A CGE Analysis of the Gender Productivity Gap in Nigeria's Agriculture Sector

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1. Introduction

This study examines the impacts of the gender productivity gap in the Nigerian agriculture sector as well as the effects of policy interventions aimed at closing the gap using a gendered computable general equilibrium (CGE) model. The agriculture sector is critical to Nigeria's economic growth and development. Investment in the sector improves productivity, employment opportunities, and reduces poverty and enhances sustainable development (World Bank, 2014). But a peculiar feature of the sector is the gender gap in access to farm inputs and in productivity levels (Oseni, Goldstein and Utah, 2013; Mukasa and Salami, 2015).

Several studies in the literature have analysed the gender gap in Nigeria's agriculture sector. Foremost among these studies are Mukasa and Salami (2015), Oseni, Goldstein and Utah (2013), Oseni, et al. (2015) and Oladeebo and Fajuyigbe (2007). While these studies have contributed to the literature on the gender gap in the agriculture sector in Nigeria, the analysis are mainly limited to either determining the availability of the gender gap, estimating the extent of the gap, or exploring the causes and determinants of the gap.

The impacts of policy measures to improve the productivity of female farmers and close the gender gap is well researched in the literature (Karamba and Winters, 2015; Ngoma, Machina and Kuyeta, 2019; Anderson, et al., 2020). But studies on the economy-wide impacts of the gender gap or impacts of policy interventions to close the gap using CGE models are rare. One study that used a partial equilibrium approach to estimate the welfare and GDP effects of closing the gender gap in

agricultural productivity in Malawi, Tanzania and Uganda is UN Women/UNDP/UNEP/World Bank (2015). The study found evidence of gender productivity gap and estimated the cost of the gap in Malawi, Tanzania and Uganda; but it neglects the general equilibrium effects. For example, the study assumed that increasing the productivity of female farmers does not affect the productivity of male farmers or agricultural prices. The study also found that access to male labour constrains the productivity of female farmers. Our analysis builds on this study by incorporating general equilibrium effects, and distinguishing different types of male and female labor.

CGE models have been used to analyse the economic impacts of public policy in Nigeria, ranging from government expenditure, education, climate change, agriculture, and energy (Nkang, et al., 2013; Odior, 2014; Montaud, et al. 2017; Bosello, et al., 2018; and Omoju, et al., 2020). But none of these CGE model incorporates gender analysis, thereby failing to capture the gender effects of public policies. Fontana and Wood (2000), Fontana and Rodgers (2005) and Fontana (2015) have noted the importance of incorporating gender in the CGE framework. Fontana and Wood (2000) modeled gender by incorporating leisure and unpaid work. Other means of incorporating gender in a CGE model is through gender-disaggregated labour shares and household structures (Arndt and Tarp, 2000; and Fontana, 2015). Our study builds on these literature by analysing gender from a gendered labour shares. But we went further to disaggregate these gendered labour shares into whether they are provided by unpaid household

labour or paid hired labour, following Oseni, et al. (2015). This disaggregation is critical due to the unequal access of male and female farmers to different labour types. It is also based on key strand of the gender-in-agriculture literature, which argues that market inefficiencies, especially in the credit and labour markets, are key drivers of the productivity gap.

Palacios-Lopez and Lopez (2015) estimated that 34% of the agricultural labour productivity gap in Malawi is due to differences in labour market access. Also, one source of the productivity gap in Nigeria is unequal access to labour inputs (Mukasa and Salami, 2015), with female farmers depending disproportionately on unpaid household labour. In the Nigerian context, women are disproportionately employed as unpaid family labour in the agriculture sector in Nigeria, and female farmers also rely more on family labour than their male counterparts (Oseni, et al., 2015), who have more resources to acquire hired labour. If women farmers in Nigeria have more access to hired male labour at competitive wage rate, this could contribute to boosting productivity.

This study contributes to the gender-in-agriculture literature in Nigeria in a number of ways. First, to the best of our knowledge, it is the first study to estimate the economy-wide impacts of the gender productivity gap in the agriculture sector in Nigeria as well as the policy interventions aimed at closing the gap. Second, it contributes to the CGE modeling literature in Nigeria by incorporating gender. It models gender differences in the distribution of labour between household and hired labour.

Thus, this study attempts to contribute to the literature by analysing the economy-wide impacts of the gender productivity gap in the agriculture sector using a CGE model. It also examines the effects of policy interventions aimed at closing the gap. The interventions examined in this study are based on the policy direction of the National Food Security Program (NFSP), and include increasing the stock of capital in the female-managed crops via access to farm inputs, enhancing public investment in the sector, and restricting importation of agricultural commodities via higher import tariff.

1.1 Overview of Nigeria's agriculture sector

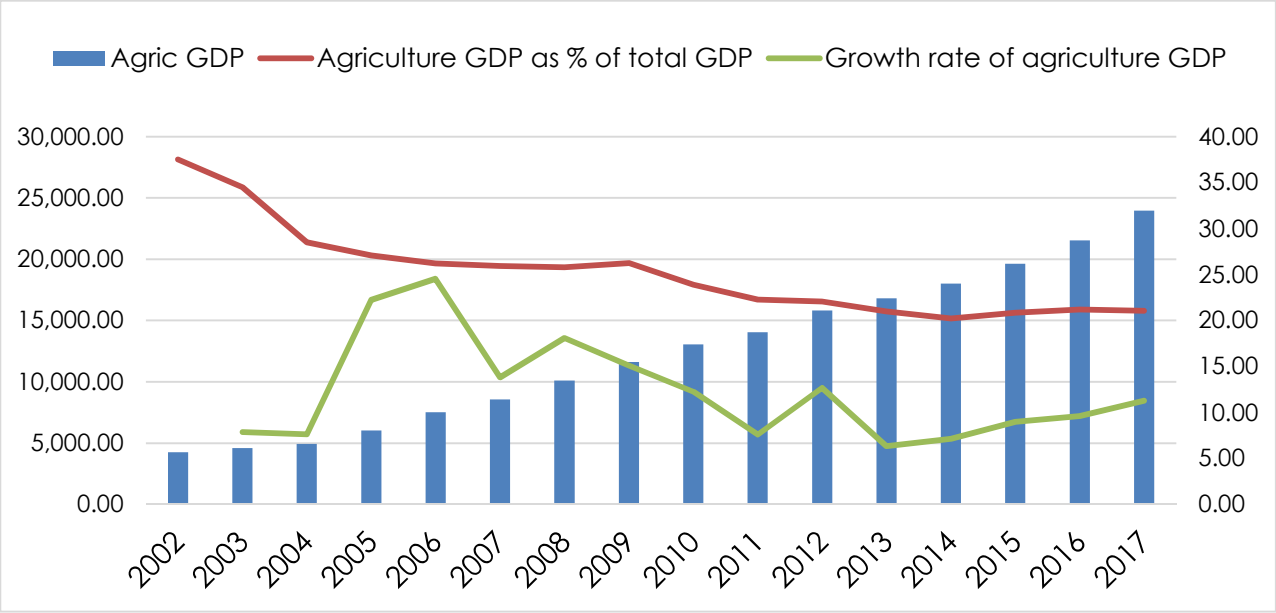
The agriculture sector in Nigeria is a key sector of the economy in terms of contribution to GDP, employment and export earnings. Agriculture GDP increased from ₦1,508 billion in 2002 to ₦23,952 billion in 2017 (see Figure 1), but the contribution of the sector to aggregate GDP declined from 37.5% in 2002 to 21.1% over the same period. The growth rate of the sector also declined from 24.6% in 2006 to 11.3% in 2017. In addition, the sector's contribution to export in recent years remains very low at 5% (CBN, 2017).

The poor performance of the sector has raised concerns about the ability to ensure food security and attain the poverty and hunger-related targets of the Sustainable Development Goals (SDGs). Nigeria was ranked 93rd out of 117 countries on the 2019 Global Hunger Index and 158th out of 189 countries on the 2018 UNDP Human Development Index. Over 52% of the rural population are under the poverty line compared to only 18% of the urban population. The high population growth rate

relative to the dwindling food production capacity increases the likelihood of a food crisis. The recently published Nigeria's food security outlook report by the Famine Early Warning Systems Network (FEWS NET) painted a gloomy prospects for the country (FEWS NET, 2020).

