresholds* τ_j *are assumed constants (Heckman, Urzua, and Vytlacil 2006).*

terms. To the extent that we are interested in the estimation of the impact of farm household market orientation (C_{ij}) on food and nutrients consumption, we denote the observed food and nutrients consumption outcomes as Y_{ij} for the three market orientations. We express the outcomes as linear functions of a vector of observed independent variables, X_i as;

$$Y_{ij} = \begin{cases} \beta_1' X_i + \epsilon_{i1} \; if \; C_i = 1 \\ \beta_2' X_i + \epsilon_{i2} \; if \; C_i = 2 \\ \beta_3' X_i + \epsilon_{i3} \; if \; C_i = 3 \end{cases} \tag{3}$$

where the vector of coefficients, β_j, of X_i are allowed to depend on the treatment options, and ϵ_{ij} is assumed to have a zero mean and variance of σ_j^2, for each $j = 1,2,3$.

Households' market orientation in this study are nonrandom and implies that orientation status of farmers could differ systematically due to self-selection of households into categories. Selection bias can result from both observed factors (such as education, landholding, wealth, etc.) and unobserved factors (such as innate abilities). Such factors may simultaneously drive correlations in households' market orientation and the outcomes, which will result in omitted variable problem (Heckman, Humphries, and Veramendi 2018). As a result, estimation of equation (3) with ordinary least squares will generally result in biased and inconsistent estimates. We can control for the observed sources of selection (to the extent possible) with detailed household and contextual data, but the unobservable factors remain a source of concern for this analysis.

In order to account for the threats of selection bias and omitted variable problem in the light of the ordered nature of the selection variable, we employ the ordered probit selection model (Heckman, Urzua, and Vytlacil 2006). This is a parametric model that assumes joint normality of the errors in equations (2) and (3) (i.e., ϵ_{ij}, μ_{ij}), and uses full information maximum likelihood procedure to jointly estimate a first-stage ordered probit of household market orientation in equation (2), and a second-stage outcome models for the three regimes of market orientation (equation (3). The process accounts for selection bias and omitted variable problem by inserting calculated inverse Mills ratios from the first-stage ordered choice model into the second-stage food and nutrients consumption model. The coefficients of the inverse Mills ratios, which we denote as ρ_j= Corr(ϵ_{ij}, μ_{ij}), define the correlation between the errors in equations (2) and (3). Significance of the correlation coefficients, ρ_j, will suggest the presence of selection bias indicating that households' market orientation decisions are endogenous. The signs of the ρ_js show the pattern of correlation.

A critical concern is that the estimation of the selection and outcome equations requires an exclusion restriction, or a source of variation to avoid collinearity and enhance identification. However, an issue that complicates the exclusion restriction in the ordered choice setting is the need for an instrument for each transition (Heckman, Urzua, and Vytlacil 2006). The three ordered choices give two transitions (i.e., subsistence to surplus, and surplus to commercial) which intuitively suggest the need for at least two instruments. In this study, we use farmers' access to preplanting input contract for the past five years prior to the 2015 cropping season, telecommunication network coverage at the location of the household and the presence of at least periodic market in the village as instruments.

Past preplanting input contract, is correlated with farmer market orientation, because it contributes to minimizing market risks and transaction costs (Mishra et al. 2018). Whereas we do not expect past preplanting contract to directly affect current food and nutrients consumption, it is possible that it may affect current consumption through past food stored for current consumption. Table 2 (panel B) shows this is not a threat, because very few (6%) households reported saving food from previous season. Also, these households do not systematically differ across market orientation (table A1, panel C) and past preplanting contract status in table B1 in appendix B. Access to telecommunication network coverage and village markets in Ghana vary substantially across villages (Zanello 2012), and are expected to be good predictors of household market orientation, because these can increase households' access to real-time market information and reduce transaction cost of marketing, which are key constraints to market engagement in these areas (MoFA 2017). However, these instruments should not directly affect households' current food and nutrients consumption, other than through households' market engagement. We further control for distance to the town center, household income, and assets to ensure that the instruments are not picking up any proximity, wealth, and income effects.

