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Implications of the Fertilizer-Subsidy Programme on Income Growth, Productivity, and Employment in Ghana

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Abstract

We examined the economy-wide impact of a fertilizer-subsidy programme in Ghana with a focus on agricultural-sector productivity, overall economic growth, employment, and welfare. We adopted a modified version of the standard PEP-1-t model. Our results suggest that the fertilizer-subsidy programme improved GDP growth and sector-based productivity—notably, in the main agricultural subsectors and the food industry. Specifically, compared to the business-as-usual scenario, the implementation of the fertilizer-subsidy programme in 2017 improved the productivity of the maize, sorghum, and rice subsectors by about 8.3%, 4.5%, and 3.8%, respectively. These effects were, however, about four-times, three-times, and six-times higher in 2020 than their 2017 levels, respectively. We also observed important positive effects on the value-added of the food industry, indicating the presence of a backward linkage with agriculture. The unemployment rate among skilled labour (except urban skilled labour in agricultural) fell under the programme, and the decline in unemployment was relatively more pronounced for rural skilled labour in non-agricultural activities. In addition, we found evidence of positive effects on household consumption and, subsequently, on welfare. Based on these findings, we recommend that the fertilizer-subsidy programme be implemented and, if possible, extended beyond its planned implementation period.

JEL: C68; D24; I32; Q18.

Keywords: Agricultural sector, Fertilizer subsidies, Productivity, Economic Growth, Employment, CGE modelling

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I. Introduction

Development-policy practitioners around the world have acknowledged the importance of inclusive growth in the fight against poverty and inequality. This broad concern, however, dwells largely on the pattern and sources of economic growth as well as on the distribution of the benefits of growth. In most developing countries, the agricultural sector is relatively more labour intensive and contributes relatively more to labour absorption than do non-agricultural sectors (Vargas et al., 2017). In Ghana, for example, the agricultural sector employs the majority of the labour force, especially in rural areas.[1] This phenomenon suggests that an agricultural-sector-led economic expansion may be relatively more inclusive—in terms of the distribution of the gains from growth—than non-agricultural sector-led growth (Breisinger, Diao, Kolavalli & Thurlow, 2008).

As in many other developing countries, especially those in sub-Saharan Africa, the Ghanaian economy has witnessed the promulgation of numerous agricultural sector policies/programs all aimed at increasing agricultural output and productivity and improving the economic lives of poor smallholder farmers. A major component of recent agricultural sector support programs, however, is subsidization of the price of fertilizer by the government of Ghana. In particular, the government of Ghana launched the national fertilizer-subsidy programme in 2008 to provide fertilizer at subsidized prices to smallholder farmers. This programme witnessed an important boost in 2017 following the implementation of the Planting for Food and Jobs programme (hereafter, PFJ). Among other things, PFJ was expected to increase the availability and accessibility of farm inputs to farmers, reduce their cost of production, and ultimately allow farmers to apply the right quantities of fertilizer.

Given the high cost of implementation of a fertilizer-subsidy programme coupled with the rather mixed evidence on its effects (see, e.g., Morris et al., 2007; Dorward & Chirwa, 2011; Druilhe & Barreiro-Hurlé, 2012; Warr & Yusuf, 2014), there was a need for a deeper analysis of the economic consequences of the fertilizer-subsidy programme in Ghana. Consequently, we examined the economy-wide effects of the fertilizer-subsidy

[1] In Ghana, about three-quarters of rural dwellers are engaged in agricultural activities (Ghana Statistical Service, 2014). Moreover, the agricultural sector absorbed in excess of 58% of the labour force in 1992 and about 44.7% in 2012, on average (Danquah & Iddrisu, 2017).

programme (through PFJ) in Ghana with a focus on the welfare implications of such an intervention. Specifically, this study was underpinned by the following research questions:

(i) what is the impact of the fertilizer-subsidy programme on productivity/production by sector?

(ii) what is the impact of the fertilizer-subsidy programme on overall GDP performance?

(iii) what is the impact of the fertilizer-subsidy programme on labour-market outcomes with a focus on the evolution of the unemployment rate among skilled labour? and

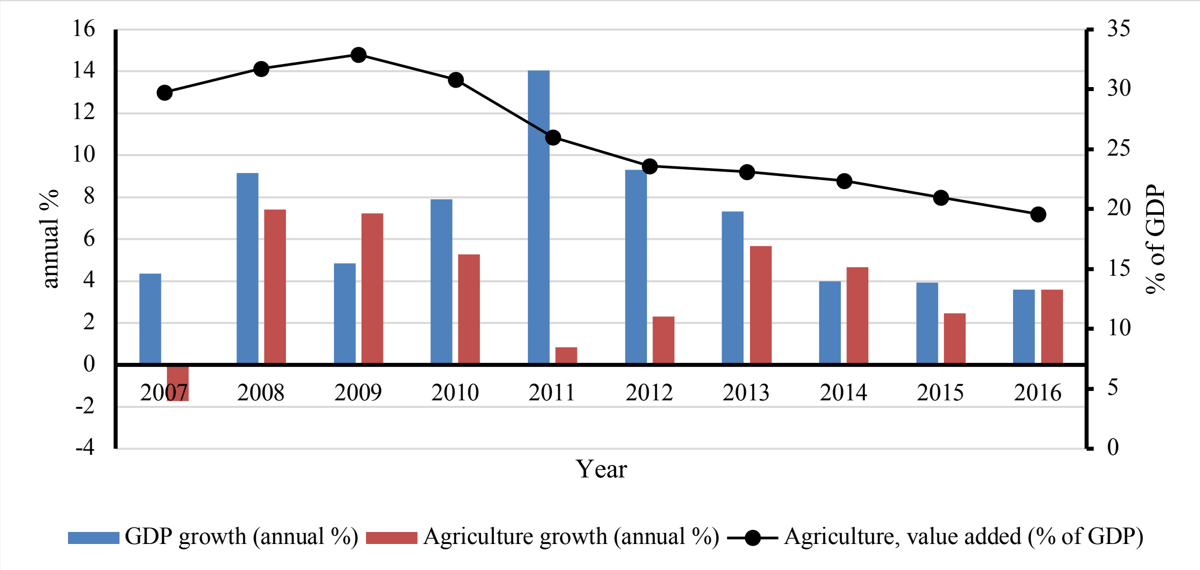
(iv) what is the impact of the fertilizer-subsidy programme on household welfare?

II. Context of the Study

Agricultural activities in Ghana are predominantly conducted on a smallholder basis with the majority of farm holdings being less than two hectares in size. However, there are some pockets of large farms and plantations for oil palm, rubber, and coconut, and, to a lesser extent, maize, rice, and pineapple. Traditional farming methods, which involve the use of hoe and machete, remain the predominant method of farming in Ghana while mechanised farming continues to be limited. Ghana's agriculture is also heavily reliant on rainfall, and irrigated farming is not widely used.

In recent times, the growth of the agricultural sector in Ghana has been rather sluggish. For instance, Ghana's agricultural growth has been less rapid than growth in the non-agricultural sectors over the period 2010-2016, expanding by an annual rate of 3.6%, relative to 7.2% growth for the whole economy, on average (see Figure 1). Furthermore, the relative contribution of the agricultural sector to Ghana's gross domestic product (GDP) declined consistently from 33% in 2009 to about 19.6% in 2016 (Figure 1) and further to 18.5% in 2017 (Government of Ghana, 2018). In particular, between 2010 and 2017, the contribution of the agricultural sector to the GDP declined by more than 37% (Government of Ghana, 2018).

Figure 1: Trends in Agricultural Sector Performance and GDP Growth Rate in Ghana, 2007-2016



Source: Authors' calculations based on the World Bank's WDI dataset (2018).

Growth in Ghana's agricultural sector has been largely attributed to extensive forces (for instance, land expansion) rather than improvements in productivity (Breisinger, Diao, Thurlow & Al-Hassan, 2008), thus raising concerns about the sustainability of agricultural growth, especially in the context of rising levels of urbanization in the country.[2] Indeed, the yield gap of agricultural activities (the exploitable difference between actual and potential output) has widened over time (Ministry of Food and Agriculture, 2016). Considering the production of the three major staple food crops in Ghana—maize, rice, and sorghum—we observed that only 35%, 46%, and 55%, respectively, of their potential yield was achieved in the 2015 planting season (see Table 1). Overall, the yield gap of agricultural production in Ghana ranges between 14% and 73% (Ministry of Food and Agriculture, 2016). The huge yield gaps in the production of Ghana's staple food crops present significant food-security challenges in the economy. Recent estimates have suggested that Ghana currently produces only 51% of its cereal needs and less than a-third of the raw materials required in agro-based industries, leaving about 5% of Ghana's population food insecure; around two million Ghanaians are vulnerable to food-security challenges (Darfour & Rosentrater, 2016).

Low on-farm productivity has been linked to a number of factors, including low accessibility or inadequate use of nutrient fertilizer. The average fertilizer-application rate

[2] An expanding urban population growth rate is expected to increase demand for food while at the same time reducing the amount of land available for agricultural activities.

for countries in sub-Saharan Africa is 7.1 kilograms per hectare; this is substantially lower than the average rates for other developing countries (e.g., 129.4 kilograms per hectare, on average, for countries in South Asia; Druilhe & Barreiro-Hurlé, 2012). The use of modern agricultural inputs such as fertilizer is an essential feature of agricultural transformation. The experience of most countries in the world suggests that agricultural transformation has led to increased agricultural productivity (Houssou, Andam & Asante-Addo, 2017).

Table 1: Average and Potential Yield of Selected Food Crops under Rain-Fed Conditions in Ghana, 2015, in Metric Tons per Hectare

Crop	Average Yield (On Farm) (MT/Ha)	Potential Yield (MT/Ha)	% Achieved
Maize	1.92	5.50	34.91
Rice (paddy)	2.75	6.00	45.83
Sorghum	1.10	2.00	55.00
Millet	1.00	2.00	50.00

Source: Ministry of Food and Agriculture (2016). MT = metric tons; Ha = hectare.

Meanwhile, as is typical of most sub-Saharan African countries, growth in Ghana's agricultural output has not been driven by increases in productivity because recorded agricultural output expansion has been linked to increases in the total area of land under cultivation over time. The level of adoption of modern technology such as fertilizer application in agricultural production in Ghana is very low. Benin et al. (2013) and Bumb, Johnson, and Fuentes (2011) have indicated that the average intensity of fertilizer application in Ghana was less than eight kilograms per hectare of cultivated land in 2008. The low intensity of fertilizer application was partly attributed to high fertilizer prices (Benin et al., 2013).

In order to improve the productivity of the agricultural sector, the government of Ghana, together with its development partners, has rolled out a number of agricultural-sector support schemes over the past few years. In 2007, for instance, the country developed its second long-term Food and Agriculture Sector Development Policy (hereafter, FASDEP II) within the regional framework of the Comprehensive African Agriculture Development Programme (hereafter, CAADP) to provide a guideline for development plans in those sectors. FASDEP II emphasized achieving food security and income growth through efficient resource use, greater competitiveness, and technological enhancement (Ministry of Food and Agriculture, 2007). This long-term policy framework led to the development of a number of Medium-Term Agriculture Sector Investment Plans (hereafter, METASIP). In METASIP I (2011-2015) and II (2014-2017), as the government underlined the need to remove constraints and promote agricultural modernization through better access to inputs, extension services, and markets. The government of Ghana, in 2017, launched a nationwide Planting for Food and Jobs programme (hereafter, (PFJ), which fit under METASIP III (2018-2021).

The overall goal of the PFJ programme is to promote food security, employment, and poverty reduction through transformation of the agricultural sector. Specifically, PFJ aims both to encourage the adoption of technologies (such as improved seeds and fertilizers) by providing incentives and appropriate training to farmers and to improve access to markets through extensive use of information and communication technology.

The programme is to be implemented over four years, from 2017 to 2020, with a total estimated cost of GH¢ 3,300,721,266 (USD $717,548,101). The implementation of PFJ is based on five main pillars: (i) seed access and development, (ii) fertilizer access and fertilizer systems development, (iii) extension services, (iv) marketing, and (v) eAgriculture. The programme is expected to enhance public-private partnership, raise productivity and farm incomes, and create jobs along the value chain. Even though a fertilizer-subsidy programme (FSP) was begun 2008, it remains an important feature of the PFJ programme.[3]

2.1 The Fertilizer-Subsidy Programme under the PFJ

Under its second pillar, the PFJ includes a nationwide fertilizer-subsidy programme with a total estimated cost of GH¢ 1,842,504,980 (USD $400,544,561)[4] over the four years from 2017-2020. The key objective of the program is to encourage appropriate fertilizer use through a price subsidy, knowledge dissemination (capacity building), and timely availability and accessibility of support services. Prior to the PFJ programme, fertilizers such as nitrogen-phosphorus-potassium (hereafter, NPK), urea, and sulfate of ammonia were available to farmers at subsidized prices through the National Fertilizer Subsidy Programme,

[3] Fertilizer subsidies were a key component of the government of Ghana's agricultural sector policy in the 1970s and early 1980s (Resnick and Mather, 2016).

[4] This estimated cost includes the cost of extension services, workshops, and training activities that aimed to ensure the adequate use of fertilizer and other soil-management practices.

instituted in July 2008.[5] According to Ministry of Food and Agriculture (2017), however, the impact of the National Fertilizer Subsidy Programme on accessibility and adoption, notably by smallholder farmers, was very limited. Most smallholder farmers targeted by the programme still could not afford to pay the subsidised price of the fertilizers. This led to the capturing of the benefits of the programme by large commercial and well-to-do farmers. To promote the adoption of fertilizers among smallholder farmers, in particular, a new approach was needed—perhaps one that incorporated a flexible payment system into the subsidy.

