Cost-Benefit Analysis of USAID/Nigeria's MARKETS II Program

FINAL

Prepared for:
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Preface

USAID/Nigeria approached E3 in 2014 to ask for assistance with a cost-benefit analysis (CBA) of their Feed the Future program. The field work took place in May of 2014 and the analysis was completed between June and November with significant involvement from USAID/Nigeria and the staff with the Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites (MARKETS II).

The CBA field team comprised Jerrod Mason, Kristen Schubert, James Lykos, William Hall, and Emmanuel Odiedi as well as with support from the MARKETS II staff. The data quality control and report finalization was additionally supported by Rachel Bahn, a consultant with E3, Greg Gangelhoff, an economist with E3, and Crystal Bird Ogbadu, Contracting & Agreement Officer in Nigeria. Finally, intern Adam Godbey helped to finalize the report.

The team met with stakeholders in Abuja before traveling to the Benue, Enugu, and Ebonyi States. Throughout this time, the team collected data and held discussions with the following stakeholders:

- Nigeria Expanded Trade and Transport Program (NEXXT) Program Managers – to understand the constraints with internal and external transit of goods;
- MARKETS II Program Managers – several meetings and a field visit to understand the potential impact of the program on the farmers and the value chain as a whole;
- United Nations Industrial Development Organization (UNIDO) – discussion on the value chain potential in Nigeria, for each value chain;
- International Food Policy Research Institute (IFPRI) – to gain access to farm budgets information, the policy environment, and a better understanding of the fertilizer voucher program (GES);
- MIKAP Factory (Rice Processor) – to understand how rice processors network with farmers;
- Hule & Sons (Soy Processor) – to understand how soy processors network with farmers;
- Onojon FMCS (Rice Cooperative) – for data on rice farm budgets and the impact of MARKETS II;
- Ikwo Divine Favor FMCS (Rice Cooperative) – to gather data on rice farm budgets and the impact of MARKETS II;
- International Fertilizer Development Center (IFDC) – to learn more about the fertilizer subsidy and domestic market production potential; and,
- International Institute of Tropical Agriculture (IITA) – to gather information on cassava, maize, and soy research of improved seeds/stems.

The main report consists of (a) the executive summary with an overview of the project and the results, (b) the financial analysis methodology and results for each value chain, (c) the economic analysis methodology and results for each value chain, (d) the weaknesses of the models, (e) the results of the sensitivity analysis with results also described for each value chain, and (f) what additional analysis that could be of interest to the Mission. The last chapter has a list of references. Within these chapters, the results of the analysis for aquaculture, cassava, cocoa, maize, rice (both lowland rainfed and irrigated production systems), sorghum, and soybean are discussed.

The CBA team gratefully acknowledges the assistance provided by different organizations and individuals for completion of this report and especially the generous amount of time the MARKETS II team spent on data collection and validation, as well as responding numerous requests for clarification. The USAID/Nigeria Mission also spent countless hours reviewing the models and the report and provided extremely helpful comments throughout the whole process. This was a collective effort by the E3 Bureau and the USAID mission in Abuja.

Contents

List of Acronyms

ATAP	Agricultural Transformation Action Plan
ATP	Agricultural Transformation Program
BtM2	Bridge to MARKETS 2
CBA	Cost-Benefit Analysis
CF	Conversion Factor
E3	Bureau of Economic Growth, Education, and Environment
FCR	Feed-conversion ratio
FTF	Feed the Future
ha	hectares
Kg	kilograms
MARKETS	Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites
IFPRI	International Food Policy Research Institute
IRR	Internal Rate of Return
MT	Metric Ton
₦	Nigerian Currency Unit (Naira)
NGN	Nigerian Currency Unit (Naira)
NPK	Fertilizer with the chemical elements of nitrogen (N), phosphorus (P), and potassium (K)
NPV	Net Present Value
USAID	United States Agency for International Development
UDP	Urea Deep Placement
WTP	Willingness to Pay

Executive Summary

Project Description

The Maximizing Agricultural Revenue and Key Enterprise in Targeted Sites (MARKETS II)[1] is USAID/Nigeria's flagship project under their Feed the Future (FTF) Agricultural Transformation Program (ATP) and is a successor to the previous seven years of the MARKETS and the Bridge to MARKETS 2 (BtM2) projects. For the five years following its creation in April 2012, MARKETS II aims to sustainably improve the performance, incomes, nutrition, and food security of Nigerian poor rural farmers or smallholders in an environmentally appropriate manner through proven private sector demand-driven market interventions, focusing specifically on constraints in the agricultural value chain. Key objectives aim to help smallholder farmers access better inputs (such as improved seeds and optimal use of fertilizer), adequate finance, better water management, appropriate technology, extension services, and improved nutritional uses of grown or purchased basic foods.

MARKETS II plans to invest $60.5 million in activities focused primarily on the large population of smallholder farmers with between 1 to 5 hectares of land under cultivation. MARKETS II also works along the value chain through producer and processing associations, credit organizations, agribusinesses (suppliers, contractors, transporters and especially agro-processors) and state and federal public institutions to identify and alleviate constraints to well-functioning markets. Given the importance of including women and youth in the rural economy, MARKETS II identifies and supports agricultural opportunities along the value chain and incorporates farming services and micro- and small scale processing activities in its assistance approach. The MARKETS II team aims to work with 696,855 smallholder farms engaging in aquaculture, cassava, cocoa, maize, lowland rice and irrigated rice, sorghum, and soybean production. MARKETS II discontinued work with sesame farmers after the first year, so this commodity was not included in this cost-benefit analysis (CBA). MARKETS II activities are currently in 15 states and the Federal Capital Territory (FCT) in Nigeria; the CBA was done at a national level, but could be broken into a regional analysis if regional data are available.

In the Financial Analysis, the CBA focused on the impact on smallholder farmers as the primary beneficiaries of the program, although the analyst team recognizes that MARKETS II activities have broader impacts for agricultural business services and other actors involved in the value chain, and for specific populations (e.g., women and youth) for many of their commodities. Starting from the farmer perspective, the Economic Analysis determines the overall impact of the project on Nigeria's economy, after accounting for all social costs and benefits. All relevant assumptions were then tested using a Sensitivity Analysis & Risk Variables.