The final issue is the potential endogeneity of household income. Household income may be endogenous in the market orientation equation, because increased commercialization can lead to increased farm income through high price premiums. In the food and nutrients consumption equation, household income may be endogenous because of the joint production and consumption decisions among agricultural households in developing countries (Fafchamps 1992). To account for the potential endogeneity, we employ the Control Function approach (Wooldridge 2010; Abdulai and Huffman 2014), using households experience of any shock on the farm due to weather or wildfires in the past five years as instrument. Such shocks are usually exogenously determined by idiosyncratic factors and are expected to be good predicters of households' total income, because of the association between such shocks and household crop output and income. Given this, we estimate a first-stage generalized linear model of household income on the instrument and other controls, and then insert the predicted residuals into the selection and the outcome equations to account for the potential endogeneity of household income.

Given the correction for sample selection and the identification issues, we estimate the average treatment effects for transitioning between two orientations, j and $j + 1$, on the population ($ATE^{\dagger}$), on everyone at the transition point between j and $j + 1$ (ATE), on the treated (ATT) and on the untreated (ATU). The difference between $ATE^{\dagger}$ and ATE shows the difference in the characteristics of farmers in the entire population and those at the transition between two market orientations. In addition, the difference between the ATT and ATE measures sorting on gains, whereas the difference between ATU and ATE measures sorting losses (Heckman, Humphries, and Veramendi 2018). Finally, the relationship among ATE, ATT, and ATU shows the pattern of sorting on gains, such that if ATT > ATE > ATU, this will suggest positive selection on gains, and if ATU > ATE>ATT will indicate reverse selection on gains (Cornelissen et al. 2018).

Results and Discussion

This section presents and discusses the results of our estimations. We first present the results of the first-stage estimates of households' market

orientation and the second-stage estimates of food and nutrient-rich foods consumption. We next report the results of the treatment effects of households' market orientation.

First- and Second-Stage Results

We report the marginal effects of the first-stage ordered probit estimates of determinants of household market orientation in table 3, with subsistence-oriented as the base category. The estimates show that household income and wealth significantly affect market orientation. In particular, a percentage increase in household income decreases the probabilities of being subsistence- and surplus-oriented by 0.14 and 0.13, respectively, and increases the probability of being commercial-oriented by about 0.27. The estimates show that a percentage increase in household livestock value significantly increases the probability of being commercial-oriented by about 0.04.

Similarly, the probability of being subsistence-oriented household decreases by about 0.11, while that of being surplus and commercial-oriented households increase by 0.09 and 0.01 respectively, when the value of household durable assets increases by 1%, *albeit* not significant for commercial-oriented. These estimates generally suggest that wealthy households appear to be more commercially inclined than less wealthy households. These results confirm the finding by Abdulai and CroleRees (2001) that household income and wealth play important roles in households' diversification away from subsistence agriculture. Wealthy households tend to be less vulnerable to risks of market failures and exposure to food insecurity, because of the relatively high security due to their wealth and income, compared to poorer households who are severely affected by market imperfections and inefficiencies (Von Braun, Kennedy, and Bouis 1989; Abdulai and Aubert 2004; Ogutu, Godecke, and Qaim 2019).

Our results further show that the instruments strongly predict the probability of either being subsistence-, surplus-, or commercial-oriented household. The estimates show that households with past preplanting input contracts are more likely to be surplus-oriented, whereas those with access to telecommunication network and markets in the village are more likely to be commercial-oriented. We test the validity of the instrument by regressing the respective outcomes on our set of controls and the instruments in part B of table B3, and the results show that all the instruments are valid, as they do not significantly explain food and nutrients consumption.

We further check the relevance and validity of these instruments by presenting test diagnostics of a generalized method of moments (IV-GMM)[6] estimations of the effect of commercialization on the outcomes in table B2. The diagnostics test statistics reported at the bottom of table B2 (col. 1) further suggest the instruments are together relevant, and as such, good predictors of household degree of commercialization. Specifically, the Cragg-Donald F-statistic of 14.75, the Kleibergen-Paap rk Wald F-statistic of 45.98 and the associated Angrist and Pischke (2009) p-value ($p = 0.000$) all reject the null hypothesis that the instruments are weak. Moreover, given the Hansen J test statistic of 3.452 and the p-value of 0.178, we cannot reject the null hypothesis

[6]*We use the IV-GMM estimator because of its efficiency over the conventional two-stage least squares when the equation is over-identified (which is the case in our application as the number of instruments, three, exceed the number of endogenous regressors of one) and its robustness to heteroskedasticity (Kuma et al. 2018).*