Consequently, the PFJ's fertilizer-subsidy programme, in addition to a 50% subsidy on the price of fertilizers (NPK, urea, sulfate of ammonia, and bio-fertilizer), included a novel option that encouraged fertilizer intake by farmers, especially by smallholders, whose incomes were low and whose resources for purchasing agricultural inputs were limited. Specifically, the programme provided eligible farmers with a 50% subsidy, allowing them to pay 25% of the fertilizer price as a down payment with another 25% due after the harvest. If beneficiaries did not pay the remaining 25% of the fertilizer price for two consecutive planting seasons, they would become ineligible and removed from the programme until the clearance of their debt. Additionally, to prevent misuse, each eligible farmer was entitled to no more than six bags of bio-fertilizer for the production of soya beans, ten bags of NPK, and five bags of urea or sulfate of ammonia for other crops, which corresponded to a maximum fertilized crop area of two hectares per farmer (see Table 2).

Table 2: Recommended Fertilizer for Distribution under the PFJ Programme

Crop	Maize	Rice	Sorghum	Soya beans	Tomatoes	Chili peppers	Onions
NPK (bags/Ha)	5	5	5		5	5	5
Urea or sulfate of ammonia (bags/Ha)	2.5	2.5	3		2.5	2.5	2.5
Bio-fertilizer				3			

Note: 1 bag= 50Kg.
Source: Ministry of Food and Agriculture (2017).

The eligibility of farmers for the programme was based mainly on the cultivation of

[5] The program was initially implemented as a response to the hike in global food and energy prices which affected domestic prices of staple foods and fertilizer (Banful, 2009). Implementation continued up to 2014 but was suspended in 2015 before resuming in the 2016 planting season.

targeted priority crops, including maize, rice, sorghum, soya beans, tomatoes, onions, and chili peppers. These crops were identified by the Ministry of Food and Agriculture as major contributors to (a) food security, (b) smallholder-farm profitability and incomes, (c) supply of raw material for the livestock and industrial sectors, (d) reduction in food imports, (e) job creation, and (f) economic activity from segments along the value chain. The programme enrolled urban, periurban, and rural farmers who were constrained in productive resources and willing to benefit from the subsidy programme. The distribution of fertilizers involved both private and government channels at the regional and district levels, with private companies responsible for the importation of fertilizers. The programme intended to cover a total of two million hectares by 2020. The targeted areas for each of the prioritized crop sectors under the PFJ are shown in Table 3.

Table 3: Targeted Crop Areas under the PFJ Programme (in Hectares)

Crop	2017	2018	2019	2020
Maize	150,000	578,668	907,780	1,182,040
Rice	30,000	124,628	198,380	259,840
Sorghum		118,494	197,490	263,320
Tomatoes	10,000	27,174	42,090	54,520
Onions	1,000	4,560	7,400	9,767
Chili peppers	10,000	10,046	13,678	16,704
Soya beans		78,750	131,250	175,000
Total	**201,000**	**942,321**	**1,498,068**	**1,961,191**

Source: Ministry of Food and Agriculture (2017)

Evidence suggests that the cost of the FSP has increased since its inception in 2008 from GH¢ 20.65 million to GH¢ 138 million in 2016 and then to GH¢ 239 million in 2017 (see Table 4). The amount spent by the government for the fertilizer-subsidy programme in 2017 was over 73% higher than 2016 spending and was, by far, the highest annual jump in fiscal allocation to the programme since 2008. Between 2008 and 2016, the government spent about GH¢ 570.8 million to subsidize about 1,084,055 metric tons of fertilizer. It is worth noting that the cost of the FSP constitutes a considerable share of the budget of the Ministry of Food and Agriculture. Indeed, the fertilizer subsidy alone assumed 24% of the Ministry of Food and Agriculture budget in 2008, rose to 45% in 2012, and then fell to about 28% in 2016. Further, due to increases in the price of fertilizer products over time coupled with government's budgetary limitations, the fertilizer-price-subsidy rate significantly declined over time. In particular, from a subsidy rate of 49% in 2008, the rate of fertilizer subsidy declined to 26% in 2016. Through the PFJ programme, however, the subsidy rate on the price of fertilizer was raised to 50% and the volume of subsidized fertilizer offered to farmers in 2017 stood at about two-times larger than the 2016 level (see Table 4).

Table 4: Ghana's Fertilizer Subsidy Budget, Volume, and Cost: 2008-2018

Item/Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
National budget ('000 GH¢)		5,059,868	6,461,698	6,584,782	7,926,233	13,529,707	31,839,601	36,290,424	44,001,267	50,109,852	55,915,600
Agric. Budget ('000 GH¢)		87,102	202,629	256,886	221,551	262,240	292,480	306,892	411,821	501,502	N/A
% of national budget		1.7	3.1	3.9	2.8	1.9	0.9	0.8	0.9	1	N/A
Subsidy amount ('000 GH¢)		20,654	34,400	30,002	78,746	117,437	64,005	-	87,600	138,000	238,762
% of agric. budget		24	17	12	36	45	22	-	21	28	N/A
Fertilizer subsidized (MT)		43,176	72,795	91, 244	176,278	173,755	166,807	-	180,000	134,000	296,000
Disbursement methodology		Coupon	Coupon	Waybill	Waybill	Waybill	Way bill	-	Way bill	Waybill	Waybill
NPK	Farmer pays (GH¢)	26	26	27	30	39	51	-	89	85	57.5
	Subsidy cost (GH¢)	25	25	17	26	37	21	-	26	N/A	57.5
	Subsidy rate (%)	49	49	38	46	49	29	-	23	N/A	50
Urea	Farmer pays (GH¢)	26	26	25	29	38	50	-	84	80	47.5
	Subsidy cost (GH¢)	26	26	16	22	N/A	18	-	21	N/A	47.5
	Subsidy rate (%)	50	50	39	43	N/A	27	-	20	N/A	50
SOA	Farmer pays (GH¢)	18	18	18	26	35	44	-	-	-	N/A
	Subsidy cost (GH¢)	16	16	16	15	N/A	4	-	-	-	N/A
	Subsidy rate (%)	47	47	47	37	N/A	8	-	-	-	50
Average subsidy rate including transport (%)		49	49	42	42	43	21	-	22	26	50

Notes: The government did not provide a fertilizer subsidy in 2014; N/A = not available; NPK = nitrogen-phosphorus-potassium; SOA= sulfate of ammonia.
Source: Houssou, Andam, and Asante-Addo (2017), Government of Ghana (2018), and Ministry of Food and Agriculture (2017).

III. Literature Review

The empirical literature provides evidence of the importance of agriculture in promoting economic growth and reducing poverty and inequality (Ravallion & Datt, 1996, e.g.). Mellor, Altaf, and Salam (2001) showed that, despite the relatively large contribution of the manufacturing sector to economic growth, growth in the agricultural sector was more critical for employment and poverty reduction in Pakistan. Loayza and Raddatz (2010), in a cross-country study, found that growth in sectors that employed low-skilled labour (agriculture, construction, and low-skilled manufacturing, e.g.) had the greatest impact on poverty reduction. This conclusion was similar to that of Bourguignon and Morrisson (1998), who observed that agricultural development was the most efficient way of reducing inequality and poverty.

Dorosh and Thurlow (2016), Diao et al. (2012), and Arndt et al. (2010) disaggregated agriculture and non-agricultural sectors in order to compare the effects of growth on poverty reduction by subsector. In particular, Dorosh and Thurlow estimated poverty-growth elasticities for different non-agricultural subsectors within a dynamic Computable General Equilibrium (hereafter, CGE) model using data on five African countries (Malawi, Mozambique, Tanzania, Uganda, and Zambia). Their modelling strategy reflected a range of initial conditions including, the varying importance and composition of the agriculture, industry, and service sectors. The authors found that, although agriculture development was important for poverty reduction, some subsectors of services and manufacturing were equally or even more potent in contributing to welfare growth on the continent. In addition, focusing on Ethiopia, Diao and Pratt (2007) conducted an economy-wide and spatial analysis of the effects of agricultural growth in various subsectors (staple crops, livestock, and export crops) on economic growth and poverty reduction at the regional and national level. Their simulation results suggested that appropriate measures to enhance growth in staples, or in livestock associated with staple crops, would effectively reduce poverty in Ethiopia.

Using a CGE model with microsimulations at the household level in a *top-down* approach, Beyene et al. (2016) examined the impact of productivity growth (which resulted from improved seed use for wheat and maize production) on poverty and inequality in

Ethiopia. The authors concluded from simulation results that the adoption of improved wheat and maize seeds by farmers led to an increase in food production, GDP, and income growth. The findings also suggested that an increase in productivity as a result of technology led to a drop in the incidence of poverty in the country, via income and price effects, especially in urban dwellings. Diao, Hazell, and Thurlow (2010) used economy-wide simulation models, including a CGE model for Kenya, Uganda, and Zambia, to examine the impact of alternative growth paths on overall economic growth and poverty reduction in low-income African countries. The authors found that non-agricultural growth was less effective at reducing poverty, on average, than agricultural growth.

Likewise, Warr and Yusuf (2014) compared the relative effectiveness of fertilizer subsides and market protection for rice as policy instruments for poverty reduction and food self-sufficiency in Indonesia. The analysis was based on a CGE-integrated multi-household approach that employed three scenarios for a 10% reduction in rice imports relative to baseline, by assuming three values for elasticity of substitution between fertilizer and other factors of production. In the first scenario, which involved fertilizer subsidies, the level of the subsidy was determined endogenously. Their results showed that the fertilizer subsidy was relatively more potent in boosting income. Unlike import restrictions, the fertilizer subsidy also contributed to poverty reduction through wage increases for unskilled workers and a drop in the consumer price of rice, thereby increasing the purchasing power of poor households.

In the case of Ghana, Breisinger, Diao, Kolavalli, and Thurlow (2008) used a dynamic CGE model to examine the growth linkages of the cocoa subsector in Ghana and its contribution to Ghana's ability to reach a middle-income country status. The authors found that the poverty-growth elasticity in the cocoa subsector was low and, thus, that further growth in the subsector was not likely to result in a large reduction in poverty.

Breisinger, Diao, Thurlow, and Al-Hassan (2008), using a dynamic CGE modelling approach, also observed that bridging the crop-yields gap and taking measures to enhance productivity growth in the fisheries, forestry, and livestock sectors would help Ghana achieve 6% agricultural growth target under the CAADP. Furthermore, Breisinger et al. (2009) examined the impact of a green revolution on overall growth and poverty reduction in Ghana by using a dynamic general equilibrium model combined with a microsimulation model. Although the study considered improved seeds and fertilizer as inputs in the production of agriculture goods, their scenario was based on exogenous increases of total factor productivity in the production of crops and livestock. The findings suggested that agricultural growth through increases in productivity positively affected economic growth and had a strong poverty-reducing effect.

The focus and modelling strategy employed in our study differs strikingly from that of Breisinger et al. (2009). Unlike them, for instance, who analyzed the economy-wide effects of productivity-driven agriculture growth, our study focused on evaluating the effects of a specific agriculture policy (i.e., the PFJ fertilizer-subsidy programme) on productivity, economic growth, employment, and welfare. Hence, in contrast to the strategy of the Breisinger group (2009), our study allowed total factor productivity to be endogenously determined in the model. In addition, our modelling approach was designed to allow output in agricultural subsectors to be influenced not only through changes in productivity but also via changes in the cost of production, which resulted from government spending on the fertilizer-subsidy programme.

IV. Research Objective and Methodology

The primary aim of this study was to analyze the dynamic effects of Ghana's recent Planting for Food and Jobs programme on development outcomes in Ghana. Specifically, the study sought to shed light on the impact of the fertilizer-subsidy programme on output by sector, job creation, and household welfare. While a fertilizer-subsidy programme has existed since 2008 (through the National Fertilizer Subsidy programme), the current program, which began in 2017, makes fiscal allocations far beyond those of the original NFS program. This makes it important to assess the economy-wide effects of the current subsidy programme with a focus on the key goals of the government's PFJ programme (i.e., to boost agricultural productivity and provide much-needed jobs for Ghanaians).

In order to achieve this objective, we employed an agricultural-sector-specialized dynamic CGE model which allowed for the presence of unemployment (albeit, only among skilled labour[6]) and restricted the mobility of labour to within agricultural and non-agricultural sectors only. The choice of a dynamic CGE model is motivated by the fact that, unlike static CGE models, the dynamic CGE model is able to account for growth effects, thus rendering the dynamic CGE models adequate for medium-term analysis of the poverty effects of economic policies (Annabi, Cockburn & Decaluwé, 2004).

3.1 The Dynamic Computable General Equilibrium Model

This study employed a modified version of the Standard PEP-1-t model, which is a one country, multi-sector, recursive dynamic CGE model (Decaluwé et al., 2013).[7] The PEP-1-t model has a neoclassical structure with equations that describe the structure of production for various economic sectors, the behavior of private households and the government, import demands, exports, market-clearing conditions for factors and commodity markets, and a host of macroeconomic variables and price indices. The equations that describe the supply-and-demand behaviors of private economic agents are based on a perfect competitive market assumption in which agents are assumed to be price-takers. The model considers the economic characteristic of a small open economy that faces fixed world market prices for its exports.

