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Distributional Effects of Higher Cassava Yields in Nigeria

An Ex Ante Analysis

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ABSTRACT

This study demonstrates a method of providing ex-ante estimates of the distributional welfare effects of yield-increasing technology. We apply this approach to estimate the impact of a 10% increase in cassava yields in Nigeria. Using data from the 2012-13 Nigeria General Household Survey, we simulate the effect of the technology on each household in the sample (micro-simulation), taking into account both the yield increase and the resulting price reduction. The results suggest that the higher cassava yield would increase average household income by 0.2 percent, generate aggregate benefits of US\$ 219 million per year, and reduce poverty by 0.2 percentage points, lifting 385 thousand people from poverty. Cassava growers who have net sales (11 percent of Nigerian households) would experience a reduction in income and an uptick in poverty due to the lower price. However, net-buying growers (10 percent) and consumers (47 percent) would benefit both in terms of income and poverty reduction. Smaller farms gain since many are net buyers who benefit from the lower price. Larger farms lose because many of them are net sellers who are adversely affected by the lower price. As most of the benefits of technology change are transferred to consumers (including many rural consumers), the cassava consumption patterns are at least as important as grower characteristics in determining the distributional impact of the technology. Applying this approach to all major crops in a country would help policy makers prioritize agricultural research across commodities to increase the poverty-reducing impact.

Keywords: Cassava, Nigeria, technological change, income distribution, poverty

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1. INTRODUCTION

1.1. Background

Cassava plays a critical role in global food security, being the third most important staple food in the tropics in terms of caloric contribution to the diet, after rice and maize (CGIAR, 2017). Furthermore, several agronomic characteristics make it valuable to food-insecure households. First, cassava grows well in poor soils and does not require chemical inputs. Second, the root can be “stored” in the ground, delaying harvest for up to three years, so it can be harvested only when needed, such as following a poor harvest of other food crops. Third, in many tropical regions, cassava is one of the cheapest source of calories (Nweke et al., 2002).

The contribution of cassava to food security is greatest in sub-Saharan Africa. Eight of the top 15 cassava producers in the world are in sub-Saharan Africa: Nigeria, Ghana, Democratic Republic of Congo, Angola, Mozambique, Malawi, Tanzania, and Cameroon. Unlike in Thailand, which exports more than 80% of its production, and Brazil, which uses more than half as feed and industrial raw materials, almost all cassava production in sub-Saharan Africa is produced on small farms and used for human consumption (FAO, 2017b).

Nigeria is the largest cassava producer in the world. According to the FAO (2017a), the country harvests more than 50 million tons of cassava in fresh root form each year. Cassava is one of the four main food crops, along with rice, maize, and yams, each of which represents 10-11% of the caloric intake of the population (FAO, 2017a). The government of Nigeria has implemented several programs to promote cassava. As part of the 2002 Presidential Initiative on Cassava, the government required bakers to use 5% cassava flour in bread.

The International Institute for Tropical Agriculture (IITA), the International Center for Tropical Agriculture (CIAT), and national agricultural research centers invest in agricultural research to raise yields and increase pest resistance. For example, the government of Nigeria spent close to \$ 400 million

on agricultural research in 2011, and 10 percent of its researchers were concentrating on cassava breeding. One important policy issue is the social return on investment in public agricultural research. Alston et al. (2000) summarize the results of hundreds of studies, finding that the median annual rate of return to agricultural research was 40%. A study of the returns to investment in agricultural research in cassava in India found a rate of return of 104% (Srinivas, 2009).

Policy makers and development agencies are not only interested in the aggregate rate of return, but also in the distribution of benefits and costs of yield-increasing technology. More specifically, they may wish to prioritize agronomic research on commodities with the largest contribution to poverty reduction.

Research on this topic is relatively sparse, due to both methodological issues and data availability. This paper demonstrates an approach to estimating the poverty impact of yield-increasing technology, which could be useful for prioritizing different commodities in the allocation of scarce funds for agricultural research.

1.2. Objectives

This study has two objectives. The first is to estimate the distributional effects of improvements in cassava productivity in Nigeria. Using nationally-representative household survey data and a micro-simulation approach, we simulate the effects of higher yields on the income of farmers and consumers, as well as the impact on different types of households defined by region, farm size, and income category to provide a higher-resolution picture of who benefits and who loses from yield improvements. We also estimate the change in the incidence of poverty for different types of households, an important consideration given the objectives of the IITA, CIAT, and the Nigerian government to reduce poverty and food insecurity.

The second objective is to demonstrate the value of using household survey data and micro-simulation methods in the analysis of the distributional effects of productivity gains. Micro-simulation methods have been widely used to study the impact of price changes on income distribution (see Deaton, 1989; Minot

and Goletti, 1998; Ivanic and Martin, 2008; Wodon and Zaman, 2008). However, this approach has rarely been used to estimate the distributional effect of yield-increasing technology. To our knowledge, this is the first study to use nationally-representative household survey data to estimate the impact of yield-increasing technology on poverty and income across different household types.

2. BACKGROUND

It has long been recognized that improved agricultural technology offers benefits to farmers, but may also reduce agricultural prices, which offset some of the gains. Cochrane (1958) proposed that farmers in the United States were caught on a “technology treadmill”, where the flow of yield-increasing technology continually lowers prices. Early adopters win in the short run, but consumers are the ultimate beneficiary. In the context of developing countries, the distributional impact of new technology was widely debated in the wake of the Green Revolution. Hayami and Herdt (1977) used producer surplus and consumer surplus to evaluate the distribution of benefits from agricultural technology in the Philippines. They estimated the impact on small and large farmers and rural and urban consumers. Other studies applied variants of this approach in Colombia (Scobie and Posada, 1978), Bangladesh (Alauddin and Tisdell, 1986), Pakistan (Renkow, 1993), and multiple Asian countries (David and Otsuka, 1994). IFPRI (2018) describes a tool for assessing the welfare impact of yield-increasing technology under different assumptions about supply and demand response, adoption, and tradability. However, these studies estimated the welfare impact on a few types of households, such as small and large farmers, rather than estimating welfare impact across a representative sample of households.