The increasing demand for food vis-à-vis shrinking domestic supply has resulted in massive food importation and food price inflation. Data from the World Integrated Trade Solutions (WITS) of the World Bank puts food imports as a percentage of total imports at 4.0% in 2018. Wheat, fish, milk and dairy products, rice and sugar are among the major food import commodities, from sources such as the USA, France, Thailand, India, Netherlands and China (Vaughan, et al., 2014). Food inflation rate stood at 14.7% as at December 2019 (year-on-change) compared to 9.3% for non-food inflation rate, according to the Central Bank of Nigeria. Over-dependence on food importation poses a serious economic development challenge considering the food needs of the country and the pressures such food imports exert on scarce foreign reserves and the exchange rate.

Figure 1: Agriculture GDP and share in total GDP, 2002-2017



Source: Data obtained from CBN Statistical Bulletin

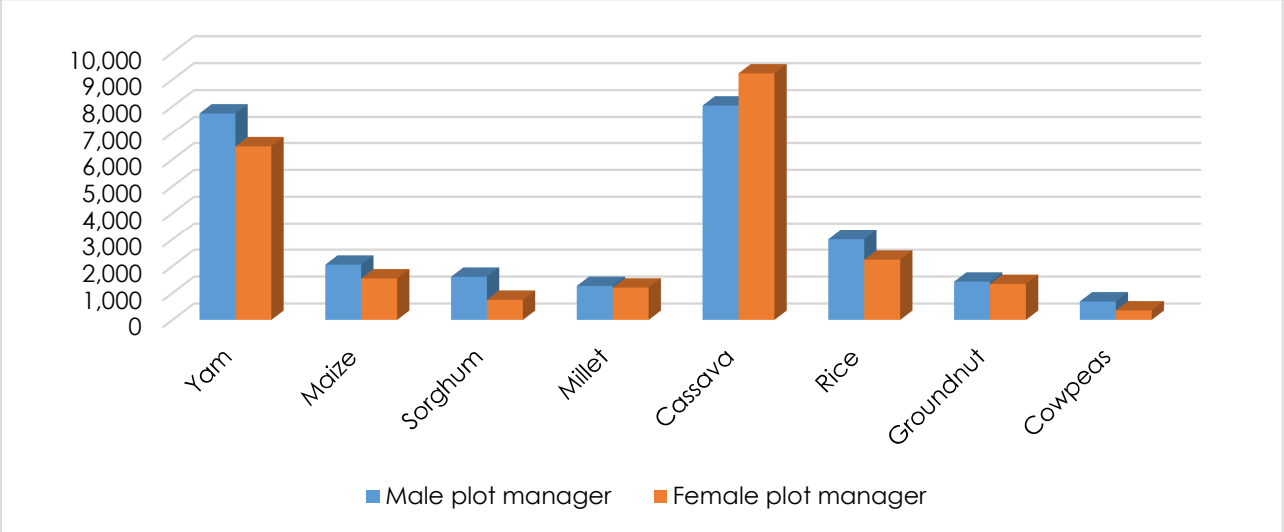
One of the core characteristics of the Nigerian socio-economic development experience is gender inequality. According to the United Nations Development Programme (UNDP)'s Human Development Report 2020[1], Nigeria's gender development index (GDI) in 2019 stood at 0.881, ranking 161th out of 189 countries. Gender disparity is also reflected in expected years of schooling (female 9.4; male 10.6), mean years of schooling (female 5.7; male 7.7), female-to-male unemployment rate (1.20%) and gross national income per capita (female $4,107; male $5,692 PPP).

Gender inequality is also prevalent in the economic sectors in Nigeria, including in agriculture. According to the Federal Ministry of Agriculture and Rural Development (FMARD, 2019), women account for 60%-79% of rural labour force,

[1] Briefing note for countries on the 2020 Human Development Report: Nigeria

but are five times less likely to own land than men. Wage disparity between male (₦1,454) and female (₦1,246) labour is evident in the sector (NBS and World Bank, 2019). There is also a marked difference in productivity[2], measured by crop yields (kg/hectares), in between male and female plot managers in Nigeria, as shown in Figure 2. Mukasa and Salami (2015) estimated gender productivity gap in the agriculture sector in Nigeria as 18.6%, and attributed the gap to the disadvantages of women in access to large quantity and quality of land as well as labour inputs. This corroborates the earlier conclusions of Oseni, Goldstein and Utah (2013). They found that the gender gaps in agriculture earnings in Nigeria can be attributed to unequal access to land, labour physical inputs and tools, and information.

Figure 2: Yields of selected crops by male and female plot manager



Source: (NBS/World Bank, 2019)

[2] Productivity in this context and has described by other studies is crop yield or output per hectare of land in male and female-managed farms.

The poor performance and gender productivity gap in the agriculture sector necessitated the need for more inventive ways of thinking about agricultural transformation, food security and women's productivity. This motivated the launch of the National Food Security Program (NFSP) in 2016. The NFSP was launched to promote the development of the agriculture sector and enhance food security. It has a broader focus and emphasis on skills acquisition, employment generation and poverty reduction among women and youth. The specific interventions in the NFSP include public investment in the agriculture sector, improving access to critical farm inputs, training and skills acquisition, and subsidies.

2. Literature review

The agriculture sector plays a vital role in reducing poverty level and fueling economic growth. However, the performance of the sector globally is impeded by several factors, including inability of women to access key resources, services and markets (FAO, 2011). The gender gap in the sector undermines agricultural productivity and overall socio-economic development goals. According to the FAO Report, women across developing regions have similar challenges of in inputs, services and assets such as labour, land, education, livestock, extension and financial services.

The gender gap in the agriculture sector in Nigeria has attracted significant interest in the academic literature. The first strand of the literature examines the availability and causes of the gender productivity gap. Adeleke et al. (2008) found no significant differences in the productivity of male and female maize farmers in

Nigeria, after accounting for agricultural input use. This result corroborated earlier findings by Oladeebo and Fajuyigbe (2007). In their study of rice farmers in Osun State of Nigeria, they found that female rice farmers are more technically efficient than their male counterpart, when years of education and age are accounted for.

On the contrary, other studies established evidence of the gender productivity gap. For example, Peterman et al. (2010) found there is productivity gap between male and female-managed plots, and also between male and female-headed households in Nigeria and Uganda, even after accounting for agricultural inputs, a range of socio-economic variables, and crop choices. They noted that the gender differences in productivity depend on gender indicators, crop-specific samples, bio-physical characteristics, and agro-ecological zone.

Oseni, et al. (2015) employed data from the General Household Survey Panel 2010–2011 and the Oaxaca-Blinder decomposition method to analyze differences in agricultural productivity across male and female plot managers in Nigeria. The study found that gender gap in productivity and the causes vary across location. Women from the North are 28% less efficient than men after controlling for observed factors of production, while there were no significant gender differences in productivity in the South. The study further revealed that structural factors is more important in explaining the gap in the North than endowment factors, indicating that if women farmers in the North are given the same level of resources as men, they will still be less efficient. The reverse is the case in the South. Endowment factors are more important than structural factors in explaining the productivity gap. With

the same level of farm inputs, women farmers in the South will perform as much as men farmers. Similar to Oseni, at al. (2015), Ekerebi and Adeola (2017) found a gender harvest value gap across the Northern and Southern parts of Nigeria. They attribute the gender gap partly to differences in wealth, education and access to irrigation. The North is predominantly Muslim, so women are more constrained in hiring male labour and accessing markets.

Another strand of the literature evaluates the impacts of policy measures aimed at improving the productivity of female farmers and closing the gender gap. As noted by Anderson, et al. (2020) in their systematic review, there are evidence of significant economic benefits from closing the gender gap, but studies that estimated these economic benefits are rare. Karamba and Winters (2015) investigate the impacts of the farm input subsidy program on agricultural productivity (value of output hectare per) in Malawi using plot-level nationally representative data. Using spatial fixed effects and propensity score methods, they found that the program increased the productivity of both male and female farmers, but does not disproportionately increase the productivity of female farmers relative to their male counterparts. This is also similar to the findings of Ngoma, Machina and Kuteya (2019) for Zambia. However, contrary to Karamba and Winters (2015), Fisher and Kandiwa (2014) found the Malawi's farm input subsidy program helped close the gender gap in modern maize adoption. The program consisting of both maize seeds and fertilizer coupons have a positive impacts on modern maize adoption for female farmers while there are no effects on male farmers.