Households earn their incomes from remuneration to factors of production and transfers from other economic agents while the government earns its income through taxation and transfers from other economic agents. Households spend their income on both domestically produced commodities and on imports as well as make transfers to other economic agents. In this way, the model assumes that domestic producers can increase their share of the export market as long as they are able to offer a price for their product that is competitive with the world market price (conditional on the price elasticity of export demand). In the PEP-1-t model, each period is solved as a static equilibrium, subject to the variables inherited from the preceding period. A more comprehensive discussion of the key features of the PEP 1-t model is contained in Decaluwé et al. (2013).

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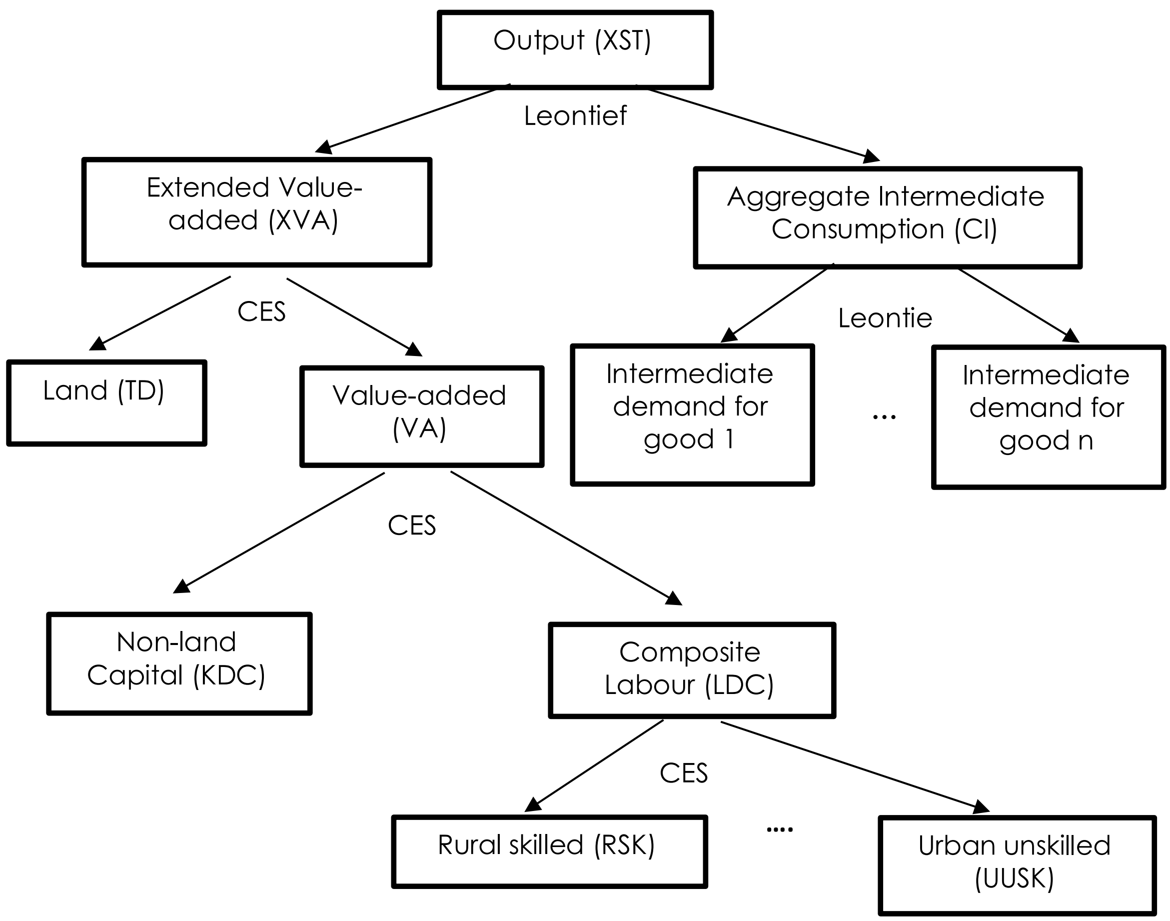
[6] This assumption emanates from the evidence that, in Ghana, unemployment is higher among the educated than the uneducated, particularly among youth (Baah-Boateng, 2013).

[7] It has its origin in the Standard PEP-1-1 model, a static, one-country, multi-sector CGE model developed by Decaluwé et al. (2013).

We modified the standard PEP-1-t model to reflect the peculiarities of the Ghanaian economy and to allow us to address our research objectives. Specifically, we undertook the following modifications: First, we modified the structure of production in the agricultural sector to allow for the use of fertilizer to play an explicit role in productivity in the agricultural sector. Second, we considered four categories of labour: rural skilled, urban skilled, rural unskilled, and urban unskilled. Third, we allowed for the presence of unemployment in the labour market but only for skilled labour while the market for unskilled labour is assumed to be in equilibrium. Third, we restricted labour to move only within agricultural and non-agricultural sectors with no movement across these sectors. The structure of agricultural production used in this study is presented in Figure 2.

Figure 2: Structure of Agricultural Production



In the first nest of the agricultural production structure, we modeled total output as a Leontief function of extended value-added and a composite intermediate good in the first nest. To capture complementarity between land, on the one hand, and other agriculture sector production inputs on the other, we defined extended value-added as a Constant Elasticity of Substitution (hereafter, CES) combination of value-added and land (second nest) while allowing for a small degree of substitutability. The composite intermediate good was modeled as fixed proportions of various intermediate commodities. At the next level, value-added was defined as a CES function of composite labour and composite capital. One level down, composite labour and composite capital were specified as a CES function of different types of labour (rural skilled, rural unskilled, urban skilled, and urban unskilled) and of different types of capital (livestock and equipment), respectively.

3.2 Modelling Strategy

Given the objective of this paper, we conducted two main modelling approaches. In the first, we modeled the impact of the fertilizer-subsidy programme on productivity by sector. Second, we modeled the labour market to allow for the presence of unemployment among skilled labour and to make the wage rate adjust to changes in the unemployment rate.

3.2.1 Modelling the Effect of Fertilizer Subsidies

We followed the approach adopted by Arguello, Valderrama, and Acero (2012) to model the impact of fertilizer subsidies on agricultural productivity. In this vein, we posited that fertilizer-price subsidies would have two effects. First, they were expected to improve fertilizer use and thus exert a positive impact on agricultural productivity. Second, fertilizer price subsidies were anticipated to reduce the cost of agricultural activities and thus lower the cost of using productive capital (and, in particular, of land). In this way, they acted as a subsidy for productive capital. We modeled these effects as follows:

$$FL_{agrj,t} = \frac{SFZ_{agrj,t}}{ucHa_{agrj}} * \frac{1}{\pi} \dots\dots\dots\dots\dots\dots\dots\dots\dots.. (3.1)$$

$$FLE_{agrj,t} = FL_{agrj,t} * ygap \dots\dots\dots\dots\dots\dots. (3.2)$$

$$FLP_{agrj,t} = \frac{FLE_{agrj,t}}{TD_{agrj,t}} + 1 \dots\dots\dots\dots\dots\dots\dots. (3.3)$$

$$XVA_{agrj,t} = B_{agrj}^{XVA} * FLP_{agrj,t} * \left\{\beta_{agrj}^{XVA} VA_{agrj,t}^{-\rho_{agrj}^{XVA}} + \left(1 - \beta_{agrj}^{XVA}\right) TD_{agrj,t}^{-\rho_{agrj}^{XVA}}\right\}^{-1/\rho_{agrj}^{XVA}} \dots\dots (3.4)$$

$$ttitf_{agrj,t} = \frac{-SFZ_{agrj,t}}{R_{agrj,t} * TD_{agrj,t}} \dots\dots\dots\dots\dots\dots (3.5)$$

$$RRT_{agrj,t} = R_{agrj,t} * \left(1 + ttit_{agrj,t} + ttitf_{agrj,t}\right) \dots\dots\dots\dots\dots (3.6)$$

where:

$FL_{agrj,t}$ = Newly fertilized land in activity agrj at time t

$FLE_{agrj,t}$ = Fertilized land in non-fertilized equivalent in activity agrj at time t

$SFZ_{agrj,t}$ = Total amount of subsidy on fertilizer in activity agrj at time t

$ygap$ = Yield gap between fertilized and unfertilized land

$FLP_{agrj,t}$ = Fertilized land productivity factor in activity agrj at time t

$RRT_{agrj,t}$ = Rental rate of land paid by activity agrj including taxes

$R_{agrj,t}$ = Rental rate of land in activity agrj at time t

$ttitf_{agrj,t}$ = Subsidy rate received for land by activity agrj in time[8]

$ttit_{agrj,t}$ = Tax rate paid for land by activity agrj in time t

$ucHa_{agrj}$ = Cost to government of a hectare of fertilized land used in activity agrj

π = Implicit subsidy rate on the per unit price of fertilizer at time t.

Because the government financed the subsidy, we modeled the subsidy as a negative tax on capital that would thus lead to a reduction in total government revenues from taxes on capital ($TIKT_t$). This would, in turn, result in a reduction in total government income (YG_t), which would then translate into a reduction in government savings (SG_t) given the levels of government transfers to non-governmental agents ($\sum_{agng} TR_{agng,gvt,t}$) and current government expenditures on goods and services (G_t). We represented these mechanisms as follows:

$$SG_t = YG_t - \sum_{agng} TR_{agng,gvt,t} - G_t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.7)$$

$$YG_t = YGK_t + TDHT_t + TDFT_t + TPRODN_t + TPRCTS_t + YGTR_t \dots\dots\dots\dots (3.8)$$

[8] Given the way $ttitf_{agrj,t}$ was computed in Equation (3.5), the value of $ttitf_{agrj,t}$ is negative by default.

$$TPRODN_t = TIWT_t + TIKT_t + TIPT_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.9)$$

$$TIKT_t = \sum_{k,j} TIK_{k,j,t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.10)$$

$$TIK_{k,j,t} = ttitf_{j,t} * R_{j,t} * TD_{j,t} \ldots\ldots\ldots\ldots\ldots\ldots (3.11)$$

where:

SG_t = Government savings at time t

YG_t = Total government income at time t

$TR_{agng,gvt,t}$ =Total transfers from government to non-governmental agents at time t

G_t = Current government expenditures on goods and services at time t

YGK_t = Government capital income at time t

$TDHT_t$ = Total government revenue from household income taxes at time t

$TDFT_t$ = Total government revenue from business income taxes at time t

$TPRODN_t$ = Total government revenue from other taxes on production at time t

$TPRCTS_t$ = Total government revenue from taxes on products and imports at time t

$YGTR_t$ = Government transfer income at time t

$TIWT_t$ = Total government revenue from payroll taxes at time t

$TIKT_t$ = Total government revenue from taxes on capital at time t

$TIPT_t$ = Total government revenue from production taxes (excluding taxes directly related to the use of capital and labour) at time t

$TIK_{k,j,t}$ = Government revenue from taxes on type k capital used by industry j at time t

3.2.2 Modelling the Labour Market

As indicated earlier, we assumed that unemployment existed among skilled labour while the market for unskilled labour was assumed to be in equilibrium. Accordingly, the equation that describes the behavior of the skilled labour market was:

$$LS_{skl,t} = \left(\sum_j LD_{j,skl,t} \right) + UN_{skl,t} \ldots\ldots\ldots\ldots\ldots \quad (3.12)$$

where:

$LS_{skl,t}$ = *Labour supply of skilled workers at time* t

$LD_{j,skl,t}$ = *Labour demand by activity j for skilled workers at time* t

$$UN_{skl,t} = \text{Number of unemployed persons at time } t.$$

We restated the above equation to reflect the unemployment rate but not the number of unemployed persons as follows:

$$LS_{skl,t} = \frac{(\sum_j LD_{j,skl,t})}{1 - unr_{skl,t}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.13)$$

where:

$$unr_{skl,t} = \text{Unemployment rate at time } t$$

Next, we accounted for the trade-off between unemployment and the wage rate by exploiting the salient property of the wage-curve equation (Blanchflower & Oswald, 1989; 2005). The wage curve illustrated the negative association between unemployment and the wage rate.[9] We expressed the wage curve as follows:

$$W_{skl,t} = A_{skl,t} * unr_{skl,t}^{\varepsilon_{skl}} * PIXCON \ldots\ldots\ldots\ldots\ldots\ldots\ldots. \quad (3.14)$$

Where:

$$W_{skl,t} = \text{Wage rate of skilled labour at time } t$$

$$A_{skl,t} = \text{Level parameter at time } t$$

$$\varepsilon_{skl} = \text{Wage elasticity with respect to unemployment; } \varepsilon_{skl} = -0.1$$

$$PIXCON = \text{Consumer price index.}$$

V. The Social Accounting Matrix (SAM)

Our dynamic CGE model was calibrated to economic data that reflected the condition of the Ghanaian economy in 2015.[10] These data were referred to as the Social Accounting Matrix (SAM) of Ghana and took stock of the economic conditions of the country at a given point in time. The 2015 Ghana SAM was prepared by the International Food Policy Research Institute; the Institute for Statistical, Social and Economic Research; and the Ghana Statistical Service (2017). The Ghana SAM was an extension of the Standard

[9] Blanchflower and Oswald (1989) showed a negative relationship between the unemployment rate and the wage rate at low levels of unemployment but not at high levels of unemployment.

[10] The 2015 SAM, was, however based on a 2004 Supply and Use Table (hereafter, SUT). While this SUT is obviously not recent, it is the latest available for Ghana.