In the 1980s, household survey data in developing countries revealed unexpected heterogeneity within rural areas. For example, several studies showed that net sales of staple crops tended to be concentrated among a small proportion of farmers, while a large share (sometimes a majority) of farmers were net buyers of the staple food crops (Weber et al., 1988). The increased availability of household survey data allowed the development of micro-simulation methods, in which the welfare impact is estimated for each

household in the survey sample. This approach allows the researcher to describe the welfare impact on different types of households and to estimate the change in incidence of poverty.

To measure the short-run welfare impact of food price changes, Deaton (1989) proposed the concept of the net benefit ratio (NBR), defined for each household and a given commodity as the value of net sales as a proportion of household income or expenditure. The NBR is positive for net sellers and negative for net buyers (including farmers who produce a portion of their requirements and purchase the rest). The NBR can be considered the elasticity of household welfare with respect to changes in the price of the commodity in the short term, before the household has time to adjust to the new prices. Deaton (1989) estimated the welfare impact of a rice price change on households in Thailand, plotting the NBR by per capita expenditure.

Deaton's approach has been extended in several ways. First, information on the price elasticities of supply and demand can be used to estimate the medium-term welfare impact, taking into account the adjustment of the household to the price change (see Minot and Goletti, 1998). Second, some studies incorporate the effect of commodity price changes on wages and the second-round impact on household income (Ravallion, 1990). Third, some studies drop the assumption that the proportional change in producer prices and consumer prices be the same. In this case, the NBR must be separated into the value of crop production as a share of income and the value of crop consumption as a share of income (Minot and Goletti, 1998; Dawe and Maltsoğlu, 2014).

Different versions of Deaton's micro-simulation approach have been used widely in the analysis of the impact of price changes on income and poverty, particularly in response to the food price spikes in 2007-08 (Ivanic and Martin, 2008; Wodon and Zaman, 2008; Mghenyi et al., 2011; Vu et al., 2011).

To our knowledge, only two other studies use a micro-simulation approach in examining the ex-ante distributional effect of yield-increasing technology. Takeshima (2009) carries out an ex ante study of the impact of genetically-modified cassava in Benin. The results focus on the change in income for households in different income categories. Appel et al. (2019) combine the results of a general

equilibrium model with household survey data to estimate the impact of yield-increasing technology in Rwanda.

This study builds on previous research in two ways. First, it exploits the richness of the household survey data to examine the impact on a wide range of household types, defined by income, farm size, sex of head of household, region, and net position in cassava. Second, in addition to calculating the income effect, we estimate the impact of yield-increasing technology on the incidence of poverty overall and for each subgroup. Because of uncertainty in the estimates of some key parameters, such as supply and demand elasticities, we also analyze the sensitivity of the results to changes in these parameters.

3. DATA AND METHODS

3.1. Data

This study relies primarily on the 2012-13 Nigeria General Household Survey, the second round in a three-round panel. The survey was implemented as part of the Living Standards Measurement Study with technical support from the World Bank and financial support from the Bill and Melinda Gates Foundation. It makes use of a stratified random sample of 4,802 households in urban and rural areas of the country. The data were collected in two rounds, a post-planting survey in November 2012 and a post-planting survey in April 2013. Each round relied on three questionnaires: a household questionnaire, an agricultural questionnaire, and a community questionnaire (NBS, 2017).

In this analysis, we use the data from the household questionnaire for information on the location, sex of head of household, farm size, and per capita consumption expenditure, which we use as a measure of standard of living. In addition, the household questionnaire contains a consumption and expenditure module with data on more than 100 food items using a seven-day recall period. Among the food items were four cassava products: fresh root, cassava flour, yellow gari, and white gari. Gari is a granulated form of cassava which has been crushed, washed, and fried. It is the most common form of cassava consumption in Nigeria.

The Agricultural Questionnaire gathered information on land use, farm labor, agricultural inputs, agricultural machinery, irrigation, crop harvest and utilization, livestock ownership, and fishing activities. It was administered in two rounds, the first after the main planting season and the second after the main harvest.

3.2. Methods

This section describes the methods used to estimate household-level impact of higher cassava yields on income. The first task is estimating cassava production and consumption. The post-harvest questionnaire asks about the quantity harvested by each household since the earlier interview carried out for the post-planting round of the survey, a period of 3-5 months. In the post-harvest interview, many plots were not harvested and the reason given was that it was not the harvest period. Most of these unharvested plots were cassava. The volume of crop production for those plots that reported no harvest during the post-harvest interview was estimated using information on the area of the plot and average yields for the crop in that zone. In cases where the area of the plot was not available, we used the average production on a plot of the same crop in the same zone.

To estimate the value of household consumption of cassava products, information on the quantity and value of purchases was used to calculate the median unit values for each of the four cassava products and each zone. These prices were used to impute the value of cassava products grown and consumed by the same household and cassava products received as gifts, for which no market prices were available.

The welfare impact of yield and price changes as a proportion of household income can be approximated¹ for each household as follows:

$$\frac{dY}{Y} = \frac{P_p Q}{Y} \pi \frac{dQ}{Q} + \frac{P_p(Q + dQ)}{Y} \frac{dP_p}{P_p} + \frac{1}{2} \varepsilon_S \frac{P_p Q}{Y} \left(\frac{dP_p}{P_p} \right)^2 - \frac{P_c C}{Y} \frac{dP_c}{P_c} - \frac{1}{2} \varepsilon_{HD} \frac{P_c C}{Y} \left(\frac{dP_c}{P_c} \right)^2 \quad (1)$$

where Y is household income,

¹ This is a second-order Taylor-series approximation of the welfare impact for any supply and demand curves.