Table 3 First-Stage Determinants of Market Orientation

	Subsistence-Oriented (1)		Surplus-Oriented (2)		Commercial-Oriented (3)	
	Marginal effect	S.E.	Marginal effect	S.E.	Marginal effect	S.E.
HHAge	−0.001	0.001	0.001	0.001	9.1E-5	0.001
HHSex	−0.029	0.053	0.137**	0.057	−0.108**	0.042
HHEducation	−0.009	0.008	0.005	0.008	0.003	0.005
HHSize	0.013	0.011	−0.017	0.012	0.004	0.008
HHLandholding	−0.014	0.017	0.007	0.018	0.006	0.012
CB_Assoiations	0.022	0.019	−0.047**	0.020	0.025	0.015
Log HHIncome	−0.144**	0.064	−0.130**	0.064	0.274***	0.047
Log HHLivestock	−0.016	0.011	−0.020	0.014	0.036***	0.012
Log HHDAsset	−0.107***	0.029	0.096***	0.030	0.010	0.021
Town distance	−0.001	0.021	0.006**	0.003	−0.005**	0.002
Local wage	0.041*	0.021	−0.062**	0.023	0.020	0.018
Gushegu	0.060	0.084	−0.246**	0.108	0.186*	0.092
Karaga	0.041	0.087	−0.352***	0.110	0.310***	0.094
Savelugu-Nanton	0.140	0.085	−0.386***	0.097	0.245***	0.084
PreProductContract	0.272***	0.061	−0.220***	0.063	−0.051	0.046
HHMobileNetwork	−0.228***	0.054	0.100*	0.056	0.128***	0.037
CMarket	−0.039	0.048	−0.099*	0.053	0.138***	0.040
HHIncomeResid	0.139	0.089	0.075	0.089	−0.214***	0.056
Log likelihood			−426.27			
LR $X^2(36)$			217.65			
Prob X^2			0.000			
X^2 (3) excluded instruments			39.60			
Prob X^2			0.000			
Number of observations		180	206		114	

Notes*: First-stage generalized ordered probit estimation of equation (2). Column (1) presents the marginal effects and the standard errors (S.E.) of the various covariates on the likelihood of being a subsistence-oriented household. Columns (2) and (3) report the marginal effects and standard error of the covariates on the likelihood of being a surplus-oriented and commercial-oriented household respectively. The asterisks ***, **, and * are significance at 1%, 5%, and 10% levels, respectively.*

of zero correlation between the instruments and the error term (the second-stage estimates are reported in part A of table B3).

We report results of the second-stage estimates of food and nutrients consumption in tables C1 and C2. The estimates show that education significantly increases the consumption of food, protein, and hem iron-rich foods for subsistence-oriented households, and the consumption of food and only vitamin A-rich foods for surplus-oriented households. This confirms past findings that education is positively associated with better food and dietary diversity (Issahaku and Abdulai 2020). In addition, an increase in household size results in increased consumption of food and vitamin A-rich foods, although weakly significant at the 10% level, for surplus-oriented households. This suggests the labor effect of household size, which contributes to increased crop production, outweighs the dependency effect for the surplus-oriented households, and thus explains the positive effect of the household size[7] in this case.

[7]*Family labor is an important part of household labor in the sample and constitutes about 74% of the total labor days used on households' farms in the sample.*

The results further reveal that household income significantly increases food and vitamin A food consumption for surplus-oriented households, as well as the consumption of protein and hem iron foods for surplus and commercial-oriented households, lending support to past studies that income growth tend to increase calorie intake (Abdulai and Aubert 2004; Colen et al. 2018; Kuma et al. 2018). However, household income generally reduces food and nutrient-rich food consumption for subsistence-oriented households, although not statistically significant. This suggests that some sales of crops by subsistence-oriented households are due to distress that results in a trade-off between household food and nutrients consumption on one hand and the household income on the other hand. This incidence has been reported in the context of developing countries where farmers are forced to sell their harvest to meet immediate financial requirements (such as servicing of debts or other household needs) and later on have to buy food from the market, or borrow food to meet household food needs (Reardon et al. 2006; Jacoby and Minten 2009).