While the gender differences in productivity in the agriculture sector are noted, empirical analysis that investigate the economy-wide effects of this gender productivity gaps or the economic benefits of narrowing it in Nigeria are rare. UN Women/UNDP/UNEP/World Bank (2015) estimated that the gender gap in the agriculture sector in Malawi, Tanzania and Uganda costs $100 million, $105 million, and $67 million in GDP annually respectively. Closing the gap will increase annual crop output by 7.3%, 2.1%, and 2.8% in the three countries. Mukasa and Salami (2015) estimated that closing the agriculture gender productivity gap in Nigeria will increase production by 2.8%, increase monthly consumption per adult equivalent by 2.9% and reduce the prevalence of poverty among household with female-managed lands by 1.2%. But this analysis was based on micro-level data and does not capture the macro-level and inter-sectoral effects. This study advances the gender-in-agriculture literature in the Nigerian context by analysing the economy-wide impacts of the gender productivity gap as well as NFSP interventions aimed at closing the gap, using a CGE model.

Numerous studies have modeled gender issues within a CGE framework (Fontana, 2015). Fontana and Wood (2000) modeled gender in a CGE framework by incorporating leisure and unpaid work. Arndt and Tarp (2000) investigated the interactions between agricultural technology improvements, risk-reducing behavior and gender roles in agricultural production in Mozambique using a CGE model. Acknowledging that availability of labour is a major constraint for cassava production – a key female-intensive crop -, and the critical role of female labour in

cassava production, they modeled the gender effects through gender-disaggregated labour shares. Our study, following Mukasa and Salami (2015)'s analysis that access to labour is a driver of gender productivity gap in Nigeria, toes the path of Arndt and Tarp (2000) in the modeling of gender through labour shares. But we went further to disaggregate these gendered labour shares into whether they are provided by unpaid household labour or paid hired labour. Women are disproportionately employed as unpaid household labour in the agriculture sector in Nigeria, and female farmers also rely more on family labour than their male counterparts, who have more resources to acquire hired labour.

From the review of the literature, it is evident that unequal access to resources is a major constraint to the productivity of female farmers in Nigeria. Well-targeted measures can enhance the productivity of female farmers and close the gender gap. Gender issues are modeled in CGE models in several ways, but this focus on gendered labour shares, and the source of these labours.

3. Data

The baseline data for a CGE model is the social accounting matrix (SAM). The SAM describes the structure of the economy, as well as the interdependence of various sectors and economic agents within the economy. This study uses the Nigerian SAM developed by Nwafor, Diao and Alpuerto (2010). The SAM is based on the national accounts data and input-output data of 2006. In the absence of a new SAM or input-output data to build a new SAM, we use the cross-entropy method developed by Lemelin, Fofana and Cockburn (2013) to update the SAM to 2016

economic data. The data used for updating the SAM are obtained from the Annual Statistical Bulletin of the Central Bank of Nigeria (CBN), and include the proportion of trade, revenue, gross fixed capital formation, sectoral output in GDP.

The SAM contains 27 crop sectors and commodities, 10 livestock sectors and commodities, 1 fishery sector and commodity, 1 forestry sector and commodity, and 22 non-agriculture sectors and 23 non-agriculture commodities. Though the National Program on Food Security (NFSP) encompasses all agriculture activities, specific focus and priority is given to grain crops. According to the Living Standard Measurement Survey (LSMS) Integrated Surveys on Agriculture (LSMS-ISA) (NBS/World Bank, 2019), the most important crops in Nigeria include rice, maize, sorghum, millet, cassava, yam, beans, groundnut and oil seed. These are also the crops with active women participation. We retain 9 crop sectors and commodities and merge the remaining crop sectors and commodities as "other crops". Hence, we have a total of 10 crop sectors - rice, maize, sorghum, millet, cassava, yam, beans, groundnut, oil seed and other crops. The crop sectors are further disaggregated into male and female-managed sectors based on data from the LSMS-ISA. After all the adjustments, there are 41 sectors and 32 commodities in the final SAM.

We re-arrange the labour account in the SAM into agriculture and non-agriculture labour. Agricultural labour is used only in the agriculture sector, and comes from either family/household or hired labour. The proportion of family and hired labour used to disaggregate the SAM is also based on data from the LSMS-ISA. The family

and hired labour are further disaggregated according to gender based on data from the LSMS-ISA. After the disaggregation, we have family male labour, family female labour, hired male labour and hired female labour. Non-agriculture labour is used in the non-agriculture sectors. Using the proportion of male and female employment data in the 2011 National Bureau of Statistics' "Women and Men in Nigeria" report, the non-agriculture labour is disaggregated into male and female labour. Agricultural and non-agricultural labour are supplied by rural and urban households, and labour is mobile across agricultural and non-agricultural sectors.

The SAM has two households (rural and urban), firms, government and the rest of the world. Due to lack of reliable data, we didn't categorise households by gender. Households obtain income from production factor income, and transfer from firms and the government. From the income, households pay direct taxes, purchase goods and services, and save the remaining income. Firms earn income from capital factor. The expenditure of the firm include payment of direct taxes, transfer to households, and savings. The government module in the SAM reflects public revenue and expenditure. Government revenue comes from taxes, capital income and income from abroad. The tax incomes mainly consist of direct tax, indirect tax and import tax. The direct tax comprises of individual income tax and corporate income tax. The expenditure of the government include government consumption of commodities, transfer to household in the form of social security and government expenditure.

The rest of the world is an external agent that depicts the international trade relationship between Nigeria and other countries. This shows the importation of commodities from the rest of the world and the exportation of Nigerian commodities to other countries. The relationship between the export and import in the SAM is depicted by the current account balance. Other parts of the SAM include savings-investment, stock variations, transaction costs and the total column and rows.

3.1 Overview of the Nigerian agriculture sector based on the SAM

The structure of the Nigerian economy based on the updated SAM is briefly discussed in this section. Only three production factors – land, labour and capital - are employed in the agriculture sector, and their intensity varies according to each crop. However, it is clear from Table 1 that labour and land are the most dominant production factors in the sector. This is as a result of the small-scale nature of Nigerian agriculture and lack of commercial and mechanized farming. All the crops also use varying proportion of different types of labour. However, household labour accounts for the highest proportion of labour used in the agriculture sector. Within the household labour supply, male labour supply is proportionally higher.

Hired women labour supply is the lowest in all crop sectors (Table 1). This suggests that women largely participate in the agriculture labour market as family labourers. Very few women receive wages for services rendered in the agriculture sector. For example, only 7.3% of female labour in the rice crop sectors are hired and receive

wages, compared to 15.8%, which constitute family labour. Similarly, the supply of hired female labour in the yam crop sector is only 0.7% compared to 31.2% of female family labour supply. Of all the crop sectors, millet and groundnut have the highest proportion of female hired labour at 10.9% and 10.4% respectively. In summary, the data characterises the agriculture sector in Nigeria as labour-intensive, with majority of the labour being supplied by family relative to hired labour. Also, the proportion of women hired labour is comparatively low, suggesting most women work in the agriculture sector as family labourers without wages.