P_p is the producer price of cassava root,
 Q is the household production of cassava,
 π is the ratio of producer surplus (profit) to gross revenue,
 ϵ_S is the elasticity of supply,
 P_c is the consumer price of cassava,
 C is the quantity of cassava consumed by the household, and
 ϵ_{HD} is the Hicksian price elasticity of cassava demand.

The first term on the right side describes the effect of the yield increase on the welfare of a cassava-growing household as a proportion of income. The first ratio ($P_p Q/Y$) is the production share, that is the share of cassava production in household income, a measure of the importance of cassava production to the household.

The second term on the right side is the short-term proportional welfare loss to cassava growers from the reduction in the producer price of cassava caused by the yield increase. It is the short-term loss in the sense that it does not take into account the producer response to the lower price.

The third term is the effect of the producer response to the price decrease. The sum of the first three terms is the effect on growers of the yield increase and subsequent producer price reduction. The sum may be positive or negative, depending on whether the gains from the yield increase are greater or less than the losses associated with the lower price.

The fourth term is the short-term proportional welfare gain to cassava-consuming households resulting from the lower consumer price. It is the short-term gain in the sense that it does not take into account the consumer response to the lower price. The first ratio ($P_c C/Y$) is the consumption share, that is, the share of the value of cassava consumption in the household budget.

The last term represents the proportional welfare benefit as the consumer adjusts to the new price. The Hicksian (compensated) demand elasticity (ϵ_{HD}) is used in calculating the welfare impact in equation 1.

The second and fourth terms represent the short-term impact of the price change on producers and consumers, respectively. If the producer price and consumer price had the same proportional change, these two terms would collapse to the expression used by Deaton (1989). The net benefit ratio (NBR), proposed by Deaton as a convenient short-term elasticity of welfare with respect to price, is $PQ/Y - PC/Y$ in our notation.

In order to implement equation 1, we need to combine household survey data with some information on cassava markets. The 2012-13 Nigeria General Household Survey provides information about the value of cassava production (P_pQ) and consumption (P_cC) for each household. The survey also provides the value of consumption expenditure for each household, which we use as a proxy for income (Y).

Few studies have estimated the supply elasticity of cassava in sub-Saharan Africa. One recent study used time-series data from Nigeria to estimate a supply elasticity of 0.38 (Obayelu and Ebute, 2016). We adopt a supply elasticity for cassava root (ϵ_s) of 0.40.

Regarding the demand elasticity, Tsegai and Kormawa (2009) estimate the Marshallian elasticity of demand for gari as 0.407, which we round to 0.4. We use the Slutsky equation and their estimate of the income elasticity (1.1) to calculate a Hicksian demand elasticity of -0.35. Given the uncertainty regarding the elasticity estimates, we carry out a sensitivity analysis with alternate price elasticities of supply and demand.

To calculate producer surplus, we need an estimate of π , the producer surplus as a proportion of the gross value of production. Assuming a constant supply elasticity (ϵ_s) of 0.4, the producer surplus as a proportion of gross revenue can be calculated as $1/(1 + \epsilon_s) = 0.714$. In other words, about 71% of the value of production consists of profits (producer surplus).

We simulate the effect of a 10% increase in cassava yields on household welfare. This is a plausible magnitude of yield increase for an improved variety of cassava being grown under farm conditions. The main simulations assume that all cassava growers adopt the new technology and achieve the 10% increase

in yields. Later, we examine the sensitivity of the results to this assumption by running an alternative version in which only farmers among the top two expenditure quintiles adopt the technology.

We also assume that the supply curve “pivots” rather than shifting in a parallel manner. In other words, we assume that the productivity increase is constant in proportional terms (not in absolute terms) across different prices. This conservative assumption is recommended by Takeshima (2009).

We need information about marketing margins between cassava root and gari to estimate the derived demand for cassava root, which is used to estimate the percentage change in root and gari prices. The median farm-gate price of cassava root in the 2012-13 Nigeria General Household Survey was 24 Naira/kg, while the median consumer price of gari was 131 Naira/kg². Based on the 4:1 conversion ratio in processing cassava root to gari and a 7% post-harvest loss (Naziri et al., 2014), this implies that the fixed processing cost is 27.8 Naira/kg of gari. From this, we calculate that the Marshallian elasticity of derived demand for fresh root is -0.315.

In the case of a system with double-log supply and demand curves, the effect of a supply shift on the equilibrium producer prices can be expressed as $dP_p/P = (dQ/Q)(1/(\epsilon_S - \epsilon_{Dr}))$, where ϵ_{Dr} is the elasticity of derived demand for cassava root. Given a 10% shift in supply, a supply elasticity of cassava root of 0.4 and a derived demand elasticity of -0.315, the change in cassava root price is -14%. Given our marketing margins (part of which is fixed), the change in the price of gari is -11%.

After calculating the welfare effect of the yield increase for each household using equation 1, the next step is to aggregate the results using the sampling weights. We aggregate to groups of households defined by location (urban or rural), region, farm size, expenditure category, and net position in cassava (net sellers, net buying grower, consumers, and non-participants). For each group of households and for all Nigerian households, we can calculate the average proportional change in income, the total change in income, and changes in the incidence of poverty.

² In November 2012, the exchange rate was 159 Naira/US\$, according the Central Bank of Nigeria (2017).

4. RESULTS

The results are divided into three parts. First, we explore the importance of cassava production and cassava consumption as a proportion of income for different types of households. Next, estimates of the welfare impact of a 10% increase in cassava yields are presented, including the percentage change in income, the aggregate value of net benefits (or losses), and the change in the poverty rate. Finally, we test the sensitivity of the results to alternative supply and demand elasticities and a different assumption regarding technology adoption.

4.1. Importance of cassava production and consumption

Table 1 shows the distribution of Nigerian households and population according to their net position in cassava. Almost 3.6 million households (with 39 million people) grow cassava, of which slightly more than half are net sellers. Roughly 70 million people live in households that neither grow nor consume cassava, including urban households that prefer and can afford other staples, as well as rural households living in the northern zones where cassava does not grow well. For net sellers, cassava production represents about one-third of their income and consumption 7%. Net buyers grow less and consume more, as a proportion of income. Overall, the net benefit ratio is slightly negative in value terms, reflecting the value added in processing and distribution.