[1] Contract Number: AID-620-C-12-00001

Results

All value chains have positive financial net present values (NPVs) at the farm level (see table below) for each cohort of farmers during each year of project implementation, each evaluated over a 10-year period of time.[2] This implies that farm households in each value chain are experiencing increased incomes as a result of the project. Aquaculture farmers appear to benefit the most, and quite significantly, from the MARKETS II intervention. Irrigated rice farmers and cocoa farmers also benefit quite significantly from the improved techniques and inputs introduced to them by the MARKETS II team.

Aquaculture, cocoa, maize, rice, and sorghum farmers will have steadily increasing cash flows over time in the absence of pest, climatic events, or other shocks. This strongly suggests that once farmers adopt, their new cultivation practices should be sustainable over time. On the other hand, soy farmers may have years with low cash flows initially, but farmers should still have higher cash flows than they would in the absence of the project. Additionally, cassava farmers adopting MARKETS II practices will experience a 677% increase in their costs for physical inputs; these large start-up costs may negatively impact adoption of these cultivation techniques and improved varieties and this could be an issue for sustainability in the long-term.

Financial viability, per farmer

	NPV (USD)	NPV (1,000 NGN)
Aquaculture farmer	$8,465	₦ 1,334
Cassava farmer	$406	₦ 64
Cocoa farmer	$3,936	₦ 620
Maize farmer	$1,372	₦ 216
Rice – Rainfed farmer	$1,869	₦ 294
Rice – Irrigated farmer	$4,972	₦ 783
Sorghum farmer	$695	₦ 109
Soybean farmer	$913	₦ 144

In terms of the economic impact of the project, the results suggest that USAID's investment in the Nigerian agricultural sector is adding over $613 million in present value to the economy over 10 years (see table below) due to surplus at the farm level. The vast majority of this value is added from the aquaculture, cocoa, and lowland rainfed rice value chains. Finally, cassava and sorghum production add value to the economy, but these results are sensitive to a number of variables such as yields and the market price for outputs; these interventions should be monitored carefully.

[2] This means all farmers are evaluated on a 10-year time span but each cohort of farmer starts in different years; this annual difference is modeled into each value chain.

Results of the Economic Analysis

	Economic Net Present Value (NPV)	Modified Economic Internal Rate of Return (IRR)[3]	Beneficiaries
Whole Economy	***USD***	***%***	***#***
Aquaculture	$92,082,894	N/A	30,300
Cassava	$5,189,509	21%	35,000
Cocoa	$247,338,270	42%	88,000
Maize	$53,094,453	43%	92,200
Rice – Rainfed	$101,407,462	26%	264,735
Rice – Irrigated	$44,175,510	44%	40,000
Sorghum	$25,845,736	43%	82,120
Soybean	$26,681,952	37%	64,500

Recommendations for Project Implementation

A sensitivity analysis was conducted for all farm models to determine which variables seem to have a significant impact on the outputs of the model. A number of variables were identified as "risk variables", since variation in these assumptions creates a source of risk within the value chains. Some value chains are susceptible to the price of imported inputs; aquaculture, in particular is sensitive to the price of the price of imported fish feed. These variables are described at length in the Sensitivity Analysis section of this report.

Yields per hectare, as the one of the most sensitive variables for all value chains, need to continue to be monitored as they have been to date. For most value chains, yields per hectare are expected to increase quite significantly compared to what farmers were doing before the MARKETS II intervention. In some cases, MARKETS II yields per hectare are increasing to levels that are somewhat uncommon in Nigeria; these variables should be corrected in the models if yields per hectare, on average, fail to reach such levels over time. Specific items include:

- In the case of rainfed rice in lowland areas, the project is using FARO 44 and expects a yield of 5.6 MT per hectare. This is expected to be an average across all 265,000 lowland rainfed farmers over seven years after they achieve these yields. Agronomists with IFPRI who were interviewed expressed doubt that these farmers could achieve those levels on average. IFPRI results show that lowland rainfed rice farmers using FARO 44 have achieved yields on average of 2.8 MT per hectare. This is likely a testament to MARKETS II approach when working with these farmers and achieving much higher yields relative to other Nigerian farmers using the same rice; however, this assumption needs to be monitored.

[3] While the economic internal rate of return (IRR) assumes the cash flows from a project are reinvested at the IRR, the modified economic IRR assumes that positive cash flows are reinvested at the cost of capital – in this model it is assumed to be reinvested at 12%. This is more reasonable than assuming farmers are collectively reinvesting their extra income and continually earning rates of return as high as 210%, as in the case for irrigated rice.

- In the case of irrigated rice, the project targets an average of 6.7 MT per hectare for irrigated rice. This is expected to be an average across all 40,000 irrigated rice farmers over seven years after they achieve these yields. IFPRI results show that irrigated farmers using FARO 44 have achieved the following yields: Zamfara state farmers have 5.5 MT per hectare; Kebbi farmers have 5.4 MT per hectare on average; and Nasarawa farmers using river diversion for FARO 44 achieve only 2.3 MT/ha. Again, this is likely a testament to MARKETS II approach to working with these farmers and achieving much higher yields relative to other Nigerian farmers using the same rice; however, this assumption needs to be monitored.
- For soy farmers, the model indicates that they experience negative incremental cash flows during the first year of the project, before soy yields have reached their maximum—in other words, they would be earning more money in that year without the project. This suggests that farmers, who may not be able to finance a year of negative incremental cash flows, may be hesitant to adopt the practices identified under the project, even if gains in future years more than offset the initial losses. MARKETS II may need to work with farmers to identify if they have sufficient access to finance to ensure that they are able to stay with the program and reap the future benefits in spite of the initial cost.
- Cassava is a main staple in the Nigerian diet and increased cassava production has considerable food security benefits. However, the cassava value chain offers the lowest benefit to farmers of all value chains analyzed. In addition to a modest increase in farm incomes (only $406 over a 10-year period of time or, on average, just over $40 per year in present value terms) there is a significant increase in production costs involved in switching production techniques (677% increase in production costs). While some of these costs come from purchasing improved inputs, it also requires additional labor, particularly during the labor-intensive harvest period. The gains made by MARKETS II may be jeopardized over the long-term given the increased labor requirements and only modest income increases. This value chain should be monitored closely to determine if it will be sustained after the completion of the MARKETS II project.