Table 1: Factor intensity in the agriculture sector (%)

Sectors	Male household labour	Female household labour	Male hired labour	Female hired labour	Capital	Land
Rice	22.75	15.81	13.50	7.27	0.91	39.76
Maize	24.16	21.42	9.77	6.25	1.08	37.33
Sorghum	25.89	13.34	12.94	7.28	0.58	39.97
Millet	25.45	11.97	15.08	10.92	0.49	36.09
Cassava	21.91	31.53	3.03	3.57	0.70	39.25
Yams	21.67	31.17	2.63	0.74	0.77	43.02
Beans	21.96	15.90	7.30	8.92	0.99	44.93
Groundnut	23.54	14.43	7.51	10.37	0.97	43.19

Oil/beniseed	24.59	19.32	9.26	6.98	2.59	37.25
Other crops	22.47	17.66	8.46	6.38	2.11	42.90

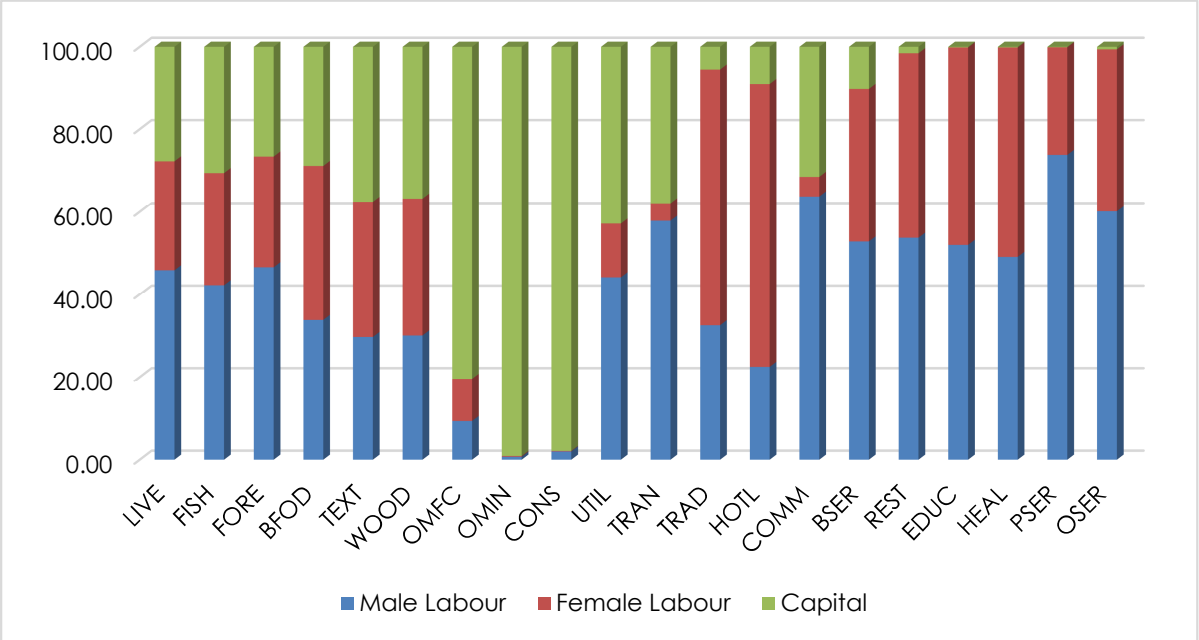
Source: Authors computation

Capital and labour are the only factors of production used in the non-agriculture sectors (Figure 3). Labour is used mostly in all the sectors except, oil, gas and mining (OMIN), construction (CONS) and other manufacturing sectors (OMFC) which are capital intensive by up to 99%, 97% and 80% respectively. The value added of the education, health, public administration, trade, hotel, real estate, other services sectors consist of labour by about 90%. Livestock, fisheries, forestry, and food and beverages also employs large proportion of labour relative to capital. In terms of the gender composition of labour, male labour accounts for a higher proportion of labour supply in the non-agriculture sector. Male labour accounts for 45.9%, 42.3%, and 46.6% of the value added in the livestock, fishery and forestry sectors compared to female labour, which accounts for 26.4%, 27.2% and 26.8% respectively.

The contribution of female labour to total value added is higher than men's in a few sectors, namely beverages and processed food, textiles, wood and furniture, other manufacturing, wholesale and retail trade, hotel and restaurants, and health. Female labour accounts for the largest component of value added in the wholesale and retail trade, and hotel and restaurant sectors at 62.0% and 68.6% respectively. In contrast, the contribution of female labour to total value added in the transport, communications, public administration, and other services sectors

are 4.3%, 4.7%, 26.1% and 39.3%, lower than that of male labour, which are 57.9%, 63.8%, 73.8% and 60.1% respectively.

Figure 3: Factor intensity in non-agriculture sector



Source: Authors computation

The NFSP identifies the crop sector as a major priority area of intervention. The share of the value added of individual crop sector to total agriculture value added is presented in Figure 4a. Cassava, yam and "other crops" have the highest share of value added, while oil seed, rice and beans have the lowest share of

agricultural value added. Nigeria accounts for about 20% of cassava production in the world, and the sector is largely dominated by female farmers who are mostly smallholders on small plots for family consumption and local sale. The gender intensity of individual crop activities is presented in Figure 4b. Only the cassava sector has higher female intensity. Women farmers account for 53% of the activities in the sector. In the other crop sectors, female intensity is lower than that of male, but the gap is small. However, the gender intensity gap is wide in the sorghum and beans sectors, with the female intensity only 32% and 34% respectively.

Figure 4a: Crop sector value added as % of total agriculture value added (%)

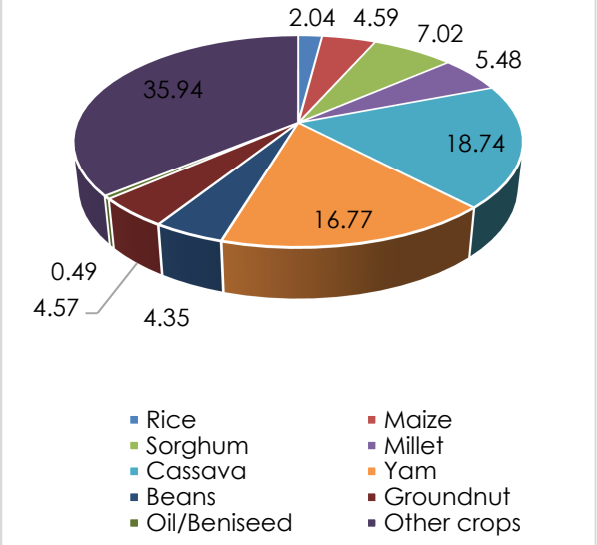
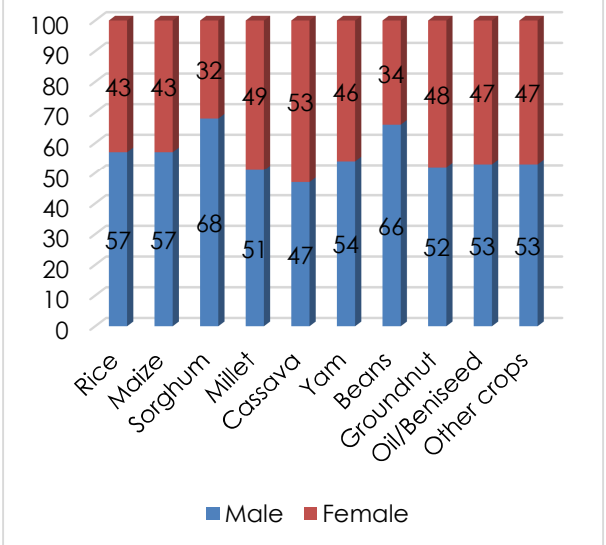


Figure 4b: Gender intensity of crop sector activities (%)