Table 1. Number of households and population by net position in cassava

Net position in cassava	Total number of households	Total population	Average production share	Average consumption share	Average net benefit ratio
	(million)	(million)	(fraction)	(fraction)	(fraction)
Grower, net seller	3.53	19.98	0.340	0.073	0.268
Grower, net buyer	3.03	19.30	0.060	0.187	-0.127
Consumer	14.56	83.02	0.000	0.051	-0.051
Non-participant	10.06	70.20	0.000	0.000	0.000
Total	31.18	192.50	0.044	0.050	-0.006

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Table 2 shows the percentage of households in each category that are cassava growers who are net sellers, cassava growers who are net buyers, consumers who do not grow cassava, and non-participants who

neither grow nor consume cassava. Overall, only 11% of households are net seller of cassava, 10% are net buyers, 47% are consumers, and 32% are non-participants.

In urban areas, most households are consumers (67%), followed by non-participants. Just 10% are cassava growers. In the rural sector, there are slightly more households that are net seller growers (16%) than net buyer growers (13%). One-third of rural households are cassava consumers and 39% do not participate in cassava markets at all.

By zone, the South East and South South have relatively large numbers of cassava growers. In the South East, over half of the households are cassava growers. In contrast, in the North East and North West, more than three-quarters of the households neither grow nor consume cassava.

Across expenditure quintiles, there is no clear pattern among net selling growers, but net buying growers become less common in the higher quintiles. The proportion of households that are non-growing consumers rises across the expenditure categories, presumably reflecting urban households, who tend to have higher incomes than rural households. In contrast, non-participants fall from 53% among the poorest quintile to 20% among the richest.

Households with a female head of household have a higher percentage of net sellers (17%), net buyer growers (13%), and consumers (57%) than households with a male head. This reflects a greater participation in cassava production and consumption in general among female-headed households.

Table 2. Distribution of households by net position in cassava and type of household

	Sector	Net position in cassava				Total
		Grower, net seller	Grower, net buyer	Consumer	Non- participant	
		(percent of households in each row)				
Sector	Urban	4	6	67	23	100
	Rural	16	13	33	39	100
Zone	North Central	11	14	44	32	100
	North East	3	2	11	84	100
	North West	2	0	23	76	100
	South East	23	35	40	2	100
	South South	25	12	62	2	100
	South West	8	4	73	15	100
Expenditure quintile	Poorest	10	13	23	53	100
	2 nd	15	14	32	40	100
	3 rd	12	12	45	32	100
	4 th	12	9	56	24	100
	Richest	9	4	67	20	100
Sex of head of household	Male	10	9	45	36	100
	Female	17	13	57	13	100
Farm size	No land	0	0	77	23	100
	Less than 0.5 ha	27	35	24	14	100
	0.5 - 1.0 ha	24	25	15	37	100
	1 - 2 ha	25	15	18	42	100
	2 - 5 ha	17	6	24	52	100
	More than 5 ha	12	7	18	63	100
	Total	11	10	47	32	100

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Households with no land are primarily non-grower consumers (77%). Among farmers with less than 1 hectare of land, roughly half grow cassava, including net buyers and net sellers. However, the proportion of farmers growing cassava declines as farm size increases. This may be linked to the labor requirements of cassava harvesting, which make the crop less interesting to larger farmers. In addition, among cassava growers, the ratio of net sellers to net buyers increases with farm size. This is not surprising, as larger cassava growers are more likely to produce more than needed for household consumption.

4.2. Distributional impact of higher cassava yields

This section describes the distributional impact of higher cassava yields and the resulting reduction in price of both cassava root and gari. The distributional impact is described in terms of the percentage change in income (Table 3), the total change in income (Table 4), and the change in the incidence of poverty (Table 5).

Table 3 shows the proportional change in income for each household type. The first column shows the

effect of the yield increase alone, with no change in price (the first term in equation 1). The second column gives the overall effect of yield and price changes (equation 1).

Overall, the improved cassava technology raises household income by 0.2%, as consumer gains outweigh losses by cassava growers. The yield increase alone increases the income of net sellers 2.4%, while net buyers, who have less cassava production, see smaller gains. Consumers and non-participants are unaffected. Overall, taking the price reduction into account, net sellers lose 1.9% of their income as the lower price more than offsets gains from the higher yields. However, net buyers and consumers gain from the lower price.

Both urban and rural growers gain from higher yields, but the rural gains are larger in percentage terms. In both locations, growers lose once the price reduction is accounted for. Cassava consumers gain from the reduction in retail price. Overall, both urban and rural households benefit, with urban households benefitting slightly more.

Looking at the regional patterns, growers in all zones benefit from an increase in yield alone, with the largest gain in the South South. Taking price reductions into account, every region experiences an increase in average income except the South South, which has many commercial cassava growers. The North West and North East are hardly affected by the new technology because they neither produce nor consume much cassava.

Among expenditure categories, growers in all categories benefit from higher yields alone. Looking at the overall effect, each quintile also gains, as the benefits to consumers and net buyers exceed the losses to net sellers in each category. The proportional increases in income are largest for households in the poorest quintile and smallest for those in the top two quintiles.

Female-headed households experience a slightly greater proportional gain compared to male-headed households (0.3% vs. 0.2%). Cassava is more important in the consumption patterns of female-headed households than male-headed households.

Households with no farm or a farm with less than 1.0 hectare gain, while larger farms lose. This is related to the fact that larger farms are more likely to be net sellers, who lose from the reduction in cassava prices.