Financial Analysis

The financial analysis was conducted to determine the net incremental impact on the incomes of the farmers as well as the financial viability and sustainability of the MARKETS II project from the main beneficiary's perspective – the smallholder farmer. Financial viability, or the capability for these farmers to finance and profit from the improved agronomic practices the MARKETS II team is building, is a critical component to determine whether these practices are affordable on an annual basis and adoptable over the long-term. It also lends evidence as to the likelihood that other non-MARKETS II farmers will also adopt these practices. Additionally, long-term financial viability of the program – measured over a ten-year period from the beginning of the MARKETS II program – also provides an indication of the overall sustainability of the program after MARKETS II is completed. MARKETS II farmers are for the most part switching from traditional practices to high inputs and their inward and outward cash flows were calculated to measure financial viability and sustainability of the program, as well as determine which value chains were achieving particularly significant increases in the wealth for the smallholder farmers.

All value chains are modeled to determine their incremental impact – which compares the farm budget with the MARKETS II best agronomic management practices – or the "with-project" scenario - to what the farm budget would have been over the same period using the traditional practices – or the "without-project" scenario. This measures how much better off the farmers are compared to what their alternative likely would have been in the absence of the project.

Much of the data comes from the baseline survey conducted by MARKETS II and primary data during a data collection trip in May of 2014, as well as secondary research (see References). The financial analysis is calculated from the perspective of one "typical" farmer, where the average data points have been used wherever reasonable to capture the most standard farm budget at the country level, per commodity. This allows the CBA to average any major variance in cost data throughout the country (e.g. to prevent the results of the nation-wide model from being skewed by a region where farmers have unusually high costs). The following section describes the basic model for each commodity, and any commodity-specific assumptions are described under the individual commodities listed below.

Some models have evaluated the additional impact of the mechanization tools that are under consideration and development in the MARKETS II program (e.g., urea deep placement applicators, row planters for maize, cassava lifters); however, as the costs and expected benefits of these "innovations" are not yet known with any confidence, the additional impact of these interventions are not included in the overall project results.

Cash Inflows

Yields, when using the improved seeds and stems, increase greatly over the yields from traditional seeds and stems and this drives the main benefit from the MARKETS II program. It was assumed that these farms yields do not increase immediately upon entering the program – rather, yields increase to roughly 80% of the average maximum estimated yield in the first year and increases each year after that until yields reach their average maximum potential (as indicated by the life of project yield targets MARKETS II has estimated).

For the traditional practices modeled in the "without-project" scenario, the models calculated average yields as was measured by the MARKETS II baseline survey of their beneficiaries. However, over the next ten years it was too conservative to assume that these yields would stay constant given the considerable amount of investment activity into the agricultural sector by many donors and the Nigerian government under the recently launched Agricultural Transformation Action Plan (ATAP)[4]. Consequently, all commodities have modeled a certain percentage increase in traditional yields over the ten-year period to bluntly capture the impact that this investment activity has on the average Nigerian farmer and the probable increase in average national yields overall for all commodities. However, without a reasonable estimate for what the impact of this activity will be, a conservative estimate was used for the annual percentage increase in yields of traditional cultivation practices ranging from 1% for cassava and rice to 2.6% for maize.[5]

The revenue from the sale of the surplus commodity (after deducting post-harvest losses and household consumption from total yield) is the main cash inflow in the farm budgets for these commodities. Sales of the surplus commodity are valued at the price farmers receive at the processor or the market, minus the transportation necessary to bring the goods to market. In many cases, farmers also receive income from intercropping their commodities; however, if the MARKETS II intervention did not have a significant impact on the yields or inputs required for the intercropped commodity, there is no incremental impact and it was not modeled into the CBA.[6] Additionally, the majority of farmers consume part of their own crop production[7] which is treated as a cash inflow valued at the price they would have received had they sold the commodity instead. Finally, in the cases where MARKETS II helped to introduce the majority of farmers to new sources of financing for purchasing inputs, this loan income was also calculated as a cash inflow (repayment of the loan was also calculated as an outflow).

Cash Outflows

For all cultivation techniques and for all commodities except aquaculture, labor is the largest input. For farms using traditional cultivation practices in the "without project" scenario, labor represents an average of 68% of total annual production costs as indicated by the graph below:

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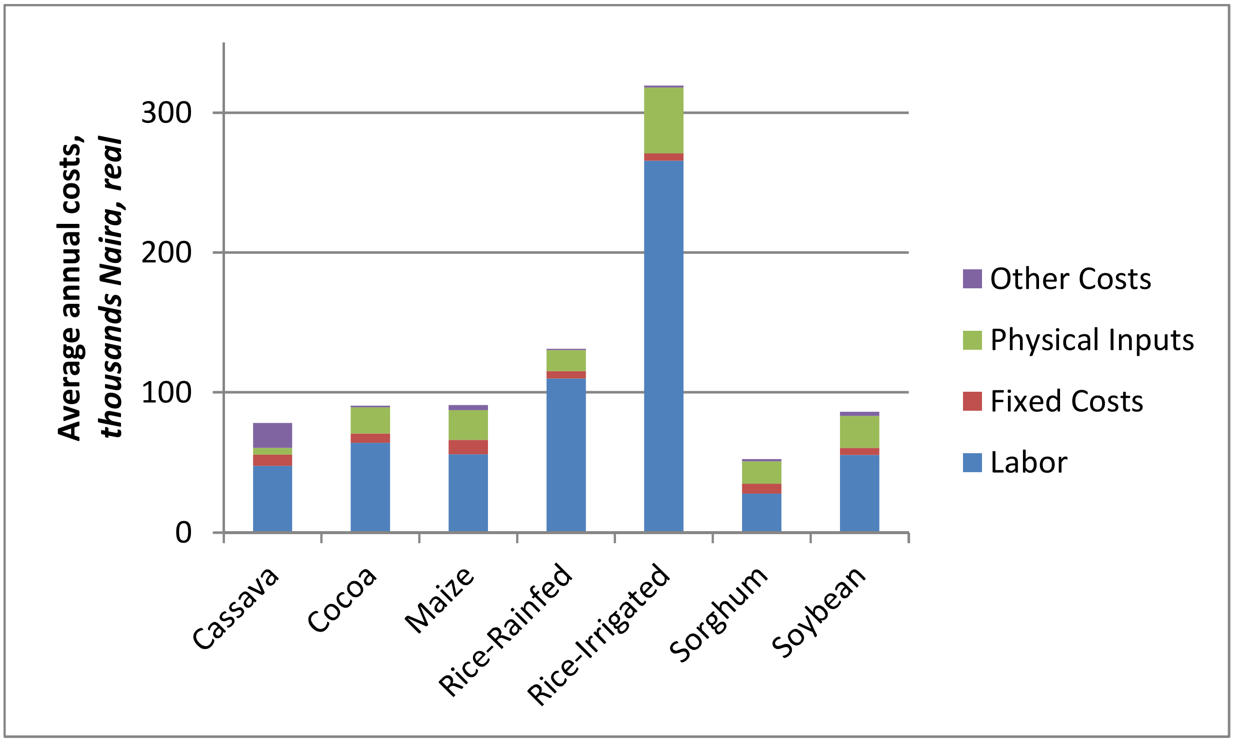
[4] In August 2011, the Government of Nigeria unveiled its plans to pursue a new agricultural development strategy designed to increase food production and employment with the ultimate objective to diversify the economy from the dominant oil sector and to attain food security. The strategy will focus on significantly increasing production of five key crops: rice, cassava, sorghum, cocoa and cotton. The aim of this new plan is to make agriculture a business rather than a development issue with emphasis on public-private partnership (PPP) and is expected to inject a total of ₦300 billion ($2 billion) additional income into the hands of Nigerian farmers.

[5] Cocoa did not have an increase in traditional yields modeled in, as discussed in the cocoa section below.

[6] Please see the cassava section for a detailed description for how cassava intercropping income for cassava farmers changes with the MARKETS II Program and how this was incorporated into the model. The soybean value chain is also rotated with maize, which has been modeled.

[7] Except for the cocoa farmers.

Without-project production cost categories



Aquaculture production costs not included in this graph
Rice Irrigated includes two production cycles – one in the rainfed rice in the wet season and irrigated rice in the dry season

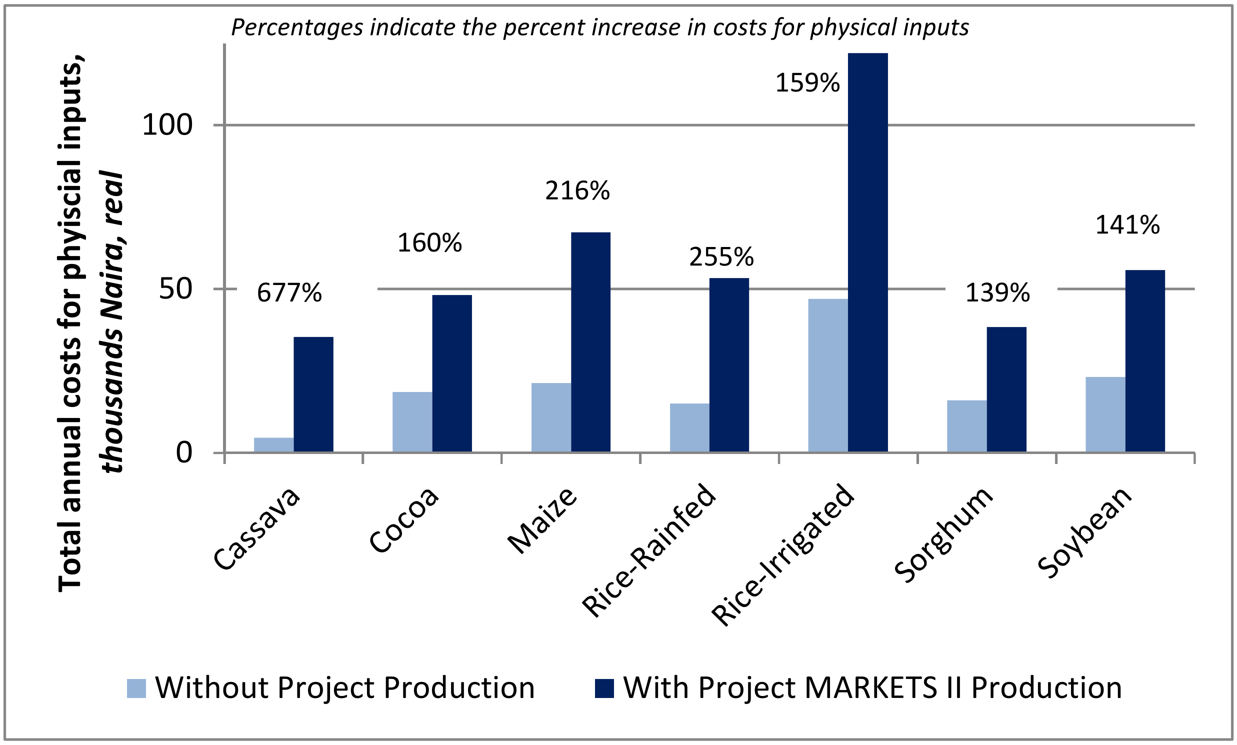
Labor costs for both the "without-project" and "with-project" scenarios were broken into the largest relevant labor categories (e.g. land clearing and preparation, planting and fertilizing, weeding/bird scaring, harvesting, threshing, and bagging). Costs for hired labor and the opportunity cost of family labor were calculated based on the MARKETS II baseline survey, where possible, and supported using other farm budgets from the literature.[8] Hired labor is more expensive than family labor, primarily because hired labor tends to be for the most labor intensive activities, which comes at a higher rate than low intensity activities such as bird scaring for rice production, typically performed by children on the farm. Using the improved techniques taught by the MARKETS II program, the labor costs continued to be the largest cost component for all farmers although this cost component decreased overall as the costs for other inputs increased. The estimate for the change in labor required for traditional production and for MARKETS II production was primarily based on interviews with the MARKETS II field staff and the farmers during the May 2014 data collection trip. As an example, when farmers begin to use more herbicide the labor costs for weeding were estimated to decrease overall with the MARKETS II production technique. Any changes in the total labor required occurred to the hired labor categories, under the assumption that farmers will decrease hired labor before their own family labor, given that hired labor is more expensive. Finally, the opportunity cost for training as part of the MARKETS II program was also incorporated into the labor costs for the MARKETS II model, estimated at 10-30 days