Similarly, household wealth plays an important role in enhancing food and nutrients consumption. In particular, an increase in the value of household livestock significantly increases household food and nutrient-rich food consumption for subsistence, while significantly increasing the consumption of only nutrient-rich foods for surplus-oriented households. Furthermore, an increase in the value of household durable assets is estimated to significantly increase food consumption for subsistence and surplus-oriented households, and to increase nutrient-rich foods consumption for all groups.

We report the ρs, which show the correlation between the errors in equations (2) and (3) at the bottom of tables C1 and C2. The estimated correlations are weakly significantly different from zero ($p < 0.1$) for protein and hem iron foods consumption in the commercial-oriented category, indicating the presence of self-selection. This implies that transitioning into commercial-orientation may not have the same effect on protein and hem iron foods consumption for the other two market orientations if they transition (Heckman, Urzua, and Vytlacil 2006; Abdulai and Huffman 2014). The positive signs of the coefficients indicate reverse selection on unobserved gains, suggesting that farm households with more than average protein and iron-rich food consumption have lower probabilities of transitioning into commercial-oriented category.

Treatment Effects Measures

Table 4 presents the treatment effects estimates of farm households' transition between market orientation. Panel A presents the treatment effects between subsistence and surplus-oriented, while panel B reports the treatment effects between surplus and commercial-oriented. We report the treatment effects between subsistence and commercial-oriented in panel A of table 5, although we mainly focus on table 4 in what follows.

In respect to transitioning between subsistence and surplus orientation (panel A), the ATE† estimates for the entire population show that moving from subsistence- to surplus-oriented increases food consumption by 14.9%, and the consumption of vitamin A-, protein-, and iron-rich foods by 18%, 25% and 26%, respectively, for an average household chosen at random. This is higher than the other treatment effects measures (i.e., ATE, ATT and ATU)

Table 4 Treatment Effects Estimates of Household Market Orientation on Food and Nutrients Outcomes

	(1) Food		(2) Vitamin A		(3) Protein		(4) Hem iron	
	Treatment effect	**% of base choice**	**Treatment effect**	**% of base choice**	**Treatment effect**	**% of base choice**	**Treatment effect**	**% of base choice**
Panel A								
Subsistence *vs*. Surplus								
ATE†	4.405*** (0.159)	14.89	1.893*** (0.087)	17.73	1.231*** (0.072)	25.27	0.780*** (0.049)	26.42
ATE	3.462*** (0.151)	11.62	1.338*** (0.079)	12.51	0.825*** (0.065)	17.89	0.517*** (0.046)	18.66
ATT	3.971*** (0.530)	13.34	1.705*** (0.254)	15.72	1.102*** (0.179)	21.89	0.668*** (0.117)	21.66
ATU	2.879*** (0.490)	9.65	0.919*** (0.245)	8.73	0.509** (0.179)	12.33	0.345*** (0.115)	14.30
Panel B								
Surplus *vs*. Commercial								
ATE†	6.107*** (0.206)	17.97	1.892*** (0.087)	15.05	2.360*** (0.078)	38.67	1.635*** (0.053)	43.79
ATE	4.959*** (0.256)	14.29	1.639*** (0.116)	12.41	1.917*** (0.099)	27.67	1.303*** (0.067)	30.42
ATT	2.664*** (0.619)	7.31	0.831*** (0.261)	5.77	1.164*** (0.228)	13.93	0.724*** (0.149)	13.81
ATU	6.229*** (0.427)	18.46	2.087*** (0.179)	16.63	2.333*** (0.130)	38.02	1.623*** (0.085)	43.25

Notes*: the table shows ordered Heckman treatment effects estimates of the impact of household market orientation on households' food, vitamin A-, protein-, and hem iron-rich foods consumption between subsistence and surplus in panel A, and between surplus and commercial in panel B. ATE† is the average treatment effects for the entire population; ATE is the average treatment effects for those at the point of deciding between two orientation, ATT is average treatment effects on the treated and ATU is average treatment effects on the untreated. Values in parenthesis are robust standard errors. The asterisks *** and ** are significance at 1% and 5% levels, respectively.*

Table 5 Treatment Effects Between Subsistence and Commercial, and Difference in Treatment Effects Between Subsistence to Surplus for Nonsellers and Those Selling Less Than 25%