Nexus Structure and consisted of fifty-five activity sectors, fifty-six commodity sectors, three types of factors of production (i.e. labour, in which rural and urban were disaggregated by level of education), land, and capital, which was (disaggregated by crop, livestock, mining, and other sectors).[11] The household sector was divided spatially into urban and rural households with rural households further disaggregated into farm households (households that earned crop and/or livestock income) and non-farm households (households that did not earn crop and/or livestock income). Households were further disaggregated into per-capita-expenditure quintiles.

For the purpose of our analysis, we made three main adjustments to the original structure of the 2015 Ghana SAM. First, we reclassified labour into skilled and unskilled with each category further disaggregated across locality (rural or urban). The result was four main labour categories: rural skilled, rural unskilled, urban skilled, and urban unskilled. Second, we regrouped the activity accounts into nine activity categories: maize, rice, sorghum, other agricultural production activities, food-processing industries, chemical industries, other industrial activity accounts, service, and public administration. Third, unlike the original version of the Ghana SAM, our SAM did not consider households' consumption of their own agricultural production (i.e., self-consumption).

4.1 Key Characteristics of the Ghanaian Agricultural Sector in 2015

Before we present the results from the simulation, it is important to discuss some of the salient features of the agricultural sector in Ghana. In terms of total value-added, the share of the agricultural sector value-added stood at about 18% in 2015 while the industrial and services sectors produced 28% and 49% in total value-added, respectively (see Appendix Table A1, Column 1). The three main staple crops in Ghana—i.e. maize, sorghum, and rice—accounted for about 2%, 1%, and 1% of total value-added, respectively. The share of value-added in total value by sector was relatively higher in agricultural than in the industrial and services sectors. In particular, the share of value-

[11] Note that crop capital refers to capital used in support of agricultural crops (e.g., machinery and equipment such as tractors, irrigation infrastructure, etc.) while livestock capital refers to live animals and capital used for livestock production (e.g., beehives, paddocks, etc.); see International Food Policy Research Institute, the Institute for Statistical, Social and Economic Research, and the Ghana Statistical Service (2017).

added in total sectoral value stood at about 72%, 33%, and 51% for agricultural, industrial, and service sectors, respectively (see Column II of Appendix Table A1). For maize, sorghum, and rice production activities, value-added assumed about 87%, 95%, and 90% of total value by sector, respectively.

In terms of international trade, about 9.7% of agricultural commodities in Ghana are imported; over 40% of rice consumed in Ghana is not produced locally. The importation of maize and sorghum is zero. More than 43% of industrial/manufactured products in Ghana are imported while about 9.6% of services consumed in the country are imports. Further, only 17.5% of goods and services produced in Ghana are exported with export shares by sector ranging from 9.9% for services, to 10.1% for agricultural products, and then to 27.8% for industrial/manufacturing products. Unsurprisingly, only industrial/manufactured products are used as investment goods, but no agricultural or service product is. A majority (73%) of products used for investment purposes are construction while 24% of investment goods are machinery and equipment (see Appendix Table A1, Column V).

Considering relative factor intensities across agricultural subsectors, we observed that the capital-labour ratio was 1.39 for maize, 0.58 for sorghum, and 0.66 for rice. That is, among the three staple crops in Ghana, maize had the highest capital-labour ratio. The average capital-labour ratio for the entire agricultural sector, however, was 4.37 with poultry production having a capital-labour ratio of 24.52. In addition, the share of skilled labour in total agricultural labour was about 7.5% on average. In terms of the maize, sorghum, and rice subsectors, only 6%, 3%, and 3%, of labour used in these subsectors was skilled, respectively. We present this information along with other key indicators in Table 5.

Regarding the composition of labour demand in various agricultural subsectors, Table 6 shows that the agricultural sectors relied more on rural unskilled labour than did the rest of the economy. Specifically, about 74.4% of labour in the agricultural sector was rural unskilled labour while the share of rural skilled labour in the total agricultural labour was 4.6% on average. Furthermore, only 3% of labour used in the agricultural sector was urban skilled labour with a little over 18% of agricultural labour being urban unskilled labour.

Table 5: Relative Factor Intensity in Agricultural Subsectors in Ghana, 2015

Sector	Capital-Labour (K/L) Ratio	Land-Labour (TD/L) Ratio	Capital-Land (K/TD) Ratio	Skilled Labour share
Maize	1.39	1.07	1.3	0.06
Sorghum and millet	0.58	0.45	1.27	0.03
Rice	0.66	0.48	1.38	0.03
Other cereals	0.2	0.16	1.27	0.03
Pulses	1.17	0.91	1.29	0.03
Groundnuts	1.61	1.1	1.46	0.03
Other oilseeds	1.06	0.84	1.26	0.03
Cassava	1.94	1.52	1.27	0.02
Other roots	3.55	2.51	1.41	0.04
Vegetables	1.42	0.91	1.57	0.18
Sugar cane	1.16	0.75	1.54	0.04
Tobacco	1.04	0.69	1.52	0.04
Cotton and fibers	2.16	1.73	1.25	0.1
Fruits and nuts	0.76	0.51	1.49	0.08
Cocoa	1.11	0.72	1.54	0.04
Coffee and tea	1.61	0.88	1.82	0.13
Other crops	34.19	0	0	0.08
Cattle	2.86	0	0	0.08
Poultry	24.52	0	0	0.15
Other livestock	4.42	0	0	0.19
Forestry	5.14	0	0	0.02
Fishing	3.51	0	0	0.22

Source: 2015 Ghana SAM.

Production activities in the maize, sorghum, and rice subsectors relied disproportionately more on unskilled labour (about 94%, 97%, and 98%, respectively) than on skilled labour. Unlike the agricultural sector, about 25% of labour in the non-agricultural sector was skilled. This incidence may have implications for the extent to which increases in productivity in the agricultural sector affect the level of unemployment among the skilled labour force in Ghana. We envisaged that the impact (if any) of improved agricultural productivity on the unemployment rate among skilled labour would have been indirect, notably, through its impact on the activities of non-agricultural sectors.

Table 6: Composition of Labour Demand by Agricultural Subsectors and the Rest of the Ghanaian Economy in 2015

	skilled labour		unskilled labour	
Sector	**Rural**	**Urban**	**rural**	**urban**
Maize	0.02	0.04	0.71	0.23
Sorghum and millet	0.01	0.01	0.83	0.14
Rice	0.02	0.01	0.84	0.14
Other cereals	0.02	0.01	0.83	0.14
Pulses	0.02	0.01	0.83	0.14
Groundnuts	0.02	0.01	0.8	0.17
Other oilseeds	0.01	0.02	0.84	0.13
Cassava	0.01	0.01	0.9	0.08
Other roots	0.02	0.02	0.75	0.21
Vegetables	0.18	0	0.64	0.18
Sugar cane	0.04	0	0.96	0
Tobacco	0.04	0	0.95	0.01
Cotton and fibers	0.03	0.07	0.48	0.42
Fruits and nuts	0.06	0.02	0.72	0.21
Cocoa	0.04	0	0.96	0
Coffee and tea	0.09	0.04	0.84	0.04
Other crops	0.08	0	0.92	0
Cattle	0.01	0.08	0.17	0.75
Poultry	0.06	0.1	0.67	0.17
Other livestock	0.17	0.02	0.62	0.19
Forestry	0.02	0	0.62	0.36
Fishing	0.04	0.18	0.49	0.29
Rest of the Economy	0.03	0.22	0.3	0.45

Source: 2015 Ghana SAM.

VI. Application and Results

The discussion in this section is based on the results of two separate simulation exercises—i.e. a business-as-usual (BAU) scenario and an alternative scenario that accounted for the role of fertilizer subsidies in determining total factor productivity (a fertilizer-subsidy scenario). As such, we present the percentage deviations of the outcomes obtained under the fertilizer subsidy scenario relative to the BAU scenario.

5.1 Scenario Design

We used actual fiscal allocations for implementation of the fertilizer-subsidy programme for the year 2017 and projected fiscal allocations for the years 2018-2024 as the policy variable in our simulation exercise. Using information on targeted crop areas and the cost of fertilizing a hectare of land,[12] we split total fiscal allocations under the programme across four agricultural sectors (maize, rice, sorghum, and other).[13] Table 7 presents the implicit cost of the fertilizer-subsidy programme under the PFJ programme.

Table 7: Implicit Cost of the Fertilizer Subsidy under the PFJ Programme ('000 GH¢): 2017-2020

Crop	2017	2018	2019	2020
Maize	146,621	235,084	368,786	480,204
Rice	30,024	50,952	84,921	113,228
Sorghum	31,578	50,630	80,592	105,560
Other priority crops	30,540	27,604	48,106	56,528

Notes: Other priority crops included tomatoes, onions, chili peppers, and soya beans.
Source: Authors' calculations based on information from the Ministry of Food and Agriculture (2017).

Given that the PFJ programme has a four-year (2017-2020) implementation period, we extended the implementation period to 2024 in order to trace the impact of the fertilizer-subsidy programme over eight years. Because no official projected fiscal allocations were available for the years beyond 2020, we computed allocation for these years under the assumption that the allocations to the maize, rice, sorghum, and other agricultural sectors would grow at an annual rate of 10%.[14] These projected allocations are presented in Table 8.

[12] We computed the cost of fertilizing a hectare using the recommended fertilizer quantity per hectare and the 2017 unit price (per bag) of each type of fertilizer.

[13] Allocations to other agricultural sector represented allocations made to farmers engaged in cultivation of tomatoes, onions, chili peppers, and soya beans.

[14] As observed in Table 7, the implicit cost of the fertilizer-subsidy programme increased at a declining rate over the planned implementation period (2017-2020). Specifically, fiscal allocations increased by about 40% on average for all priority crops between 2018 and 2019 and by 20% between 2019 and 2020. The percentage decline in the growth rate of the fiscal allocation between the 2018-2019 and the 2019-2020 periods was 50%. Using this pattern of growth in fiscal allocations, we assumed a drop in the growth rate of fiscal allocations by half between 2020 and 2021 (i.e., a 10% increase in the fiscal allocation between 2020 and 2021) and thereafter maintained a constant rate of growth (10%) in fiscal allocations for subsequent years.

Table 8: Estimated Cost of the Fertilizer Subsidy under the PFJ Programme ('000 GH¢):2021-2024

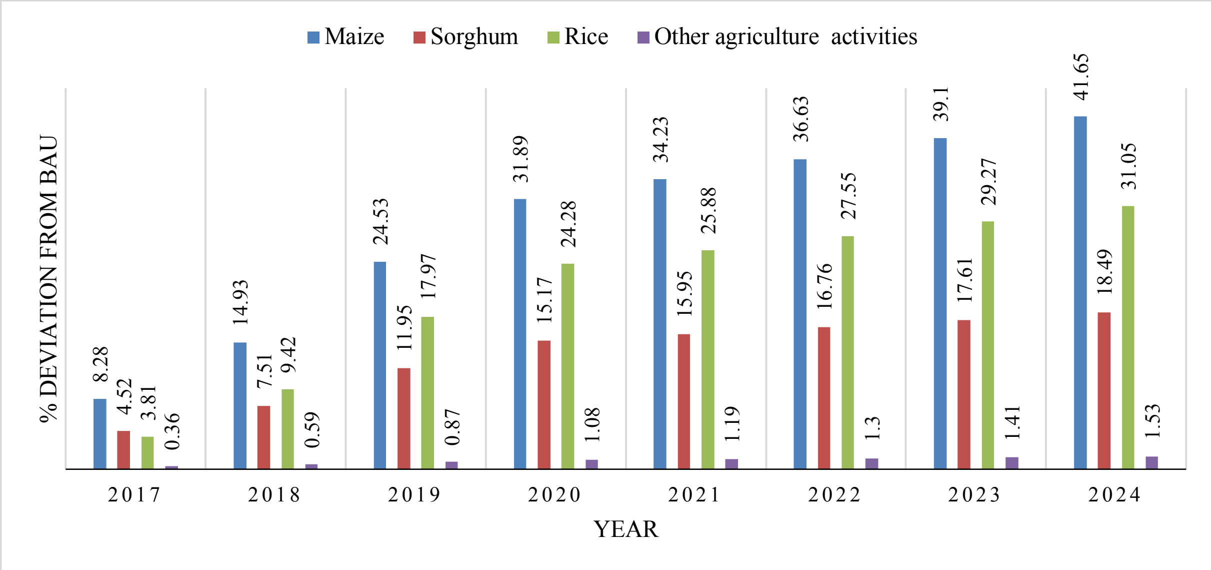
Crop	2021	2022	2023	2024
Maize	528,224	581,047	639,152	703,067
Sorghum	116,116	127,728	140,500	154,550
Rice	124,551	137,006	150,706	165,777
Other priority crops	62,181	68,399	75,239	82,763

Notes: Other priority crops include tomatoes, onions, chili peppers, and soya beans.
Source: Authors' calculations.

5.2 Productivity and Production in the Agricultural Sector

Figure 3 presents the simulation results for the productivity effects of the fertilizer-subsidy programme. In Figure 3, we observed that, for all three main agricultural subsectors, total factor productivity improved significantly relative to business-as-usual levels between 2017 and 2024. Additionally, the change in productivity grew over time. This outcome was observed not only during the planned implementation period of the fertilizer-subsidy programme under the PFJ (2017-2020) but even beyond. In particular, the rise in productivity was observed for the production of maize, sorghum, rice, and other crops. In 2017, the rise in productivity was highest in the maize sector, followed by sorghum, rice, and other agricultural activities, with an increase of 8.3%, 4.5%, 3.8%, and 0.4%, respectively (see Figure 3). From 2018 on, however, while maize still registered the greatest performance, the increase in productivity in the rice sector was higher than that of sorghum and other agricultural activities. The relatively weak impact of the subsidy on productivity changes in other agricultural activities may be explained by the high level of aggregation in that category.