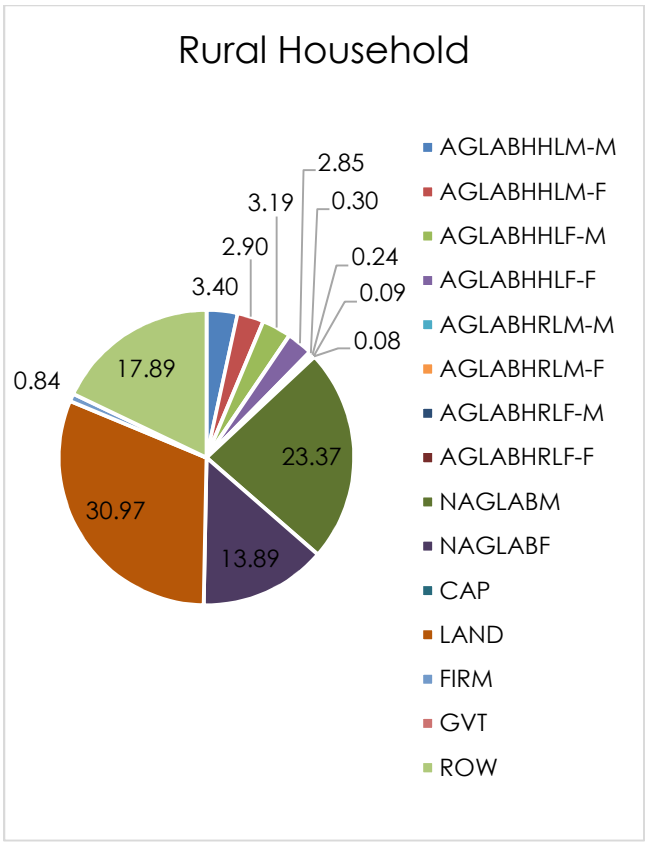
Source: Authors computation

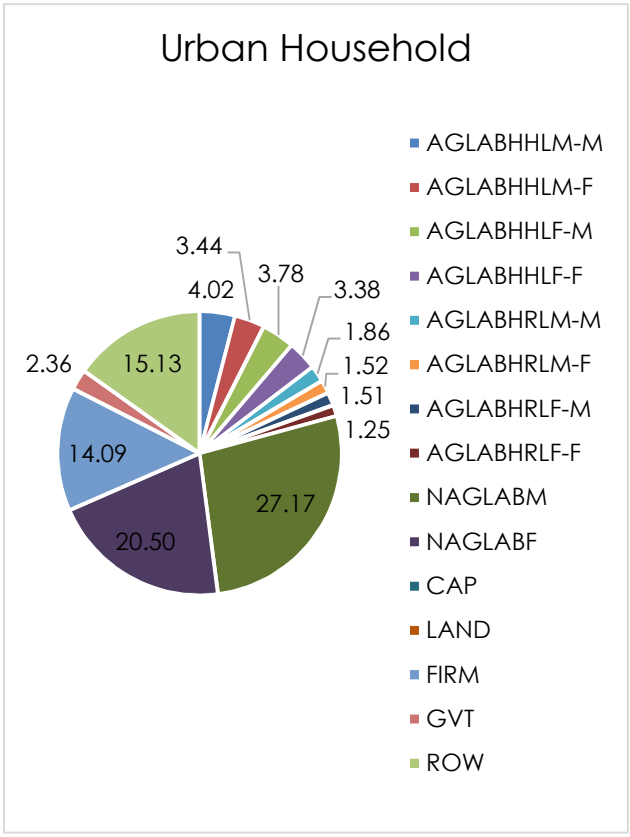
Household in the SAM is categorized into rural and urban households. The income dynamics of the households are presented in Figure 5 below. For rural household,

income from land accounts for 31.0% of total household income. Income from non-agriculture labour earned by men and women is 23.4% and 13.9% respectively. They get 17.9% of income from remittances. Expectedly, income from hired agriculture labour for women and men is only 0.2% and 0.5% respectively.

The income distribution dynamics is similar to urban households. However, urban households earn about 14.1% of their income from transfer from firms compared to only 0.8% by rural households. Also, urban households earn 2.4% of their income from government transfer while rural households earn no income from government transfer. In terms of the gender dimension, women earn less than their male counterparts in both the agriculture and non-agriculture labour income in both rural and urban households.

Figure 5: Household income source as % of total income





Source: Authors computation

4. The methodology

CGE model is used to assess the impacts of the gender productivity gap in the agriculture sector as well as policy measures to close the gap in this study. CGE models are employed to investigate the economy-wide, distributional and welfare impacts of public policies (Wing, 2004). They presume that consumers seek to maximise utility given a budget constraints while producers aim to minimise production costs. Among other applications, CGE models have been widely used to evaluate the impacts of agricultural policies (Shikur, 2020). CGE models have been used to analyse public policies on issues in Nigeria, ranging from agriculture, climate change, energy, government expenditure, to trade liberalisation (Nkang,

et al., 2013; Odior, 2014; Montaud, et al. 2017; Bosello, et al., 2018; and Omoju, et al., 2020). But these models do not capture gender. Our model differs from these CGE analysis by incorporating a gender module to capture the effect of government policies on gender equality.

For this study, an extended PEP 1-1 model (Decaluwe et al., 2013) is employed. The PEP 1-1 model is a single-country static model. In the model, output (XST) comprises of intermediate consumption (CI) and value added (VA), and both are a fixed proportion of output. The outputs of each sector are either sold locally (DS) or exported to the rest of the world (EXD). The disaggregation of output into local supply and export is governed by a constant elasticity of transformation (CET) function. Similarly, total consumption is made up of commodities produced locally (DD) and those imported (IM). It is assumed that locally produced commodities and imported commodities are imperfect substitute, and this relationship is expressed by a CES function following the Armington Hypothesis (Armington, 1969).

This study makes some adjustments to the standard PEP-1-1 model to adapt it to the research questions. First, the study separates agricultural output from non-agricultural output. The labour market is also segmented according to gender, following some works in the literature (Arndt and Tarp, 2000; and Fontana, 2015). But our study went further to disaggregate these gendered labour shares into unpaid household labour or paid hired labour. According to Oseni, et al. (2015), Nigerian women farmers are constrained by inability to acquire male hired labour, and mostly depend on family labour for production. Also, women are likely to work

as unpaid family labour in the agriculture sector, rather than as hired/paid labourers. Thus, following the pattern of employment in the agriculture labour market in Nigeria (according to the LSMS-ISA), agriculture labour in the model is segmented into family labour and hired labour. Hence, agriculture value added is made up of agriculture labour, capital and land while non-agriculture labour is made up of non-agriculture labour and capital. These relationships is expressed by a constant elasticity of substitution (CES) function.

After separating agriculture labour from non-agriculture labour, the non-agriculture labour across sectors is further disaggregated by gender. We use data from the Women and Men Report in Nigeria to disaggregate labour in all non-agriculture sectors into male and female labour. This shows the proportion of male and female labour in all non-agriculture sectors. Similarly, the agriculture labour is initially decomposed into family labour and hired labour using data from the LSMS-ISA. Thereafter, both family and hired labour are further disaggregated into male and female labour. At the end of the disaggregation, we have agriculture labour decomposed into whether it is family or hired labour, as well as the proportion of male and female labour in each category. This is implemented in the model using a CES function as shown in the following equations. The relative demand functions of each labour category are correspondingly computed.

$$AGLAB_j = B_j^{AGLAB}[\beta_j^{AGLAB} HHL_j^{-\rho_j^{AGLAB}} + (1-\beta_j^{AGLAB}) HRL_j^{-\rho_j^{AGLAB}}]^{\frac{1}{\rho_j^{AGLAB}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Equation 1 shows a CES reflecting the relationship between family labour (HHL) and hired labour (HRL).

$$AGHHL_j = B_j^{AGHHL}[\beta_j^{AGHHL} HHLM_j^{-\rho_j^{AGHHL}} + (1-\beta_j^{AGHHL}) HHLF_j^{-\rho_j^{AGHHL}}]^{\frac{1}{\rho_j^{AGHHL}}} \ldots\ldots\ldots\ldots 2$$