Table 3. Proportional change in income by type of household

		Yield effect	Overall effect
		(% change in income)	
Net position in cassava	Grower, net seller	2.4	-1.9
	Grower, net buyer	0.4	1.6
	Consumer	0.0	0.6
	Non-participant	0.0	0.0
Sector	Urban	0.1	0.3
	Rural	0.5	0.2
Zone	North Central	0.1	0.3
	North East	0.0	0.0
	North West	0.0	0.1
	South East	0.4	0.9
	South South	1.2	-0.1
	South West	0.2	0.2
Expenditure quintile	Poorest	0.4	0.5
	2 nd	0.5	0.2
	3 rd	0.3	0.3
	4 th	0.3	0.1
	Richest	0.2	0.1
Sex of head of household	Male	0.3	0.2
	Female	0.5	0.3
Farm size	No land	0.0	0.4
	Less than 0.5 ha	0.5	0.6
	0.5 - 1.0 ha	0.6	0.3
	1 - 2 ha	1.0	-0.5
	2 - 5 ha	0.5	-0.2
	More than 5 ha	0.2	-0.0
	Total	0.3	0.2

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Table 4 presents the aggregate change in income by type of household, expressed in millions of US dollars per year³. Net sellers lose US\$ 157 million because the price reduction more than offsets the yield increase. Net buying growers and non-growing consumers gain US\$ 113 million and US\$ 263 million, respectively.

Most of the benefits from the yield increase alone accrue to rural households, since they produce most of the cassava. However, the higher productivity reduces the price of cassava products, transferring most of

³ The results in Naira were converted to US dollars using the exchange rate of 150 Naira/US\$, the market rate in November 2012 when the survey was carried out.

the benefits to urban households. The overall effect is that urban household gain US\$ 152 million, while rural households gain US\$ 67 million.

By zone, households in the South South see the largest benefits from higher yield alone, US\$ 151 million. The other zones also benefit, but their benefits are smaller because their cassava production is smaller. However, the South South loses almost all these benefits as a result of the price reduction. Because it is the only zone with a cassava surplus, it loses the most from the reduction in cassava prices. Overall, all zones benefit to varying degrees. The South East experiences the greatest increase in income (US\$ 81 million).

Table 4. Total change in income by type of household

		Yield effect	Overall effect
		(million US\$ per year)	
Net position in cassava	Grower, net seller	207	-157
	Grower, net buyer	27	113
	Consumer	0	263
	Non-participant	0	0
Sector	Urban	29	152
	Rural	206	67
Zone	North Central	13	46
	North East	3	4
	North West	1	15
	South East	29	81
	South South	151	3
	South West	38	71
Expenditure quintile	Poorest	27	37
	2 nd	53	29
	3 rd	44	57
	4 th	68	35
	Richest	43	61
Sex of head of household	Male	201	172
	Female	34	47
Farm size	No land	0	203
	Less than 0.5 ha	43	57
	0.5 - 1.0 ha	35	20
	1 - 2 ha	86	-44
	2 - 5 ha	54	-18
	More than 5 ha	17	1
Total		235	219

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Across expenditure categories, there are no clear patterns. Households in each quintile gain between US\$ 27 million and US\$ 68 million as a result of yield increases, while the overall benefits range from US\$ 29 million to US\$ 61 million.

The aggregate benefits of the yield increase are greater for male-headed households mainly because they are more numerous than female-headed households.

As a result of higher yields alone, each farm size category gains, with farmers owning 1-2 hectares gaining the most. As for the overall benefits, they are largest for non-farm households, positive for farms with less than 1.0 hectare, but null or negative for larger farms. Larger farmers lose more from the reduced price of cassava than they gain from higher yields.

Looking at the national totals, the gains associated with a 10% increase in cassava yields alone are worth US\$ 235 million per year. Even after taking into account the effect of the lower cassava price, the aggregate net benefits are US\$ 219 million per year.

Table 5 shows the effects of a 10% increase in cassava yields on the incidence of poverty in each household category. The first column shows the original poverty rate, the second the poverty rate after the effect of higher yields, the third the poverty rate taking into account the higher yield and lower prices, and the final column shows the percentage point change in poverty between the first and third columns.

The original poverty rate is 22% among cassava growers who are net sellers and almost 30% among net buying growers. Consumers (many of whom are urban households) have the lowest rate at 12%. Non-participants (many of whom live in the north) have a 36% poverty rate. With the new technology, the poverty rate of net sellers rises 1.0 percentage point, from 22.1% to 23.1%. These households lose from the lower price of cassava. On the other hand, the poverty rate falls 1.0 percentage point for net buyers and 0.5 percentage points for consumers. Non-participants are unaffected by the changes in the cassava market.

Among the urban and rural sectors, urban households have a much lower original poverty rate (7.9%) compared to rural households (32.9%). Overall, the urban poverty rate falls 0.4 percentage points, while the rural rate falls 0.1 percentage points.

The North West has the highest poverty rate (51.5%), while the South West has the lowest rate (5.2%).

After the cassava yield increase and associated reduction in price, four of the six zones experience a decrease in the incidence of poverty. The North East is virtually unaffected by the changes in the cassava market because it neither produces nor consumes much cassava. The South South experiences a 0.6 percentage point increase in the poverty rate because the large number of net sellers in this zone lose from the lower cassava prices.

Female-headed households tend to have a lower incidence of poverty (14.1%) compared to male-headed households (24.4%). This is because many female-headed households are found in urban areas, where the poverty rate is lower. We find that improved cassava technology slightly reduces the poverty rate among male-headed households and slightly increases the rate among female-headed households. Although this disadvantages female-headed households, it actually reduces the disparity between the two groups.