Figure 3: Total Factor Productivity (%): Deviation from the BAU



Source: CGE simulation.

Further, the results also revealed an increase in the annual production of targeted crops. Table 9 reports the percentage changes in value-added over time across sectors. Because a Leontief production function links total output to intermediate consumption and value-added (extended value-added for the agricultural sector), an increase in the value-added implies a proportional change in total production. Hence, as shown in Table 9, the PFJ's fertilizer-subsidy programme increased agriculture value-added and output in the priority sectors. The maize sector registered the greatest increase in total output in the first two years of the programme (2017 and 2018), followed by the rice and sorghum sectors. From 2019 onward, however, the production of rice increased the most, followed by maize and sorghum. Again, the increase in the aggregate output of other crops was the smallest.

Furthermore, in conformity with government expectations, the PFJ fertilizer programme also had positive implications for the development of non-farm activities, mainly in the food-processing industries through forward linkages. Indeed, there was a significant impact on value-added in food-processing industries (Table 9). The impact of the programme on the value-added of other non-agricultural sectors was, however, negligible. The food industry benefitted greatly from the fertilizer-subsidy programme. Relative to the business-as-usual scenario, the value-added in the food industry grew consistently over the eight-year period from 4.5% growth in 2017 to 15% in 2020 and then to about 19% in 2024. The simulated effects of the fertilizer programme on value-added therefore suggested that the programme promoted food availability and thereby enhanced food security.

Table 9: Value-Added by Activities (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry	Chemical Industry	Other Industry	Service Industry	Public Adminis -tration
Year	***Value-Added***								
2017	4.71	3.51	3.97	0.76	4.50	0.00	-0.06	0.04	-0.03
2018	8.03	6.05	7.71	1.30	7.77	-0.01	-0.10	0.07	-0.05
2019	12.49	9.43	12.92	1.99	12.02	-0.02	-0.17	0.11	-0.09
2020	15.58	11.81	16.59	2.40	15.03	-0.03	-0.22	0.13	-0.11
2021	16.43	12.57	17.60	2.42	16.08	-0.05	-0.25	0.13	-0.12
2022	17.25	13.28	18.59	2.48	17.02	-0.07	-0.29	0.12	-0.13
2023	18.07	13.96	19.58	2.56	17.91	-0.10	-0.34	0.11	-0.15
2024	18.91	14.63	20.59	2.66	18.77	-0.12	-0.38	0.10	-0.16

Source: CGE simulation.

Given that value-added in the agricultural sector is a CES function of inputs, namely, land and composite labour-capital, one would expect the rise in value-added to result from an increase in input demand, but this was not the case. Appendix Table A2 reports percentage changes in the demand for inputs for each year. The results show that, in the maize sector, the demand for composite labour fell significantly, while the change in the demand for capital and land were negligible in the first two years of the programme (2017 and 2018). Thus, as productivity increased because of the programme, maize farmers employed less and less labour and capital. Because the model assumed a weak substitutability between composite labour-capital and land,[15] the drop in the demand for labour and capital affected the demand for land in the sector. The demand for land remained stable in 2017 before dropping in subsequent years.

Similarly, in sorghum- and rice-farming, there was a decrease in the demand for labour and capital. Though the decline was marginal in the first two years of the programme, it increased over time. At the same time, the demand for land in these two sectors barely changed over the years. Furthermore, because the model assumed labour-market segmentation, the reduction of agricultural labour in maize, rice, and sorghum was absorbed into agricultural activities, while capital, which was fully mobile across sectors, was transferred from farm to non-farm sectors.

The findings, therefore, suggest that, rather than promoting input demand—particularly the demand for labour—the increase in fertilizer use acted as a labour-saving technology (or other inputs) in the production of maize, sorghum, and rice. Thus, the

[15] The elasticity of substitution is 0.5.

increase in value-added could only be attributed to the increase in productivity in the sector. This finding is explained by the reallocation of production inputs from agriculture to non-agriculture sectors as a result of productivity gains (Gollin, Parente & Rogerson, 2002). In other words, workers involved in the production of maize, for instance, with the aim of generating a given level of output, may have moved to other activities or occupations as the level of productivity increased. With regard to non-agriculture sectors, the increase in value-added in the food-processing industries was achieved through an increase in the demand for labour and capital. It is further observed that the percentage change in composite labour was about eight times higher than that of composite capital in 2017 and that it increased at a decreasing rate over subsequent years.

5.3 Labour-Market Outcomes

Before we present the simulation results on the impact of the programme on labour-market outcomes, an overview of the evolution of the active labour force in Ghana is in order. A report published by the National Population Council in Ghana in 2017 estimated Ghana's population at 27.8 million in 2017 with a projected annual growth rate of 2.5%. Further, it indicated that about 56.8% of the population of Ghana was of working age (15-64) while the labour-force-participation rate for the economically active population in Ghana was 73%. Using this information, we computed the population of the active labour force in Ghana over 2017-2024 period (see Table 10). Recent estimates of the unemployment rate in Ghana put the unemployment rate at 5.2% for Ghana and at 3.9% and 6.5% for rural and urban areas of Ghana, respectively. This implies that about 605,000 individual members of the active labour force in Ghana were unemployed in 2017.

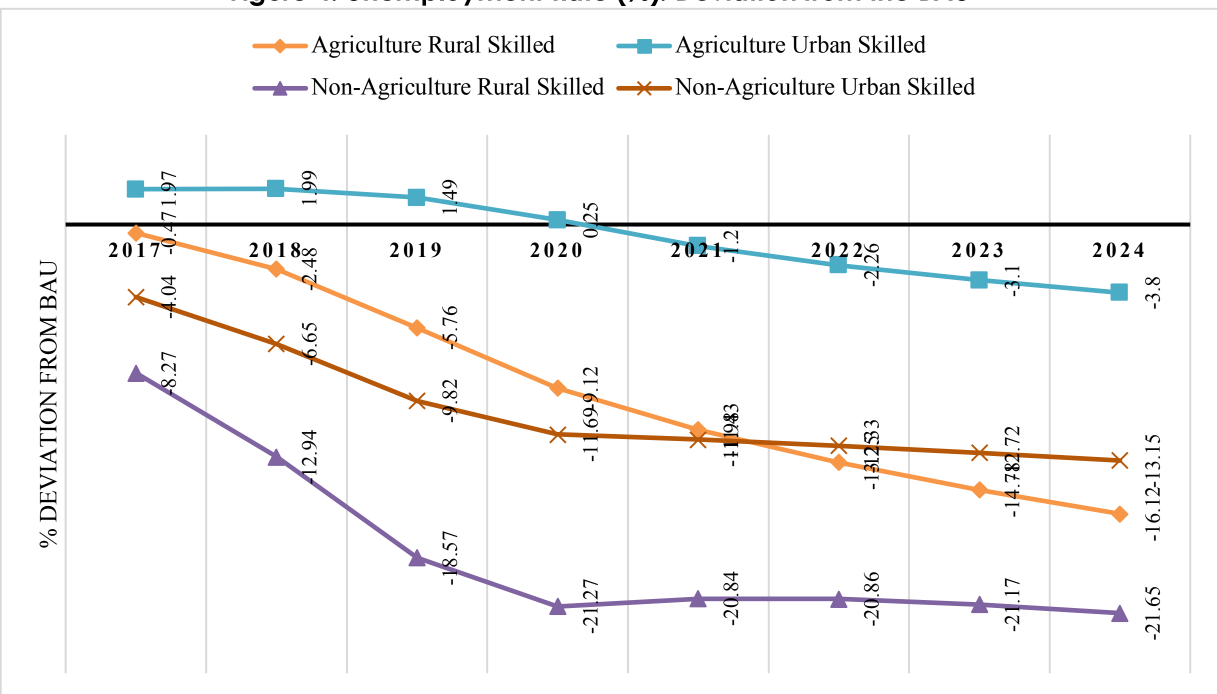
Table 10: Evolution of the Active Population in Ghana ('000), 2017-2024

	2017	2018	2019	2020	2021	2022	2023	2024
Population (total)	28,447	29,158	29,887	30,634	31,400	32,185	32,990	33,814
Working age population	15,930	16,329	16,737	17,155	17,584	18,024	18,474	18,936
Active labour force	11,629	11,920	12,218	12,523	12,836	13,157	13,486	13,823

Note: Working-age population refers to persons aged 15-64.
Source: National Population Council (2017).

The simulation results reported in Figure 4 reveal that, in general, the unemployment rate among skilled labour declined significantly over the eight-year period. It is important to recall that the model assumed the existence of unemployment only among skilled labour. Hence, the results are reported only for that category of labour. The greatest fall in the unemployment rate was observed among skilled labour in the non-agricultural sector, presumably caused by the increase in production in food-processing activities. This drop is relatively larger in the rural areas as compared to urban areas. On the one hand, when looking at the evolution of the unemployment rate among skilled labour engaged in the agricultural sector, we found that the unemployment rate among rural skilled labour remained stable in the starting year of the PFJ programme and then significantly declined from its business-as-usual level in subsequent years. On the other hand, there was a slight increase in unemployment among urban skilled labour in the agriculture sector between 2017 and 2020 and a fall beyond 2020. As shown in Appendix Table A3 (see Appendix), the newly employed skilled workers were involved in other agricultural activities, while those employed in the non-agricultural sector benefitted from the increase in the labour demand in food industries.

Figure 4: Unemployment Rate (%): Deviation from the BAU



Source: CGE simulation.

5.4 Impact on Macro-Economic Indicators

Although production increased substantially as a result of the PFJ fertilizer programme, its impact on overall real GDP growth was relatively small (Table 11). The findings from the simulations show that real GDP at basic prices increased by 0.34% in 2017 and 0.58% in 2018 relative to its business-as-usual level. This increase over the period corresponded to an increase in GDP growth rate of 0.28 percentage points, on average, over the span of the programme.

Table 11: Changes in Real GDP and Real GDP Growth (%): Deviation from BAU

	2017	2018	2019	2020	2021	2022	2023	2024
Real GDP at Basic Price	0.34	0.58	0.88	1.07	1.11	1.14	1.17	1.20
Real GDP Growth Rate	0.357	0.252	0.315	0.196	0.036	0.035	0.034	0.034

Source: CGE simulation.

Regarding international trade, we found that exports were positively affected by the programme. Table 12 shows there was an increase in exports of targeted crops and commodities from food industries relative to the business-as-usual level over time. The maize sector again registered the highest jump between 2017 and 2019, followed by rice, sorghum, and other crops, respectively. From 2020, the exports of rice were highest, followed by maize. The food-processing industries also raised exports as a result of the increase in output in the sector.

Table 12: Exports, Imports and Domestic Demand (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry	Chemical Industry	Other Industry	Service Industry	Public Adminis tration
Year	***Exports***								
2017	8.16	5.45	5.06	0.92	6.42	-0.05	-0.08	-0.08	
2018	13.3	9.3	11.16	1.52	11.15	-0.1	-0.15	-0.13	
2019	20.33	14.87	20.22	2.3	17.41	-0.16	-0.23	-0.21	
2020	24.82	18.73	26.65	2.71	21.88	-0.21	-0.3	-0.26	
2021	25.34	19.53	28.06	2.64	23.42	-0.24	-0.34	-0.27	
2022	26.09	20.43	29.58	2.64	24.82	-0.27	-0.38	-0.30	
2023	27.01	21.40	31.20	2.70	26.15	-0.30	-0.43	-0.32	
2024	28.07	22.44	32.91	2.79	27.46	-0.33	-0.47	-0.35	
Year	***Imports***								
2017	-0.60	1.75	2.64	0.52	-2.21	0.17	0.10	0.28	0.04
2018	-0.44	3.10	4.22	0.91	-3.68	0.29	0.17	0.48	0.06
2019	-0.21	4.66	6.18	1.44	-5.50	0.46	0.26	0.72	0.10
2020	0.25	5.81	7.62	1.80	-6.68	0.57	0.31	0.88	0.12
2021	0.83	6.45	8.25	1.91	-7.05	0.60	0.33	0.93	0.13

2022	1.23	6.94	8.76	2.01	-7.38	0.62	0.34	0.97	0.14
2023	1.52	7.35	9.23	2.11	-7.71	0.63	0.34	1.01	0.15
2024	1.75	7.71	9.67	2.20	-8.03	0.65	0.35	1.05	0.16
Year	***Domestic Demand***								
2017	4.71	3.51	3.97	0.72	4.02	0.04	-0.02	0.06	-0.03
2018	8.03	6.05	7.71	1.24	6.93	0.07	-0.04	0.11	-0.05
2019	12.49	9.43	12.92	1.91	10.69	0.11	-0.07	0.15	-0.09
2020	15.57	11.81	16.59	2.32	13.34	0.13	-0.10	0.18	-0.11
2021	16.42	12.57	17.60	2.36	14.26	0.12	-0.13	0.19	-0.12
2022	17.24	13.28	18.59	2.43	15.08	0.10	-0.16	0.18	-0.13
2023	18.07	13.96	19.58	2.52	15.86	0.08	-0.20	0.18	-0.15
2024	18.91	14.63	20.59	2.62	16.61	0.06	-0.25	0.17	-0.16

Source: CGE simulation.