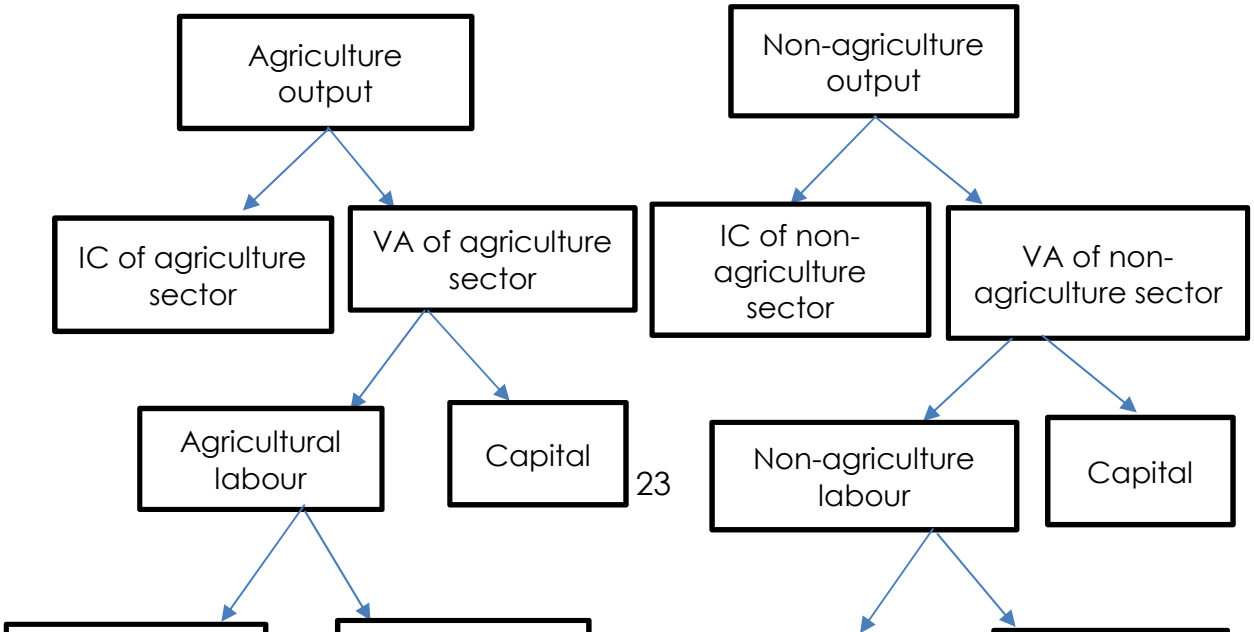
Equation 2 depicts the relationship between male (HHLM) and female family labour (HHLF)

$$AGHRL_j = B_j^{AGHHL}[\beta_j^{AGHHL} HRLM_j^{-\rho_j^{AGHHL}} + (1-\beta_j^{AGHHL}) HRLF_j^{-\rho_j^{AGHHL}}]^{\frac{1}{\rho_j^{AGHHL}}} \ldots\ldots\ldots\ldots 3$$

Lastly, equation 3 reflects the relationship between male (HRLM) and female hired labour (HRLF).

The extension of the PEP-1-1 model is depicted in Figure 6 below:

Figure 6: Schema of adjusted PEP-1-1 model



Source: Authors' compilation

There are no specific elasticity parameters for the CES functions for Nigeria. Hence, we adopt the elasticities from Decaluwé, Martens, and Savard (2001). The supply of household labour is constrained, while that of hired labour is variable subject to wages. Land and capital are sector-specific in the model. The closure rules for the model are: labour supply, current account balance, government savings, world prices and stock variation are fixed. The nominal exchange rate is the numeraire.

5. Simulations and results

The first objective of this study is to examine the economy-wide effects of the gender productivity gap in the agriculture sector. Hence, we simulate the impacts of changes in the scale parameters of male and female-managed crop sectors using data from Figure 2.

Some of the identified challenges of the agriculture sector as well as the gender productivity gap is due to lack of access to farm inputs, especially for female-managed crop sectors, inadequate public investment in the agriculture sector, and excessive importation of agriculture crop commodities. To improve agricultural productivity and close the gender gap, the NFSP seeks to increase the stock of capital in the female-managed crops via access to farm inputs (scenario A), enhance public investment in the sector (scenario B), and increase import tariff on agriculture commodities (scenario C). The increase in the capital stock will be financed by re-adjusting government expenditure. We implement the public investment in agriculture sector scenario by assuming changes in government savings will be allocated to the agriculture sector. The current administrative is poised to diversify the economy from oil, and has prioritised the development of the agriculture sector as a means of achieving this.

5.1 Impacts of productivity gap

Overall agricultural output is lower because of the gender productivity gap. According to the results, aggregate agriculture output is 6.6% lower relative to a scenario where there is no gender gap in productivity (Table 2). The outputs of beans, groundnut, maize, millet, oil/beniseed, rice, sorghum, yam, and other crops are 16.9%, 3.7%, 11.3%, 3.0, 27.2%, 12.9%, 14.1%, 6.2% and 8.9% lower compared to a no-gender productivity gap scenario. The only crop sector where the productivity of female farmers is higher than that of male farmers (cassava) has a

5.2% higher output. These results suggest that the narrower the gender productivity gap, the higher the level of aggregate agricultural output.

Table 2: Impacts of agriculture productivity gender gap (changes relative to a no-productivity gap baseline %)

Indicators	(%)
Aggregate agriculture output	**-6.6**
Beans	-16.9
Cassava	5.2
Groundnut	-3.7
Maize	-11.3
Millet	-3.0
Oil/Beniseed	-27.2
Rice	-12.9
Sorghum	-14.1
Yam	-6.2
Other crops	-8.9
Agriculture exports	
Oil/Beniseed	-29.6
Other crops	-19.9
Agricultural imports	
Rice	8.0

Maize	19.0
Millet	10.0
Bean	27.8
Groundnut	7.6
Oil/Beniseed	6.8
Other crops	28.2
Fertiliser	-9.1
Agricultural prices	
Rice	11.4
Maize	15.8
Sorghum	39.6
Millet	6.5
Cassava	-7.3
Yam	14.7
Beans	24.1
Groundnut	5.8
Oil/Beniseed	21.1
Other crops	18.4
Real GDP growth	-2.4
Consumer price index	5.6

Source: Simulation results

Similarly, the results in Table 2 show that the gender productivity gap in the agriculture sector leads to lower exports and higher imports of agricultural commodities. Exports of oil/beniseed and other crops is lower by 29.6% and 19.9% respectively. In contrast, the import of agriculture commodities increase. Imports of beans, other crops and maize increase by 27.8%, 28.2% and 19.0% respectively while that of fertilizer reduce by 9.1%. The fall in fertiliser imports is directly correlated to the fall in agricultural production. Fertiliser is used only in the agriculture sector. The reduction in agricultural exports and increase in imports is as a result of the lower agriculture output due to the gender productivity gap. Hence, import increases to compensate the fall in local production. Lower agricultural production vis-à-vis higher imports threaten food security.

Furthermore, reduction in agriculture output vis-à-vis demand leads to increase in price. From the results in Table 2, the price of major agricultural commodities (except cassava) increase, ranging from the price of groundnut which increase by 5.8% to the price of sorghum which increase by 39.6%. The increase in the price of agricultural commodities undermines food security.

The gender productivity gap leads to increase in the consumer price index (CPI) by 5.6% and reduction in real GDP by 2.4%. In other words, real GDP is lower by 2.4% and CPI is higher by 5.6% because of the gender productivity gap in the agriculture sector.

5.2 Policy Scenarios

The results of the policy scenarios[3] are presented below. It presents the economic and gender implications of the policy options.

5.2.1 Agricultural outputs and gender dimension

The three policy scenarios have varying effects on agriculture production, including the production gap between male and female-managed agriculture sectors. Increasing capital stock in female-managed agriculture sectors (Scenario A) has a mostly positive effect on the production of male and female-managed crop sectors. This intervention does not enhance the productivity of female farmers at the expense of male farmers. But the positive effects on production is much higher in female-managed sectors. For example, while production in male-managed rice sector reduces by 2.15%, that of female-managed rice sector increases by 0.64% (Table 3). For each sector, this intervention has a much larger positive effect on the output of female-managed sectors than male-managed sectors. This suggests that improving access to farm inputs and capital for female farmers have a disproportionately higher effect in boosting the production of female farmers, and is effective in closing the productivity gap.