Table 5. Effect on poverty rate by type of household

		Original poverty rate (percent) (1)	Poverty rate after yield increase (percent)	Poverty rate after yield increase and price decrease (percent) (2)	Change in poverty rate (percentage point change) (2)-(1)
Net position	Grower, net seller	22.1	20.5	23.1	1.0
In cassava	Grower, net buyer	29.6	29.6	28.6	-1.0
	Consumer	12.1	12.1	11.6	-0.5
	Non-participant	36.1	36.1	36.1	0.0
Sector	Urban	7.9	7.9	7.5	-0.4
	Rural	32.9	32.6	32.8	-0.1
Zone	North Central	17.0	17.0	16.7	-0.3
	North East	26.9	26.8	26.9	0.0
	North West	51.5	51.5	51.4	-0.1
	South East	27.9	27.7	27.3	-0.7
	South South	14.8	14.2	15.4	0.6
	South West	5.2	5.0	4.6	-0.6
Sex of head of household	Male	24.4	24.2	24.1	-0.3
	Female	14.1	13.8	14.4	0.3
Farm size	No land	9.6	9.6	9.2	-0.4
	Less than 0.5 ha	24.6	24.6	23.8	-0.7
	0.5 - 1.0 ha	35.5	35.3	35.5	-0.0
	1 - 2 ha	39.5	38.9	40.1	0.6
	2 - 5 ha	38.3	37.9	38.3	0.0
	More than 5 ha	34.6	34.1	34.6	0.0
Total		22.7	22.5	22.5	-0.2

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Somewhat surprisingly, households with farms below 0.5 hectares are less poor (24.6%) than those with larger farms (34.6-39.5%). Larger farms tend to be located in areas with lower

agricultural potential (such as semi-arid areas), and households with non-farm income may be disproportionately found among those with less than 0.5 hectares. In general, households with no land or small farms experience a reduction in poverty because many are net buyers who benefit from the lower price. Larger farms experience either no change or an increase in poverty because many are net sellers who lose from the lower price.

4.3. Sensitivity analysis

In this section, we test the sensitivity of the results to two types of changes in assumptions. First, the analysis is repeated with alternative price elasticities of supply and demand. Second, we explore the results of assuming that technology adoption is limited to high-income cassava growers rather than being universal. In both cases, we focus on the overall effects taking into account both the yield increase and the reduction in cassava prices.

Sensitivity to different elasticities of supply and demand

The elasticity of supply for cassava root was originally set at 0.4 and the Marshallian price elasticity of demand for gari at -0.40. In this section, we tested elasticities of supply for cassava root of 0.2, 0.4, and 0.6, as well as price elasticities of demand for gari of -0.2, -0.4, and -0.6.

Table 6 shows the change in the poverty rate for households grouped by net position in cassava and for the nine elasticity scenarios. Among cassava growers that are net sellers, the poverty rate rises in all scenarios, but the effect is strongest when supply and demand are most inelastic. In contrast, poverty declines among growers who are net buyers and among consumers in all scenarios, but the reduction is greatest when supply and demand are inelastic. The more inelastic supply and demand are, the larger the price reduction and the more the benefits of the yield increase are transferred from net sellers to net buyers and consumers. Although not shown in Table 6, if demand were perfectly elastic, the price would

not change and we would get the yield-only scenario where all benefits accrue to cassava growers and none to consumers.

Table 6. Sensitivity of the change in poverty rate to supply and demand elasticity assumptions

Supply elasticity of root	Demand elasticity of gari	Net position in cassava				Total
		Grower, net seller	Grower, net buyer	Consumer	Non-participant	
(percentage point change in poverty rate)						
0.2	-0.2	3.4	-1.9	-0.8	0.0	-0.2
0.2	-0.4	1.6	-1.3	-0.5	0.0	-0.2
0.2	-0.6	1.0	-1.0	-0.5	0.0	-0.2
0.4	-0.2	1.6	-1.0	-0.5	0.0	-0.2
0.4	-0.4	1.0	-1.0	-0.5	0.0	-0.2
0.4	-0.6	0.5	-1.0	-0.5	0.0	-0.3
0.6	-0.2	1.0	-1.0	-0.5	0.0	-0.2
0.6	-0.4	0.5	-1.0	-0.5	0.0	-0.3
0.6	-0.6	0.5	-1.0	-0.4	0.0	-0.2

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Table 7 shows the sensitivity of the total change in long-term income to different elasticities. In general, the more inelastic supply and demand scenarios lead to larger transfers of benefits from net sellers to net buyers and consumers. For net sellers, there is a decrease in income across all elasticity scenarios from US\$ 486 million per year for the most inelastic scenario to US\$ 61 million per year in the most elastic scenario. For both net buyers and consumers, the largest increase in income occurs with the most inelastic supply and demand scenario. The overall impact of the higher cassava yields is positive in every scenario, ranging from US\$ 191 million to US\$ 257 million.

Table 7. Sensitivity of the total change in long-term income

Supply elasticity of root	Demand elasticity of gari	Net position in cassava				Total
		Grower, net seller	Grower, net buyer	Consumer	Non-participant	
(million US\$ per year)						
0.2	-0.2	-486	203	523	0	240
0.2	-0.4	-267	152	367	0	252
0.2	-0.6	-150	124	283	0	257
0.4	-0.2	-256	137	334	0	214
0.4	-0.4	-157	113	263	0	219
0.4	-0.6	-92	98	216	0	222
0.6	-0.2	-158	104	245	0	191
0.6	-0.4	-102	91	204	0	194
0.6	-0.6	-61	81	175	0	195

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

Sensitivity to limited adoption of technology

In the original simulations, we assumed that all cassava farmers achieve a 10% increase in yields. In practice, adoption of technology is often limited, particularly in the first years after it is introduced. Higher-income farmers may be better able to afford the new technology and/or better able to tolerate the risk associated with it.

To study the sensitivity of the results to limited adoption of technology, we test a worst-case scenario for poverty reduction in which the technology is only adopted by cassava farmers in the top two expenditure quintiles. To focus on the distributional effect, we scale up the yield increase among these farmers to 21.3% to keep the aggregate increase in cassava production equal to the base simulation.