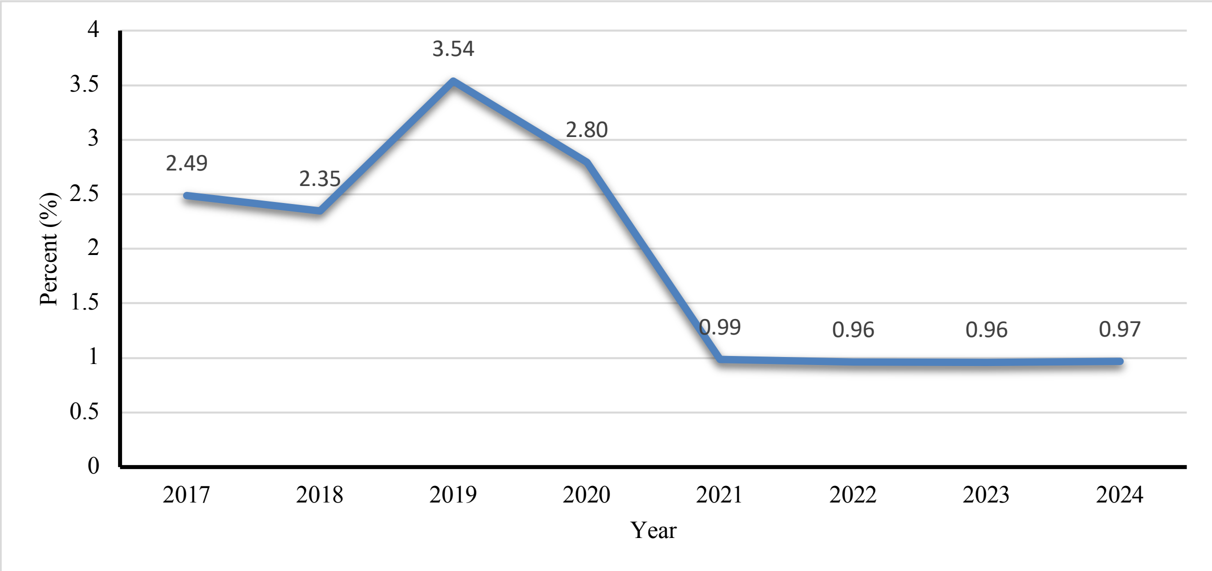
In terms of imports, we observed that the fertilizer-subsidy programme did not lead to a reduction in the imports of priority crops. As shown in Table 12, imports did not fall, but rather increased relative to business-as-usual value for rice and sorghum, in particular, over the period. For maize and other agriculture commodities, the changes are minimal. Meanwhile, imports of processed food decreased substantially for all the years, suggesting that enough production was generated to meet domestic demand as substitutes for imports. Furthermore, domestic demand increased significantly for all targeted crops as well as for manufactured food products (see Table 12). The increase in exports and domestic demand was mainly driven by the fall in prices, especially the price of maize.

Considering changes in prices, we observed an important decline in the prices of agricultural products and products from the food industry. This was not, however, the case for products from non-agricultural subsectors (excluding the food industry). As reported in Appendix Table A4, the basic price of maize fell by 16.80% in 2017 relative to the BAU scenario and by a higher percentage in subsequent years. The drop in basic prices translated into a decline in purchaser prices of these commodities. Furthermore, the production cost of processed food dropped as raw materials became relatively cheaper under the fertilizer-subsidy programme, leading to a drop in the prices of manufactured food products (see Appendix Table A4).

Regarding the impact of the fertilizer-subsidy programme on the government's overall fiscal position, we found that, throughout the years of the programme's implementation, government savings became negative, and the rate was higher when the fertilizer-subsidy programme was in force. This is unsurprising given that the fertilizer-subsidy programme was modelled in such a way as to reduce government tax revenues and, hence, total government income.

Figure 5 presents the evolution of the government's negative savings for 2017 to 2024. Compared to the BAU scenario, growth in government negative savings decreased slightly between 2017 and 2018 before rising to about 3.5% in 2019. Thereafter, the relative growth in government negative savings moderated to hit 2.8% in 2020 and below 1% beyond 2020.

Figure 5: Government Negative Savings (% Deviation from BAU)



Source: CGE simulation.

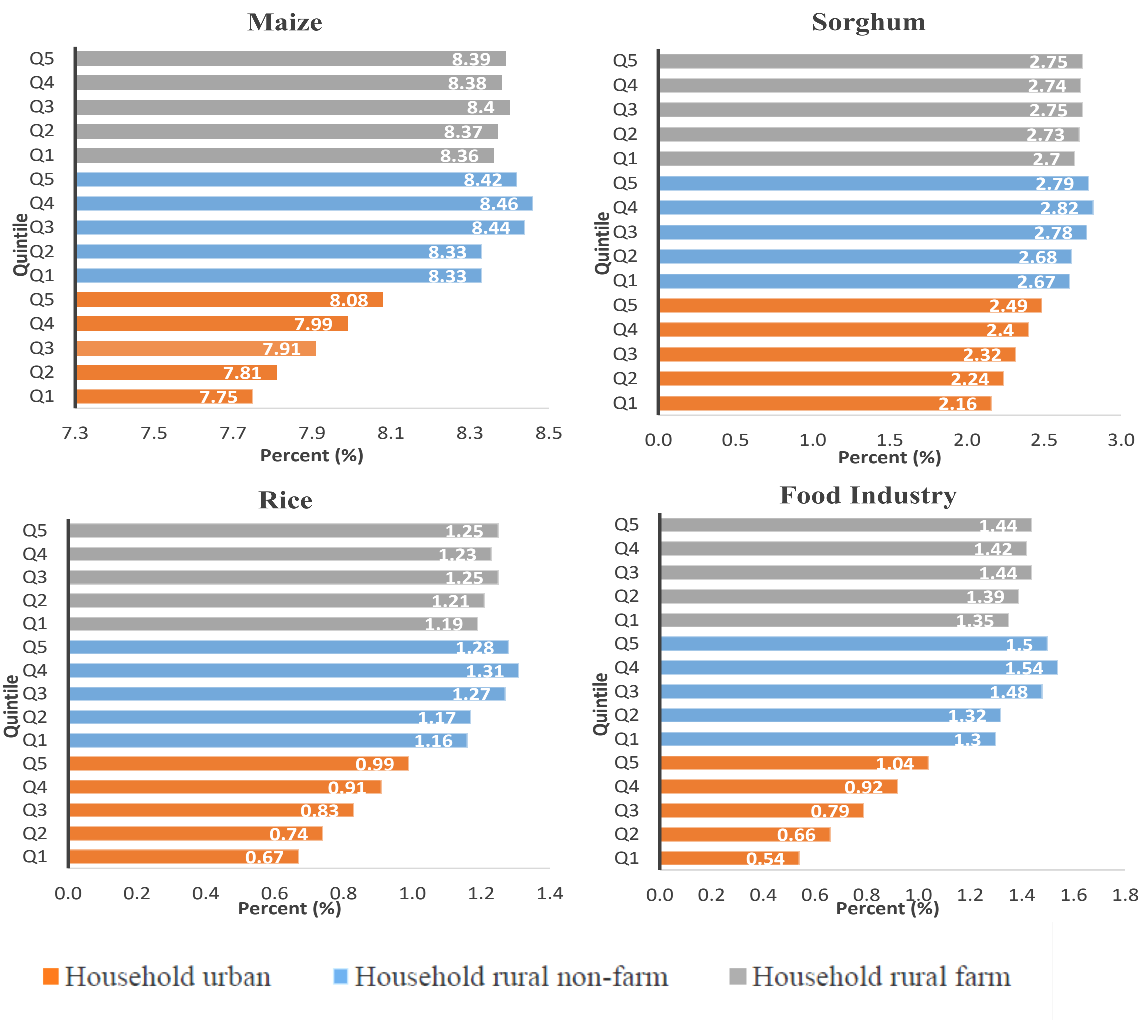
5.5 Effects on Household Welfare

To trace the effects of the fertilizer-subsidy programme on welfare, we relied on a more disaggregated form of household accounts in our SAM. As mentioned earlier, households were first disaggregated into urban and rural. Rural households were further disaggregated into farm and non-farm. These three classes of households were then individually disaggregated into five income quintiles. With respect to household consumption, the results presented in Figure 6 suggest that the fertilizer-subsidy programme led to an increase in household spending for the consumption of maize, rice, sorghum, and food products.

Overall, the increase in consumption spending was lower in rural-farm households compared to rural non-farm and urban households. This finding was consistent across quintiles. While the percentage change in household consumption expenditure seemed to be significant and increasing for maize over the period, it was relatively less substantial for sorghum, rice, and processed food products; it was almost zero in the starting year of the programme (Figure 6 and Appendix Table A5). Specifically, relative to the BAU scenario, the consumption expenditure on maize of rural-farm-households in the lower income quintile group was higher by about 7.8% in 2017. This was true for the subsequent years, albeit with the year-on-year percentage variation mimicking a positive slope curve (Appendix Table A5).

A similar trend was observed for rural-farm-households within the second income quintile and urban households in the fifth income quintile. With regard to households' consumption of other agricultural products, the change in households' consumption of products from other agricultural activities was negligible, reflecting the minimal decline in the prices of these commodities.

Figure 6: Household Consumption Expenditure (%): Deviation from the BAU in 2017



Source: CGE simulation.

Consistent with the observed effects of the programme on household consumption expenditures on agricultural products, we found important effects of the programme on household demand for products from the food industry. The impact was positive for all household categories, though there were variations across various types of households. Considering households at the bottom quintile of the income distribution, for instance, we found that the variation in the consumption of food products was 54%, 130%, and 135%, respectively, for rural farm, rural non-farm and urban households (see Appendix Table A5). The increase in household-consumption expenditures across all quintiles implied that, through the PFJ programme, the government of Ghana was on the path to achieving better food accessibility for all.

VII. Conclusions and Policy Implications

Our study examined the impact of the fertilizer-subsidy programme, under the Planting for Food and Jobs programme, on growth, employment and welfare in Ghana using a dynamic computable general equilibrium model. The government of Ghana launched the PFJ programme in 2017 as part of its policy to promote rural development and growth in production sectors. The main objectives of the programme were to transform the agriculture sector and thereby promote food security, boost employment, and reduce poverty. The implementation of the PFJ programme spans a four-year period (2017-2020) and is based on four main pillars, including a fertilizer-subsidy programme. The fertilizer-subsidy programme is expected to account for more than half of the budget allocation to the PFJ programme.

We used actual and projected fiscal allocations to the fertilizer-subsidy programme under PFJ as well as estimated allocations for four additional years after the planned implementation period as an instrument for the fertilizer-subsidy programme. Our simulation exercise revealed a number of interesting results: first, we found that the fertilizer-subsidy programme improved production levels of target crops, with the greatest change in productivity and output in maize, followed by rice and sorghum. The productivity effects were, however, relatively lower in the early years of the programme.

Additionally, the rise in production of targeted crops was expected to generate an increase in the production of manufactured food as a consequence of forward linkages. As expected, we observed an increase in the output of the food-processing industries with important consequences on factor demand. Third, the rate of unemployment among skilled labour in rural areas and among urban skilled workforce in non-agricultural sectors declined. For urban skilled labour in agriculture, there was a significant reduction in the unemployment rate only between 2021 and 2024. The decline in the level of unemployment was mainly attributable to increased labour demand by other agricultural sectors and food industries. In addition, we found positive effects on international trade, especially on exports. Imports of processed food products declined substantially under the programme while maize imports declined only in the first three years. Nevertheless, government spending on the PFJ subsidy programme may have accelerated negative government savings, especially in 2019, with possible negative implications for government debt stock.

Furthermore, households' consumption expenditures increased under the programme, indicating an improvement in household welfare. The increased production of staple food crops and food because of the programme may be consequential for food poverty or extreme poverty as well. Because our CGE model did not allow us to examine the welfare effects of the programme at a more disaggregated-level (household or individual level, e.g.), however, future researchers may want to explore these dimensions of welfare within a microsimulation framework.

The evidence provided by this study is important for current and future policy action on approaches to improving agricultural sector productivity, job-creation, and welfare enhancement. Specifically, we recommend that the implementation strategy of the PFJ programme should be maintained and that the programme should be extended beyond the planned implementation period to at least 2024, if possible.

References

Annabi, N., Cockburn, J., and Decaluwé, B. (2004). A Sequential Dynamic CGE Model for Poverty Analysis. Paper presented at the Advanced Modelling and Policy Impact Analysis (MPIA) Training Workshop. Dakar, Senegal.

Arguello, R., Valderrama, D.G., and Acero, A.W. (2012). Poverty Impacts of Agricultural Policy Adjustments in an Opening Economy: The Case of Colombia. PEP Working Paper 2012-06. Nairobi, Kenya: Partnership for Economic Policy (PEP).

Arndt, C., Benfica, R., Tarp, F., Thurlow, J., and Uaiene, R. (2010). Biofuels, Growth and Poverty: A Computable General Equilibrium Analysis for Mozambique. Environment and Development Economics, 15(1), 81-105.

Baah-Boateng, W. (2013). Determinants of Unemployment in Ghana. African Development Review, 25(4), 385-399.