[8] For example, labor costs for rainfed rice and irrigated rice were not separated in the survey data and alternative estimates for the variation in labor costs among the different rice production systems were calculated from supporting literature.

per farmer per year over the course of four years. The base model estimates that real labor wages are not changing over the next ten years, and this was tested by the sensitivity analysis (see section on Sensitivity Analysis & Risk Variables below).

Physical inputs were the second most expensive cost item for the farmers and the main cost category to increase when switching from traditional practices in the "without project" scenario to the MARKETS II production. Costs for physical inputs increase on average by 220% across all commodities, with the largest percentage increases for cassava and rainfed rice, as seen in the graph below:

Increase in physical input costs when farmers switch to MARKETS II practices



Aquaculture production costs not included in this graph
Rice Irrigated includes two production cycles – one in the rainfed rice in the wet season and irrigated rice in the dry season

Physical inputs were generally the seeds/stems/fingerlings (improved or traditional) as well as any fertilizer, insecticide, herbicides, fungicides, and bags for storage and transportation used in the production of the various commodities. Recycling of seeds was calculated using the opportunity cost of lost revenue. Estimates for the per hectare units were derived from the Package of Practices booklets used by the MARKETS II trainers, and per unit cost estimates generally came from the baseline survey and farmer interviews. Although physical input costs as a whole increased for all commodities, often there were cost categories where the per unit inputs decreased as farmers moved from traditional to MARKETS II cultivation techniques – for example, rice farmers tend to broadcast their seeds during planting and MARKETS II teaches them to plant the seeds in rows, which increases the amount of labor required for planting but reduces the total amount of seeds needed per hectare. This also increases the likelihood that the required amount of quality seed is available to the farmers.

Nigeria's land tenure system is complex and land ownership varied significantly across and within commodities – varying from farmers owning their own land, to share-cropping, to renting, and to not paying at all for the land. Capturing all these differences was difficult when trying to model the "average farmer" for each value chain. Regardless if the land was paid for on an annual basis or not, it still has an opportunity cost that needed to be calculated in the model to capture revenues the farmers could have had captured if they had rented their land to another farmer. As such, the rental rates provided in the MARKETS II baseline survey were used to estimate the market rate for land as the opportunity cost of not renting this land and instead using it for crop production.

Fixed costs included equipment necessary for the annual production of each commodity. These costs were provided in the MARKETS II baseline survey as one cost item per hectare and more specificity was not available. To stay consistent, equipment costs were also included in the models as one cost item across all commodities. Given that some farmers had larger farms than one hectare, it was assumed that there would only be a 50% increase in total equipment costs for each additional hectare given that some economies of scale can be achieved for this equipment with increasingly larger farms. The 50% figure is not empirically based elsewhere and, as such, was tested using sensitivity analysis.[9]

Finally, the last common cost component for all commodities is the transportation and storage costs borne by the farmer before the commodities are brought to the millers, processors, or the market. Again, these costs were calculated using MARKETS II baseline survey data and secondary data where available.

As can be seen across the various commodities, unit costs for all categories and particularly for labor can vary significantly among the commodities. The analysts believe this is due to regional variation in these cost categories depending on where each commodity is produced. This may be caused by differing transportation costs, labor markets, input markets, and subsidy schemes by local and regional governments. In the case of fertilizer, there is a national fertilizer subsidy scheme (GES), but local governments[10] also sometimes offer an additional subsidy that changes the market prices faced by farmers in different regions. For the most part, the model did not change any of the per unit costs as reported in the MARKETS II baseline survey with the exception of the per unit fertilizer costs; without the data to understand the various subsidies the farmers are benefitting from in each region, it would not have been possible to perform the economic analysis later, which needs to remove market distortions such as subsidies from the analysis. As such, a common national per unit price for NPK, urea, and SSP was substituted into the financial analysis across all commodities.

Price Changes and Exchange Rate

Cash inflows and outflows were calculated first in nominal terms for the financial analysis due to the presence of financing options. The Nigerian inflation rate was measured at 7.9%, which is the average

[9] In the model, this is labeled as an "equipment scaling factor".
[10] Sometimes as much as up to 100%.

projected inflation rate over the period of analysis.[11] A U.S. inflation rate of 2.5% was used to measure changes in international prices as well as the value of MARKETS II dollar-denominated assistance.

Exchange rate policies have had a marked impact on agriculture. Nigeria has pursued a policy of maintaining a relatively constant nominal exchange rate in the face of strong real exchange rate appreciation due to petroleum related capital inflows. The resulting real appreciation of the currency squeezed non-oil tradables, notably agricultural commodities which implies an indirect taxation on the agricultural sector. Large fluctuations in nominal and real exchange have contributed to substantial volatility in import parity and domestic prices in Nigeria. The government has largely had inconsistent macro-economic policies to address this situation further leading to very large swings in real exchange rates (and therefore, incentives for domestic production of agricultural commodities, particularly tradable items). In recent years, the real exchange rate has gradually appreciated by 23% between 2006 and 2012, which implies a substantial reduction in real import prices and disincentivizes domestic agricultural production.[12] Most recently however, the Naira has depreciated due to the sudden decrease in oil prices in the past 6 months. However, it is nearly impossible to predict future appreciation or depreciation in the exchange rate over the next 10 years with any precision over the period of analysis in the CBA and therefore it was treated as a 0% annual change in the projected real exchange rate. This strong assumption was tested in the Sensitivity Analysis below.