Table 8 gives the change in the poverty rate depending on the household's net position in cassava. The increase in poverty among net sellers is greater when adoption is limited (2.0 percentage points) than when adoption is universal (1.0 percentage points). This is because, with limited adoption, lower-income cassava farmers do not adopt or benefit from the new technology. Among net buyers, the poverty reduction is somewhat smaller under limited adoption compared to universal adoption. For consumers and non-participants, there is little to no difference in poverty rate when comparing a universal adoption and limited adoption. Overall, poverty declines 0.2 percentage points with universal adoption but just 0.1 percentage points with limited adoption. It is worth noting that if cassava were tradable and the price determined by world markets, the limited adoption scenario would generate no poverty reduction since our assumption is that only non-poor farmers benefit from the yield increase.

Table 8. Sensitivity of the impact on poverty to limited adoption of technology

	Baseline: Universal adoption (% point change in poverty)	Alternative: Limited adoption	Baseline: Universal adoption (million US\$)	Alternative: Limited adoption
Grower, net seller	1.0	2.0	-157	-147
Grower, net buyer	-1.0	-0.8	113	104
Consumer	-0.5	-0.5	263	263
Non-participant	0.0	0.0	0	0
Total	-0.2	-0.1	219	219

Source: Analysis of 2012-13 Nigeria General Household Survey - Wave 2

The last two columns of Table 8 show the aggregate income effect, comparing universal and limited adoption of the technology. Net sellers lose under both universal and limited adoption as a result of the lower cassava prices, but they lose less with limited adoption. Since net selling households tend to have larger farms and higher income, many of them benefit from the larger yield increase under limited adoption. In contrast, net buyers gain from the technology, but gain less when the adoption is limited. Many of these growers are less well-off, so they do not adopt the technology and do not gain from the yield increase in the limited adoption scenario. Consumers are unaffected by the adoption assumption because they are only affected by the price reduction, which declines by the same amount under the two assumptions. Non-participants are unaffected by the technology gains, whether adoption is limited or universal.

5. CONCLUSIONS

This study examines the distributional welfare effect of a 10% increase in cassava yields in Nigeria. We adopt a micro-simulation approach, using the data from the 2012-13 Nigeria General Household Survey, estimates of elasticities and marketing margins, and a second-order approximation of the household-level welfare impact.

In general, the results of this study confirm that the benefits of technology that increases the yield of widely-grown staple crops in sub-Saharan Africa will generate large aggregate benefits and tend to be pro-poor. In the case of cassava in Nigeria, we estimate that a widely-adopted technology that increases

cassava yields by just 10% would generate aggregate benefits of US\$ 219 million, as well as lifting 385 thousand people from poverty.

The results are also a reminder that farmers may not be the main beneficiaries of yield-increasing technology. Public investment in national and international agricultural research centers is often seen as helping raise farmer income and reduce rural poverty, but in the case of non-traded commodities, consumers are likely to be important beneficiaries. This is because increasing the yield of a non-tradable crop will result in lower prices, particularly if consumer demand is inelastic. The net effect of higher yields and lower prices on a farm household depends on various factors including the size of the yield increase, the elasticities of supply and demand, and the net position of the household. Growers who are net buyers gain from both the yield increase and the price reduction, but for net sellers the gains from the higher yield are offset by lower prices so the net effect is ambiguous.

The best-case scenario for net sellers is when the technological improvement occurs in a crop with highly elastic demand. At the extreme, the price of an export crop or an import substitute is largely determined by international prices and the exchange rate. In this situation, yield increases will change the traded volume but have little effect on the domestic price. As a result, all the benefits of technological change accrue to producers and none to consumers.

However, even if the crop is non-tradable and the benefits flow to consumers, this does not necessarily mean that all benefits are transferred from rural to urban households. Our findings show that a large number of rural households are net buyers of cassava. In fact, the number of rural households who benefit from lower cassava prices is more than double the number who benefit from higher prices.

Furthermore, the fact that the benefits of improved agricultural technology accrue largely to consumers does not imply that the technology has an adverse effect on the poor. In the case of cassava, the poverty reduction after the price reduction is almost as large as the poverty reduction due to the yield increase alone. This is because cassava is a staple food crop, so it is more important in the budget of poor consumers than higher-income consumers.

In the case of cassava in Nigeria, most of the benefits of improvements in agricultural technology are related to the reduction in price, which has two important implications. First, it means that the consumption pattern of the crop is at least as important as the grower characteristics and adoption patterns in determining the distributional effect. Traditionally, agricultural research is considered pro-poor if low-income farmers represent a large share of the farmers who are likely to adopt it. In the case of non-tradable crops, such as cassava in Nigeria, it is also important to consider the profile of consumers.

The second implication is that it becomes somewhat more complicated to assess the poverty impact of yield gains. It is not sufficient to examine the composition of farmers who adopt the technology and would directly benefit from the yield increases. It is also necessary to estimate the effect of higher yields on prices, which requires supply and demand elasticities. Furthermore, one needs to study the impact of lower prices on both farmers (including net sellers and net buyers) and consumers.

The methodological contribution of this paper is to demonstrate a relatively straight-forward approach to estimating the income and poverty impact of yield-increasing technology, along with resulting reduction in prices, using household survey data and estimates of several key parameters. The household survey must include both consumption and agricultural modules to estimate the importance of the crop in consumption expenditure and as a source of income. However, such survey data sets are becoming more widely available, partly as a result of the Living Standards Measurement Study project.

Such an analysis could easily be applied to a range of major crops in a country, allowing a cross-crop comparison of the aggregate income effects and the poverty impact of a given proportional increase in yield for each crop. This information would help policy makers prioritize agricultural research in different commodities to increase the poverty-reducing impact.

One limitation of this approach is that it is based on a single-crop partial-equilibrium analysis. As such, it assumes that the improved technology and the increase in production have no effect on factor prices, such as wage rates and land rental rates. In the case of cassava in Nigeria, these assumptions seem plausible.