Banful, A. B. (2009). Operational Details of the 2008 Fertilizer Subsidy in Ghana - Preliminary Report. Background Paper 18: International Food Policy Research Institute (IFPRI). Washington, DC: Ghana Strategy Support Program (GSSP),

Benin, S., Johnson, M., Abokyi, E., Ahorbo, G., Jimah, K., Nasser, G., Owusu, V., Taabazuing, J., and 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 1300. Washington, DC: *International Food Policy Research Institute.*

Beyene, L. M., Shiferaw, B., Sahoo, A., and Gbegbelegbe, S. (2016). Economy-Wide Impacts of Technological Change in Food Staples in Ethiopia: A Macro-Micro Approach. PEP Working Paper 2016-17. Nairobi, Kenya: Partnership for Economic Policy.

Blanchflower, D.G. and Oswald, A.J. (1989). The Wage Curve. NBER Working Paper No. 3181. Cambridge, MA: National Bureau of Economic Research.

Blanchflower, D.G. and Oswald, A.J. (2005). The Wage Curve Reload. NBER Working Paper No. 11338. Cambridge, MA: National Bureau of Economic Research.

Bourguignon, F. and Morrisson, C. (1998). Inequality and Development: The Role of Dualism. Journal of Development Economics, 57, 233-257.

Breisinger, C., Diao, X., Kolavalli, S. and Thurlow, J. (2008). The Role of Cocoa in Ghana's Future Development. Background Paper No. GSSP 0011. Washington, DC: Ghana Strategy Support Program (GSSP), International Food Policy Research Institute.

Breisinger, C., Diao, X., Thurlow, J., and Al-Hassan, M. R. (2008). Agriculture for Development in Ghana: New Opportunities and Challenges. IFRI Discussion Paper 00784. Washington, DC: Development Strategy and Governance Division.

Breisinger, C., Diao, X., Thurlow, J., and Al-Hassan, R. (2009). Potential Effects of a Green Revolution in Africa: The Case of Ghana. Paper presented at the 27th IAAE Conference, Beijing, China.

Bumb, B. L., Johnson, M. E., and Fuentes, P. A. (2011). Policy Options for Improving Regional Fertilizer Markets in West Africa. IFPRI Discussion Paper 1084. Washington, DC: International Food Policy Research Institute.

Danquah, M. and Iddrisu, A.M. (2017). Ghana's Long Run Growth: Policy Options for Inclusivity and Equity. Technical Report: A paper prepared for the African Development

Bank as part of the Ghana Policy Dialogue Series. Accra, Ghana: African Development Bank.

Darfour, B. and Rosentrater, K. A. (2016). Agriculture and Food Security in Ghana. American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting Paper No: 162460507. Orlando, Florida.

Decaluwé, B., Lemelin, A., Robichaud, V., and Maisonnave, H. (2013). The PEP Standard Single-Country, Recursive Dynamic CGE Model, Version 2.1. Nairobi, Kenya: Partnership for Economic Policy (PEP). Available from https://www.pep-net.org/pep-standard-cge-models.

Diao, X. and Pratt, A. N. (2007). Growth Options and Poverty Reduction in Ethiopia: An Economy-Wide Model Analysis. Food Policy, 32(2), 205-228.

Diao, X., Hazell, P., and Thurlow, J. (2010). The Role of Agriculture in African Development. World Development, 38:10, 1375-1383.

Diao, X., Thurlow, J., Benin, S., and Fan, S. (Eds.). (2012). Strategies and Priorities for African Agriculture: Economywide Perspectives from Country Studies. Washington, DC: International Food Policy Research Institute.

Dorosh, P. and Thurlow, J. (2018). Beyond Agriculture Versus Non-Agriculture: Decomposing Sectoral Growth-Poverty Linkages in Five African Countries. World Development, 109(C), 440-451.

Dorward, A. and Chirwa, E. (2011). The Malawi Agricultural Input Subsidy Programme: 2005/06 to 2008/09. International Journal of Agricultural Sustainability, 9(1), 232-247.

Druilhe, Z. and Barreiro-Hurlé, J. (2012). Fertilizer Subsidies in Sub-Saharan Africa. ESA Working Paper 12-04. Rome, Italy: Food and Agriculture Organisation of the United Nations.

Ghana Statistical Service (2014). Ghana Living Standards Survey Round Six (GLSS 6), Main Report. Accra, Ghana: Ghana Statistical Service.

Ghana Statistical Services; Institute for Statistical, Social and Economic Research (ISSER) and International Food Policy Research Institute (IFPRI). (2017). 2015 Social Accounting Matrix for Ghana. Harvard Dataverse, V1.

Gollin, D., Parente, S., and Rogerson, R. (2002). The Role of Agriculture in Development. American Economic Review, 92(2), 160-164.

Government of Ghana (2018). The 2018 Budget Statement and Economic Policy of the Government of Ghana. Accra, Ghana: Government of Ghana.

Houssou, N., Andam, K., and Asante-Addo, C. (2017). Can Better Targeting Improve the Effectiveness of Ghana's Fertilizer Subsidy Program? Lessons from Ghana and Other Countries in Africa South of the Sahara. IFPRI Discussion Paper 01605. Washington, DC: International Food Policy Research Institute, Development Strategy and Governance Division.

Loayza, N.V. and Raddatz, C.E. (2010). The Composition of Growth Matters for Poverty Alleviation. Journal of Development Economics, 93(1), 137-151.

Mellor, J. W., Altaf, Z., and Salam, A. (2001). Employment Multipliers from Agricultural Growth and Poverty Reduction [with Comments]. The Pakistan Development Review, 371-400.

Ministry of Food and Agriculture (2007). Food and Agriculture Sector Development Policy (FASDEP II). Accra, Republic of Ghana: Ministry of Food and Agriculture.

Ministry of Food and Agriculture (2016). Agriculture in Ghana: Facts and Figures (2015). Accra, Ghana: Statistics, Research and Information Directorate.

Ministry of Food and Agriculture (2017). Planting for Food and Jobs: Strategic Plan for Implementation (2017-2020). Accra, Ghana: Ministry of Food and Agriculture.

Morris, M., Kelly, V. A., Kopicki, R. J., and Byerlee, D. R. (2007). Fertilizer Use in African Agriculture: Lessons Learned and Good Practice Guidelines. Washington, DC: World Bank Directions in Development.

National Population Council (NPC) (2017). Population of Ghana: Population and the Economy. NPC Factsheet No. VIII. Accra, Ghana: National Population Council.

Ravallion, M. and Datt, G. (1996). How Important to India's Poor Is the Sectoral Composition of Economic Growth? World Bank Economic Review, 10(1), 1-25.

Resnick, D. and Mather, D. (2016). Agricultural Inputs Policy under Macroeconomic Uncertainty: Applying the Kaleidoscope Model to Ghana's Fertilizer Subsidy Programme (2008-2015). IFPRI Discussion Paper 01551. Washington, DC: *International Food Policy Research Institute.*

Vargas, R., Escobar, P., Cabrera, M., Cabrera, J., Hernandez, V., Guzman, V., and Cicowiez, M. (2017). Food Vulnerability in Guatemala: A Static General Equilibrium Analysis. PEP Working Paper, 2017-01. Nairobi, Kenya: Partnership for Economic Policy (PEP).

Warr, P. and Yusuf, A. A. (2014). Fertilizer Subsidies and Food Self-Sufficiency in Indonesia. Agricultural Economics, 45(5), 571-588.

World Bank (2018). World Development Indicators Database. Washington, DC: The World Bank.

Appendix

Table A1: Composition of Value-added, Trade, and Investment in Ghana, by Sector, 2015

Sector	Share in Value-added	Value-added share	Import share	Export share	Investment share
	I	II	III	IV	V
Maize	0.02	0.87	0	0	0
Sorghum and millet	0.01	0.95	0	0	0
Rice	0.01	0.9	0.41	0	0
Other cereals	0	0	1	0	0
Pulses	0	0.88	0.02	0.01	0
Groundnuts	0	0.93	0	0	0
Other oilseeds	0.01	0.82	0	0.3	0
Cassava	0.01	0.95	0	0	0
Other roots	0.02	0.98	0	0	0
Vegetables	0.03	0.94	0.02	0.52	0
Sugar cane	0	0.49	0	0	0
Tobacco	0	0.85	0	0	0
Cotton and fibers	0	0.6	0	0.01	0
Fruits and nuts	0.02	0.95	0.02	0.2	0
Cocoa	0.02	0.83	0	1	0
Coffee and tea	0	0.74	0.51	0.04	0
Other crops	0	0.36	0.08	0.13	0
Cattle	0	0.45	0.01	0	0
Poultry	0	0.46	0.03	0	0
Other livestock	0	0.45	0.02	0	0
Forestry	0.02	0.61	0.01	0.02	0
Fishing	0.01	0.83	0	0	0
Coal and lignite	0.05	0.64	0.1	0.15	0
Other mining	0.01	0.09	0.01	0.99	0
Meat, fish and dairy	0	0.23	0.9	0.58	0
Fruit and vegetable processing	0	0.41	0.74	0.33	0
Fats and oils	0	0.23	0.11	0.11	0
Grain milling	0	0.11	0.15	0.27	0
Sugar refining	0	0.21	0.85	0	0
Other foods	0	0.39	0.46	0.21	0
Beverages	0	0.42	0.29	0.78	0
Tobacco processing	0	0.27	0.29	0	0
Textiles	0	0.36	0.46	0.09	0
Clothing	0	0.38	0.53	0.48	0
Leather and footwear	0	0.3	0.91	0	0
Wood and paper	0.01	0.19	0.21	0.15	0
Petroleum	0.01	0.2	0.06	0.1	0
Chemicals	0.01	0.33	0.75	0.51	0
Non-metal minerals	0	0.44	0.65	0.14	0
Metals and metal	0	0.42	0.79	0.84	0

products					
Machinery and equipment	0	0.52	0.99	0.65	0.24
Other manufacturing	0	0.43	0.78	0.01	0.02
Electricity, gas, and steam	0.01	0.09	0	0	0
Water supply and sewage	0.01	0.19	0	0	0
Construction	0.17	0.73	0	0	0.73
Wholesale and retail trade	0.06	0.38	0	0	0
Transportation and storage	0.12	0.65	0.14	0.14	0
Accommodation and food services	0.06	0.63	0.16	0.31	0
Information and communication	0.02	0.36	0	0	0
Finance and insurance	0.04	0.61	0.05	0.02	0
Real estate activities	0.02	0.44	0	0	0
Business services	0.02	0.25	0.56	0.47	0
Public administration	0.06	0.45	0.15	0.05	0
Education	0.04	0.56	0	0	0
Health and social work	0.01	0.42	0	0	0
Other services	0.04	0.86	0		0

Source: 2015 Ghana SAM.

Table A2: Inputs Demand across Agricultural Activities and Food Industry (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry	Chemi-cal Industry	Other Industry	Servi-ce Industry	Public Adminis-tration
Year	**Land[16]**								
2018	-0.97	0.06	0.03	0.00					
2019	-2.17	0.17	0.05	-0.01					
2020	-3.52	0.33	0.06	-0.01					
2021	-4.79	0.53	0.09	-0.01					
2022	-5.80	0.74	0.12	-0.01					
2023	-6.59	0.94	0.16	0.00					
2024	-7.17	1.13	0.19	0.01					
Year	**Composite Capital[17]**								
2018	-0.50	-0.33	-0.25	-0.18	1.67	-0.02	-0.02	-0.01	
2019	-1.31	-0.88	-0.78	-0.45	3.98	-0.05	-0.06	-0.03	
2020	-2.51	-1.72	-1.70	-0.86	7.09	-0.09	-0.11	-0.06	
2021	-3.88	-2.69	-2.79	-1.31	10.15	-0.14	-0.19	-0.10	
2022	-5.17	-3.56	-3.81	-1.68	12.37	-0.18	-0.26	-0.14	
2023	-6.41	-4.38	-4.78	-2.02	14.08	-0.22	-0.33	-0.18	
2024	-7.62	-5.17	-5.73	-2.32	15.47	-0.27	-0.41	-0.22	
Year	**Composite Labour Demand**								
2017	-7.29	-1.50	0.27	1.25	15.60	-0.02	-0.23	0.12	-0.05
2018	-11.90	-2.09	-2.51	2.37	23.06	0.04	-0.34	0.23	-0.09
2019	-17.90	-3.45	-6.75	3.95	32.58	0.11	-0.48	0.36	-0.14
2020	-21.68	-4.43	-9.58	5.01	35.25	0.22	-0.52	0.47	-0.17
2021	-22.24	-4.38	-10.01	5.21	30.87	0.34	-0.44	0.55	-0.19
2022	-22.95	-4.47	-10.52	5.43	28.45	0.43	-0.38	0.61	-0.21
2023	-23.77	-4.64	-11.10	5.68	27.24	0.49	-0.34	0.66	-0.23
2024	-24.65	-4.87	-11.71	5.94	26.78	0.54	-0.31	0.70	-0.25

Source: CGE simulation.

[16] The value of land use in each of the agricultural subsectors did not differ between the BAU scenario and the fertilizer subsidy scenario in 2017. In 2017, the simulated values of land used in the maize, sorghum, rice, and other agricultural activities subsectors were 3,714,614.53, 1,648,048.61, 1,025,608.21, and 9,088,386.77, respectively.

[17] The levels of utilization of composite capital did not differ between the two simulated scenarios in 2017. In 2017, the demand for composite capital by each of the agricultural subsectors stood at 2,282,272.54, 442,767.41, 836,697.86, and 46,471,298.12 for the maize, sorghum, rice and other agricultural subsectors, respectively.