Incremental Cash Flows & Discounting

The incremental cash flows were calculated as the difference between net returns "with-project" under the MARKETS II improved technique and "without-project" using traditional practices. The analysis looked at cash flows over a ten-year period of production. Cash flows were discounted using a real financial discount rate of 16.8%, which is the average real bank lending rate in Nigeria for short and medium term financing needs.[13]

The use of explicit "without-project" scenarios in the value chains allows us to vary the returns of the "without-project" scenario for different value chains—in reality, we would expect the actual returns to vary across different types of agricultural activities. So for example, maize farmers may be doing slightly better in the without-project scenario than rice farmers, and we want our analysis to reflect that. However, the result of this is that, for two "with-project" scenarios that have exactly equal cash flows, the *incremental* cash flows will be smaller for the scenario with a more profitable "without-project" scenario and greater for scenarios with less-profitable "without-project" scenarios. In the case of MARKETS II, the rates of return for the "without-project" scenarios which we modeled explicitly (all value chains) range from 0% to 26%. For value chains which are evaluated relative to a high-return counterfactual such as cocoa with a 26% rate of return, the incremental cash flows will appear to be relatively smaller than for interventions for which the counterfactual is less attractive (such as irrigated rice which has only negative cash flows in the without project cash flows). In the without-project scenario, the value chains have the following modified rates of return:

[11] Source: IMF World Economic Outlook Database (5/17/2015)
[12] Gyimah-Brempong et al.
[13] On average between 2009 and 2013. Source: World Bank Development Indicators.

Modified Rates of Return for Without-Project (Counterfactual) Cash Flows[14]

	Aquaculture	Cassava	Cocoa	Maize	Rice - Rainfed	Rice - Irrigated	Sorghum	Soybean
Modified Rate of Return	N/A	N/A	26%	0%	8%	N/A	N/A	9%

The net present values (NPVs) of the incremental cash flows from the MARKETS II program, per farm, are presented below for all value chains:

*Farm-level Incremental Financial NPVs for MARKETS II**

	Aquaculture	Cassava	Cocoa	Maize	Rice - Rainfed	Rice - Irrigated	Sorghum	Soybean
NPV (1000 NGN), per farm	1,334	64	620	216	294	783	109	144
NPV (USD), per farm	8,465	406	3,936	1,372	1,869	4,972	695	913

In general, all value chains have positive financial NPVs at the farm level. This implies that farm households in each value chain are experiencing income increases as a result of the project. Incremental cash flows appear to be especially strong for aquaculture. Additionally, irrigated rice farmers and cocoa farmers also benefit quite significantly from the improved techniques and inputs introduced to them by the MARKETS II team and to a lesser extent maize, rainfed rice, and soybean producers are also experience considerable incremental financial gains.

These results are all incremental, meaning the MARKETS II investment was compared to the "without-project" scenario of what returns farmers would have received without USAID. The average opportunity cost of capital in the "without-project" scenario for farmers was 16.8%, which is the benchmark against which the MARKETS II investment is compared.

In terms of the variability of farmers' cash flows over time, there are some cases where the farmers experience years with low cash flows. Cassava and soybean are the two MARKETS II value chains where there are a few years with low cash flows after the investment year and even negative in some periods. For soybean farmers, this is only a concern in the first few years while soy yields are still low. In cassava, years when they must repurchase the stems and wait a longer period for the stem to cultivate, farmers

[14] Not all value chains can have a modified rate of return calculated if they have only negative cash flows in all 10 years (such as irrigated rice) or only positive cash flows in all 10 years (such as aquaculture, cassava, and sorghum). These modified IRRs have been reinvested at the opportunity cost of capital, or the assumed financial discount rate, or 16.8%.

experience low cash flows; they mitigate this by intercropping but interventions to help farmers save for these years will increase the sustainability of this intervention and the likelihood that farmers will continue to replace the cassava stems as regularly as recommended by the MARKETS II team. They also do not replace all their stems in the same year so the negative cash flows in the cassava value chain will not be as low as in the model.

Aquaculture, cocoa, maize, rice, and sorghum farmers will have steadily increasing cash flows over time in the absence of pest, climatic events, or other shocks. This suggests that once farmers adopt, their new cultivation practices should be sustainable over time.

Aquaculture

Nigeria is a net importer of fish, producing approximately 600,000 MT per year but consuming 1.2 million MT annually. In 2013, the government announced a series of measures designed to stimulate the aquaculture industry in Nigeria and to reduce the country's dependence on imported frozen fish. These included a new tariff structure, increasing the import tariff from 10% to 50-100% for imported fish, as well as reducing import quotas for permits to import various quantities of fish, with the goal of reducing fish imports by 25% during 2014. At the time of writing this report, tariffs on fish imports have increased to 25%, and import quotas have resulted in a very significant reduction in imports, from an annual average of approximately 600,000 MT between 2009 and 2013, to about 430,000 MT in 2014. Domestic prices have not increased very substantially yet, but if the government continues its policy to restrict imports, it is likely that this will translate into either increases in the market price of fish or leakage into black market fish import.

The aquaculture intervention targets currently operating small-scale farmers growing primarily catfish. These farmers currently face several constraints to increasing their productivity. The fingerlings that farmers have access to are often of uncertain quality, which reduces the survival rate of fish and increases the costs of production. Farmers often use poor quality fish feed, which increases the amount of feed required to grow fish to a marketable size. Additionally, farmers often lack access to markets—if buyers are unavailable to purchase their stock when they are ready to harvest, farmers can be forced to sell for low prices or to lose some of their stock.

The project will work to overcome some of these constraints to improve farmers' operations and introduce some post-harvest processing to reduce losses. The project will introduce improved water testing and use of high quality fingerlings to reduce fish losses. The project will also introduce the use of high-quality fish feed and better feeding techniques (optimizing feed timing and quantity) to improve the efficiency of fish growth. The goal of the project will be to increase farmers' productivity and on-farm income relative to the without-project scenario.