	Food	**Vitamin A**	**Protein**	**Hem iron**
Panel A				
Subsistence to commercial	(1)	(2)	(3)	(4)
ATE†	10.512*** (0.172)	3.785*** (0.095)	3.592*** (0.076)	2.415*** (0.049)
ATE	10.730*** (0.218)	3.781*** (0.120)	3.701*** (0.095)	2.502*** (0.060)
ATT	10.263*** (0.576)	4.602*** (0.259)	3.769*** (0.187)	2.393*** (0.119)
ATU	11.026*** (0.399)	3.261*** (0.202)	3.658*** (0.135)	2.571*** (0.087)
Panel B				
Subsistence to surplus				
ATU for 0 <sales <25% of output	2.912 (0.232)	0.986 (0.120)	0.569 (0.095)	0.391 (0.068)
ATU for 0 sales of output	2.642 (0.721)	0.434 (0.325)	0.078 (0.095)	0.011 (0.184)
Difference in ATUs	0.270 (0.675)	0.552 (0.344)	0.490* (0.275)	0.379* (0.194)

Notes*: The table shows ordered Heckman treatment effects estimates of the impact of household market orientation on household food and nutrient-rich foods consumption. In panel A, ATE† is the average treatment effects for the entire population; ATE is the average treatment effects for those at the point of deciding between two transitions, ATT is average treatment effects on the treated and ATU is average treatment effects on the untreated. Panel B compares the treatment effects of subsistence farmers transitioning from subsistence to surplus-oriented (i.e., ATU) between nonselling farm households and those who sell less than 25% of the output. Values in parenthesis are robust standard errors. The asterisks *** and * are significance at 1% and 10% levels, respectively.*

that condition on those making this transition. This suggests that the characteristics of those at the transition between subsistence and surplus are somewhat less favorable than those in the population, possibly due to the better characteristics of commercial-oriented households (Heckman, Humphries, and Veramendi 2018). For those transitioning from surplus to commercial orientation, the average treatment effects ($ATE^{\dagger}$) of a farm household chosen at random from the population is estimated as 18% for food consumption, and 15%, 39% and 44% for vitamin A-, protein-, and iron-rich foods consumption, respectively (panel B).

We next focus on the specific treatment effects across the outcomes, as their relationships indicate the pattern of selection as stated in the analytical framework. Regarding food consumption in column (1), the treatment effects (i.e., ATE, ATT, and ATU) are all statistically significant at the 1% level across the transitions (table 4). Recall that the ATE measures the average effects only for households transitioning between two market orientation. The results show that food consumption significantly increases by 11.6% and 14.3% for a randomly chosen farm household at the transition between subsistence and surplus-orientation and between surplus and commercial-orientation, respectively. With regards to nutrient-rich foods consumption, the ATE suggests that going from subsistence to surplus-orientation tend to increase vitamin A-, protein-, and iron-rich foods consumption by about 13%, 18% and 19%, respectively, for an average household transitioning between subsistence and surplus-orientation (panel A). Similarly, going from surplus to commercial-orientation increases consumption of foods rich in vitamin A, protein, and iron by about 12%, 28%, and 30%, respectively, for an average household transitioning between surplus and commercial-orientation (panel B).

The ATT estimates for food consumption indicate that for a surplus-oriented household, going from subsistence to surplus orientation results in 13.3% increase in food consumption, whereas for a commercial-oriented household, going from surplus to commercial orientation increases food consumption by 7.3%. The results of the ATT for vitamin A-, protein-, and iron-rich foods consumption suggest that for an average surplus-oriented household, going from subsistence to surplus-orientation increases the consumption of foods rich in these nutrients by 16%, 22% and 22%, respectively. At the same time, going from surplus to commercial-orientation increases vitamin A-, protein-, and iron-rich foods consumption by about 6%, 14% and 14%, respectively, for a commercial-oriented household.

We also considered what the returns to marketing will be should subsistence-oriented households become surplus-oriented, or surplus-oriented households become commercial-oriented in the estimates of the ATU. For subsistence-oriented household, going from subsistence to surplus orientation increases food consumption by 9.7%, while transitioning from surplus to commercial orientation increases food consumption by 18.5%. The estimates for the nutrient-rich food consumption show that for a subsistence-oriented household, going from subsistence to surplus orientation increases consumption of vitamin A-, protein-, and iron-rich foods by 8.7%, 12.3% and 14.3%, respectively, if they transition into surplus orientation. Similarly, going from surplus to commercial orientation increases the consumption of vitamin A-, protein-, and iron-rich foods by about 16.6%, 38%, and 43.3%, respectively.