Table 3: Impacts on agricultural production in male and female-managed crop sectors

	Scenario A		Scenario B		Scenario C	
	Male	Female	Male	Female	Male	Female

[3] Scenario A - increase the stock of capital in the female-managed agriculture sectors; Scenario B - public investment in the agriculture sector; Scenario C – increase in import tariff

Rice	-2.2	0.6	-0.8	-9.9	1.02	1.02
Maize	0.5	3.5	-0.2	-9.3	-0.06	-0.05
Sorghum	0.4	4.0	-0.7	-9.8	-0.07	-0.07
Millet	0.6	2.9	0.2	-9.0	-0.08	-0.08
Cassava	0.2	3.5	0.3	-8.9	-0.05	-0.05
Yam	0.3	4.6	0.1	-9.1	-0.05	-0.05
Beans	0.4	5.2	-0.3	-9.5	-0.07	-0.07
Groundnut	0.4	4.9	0.03	-9.1	-0.06	-0.06
Oil/beniseed	0.3	3.6	0.2	-9.0	-0.06	-0.06
Other crops	-0.5	3.9	0.1	-9.1	0.04	0.04

Source: Simulation results

On the other hand, public investment in the agriculture sector and imposition of import tariff on agriculture commodities have negative effects on agriculture outputs of male and female-managed sectors (scenarios B and C in Table 3). The second scenario has a disproportionately negative effect on female-managed sectors. The third scenario reduces agriculture output in the same proportion for male and female-managed sectors. Thus, these policy scenarios may be counter-productive for closing the gender productivity gap.

5.2.2 Agricultural labour market and gender dimension

The policy interventions in the agriculture sector have effects on the agriculture labour market, including the gender dimensions. Of the three policy scenarios, increasing capital stock in the female-managed crop sectors has the highest

positive impacts on wages in the agriculture labour market. Increasing capital supply in female-managed sectors lead to lower returns on capital in these sectors, but high returns on capital in male-managed crop sectors. Overall, average returns on capital increase, making capital relatively expensive than labour. Given the labour intensive nature of the agriculture sectors, there is increase in the demand for labour, which instigated the increase in wage rate.

In Scenario A, the wages of female hired labour increase more than that of male labour. For instance, the wages of hired male and female labours in male-managed agriculture sectors increase by 10.9% and 11.15 respectively and by 25.3% and 25.8% in female-managed sectors (Table 4). This points to a closing of the gender gap in terms of wages. Female farmers are also able to attract hired male and female labour due to increase in wages. These results suggest that capital supply targeted at female-managed sectors will lead to increase in wages for women relative to men. In Scenario B, the wages of female labour in male-managed sector (4.6%) is higher than that of male labour in the same sector (4.3%). However, wages decline in female-managed sectors, disproportionally declining more for male labour. This also suggests that this policy option has the tendency of closing the gender wage gap in the agriculture sector. In Scenario C, increasing tariff on agriculture commodities imports has overall negative effects on wages, with the decrease in wages higher for female labour.

Table 4: Impacts on wages

	Scenario A	Scenario B	Scenario C
Agriculture labour			
Hired male labour in male-managed sector	10.88	4.29	-1.28
Hired male labour in female-managed sector	25.26	-4.98	-1.26
Hired female labour in male-managed sector	11.12	4.59	-1.39
Hired female labour in female-managed sector	25.80	-4.73	-1.38

Source: Simulation results

5.2.3 Consumer prices

The impacts of the policy scenarios on consumer prices is presented in Table 5. Increasing capital stock in female-managed crop sectors and public investment in the sector lead to increase in the prices of agricultural commodities. Increased capital supply to female farmers reduces the cost of capital for female farmers. Due to the competition for capital, there is a disproportionately higher increase in the cost of capital for male farmers. The increase in the cost of capital for male farmers tends to override the decline in the cost of capital for female farmers, thereby resulting in overall increase in the aggregate cost of capital. The increase in the cost of capital coupled with the increase in wages lead to higher production costs. The higher production cost is translated into higher consumer prices. As shown in Table 5, the price increase ranges from 8.0% for rice to 13.62% for yam.

Public investment in female-managed crop sectors will also lead to high consumer prices while import tariff on agricultural crop imports will result in lower domestic prices.

Table 5: Impacts on consumer prices

Commodities	Scenario A	Scenario B	Scenario C
Rice	8.04	1.76	0.53
Maize	13.28	3.51	-1.57
Sorghum	13.14	2.44	-1.60
Millet	13.42	3.98	-1.60
Cassava	13.16	4.46	-1.64
Yam	13.62	3.79	-1.65
Beans	13.33	2.25	-1.61
Groundnut	13.18	4.35	-1.63
Oil/beniseed	13.19	3.99	-1.60
Other crops	10.98	4.05	-1.38

Source: Simulation results

5.2.4 Imports, exports and agricultural trade balance

The policy interventions have implications for agricultural trade balances, and potentially food security. As seen in Table 6, increasing capital stock in the female-managed sectors leads to significant increase in importation of agriculture and non-agriculture commodities. The increase in importation is due to the relatively higher increase in local prices compared to world import prices. As a result,

imported goods become more competitive than locally produced goods, thereby leading to surge in importation. Importation of fertiliser increases in response to the increase in agricultural production induced by this policy intervention.

Public investment in the sector and imposition of import tariffs lead to reduction in imports. Expectedly, imposing tariff on importation of agriculture commodities will result in reduction in imports, as import prices will be higher compared to domestic prices.

In contrast to importation, increasing capital stock leads to a decrease in exportation of most commodities (Figure 14). The decline in exportation is due to a relatively higher increase in domestic prices compared to international prices. As a result, exports become more expensive, leading to decrease in exports.

Table 6: Impacts on imports and exports

	Scenario A	Scenario B	Scenario C
Imports			
Rice	14.18	-1.01	-4.14
Maize	29.96	2.87	-9.69
Other crops	22.90	4.38	-3.55
Livestock	43.06	-10.02	-3.58
Fisheries	34.87	-8.93	-3.03
Forestry	38.16	-9.74	-3.24
Processed food, beverages and	34.63	-5.62	-3.12
tobacco	36.34	-7.89	-3.19
Textile and leather	39.37	-5.48	-3.25
Wood, wood products and furniture	22.25	1.21	-1.98
Other manufacturing	1.43	0.34	-0.10
Other mining	22.01	-7.37	-2.00
Transport	40.45	-8.98	-3.38
Banking and financial services	1.69	-4.09	0.02
Fertiliser			
Exports			
Oil/beniseed 1	-11.97	-1.88	1.58
Oil/beniseed 2	-9.08	-10.86	1.58
Other crops 1	-10.46	-2.22	1.38

Other crops 2	-6.51	-11.16	1.38
Fisheries	-18.29	7.20	2.00
Forestry	-18.06	7.25	1.97
Processed food, beverages and	-13.81	0.42	1.64
tobacco	-15.59	2.99	1.78
Textile and leather	-17.62	7.23	1.92
Wood, wood products and furniture	-11.53	1.78	1.23
Other manufacturing	-0.51	0.05	0.04
Other mining	-16.12	6.02	1.74
Transport	-21.04	9.06	2.37
Banking and financial services			

Simulation results

5.2.5 Food security

One of the policy goals of the government is to increase food security. The definition of food security in this study follows the FAO's criteria of availability (production), accessibility (prices), and stability. Following this criteria shows that the simulated policies will have mixed effects on food security. Increasing access to farm inputs in female-managed crop sectors leads to increase in agricultural production. Hence, food security based on the criteria of availability is promising. It can be concluded that this policy option will enhance food security.

In term of accessibility, we use the prices of agricultural commodities. Table 5 shows the domestic prices of agricultural commodities. From the results, the prices