In the without-project scenario, farmers are using primarily lower-cost, low-efficiency sinking feed, which is generally produced locally or repurposed from other on-farm materials (e.g. crop residues). The farmers are not using optimal feeding strategies, which causes feed to go unconsumed by fish and reduces the efficiency of feeding. Finally, farmers are not harvesting at the optimal time, which also decreases efficiency, as fish tend to grow more slowly once they reach a certain point in the growth cycle. The project will teach improved practices to farmers to move them towards use of higher-quality inputs (particularly feed), along with better feeding and harvesting strategies to increase the efficiency of fish production and farmer income.

Results

Under most ranges of assumptions, the project has strong positive financial returns for aquaculture farmers; the aquaculture investment means farmers earn an NPV of $8,465 more than what they would have been without MARKETS II over the 10-year period of analysis. In fact, aquaculture does appear to be highly profitable in most cases for individual farmers, provided that they can raise the necessary capital to pay for tanks, equipment, fingerlings, water treatment as necessary, and especially feed until the crop matures. This model does not include a financing component, which could be important to evaluate, as the cost of maintaining a crop of fish to maturity can be quite high, and farmers may face liquidity constraints if they lack access to finance.

The financial returns to aquaculture are sensitive to the cost of feed (particularly imported feed, which is assumed to comprise 2/3 of total feed used) and the feed-conversion ratio (FCR)—that is, the rate at which feed is converted into fish mass. As the FCR increases, a greater quantity of feed is required to raise the fish to a marketable size, increasing the cost of operations, and decreasing profits. The FCR for catfish aquaculture can vary from 0.9 to above 1.4 in some cases, and is dependent upon a variety of factors. The model assumes an FCR of 1.4 for farmers using traditional practices, and an FCR of 1.2 for MARKETS farmers. It should be noted that this may be a relatively conservative assumption, and FCRs of less than 1.2 would yield significantly increased profits.

Cassava

Nigeria produces more than 34 million MT of cassava annually, thus emerging as the world's largest producer. In spite of this volume the full yield potential has not been realized since smallholder production rarely exceeds 11 MT per hectare, and most of the commercial/industrial cassava processors face a critical supply constraint. In fact, many commercial cassava agribusinesses operate below processing capacity due to the irregular supply of fresh cassava roots. MARKETS II would like to increase yields to about 24 MT per hectare on average. The majority of cassava producers are women and women are almost entirely responsible for the processing and marketing of cassava and it's byproducts in the region.[15] Cassava is also a food security commodity. Garri is highly consumed by these local farmers more than any other commodity and is the primary staple crop in Nigeria's southern communities.

The cassava farmers in MARKETS II benefit primarily from adoption of best agronomic management practices such as optimal spacing, access to the International Institute of Tropical Agriculture's (IITA's) improved disease-resistant cassava varieties, and the introduction and timely use of NPK, insecticide and herbicide to their fields – none of which farmers are using on average under traditional cultivation techniques.

[15] PIND.

The main benefit to the cassava farmer in the CBA is the increase in yields, from an average of 10.6 MT per hectare to a maximum average of 24.10 MT per hectare over time. These farmers are receiving the same market prices for their increased surplus as they would be without the project. Using the MARKETS II approach, farmers are trained to replace their stems every 3-4 years and it was assumed in the model that maximum yields were attained after the first year of stem growth and productivity decreases each year thereafter until a new stem is cultivated four years later. It takes 16 months for a new stem to grow, and in subsequent years the tuber can be harvested every 10-11 months. During the first 16 months while the new cassava stem is growing, farmers are taught to intercrop with a short-term revenue generating crop (such as groundnuts) and this source of income was modeled into the CBA for the "with-project" scenario only. This is not meant to imply that farmers are not intercropping "without-project," it is meant to only capture the incremental increase in the intercropping income while farmers adopt better agronomic management on the farm. Also during the 16 months when farmers are replacing the cassava root, planting and harvesting costs were not modeled in which means during some annual periods in the model there are lower labor inputs (every four years). This is not meant to imply that all farmers plant cassava at the same time, as modeled in the Excel spreadsheet, as in fact cassava is planted almost throughout the year; farmers stagger the planting in such a way that there is some cassava to be harvested at any time of the year.

The average cassava producers are not using much – if at all – fertilizer, insecticide, and herbicide without the project. With MARKETS II, cassava producers are buying much more NPK, herbicide, and insecticide and in fact, their total amount of labor increases as a result of the project as well – particularly due to a significantly larger harvest, which requires more labor to remove the tubers from the ground. The model also assumes that farmers do not have significant packing costs for the cassava (unlike other value chains that trade commodities in bags).

MARKETS II is also working to test and pilot cassava lifters to address the physical stress laborers suffer from bending during manual harvesting as well as to prevent tuber breakages. However, this technology was too new to understand how effective it would be or how it might be priced on the market and therefore, its impact was not analyzed.

Results

Cassava is a staple crop and is grown primarily for home consumption in the form of garri, cassava flour, or chips for sale to the market. It is difficult to harvest and extremely time sensitive, given that the tubers must be processed within roughly 24 hours of harvest before they spoil. Throughout Nigeria, labor shortages during harvest are a challenge and will remain so while yields increase for MARKETS II farmers. The incremental cash flows per cassava farmer are quite low; farmers earn an NPV of $406 more over a 10-year period of time as a result of the MARKETS II intervention. This is mostly due to the fact that although farmers are benefiting from a significant increase in yields, this surplus requires a much higher investment in inputs and labor than compared to the "without-project" scenario maintaining traditional agronomic practices. As a result, the overall incremental impact is somewhat marginal (just under 20,000 NGN more per year for farms, which have an estimated 6.7 people per household). This strongly indicates that MARKETS II investments in the cassava value chain are not having a strongly significant impact for cassava farms but may be likely to impact stakeholders further along the value chain (for example, by limiting the underutilization of capital at the cassava processors). This CBA has not analyzed the impact to stakeholders further along the value chain.

Additionally, given these significant start-up costs farmers demonstrate a marginally positive cash flow in the first year of the project (not considering opportunity cost of labor). This includes a very significant increase in the costs for physical inputs (which is a 677% increase from their traditional methods of cassava cultivation). Should there be any negative impact on their margins, such as low cassava prices or an increase in input prices, these farmers are much less likely to adopt these new practices, which involve significant start-up costs. This is a risk variable and efforts to help cassava farmers gain access to credit will likely improve adoption rates and mitigate this risk in the first-year of adoption.