Table A3: Labour Demand across Activities (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry	Chemical Industry	Other Industry	Service Industry	Public Administration
Year	***Rural unskilled Agriculture***				***Rural unskilled Non-Agriculture***				
2017	-7.19	-1.46	0.34	1.38	14.93	-0.81	-0.96	-0.69	-0.98
2018	-11.67	-1.98	-2.35	2.65	21.98	-1.17	-1.44	-1.00	-1.50
2019	-17.50	-3.22	-6.46	4.49	30.92	-1.61	-2.05	-1.40	-2.15
2020	-21.20	-4.14	-9.22	5.70	33.36	-1.70	-2.27	-1.50	-2.43
2021	-21.77	-4.10	-9.66	5.87	29.16	-1.45	-2.08	-1.29	-2.31
2022	-22.49	-4.18	-10.18	6.10	26.84	-1.32	-1.97	-1.17	-2.26
2023	-23.30	-4.34	-10.75	6.36	25.65	-1.24	-1.92	-1.11	-2.26
2024	-24.17	-4.56	-11.35	6.64	25.19	-1.21	-1.90	-1.09	-2.30
Year	***Rural skilled Agriculture***				***Rural skilled Non-Agriculture***				
2017	-7.43	-1.71	0.08	1.11	15.77	-0.08	-0.24	0.04	-0.25
2018	-12.15	-2.51	-2.88	2.10	23.34	-0.06	-0.35	0.10	-0.40
2019	-18.30	-4.16	-7.37	3.47	33.00	-0.04	-0.49	0.17	-0.60
2020	-22.15	-5.30	-10.32	4.42	35.74	0.05	-0.53	0.26	-0.69
2021	-22.68	-5.22	-10.72	4.64	31.32	0.19	-0.45	0.36	-0.67
2022	-23.39	-5.30	-11.22	4.87	28.89	0.28	-0.39	0.43	-0.68
2023	-24.20	-5.47	-11.80	5.11	27.67	0.35	-0.34	0.48	-0.69
2024	-25.09	-5.72	-12.42	5.35	27.22	0.39	-0.31	0.51	-0.72
Year	***Urban unskilled Agriculture***				***Urban unskilled Non-Agriculture***				
2017	-7.26	-1.52	0.27	1.30	15.27	-0.51	-0.66	-0.39	-0.68
2018	-11.95	-2.29	-2.66	2.33	22.51	-0.73	-1.01	-0.57	-1.06
2019	-18.08	-3.91	-7.12	3.75	31.73	-1.00	-1.45	-0.79	-1.55
2020	-21.96	-5.07	-10.10	4.68	34.24	-1.05	-1.63	-0.85	-1.79
2021	-22.56	-5.06	-10.57	4.81	29.89	-0.90	-1.53	-0.73	-1.75
2022	-23.30	-5.19	-11.13	4.98	27.49	-0.81	-1.47	-0.67	-1.76
2023	-24.15	-5.40	-11.74	5.18	26.26	-0.76	-1.44	-0.63	-1.79
2024	-25.06	-5.67	-12.38	5.40	25.79	-0.74	-1.43	-0.62	-1.84
Year	***Urban skilled Agriculture***				***Urban skilled Non-Agriculture***				
2017	-7.38	-1.66	0.13	1.16	16.03	0.14	-0.01	0.26	-0.03
2018	-12.07	-2.42	-2.79	2.19	23.77	0.29	0.00	0.45	-0.05
2019	-18.18	-4.02	-7.23	3.63	33.68	0.47	0.01	0.68	-0.09
2020	-22.00	-5.12	-10.15	4.62	36.52	0.63	0.04	0.83	-0.12
2021	-22.52	-5.01	-10.52	4.86	32.02	0.72	0.08	0.89	-0.15
2022	-23.21	-5.07	-11.01	5.12	29.55	0.80	0.12	0.94	-0.17
2023	-24.01	-5.23	-11.58	5.38	28.32	0.86	0.17	0.99	-0.19
2024	-24.89	-5.46	-12.18	5.64	27.88	0.91	0.20	1.03	-0.20

Source: CGE simulation.

Table A4: Change in Prices (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry	Chemi cal Industry	Other Industry	Service Industry	Public Adminis tration
Year	***Basic price***								
2017	-16.80	-6.18	-4.44	-0.76	-3.94	0.05	0.05	0.10	0.03
2018	-25.12	-9.96	-10.96	-1.19	-6.60	0.10	0.09	0.17	0.06
2019	-34.70	-15.32	-19.54	-1.73	-9.85	0.15	0.15	0.26	0.09
2020	-39.79	-18.62	-24.70	-1.92	-12.00	0.19	0.19	0.32	0.12
2021	-40.14	-18.88	-25.47	-1.71	-12.71	0.21	0.21	0.34	0.13
2022	-40.80	-19.38	-26.42	-1.62	-13.33	0.23	0.23	0.36	0.14
2023	-41.67	-20.03	-27.48	-1.60	-13.93	0.25	0.26	0.38	0.15
2024	-42.69	-20.79	-28.60	-1.62	-14.50	0.27	0.28	0.41	0.16
Year	***Purchaser Price***								
2017	-15.87	-5.55	-2.37	-0.64	-1.64	0.03	0.04	0.10	0.03
2018	-23.73	-8.96	-5.89	-1.00	-2.78	0.05	0.06	0.16	0.05
2019	-32.79	-13.78	-10.59	-1.45	-4.19	0.07	0.10	0.25	0.08
2020	-37.61	-16.75	-13.45	-1.58	-5.15	0.09	0.12	0.30	0.10
2021	-37.94	-16.98	-13.89	-1.38	-5.46	0.09	0.13	0.32	0.11
2022	-38.56	-17.43	-14.43	-1.28	-5.75	0.10	0.14	0.34	0.12
2023	-39.39	-18.01	-15.03	-1.25	-6.01	0.11	0.16	0.36	0.13
2024	-40.36	-18.69	-15.67	-1.25	-6.27	0.11	0.17	0.38	0.14

Source: CGE simulation.

Table A5: Household Consumption Expenditure (%): Deviation from the BAU

	Maize	Sorghum	Rice	Other agriculture activities	Food Industry
Year	***Household Rural Farm -- Quintile 1***				
2017	7.75	2.16	0.67	-0.16	0.54
2018	12.91	3.78	2.23	-0.05	1.20
2019	20.39	6.36	4.57	0.17	2.14
2020	25.46	8.28	6.28	0.44	3.04
2021	26.12	8.66	6.76	0.62	3.61
2022	27.01	9.10	7.22	0.76	4.04
2023	28.09	9.59	7.68	0.88	4.40
2024	29.34	10.11	8.14	0.99	4.71
Year	***Household Rural Farm -- Quintile 2***				
2017	7.81	2.24	0.74	-0.04	0.66
2018	13.00	3.88	2.33	0.11	1.37
2019	20.51	6.49	4.70	0.38	2.35
2020	25.57	8.40	6.40	0.64	3.23
2021	26.17	8.74	6.84	0.76	3.75
2022	27.02	9.15	7.28	0.87	4.15
2023	28.09	9.62	7.73	0.97	4.48
2024	29.32	10.14	8.18	1.07	4.78
Year	***Household Rural Farm -- Quintile 3***				

2017	**7.91**	**2.32**	**0.83**	0.10	0.79
2018	13.15	4.02	2.47	0.32	1.57
2019	20.75	6.70	4.90	0.67	2.65
2020	25.85	8.63	6.63	0.96	3.56
2021	26.42	8.94	7.04	1.04	4.04
2022	27.26	9.34	7.47	1.13	4.42
2023	28.31	9.81	7.90	1.23	4.75
2024	29.54	10.32	8.35	1.32	5.05
Year	***Household Rural Farm -- Quintile 4***				
2017	7.99	2.40	0.91	0.22	0.92
2018	13.29	4.14	2.59	0.51	1.76
2019	20.98	6.88	5.08	0.93	2.92
2020	26.12	8.84	6.82	1.24	3.86
2021	26.65	9.12	7.21	1.29	4.30
2022	27.47	9.51	7.63	1.36	4.66
2023	28.51	9.97	8.06	1.45	4.98
2024	29.74	10.48	8.50	1.54	5.27
Year	***Household Rural Farm -- Quintile 5***				
2017	8.08	2.49	0.99	0.34	1.04
2018	13.43	4.26	2.70	0.67	1.93
2019	21.18	7.04	5.22	1.15	3.13
2020	26.31	8.99	6.97	1.44	4.07
2021	26.80	9.24	7.32	1.45	4.46
2022	27.59	9.60	7.72	1.49	4.79
2023	28.61	10.04	8.13	1.55	5.08
2024	29.83	10.54	8.57	1.62	5.36
Year	***Household Rural Non-Farm -- Quintile 1***				
2017	8.33	2.67	1.16	0.60	1.30
2018	13.58	4.33	2.76	0.74	2.01
2019	21.02	6.84	5.03	0.81	2.81
2020	25.89	8.58	6.56	0.82	3.44
2021	26.39	8.85	6.94	0.84	3.85
2022	27.18	9.21	7.33	0.88	4.18
2023	28.19	9.64	7.73	0.93	4.46
2024	29.38	10.12	8.15	0.98	4.71
Year	***Household Rural Non-Farm -- Quintile 2***				
2017	8.33	2.68	1.17	0.62	1.32
2018	13.64	4.40	2.83	0.85	2.12
2019	21.21	7.02	5.20	1.07	3.07
2020	26.15	8.81	6.79	1.15	3.78
2021	26.61	9.04	7.13	1.13	4.15
2022	27.38	9.39	7.50	1.15	4.45
2023	28.38	9.81	7.90	1.19	4.72
2024	29.56	10.29	8.32	1.24	4.97
Year	***Household Rural Non-Farm -- Quintile 3***				
2017	8.44	2.78	1.27	0.78	1.48
2018	13.89	4.61	3.04	1.16	2.44
2019	21.71	7.41	5.58	1.62	3.64
2020	26.80	9.31	7.27	1.83	4.48

2021	27.23	9.51	7.58	1.77	4.80
2022	27.98	9.85	7.95	1.77	5.10
2023	28.99	10.28	8.35	1.80	5.37
2024	30.20	10.77	8.78	1.86	5.63
Year	***Household Rural Non-Farm -- Quintile 4***				
2017	8.46	2.82	1.31	0.84	1.54
2018	13.95	4.69	3.12	1.30	2.57
2019	21.86	7.56	5.73	1.86	3.87
2020	27.00	9.50	7.46	2.12	4.77
2021	27.40	9.68	7.75	2.03	5.07
2022	28.14	10.01	8.11	2.01	5.34
2023	29.14	10.43	8.50	2.04	5.61
2024	30.34	10.92	8.93	2.10	5.87
Year	***Household Rural Non-Farm -- Quintile 5***				
2017	8.42	2.79	1.28	0.80	1.50
2018	13.89	4.65	3.08	1.25	2.52
2019	21.77	7.51	5.68	1.80	3.81
2020	26.90	9.43	7.40	2.04	4.68
2021	27.27	9.60	7.67	1.93	4.96
2022	27.99	9.91	8.01	1.90	5.22
2023	28.97	10.32	8.40	1.92	5.47
2024	30.16	10.80	8.82	1.96	5.72
Year	***Household Urban -- Quintile 1***				
2017	8.36	2.70	1.19	0.65	1.35
2018	13.89	4.60	3.02	1.13	2.41
2019	21.88	7.53	5.69	1.77	3.79
2020	27.14	9.54	7.49	2.12	4.78
2021	27.59	9.76	7.82	2.08	5.13
2022	28.37	10.12	8.20	2.09	5.44
2023	29.40	10.56	8.62	2.15	5.73
2024	30.63	11.06	9.06	2.22	6.01
Year	***Household Urban -- Quintile 2***				
2017	8.37	2.73	1.21	0.69	1.39
2018	13.88	4.61	3.04	1.17	2.44
2019	21.85	7.53	5.70	1.80	3.81
2020	27.08	9.52	7.48	2.12	4.78
2021	27.51	9.73	7.79	2.06	5.11
2022	28.27	10.07	8.16	2.06	5.40
2023	29.28	10.50	8.57	2.10	5.68
2024	30.50	11.00	9.00	2.17	5.95
Year	***Household Urban -- Quintile 3***				
2017	8.40	2.75	1.25	0.74	1.44
2018	13.90	4.64	3.07	1.21	2.48
2019	21.85	7.54	5.71	1.82	3.83
2020	27.04	9.51	7.46	2.11	4.76
2021	27.43	9.69	7.76	2.02	5.06
2022	28.17	10.01	8.11	2.00	5.34
2023	29.16	10.43	8.50	2.03	5.59
2024	30.36	10.92	8.92	2.08	5.85

Year	*Household Urban -- Quintile 4*				
2017	8.38	2.74	1.23	0.72	1.42
2018	13.86	4.61	3.03	1.17	2.44
2019	21.77	7.48	5.65	1.74	3.75
2020	26.93	9.43	7.39	2.01	4.66
2021	27.31	9.60	7.67	1.90	4.94
2022	28.03	9.91	8.01	1.87	5.20
2023	29.01	10.32	8.40	1.89	5.45
2024	30.20	10.80	8.81	1.93	5.69
Year	***Household Urban -- Quintile 5***				
2017	8.39	2.75	1.25	0.74	1.44
2018	13.85	4.61	3.04	1.17	2.44
2019	21.73	7.46	5.63	1.72	3.73
2020	26.85	9.38	7.34	1.95	4.59
2021	27.20	9.53	7.60	1.82	4.85
2022	27.90	9.82	7.93	1.77	5.09
2023	28.86	10.22	8.30	1.76	5.31
2024	30.03	10.68	8.70	1.79	5.54

Source: CGE simulation.