Conclusions and Policy Implications

Food insecurity and malnutrition remain major challenges in sub-Saharan Africa, despite many interventions like the Millennium Development Goals and the Sustainable Development Goals, which aimed at reducing poverty and hunger in the world. Similarly, several authors have analyzed the policy options which have been implemented and their impacts on household welfare measures such as income, wages, as well as food security and nutrition. In this article, we presented a systematic overview of the literature on policies and strategies to improve food security and nutrition in Africa, as well as an empirical analysis on the impact of smallholder market participation as a strategy for enhancing food security and nutrition in Ghana.

The survey of the literature shows that most food security and nutrition policies and interventions in Africa have centered around indirect measures such as improving agricultural infrastructure and economic incentives, as well as providing smallholders with new agricultural technologies, and climate-smart practices to increase farm output and productivity. These indirect policy options have gained considerable attention over the past three decades. In addition to these, some direct interventions such as structural changes in relative prices and targeted food subsidies have been implemented with the aim of improving food access through lower market prices and the stabilization of consumption in times of high food price inflation. However, lack of proper targeting of the poor, removal of subsidies, as well as the lack of sustainability and exit mechanisms of these direct interventions have often led to the failure of many of these policies. These have led to governments using measures that stimulate sufficient levels of demand to improve food security and nutrition. These measures commonly involve cash transfers, income diversification strategies and increased access to markets.

To this end, several studies have examined the effects of market participation on household productivity, income, and calorie intake. However, the impacts of smallholder market participation, especially on food security and nutrition, varies across food and nutrition outcomes and also over smallholder market orientation. The results from the empirical analysis on Ghana show that gains from commercialization are higher for protein- and iron-rich foods consumption compared to that of food and vitamin A-rich food consumption, which are mainly due to increased farm and household incomes. Household income tends to increase vitamin A-rich food consumption of surplus-oriented smallholders, and protein- and iron-rich foods consumption of both surplus- and commercial-oriented smallholders. This is not surprising, given the low dietary quality in the area and the fact that most foods rich in protein and iron such as meat, fish, and eggs are generally from cash purchases compared to staple foods, which are mostly from own production (WFP and GSS 2012; GSS 2018).

In addition, food and nutrient-rich foods consumption is generally higher for smallholders transitioning from surplus to commercial, compared to their counterparts transitioning between subsistence and surplus. This is probably because the level of market integration, albeit generally low among the farmers, is comparatively higher for commercial-oriented households, due to the high profit and market orientation (Von Braun, Kennedy, and Bouis 1989; Pingali and Rosegrant 1995). In fact, we see that there is no substantial difference in consumption between pure subsistence smallholders and those who sell some but not more than 25% of the output in panel B of

table 5. These findings imply that smallholders will benefit more from marketing if they are able to sell more with the motive of making profit.

Furthermore, the pattern of consumption gains differs across market orientation. There is positive selection on gains in transitioning from subsistence orientation to surplus orientation, suggesting that more endowed subsistence-oriented households tend to benefit more in terms of consumption when they move to surplus-oriented than their less endowed counterparts. However, less endowed households appear to benefit more in going from surplus to commercial orientation, suggesting reverse selection on gains, where disadvantaged households who are less likely to transition from surplus to commercial tend to benefit more if they move from surplus to commercial. Thus, when less endowed subsistence and surplus-oriented households are able to overcome existing market constraints and transition into commercial orientation, this will substantially increase their food and nutrients consumption through increased income (Pingali and Rosegrant 1995; Abdulai and Huffman 2000). In effect, the overview of the literature and the empirical analysis suggest the following policy directions:

- To the extent that ineffective targeting of the poor has been partly responsible for the failure of many policies in sub-Saharan Africa, public policies need to move beyond "broader targeting," where sectors and subsectors that are conceived to strongly affect the poor are targeted. Thus, "narrow targeting," where poor locations and segments of the population are earmarked and targeted for food security and nutrition interventions could be considered. It is also important to promote collaboration between government and other development partners at national and local levels to develop workable criteria, and to supervise the intervention process to eschew the accrual of intervention gains to political actors and influential groups.
- Structural reforms that were implemented by many African countries initially contributed to increased output and productivity. However, the reduction or removal of subsidies on farm inputs in many cases led to increased input prices, reduced productivity, and increased food insecurity and malnutrition in the long run. Policymakers should put emphasis on how policies and interventions can ensure a balance in state efficiency and productivity, without compromising food security and nutrition in the long run. Governments can consider measures such as promotion of market access and efficient supply chains, income diversification, and other productivity-enhancing interventions that stimulate sufficient and sustained levels of production and demand.
- Smallholder commercialization can promote household food security and nutrition through increased household income, as shown by the empirical analysis. Smallholder commercialization therefore can serve as a strategy for stimulating household demand for food and nutrients, although inadequate market information and access often limit their market participation. Thus, policies should consider providing platforms such as mobile agriculture services and trainings on market intelligence and promotion services to increase smallholder commercial orientation and market integration.
- Smallholder transition from subsistence to surplus orientation tend to favor more endowed households in terms of consumption. Policymakers can consider measures that minimize smallholders resource constraints and stimulate household crop productivity in order to enhance the capacity of less endowed subsistence households. Such measures may include cash

crop programs that support farmers with inputs, and training to increase their access to improved inputs and innovations, and also to facilitate other spillover benefits between food and cash crop cultivation (Govereh and Jayne 2003).

- Conversely, less endowed households appear to benefit more in transitioning from surplus- to commercial-oriented. Thus, promotion of higher smallholder commercialization will require, in addition to output augmenting measures, the mitigation of some of the market barriers and failure (market availability, physical access and information, market standards, inadequate credits, etc.) that limit poor smallholders from engaging in sales for profit (see also Wiggins et al. 2011; Abdul-Rahaman and Abdulai 2020). Interventions such as market information platforms, farmer cooperatives, and collective actions as well as contract buying, which provides ready markets for farmers, will be quite rewarding (Ma, Abdulai, and Goetz 2018).

In addition to these policy directions, there are some potential areas that future research efforts could consider to increase our understanding of the role of smallholder market engagement, and the impacts of policies and strategies to enhance food security and nutrition in developing countries. One of such areas will be to examine how smallholder engagement in input markets, and the integration into the rural cash economy impact food security and nutrition (Von Braun, Kennedy, and Bouis 1989). This is because past studies in this area tend to focus on output market participation and drivers of diversification (Abdulai and Delgado 1999; Abdulai and CroleRees 2001). Also, studies that examined the impacts of nonfarm work mostly neglect the nutritional aspect of food security, in spite of the income elasticity differences among various food and nutrient elements (Abdulai and Aubert 2004; Owusu, Abdulai, and Abdul-Rahman 2011; Colen et al. 2018).

Another area related to the empirical analysis in this article is how farmers' market orientation and marketing affect intrahousehold production decisions and food consumption distribution, since their effects could be heterogeneously distributed across individuals and various demographic groups of household members (Carletto, Corral, and Guelfi 2017; Ogutu, Godecke, and Qaim 2019). In particular, there is the need to understand the effects of smallholder marketing and diversification on intrahousehold power and decision-making, domestic violence, and poverty. It will be interesting to also know which demographic groups are the most affected by food and nutrition insecurity, and to what extent smallholder market engagement and related policies contribute to intrahousehold distributive impacts on food and nutrition insecurity.

Moreover, not much has been done on how heterogeneities in costs and returns to climate-smart adaptation practices affect smallholder adaptation, although there is some growing interest in the literature (Di Falco, Veronesi, and Yesuf 2011; Issahaku and Abdulai 2020). There is, therefore, the need for future studies to also examine heterogeneities in returns to climate change adaptation practices, given that such returns may be different across households and adaptation strategies. In particular, it will be interesting to examine how climate change, climate shocks, and sociocultural norms impact vulnerable groups (such as the physically challenged, aged, women, and children) who are normally disadvantaged in productive capacities, and in economic and geographical mobility. It is also important to understand how

smallholder market and nonfarm engagement can be used as climate change resilience strategies, particularly for vulnerable groups in developing countries, given the reliance of many of such groups on crop marketing, and the fact that agriculture is the hardest hit sector by climate change in these regions.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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