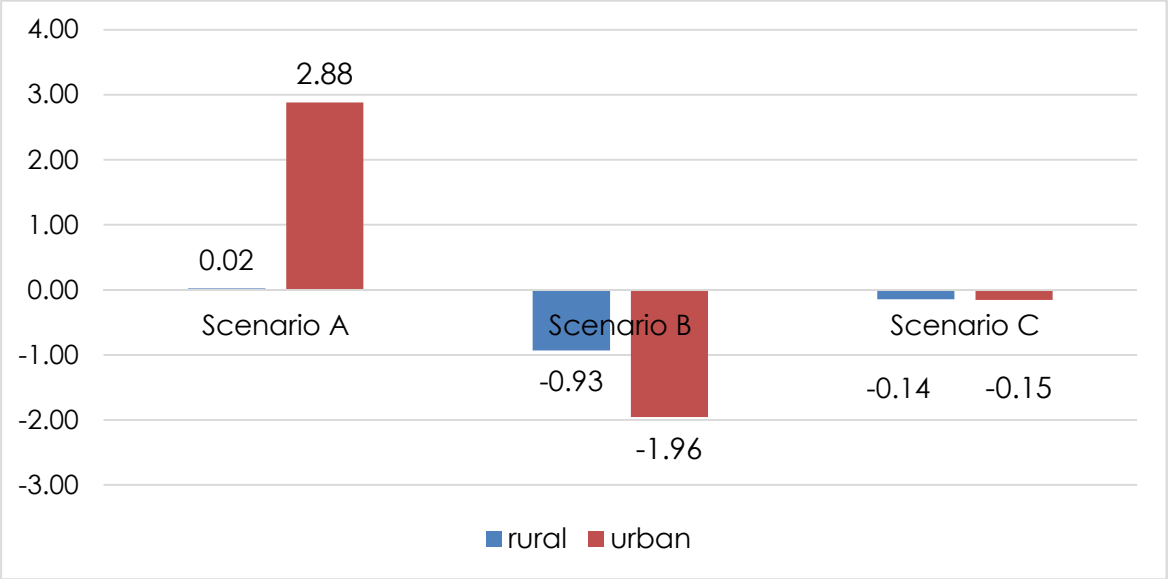
of all agricultural commodities increases by between 8.0% for rice and 13.6% for yam. Public investment in female-managed crop sectors also lead to increase in prices while tariff on imported agricultural commodities lead to lower prices. Hence, access to farm inputs and public investment in the agriculture crop sectors do not support food security when the criteria of accessibility is used.

Lastly, the changes in imports and exports vis-à-vis domestic production have implications for food security. By promoting imports and reducing exports (Table 6), increasing capital stock in the female-managed crop sectors does not support food security. This is because reliance on food importation will increase vulnerabilities to external shocks and disruptions to food supply chains. In contrast, public investment targeted at female-managed crop sectors supports food security as importation of agriculture crop commodities reduce while exportation increase.

5.2.6 Household welfare

The impacts of the policy interventions on household welfare are presented here. As seen in Figure 7, improving access to farm inputs for female-managed agricultural sectors will increase the welfare of rural and urban households by 0.02% and 2.88% respectively. The increase in welfare is due to the increase in the income of both households, which overrides the increase in prices. On the other hand, the other two policy scenarios will lead to reduction in household welfare. But the decline in welfare is more prominent when public investment is targeted in female-managed crop sectors.

Figure 7: Impacts on household welfare (real consumption budget)

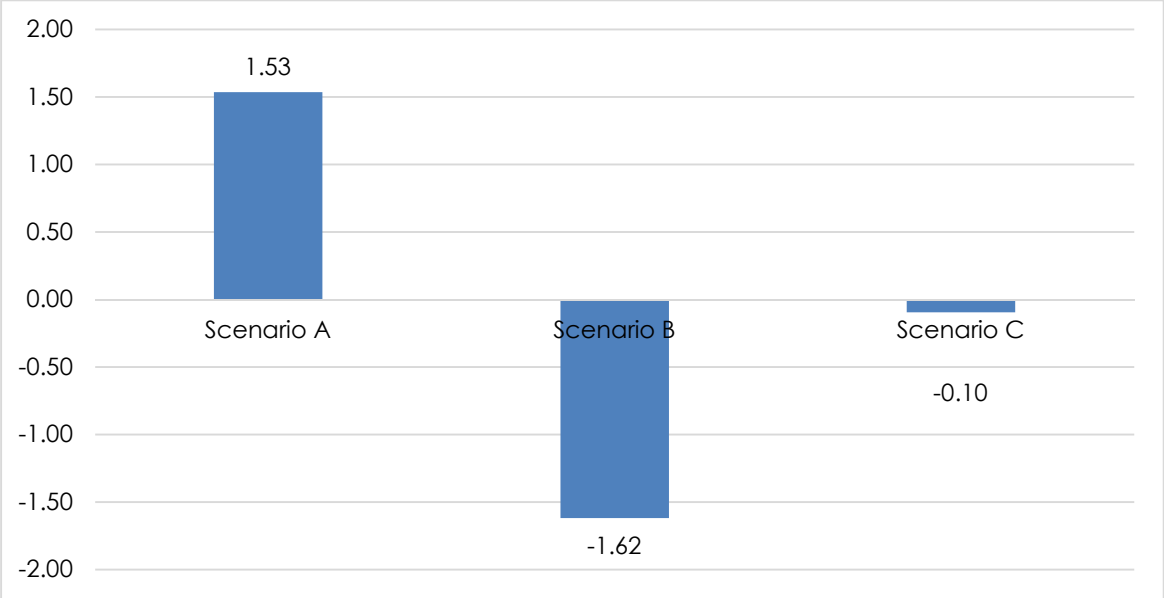


Sources: Simulation results

5.2.7 Real GDP

The agriculture sector is a major sector of the Nigerian economy. Improving access to farm inputs targeted at female-managed agriculture sectors will increase real GDP by 1.5% (Figure 8) On the other hand, public investment in the sector and tariff on imported agriculture commodities lead to fall in GDP by 1.6% and 0.1% respectively.

Figure 8: Impacts on real GDP at market price



Source: Simulation results

6. Conclusions and policy implications

The agricultural sector is a major sector of the Nigerian economy as it contributes significantly to GDP and employment. However, the contribution of the sector to the economy and the growth of the sector has declined in recent years. These have economic implications as well as efforts to achieve food security and poverty reduction. In addition to the overall decline in the sector, there is also a gender productivity gap in the sector. The productivity of female-managed crop sectors is relatively lower due to the gender-specific constraints they face, especially in the area of access to key resources and farm input.

Using an extended CGE model and updated SAM for Nigeria, this study analyses the macroeconomic impacts of the gender productivity gap and simulates the impacts of three policy options aimed at enhancing the fortunes of the agriculture sector in Nigeria, within the framework of the NFSP. We find that the gender

productivity gap undermines agricultural production potentials, as overall agriculture output is 6.6% lower trhan a baseline scenario of no gender-productivity gap. As a result, agricultural exports are lower and imports higher, and prices of agricultural commodities are higher. The combination of lower production, higher prices, dependence on imports creates food security risks. Also, real GDP is 2.4% lower and consumer price index is 5.6% higher as a result of the gender productivity gap in the agriculture sector.

In terms of policy interventions, we find that access to farm inputs for female-manaed crop sectors in terms of capital stock leads to increase in agriculture production in both male and female-managed crop sectors, with disproportionate higher increase in the output of female-managed sectors. This suggests that increasing the access of female farmers to critical farm inputs can help to close the gender productivity gap. This policy option also leads to increase in real GDP and household welfare, albeit with proportionately high welfare impacts on urban households than urban households. On the negative side, the policy option leads to increase in agricultural prices and deteriorates the agriculture trade balance (favour imports over exports). The effects of increasing access to key farm inputs for female-managed crop sectors on food security is favourable only if the criteria of food availability is used. Public investment in female-managed and reduction in import tariff, on the other hand, are not effective in boosting productivity and closing the gender gap. But they enhance agriculture exports vis-à-vis imports, while tariff reduction leads to lower consumer prices.

Based on these findings, this study recommends that while access to critical farm inputs and capital supply should be an integral parts of government's action plan in the NFSP, it may not address the challenges of high food prices and excessive food importation vis-à-vis exportations. The policy might be effective in closing the gender productivity gap, it may be insufficient to solve food insecurity from all perspectives. Hence, the government should follow the policy of providing targeted support for female farmers in terms of access to farm inputs to bridge the gender productivity gap, while complementing this with other structural and fiscal policies to achieve food security. Furthermore, closing the productivity gap between male and female farmers should take cognizance of the advantage women already have in cassava production. Providing farm resources for women to improve productivity in other agriculture sub-sectors should not undermine their advantages in cassava production.

This study is an attempt to simulate the macroeconomic impacts of the gender productivity gap in the agriculture sector in Nigeria, and also assess the impacts of the policy prescriptions of the NFSP. But much remains to be done in adopting a CGE model to properly understand gender issues in agriculture sector and rural economy in Nigeria. This will require, among other things, comprehensive data collection on intra-household decision making and resource allocation and own consumption. Further studies are required to capture the regional differences in women's role in the agriculture sector in Nigeria

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