The increase in cassava yields would only affect wages to the extent that the labor requirements of

cassava differ markedly from competing crops. Furthermore, changes in wage rates would only affect income distribution to the extent that net sales of agricultural labor are a significant share of household income. While the purchase and sale of agricultural labor is relatively common in Nigeria, it typically accounts for a small share of income. The partial-equilibrium analysis also assumes that the technology has no effect on macroeconomic variables such as the exchange rate. Because cassava trade is negligible in Nigeria, it is unlikely that the expansion of cassava production would have a noticeable effect on exchange rates. In cases where these assumptions are not realistic, a general equilibrium approach would be needed, with greater requirements in terms of data, parameters, and technical skills.

REFERENCES

- Alauddin, Mohammad and Clem Tisdell. (1986). Market analysis, technical change and income distribution: The case of Bangladesh. *Agricultural Economics*, 1(1), 1-18.
- Apell, Derek, David Laborde, Abdullah Mamun, and Will Martin. (2019). Prioritizing agriculture-related research and innovation for growth and poverty reduction in Rwanda. International Food Policy Research Institute. Washington, DC.
- Central Bank of Nigeria. (2017). Monthly average exchange rates of the Naira. Retrieved from <https://www.cbn.gov.ng/rates/exrate.asp?year=2012>.
- CGIAR. (2017). Cassava Fact Sheet. Retrieved from <http://www.cgiar.org/our-strategy/crop-factsheets/cassava/>
- Cochrane, Willard W. (1958). *Farm Prices. Myth and Reality*. Minneapolis: University of Minnesota Press.
- David, Cristina C. and Keijiro Otsuka, eds., (1994). *Modern Rice Technology and Income Distribution in Asia*. Boulder, CO: Lynne Rienner.
- Dawe, D., and I. Maltoglou. (2014). Marketing margins and the welfare analysis of food price shocks. *Food Policy*, 46, 50-55.
- Deaton, A. (1989). Rice prices and income distribution in Thailand: A non-parametric analysis. *Economic Journal*, 99 (Supplement), 1-37.
- FAO (Food and Agriculture Organization). (2017a). Food balance sheets database. Retrieved from <http://www.fao.org/faostat/en/#data/FBS>
- FAO (Food and Agriculture Organization). (2017b). Nigeria at a glance. Retrieved from <http://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/>
- Hayami, Yujiro, and Herdt, Robert W. (1977). Market Price Effects of Technological Change on Income Distribution in Semi Subsistence Agriculture. *American Journal of Agricultural Economics*, 59 (2) (May), 245-56.
- IFPRI (International Food Policy Research Institute). (2018). DREAMpy: Evaluation and priority setting of agricultural research and development projects. Retrieved from <https://www.ifpri.org/publication/dreampy-evaluation-and-priority-setting-agricultural-research-and-development-projects>

- Ivanic, M. and W. Martin. (2008). Implications of higher global food prices for poverty in low income countries. *Agricultural Economics*, 39 (November), 405-16.
- Mghenyi, E., R. Myers, and T.S. Jayne. (2011). The effects of a large discrete maize price increase on the distribution of household welfare and poverty in rural Kenya. *Agricultural Economics*, 42, 343–356.
- Minot, N. and F. Goletti. (1998). Export liberalization and household welfare: The case of rice in Viet Nam. *American Journal of Agricultural Economics*, 80 (November), 738-749.
- Naziri, D., W. Quave, B. Siwoku, S. Wanlapatit, Tu Viet Phu, and B. Bennet. (2014). The diversity of postharvest losses in cassava value chains in selected developing countries. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 115 (2), 111–123.
- NBS (National Bureau of Statistics). 2016. Basic Information Document - Nigeria General Household Survey - Panel. NBS, Government of Nigeria. Retrieved from http://siteresources.worldbank.org/INTLSMS/Resources/3358986-1233781970982/5800988-1282216357396/7337519-1309178625309/Nigeria2010_11_GHSPanel_BINFO_Feb2016.pdf
- Nweke, F.I., D.S.C. Spencer, and J. Lynam. (2002). *The Cassava Transformation: Africa's Best Kept Secret*. East Lansing: Michigan State University Press.
- Obayelu, O. A. and S. Ebute. (2016). Assessment of cassava supply response in Nigeria using the vector error correction model (VECM). *Agricultura*, 13 (1-2), 79-86.
- Ravallion, Martin. (1990). Rural welfare effects of food price changes under induced wage responses: Theory and evidence for Bangladesh. *Oxford Economic Papers*, 42 (3) (July), 574-85.
- Renkow, Mitch. (1993). Differential technology adoption and income distribution in Pakistan: Implications for research resource allocation. *American Journal of Agricultural Economics*, 75 (1), 33–43.
- Scobie, Grant and Rafael Posada T. (1978). The impact of technical change on income distribution: The case of rice in Colombia. *American Journal of Agricultural Economics*, 60 (1), 85–92.
- Srinivas, T. (2009). Impact of research investment on cassava production technologies in India. *Australian Journal of Agricultural and Resource Economics*, 53, 367–383.
- Takeshima, H. (2009). Sensitivity of welfare effects estimated by equilibrium displacement model: A biological productivity growth for semisubsistence crops in Sub-Sahara African market with high transaction costs. Discussion Paper 936. International Food Policy Research Institute, Washington, DC.

- Tsegai, D. and P. Kormawa. (2009). The determinants of urban households' demand for cassava and cassava products in Kaduna, Northern Nigeria: An application of the AIDS model. *European Journal of Development Research*, 21, 435. doi:10.1057/ejdr.2009.15
- Vu, Linh and P. Glewwe. (2011). Impacts of rising food prices on poverty and welfare in Vietnam. *Journal of Agricultural and Resource Economics*, 36 (1) (April), 14-27.
- Weber, M. T., J. M. Staatz, J. S. Holtzman, E. W. Crawford, and R.H. Bernstein. (1988). Informing food security decisions in Africa: Empirical analysis and policy dialogue. *American Journal of Agricultural Economics*, 70 (5), 1044–1052.
- Wodon, Q. and H. Zaman. (2008). Rising food prices in Sub-Saharan Africa: Poverty impact and policy responses. Policy Research Working Paper 4738. World Bank. Washington, DC.

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