Finally, the model indicates that cassava farmers experience some years with low cash flows in the "with-project" scenario. This is due to years when stems must be repurchased and cultivate for 16 months (as opposed to years when the stems are recycled and can be cultivated in 10-11 months). Cassava farmers mitigate this by intercropping but interventions to help farmers save for these years will increase the sustainability of this intervention and the likelihood that farmers will continue to replace the cassava stems as regularly as recommended by the MARKETS II team (every 3-4 years). However, farmers will stagger the production of cassava and replace stems for different cassava plants throughout the four years at different times – not all at once. This means the years with relatively high cash flows will in reality be marginally lower and the years with low cash flows will be higher. This does not impact the overall results much but does change the way we would interpret the low cash flows in the model. The MARKETS II team assures us low cash flows are not a problem in reality for cassava farmers.

Cocoa

Cocoa is Nigeria's largest agricultural export and the second largest source of foreign exchange (after oil). Nigeria was one of the bigger West African producers in the 1980s before being overtaken by Ghana and Côte d'Ivoire due to aging plantations with continuously diminishing yields, non-availability of high yielding varieties of seedling, inadequate and irregular supplies of inputs, and lack of technical/extension support among others. The declining yield of cocoa farms in Nigeria (358 kg per ha as compared to over 800 kg per ha that has been achieved at some higher yielding farms in Côte d'Ivoire) and the growing concern of quality issues and need for traceability of cocoa and certification of cocoa farmers in the global markets, portend a great challenge for sustainability of cocoa industry in Nigeria in the long run if all these issues are not adequately addressed.

MARKETS II plans to build on the previous work of MARKETS and BtM2, which networked cocoa farmers with major procuring and processing companies and worked with farmers to improve best cocoa practices to increase yields. The cocoa farmers that benefitted from these programs are modeled into the "without-project" scenario and additional MARKETS II interventions are measured by their incremental impact on the previous work done by USAID. The MARKETS II efforts focus on improving the quality and quantity of cocoa beans. Quantity is increased on average from 0.4 MT per hectare to 0.7 MT per hectare as a result of increased use of fertilizer as well as significant efforts to decrease post-harvest losses from 50% "without-project" to 20% "with-project" over time. Additionally, drying platforms are introduced to farmers to reduce the moisture content of the bean and encourage the beans to develop better flavors after the fermentation process. This improved quality, in addition to the networking of the cocoa producers, allows the producers to capture a higher price for their commodity (assumed to be roughly a 19% increase in the purchasing price at the processor). In addition, MARKETS II is supporting farmers to become certified under international cocoa standards. In the future, non-certified cocoa producers may find it difficult to sell their crop or they may be offered a lower price. This last point has not been directly modeled but MARKETS II is also working with cocoa producers to intercrop beneath the cocoa trees in order to augment their incomes. Given that these intercrops are an external source of revenue unrelated to the cocoa production, it was not modeled into the financial or economic analysis of the cocoa value chain.

Results

Cocoa producers benefit from both the increased quality and quantity of their cocoa beans. They earn an NPV of $3,936 more than they would have without the MARKETS II project over a 10-year period of analysis. This was one of the most profitable investments for MARKETS II from the perspective of the farmers.

Similar to the cassava value chain, the cocoa farmers also have a negative cash flow in the first year of the project, primarily due to the cost of purchasing the drying platforms. The assumed adoption rate modeled into the CBA might be rather optimistic if there is not sufficient credit or grants made available to these cocoa farmers to cover this significant cost item. On the other hand, the “without-project” scenario suggests that farmers would be earning roughly a 26% modified rate of return on their investments without the assistance of MARKETS II; this suggests that they might be able to save their extra earnings in order to purchase the drying platforms themselves, without assistance from external parties.

Maize

Since 2008, Nigeria has produced 7-9.5 million MT of maize per year, making it the third-largest crop in Nigeria, behind cassava and yam. In terms of area planted, maize is second only to sorghum over the same period. Nigerians harvest an average of 4.8 million hectares of maize each year. However, productivity growth has been slow and erratic, with yields actually declining on average during the 1980s, and growing at an annual rate of only 1% during the 1990s. Yield growth accelerated to an average of about 4% during the 2000s, but has been stagnant since 2010 at around 2 MT per hectare. Maize is typically grown on small plots of approximately 1 hectare, using limited improved inputs, and is generally consumed primarily by the household, rather than being marketed.

The maize value chain program is working to train, equip, and network farmers with fish feed milling companies and other large consumers. The project works with farmers to link them to improved inputs like seeds and fertilizer to prevent supply chain problems, as when farmers attempt to buy fertilizer late and are unable to get it in time for application. Farmers will be linked to banks for credit, and to fish feed processing companies for marketing.

As with the other value chains, the maize value chain financial analysis models the impact of moving maize farmers from low-input, low-yield farming techniques to high-input, high-yield techniques. In the base case, farmers use traditional techniques (broadcast seeding, limited land preparation, non-optimal fertilizer application) and limited improved inputs, especially improved seed and fertilizer. Farmers' average yield in the base case is significantly less than the national average at 1.1MT per hectare—this may be because project farmers are growing in less productive regions than the national average, or because they are using less advanced practices and inputs than the average Nigerian farmer.

Under the "with-project" scenario, farmers begin using row planting and optimal spacing of plants, and optimal quantities, as well as improved timing and method of fertilizer application. These changes increase the cost of various inputs, including physical inputs and labor, but dramatically increase the yield of maize plants, to approximately 2.5MT per hectare.[16] While this is a large increase from current yields, it only represents a small increase over the national average, and is well below the theoretical maximum average yield that farmers could achieve in Nigeria, at around 4.5-5.5 MT per hectare.

The base case farm budget was derived from MARKETS II baseline survey data on average farm usage of various inputs (including labor), while the changes from the base case modeled in the "with-project" scenario are assumptions based on the standard MARKETS II package of practices for maize, conversations with MARKETS II staff, and general research on improved maize production. Financial price data are taken wherever possible from the MARKETS II baseline survey. Crop prices are from the Nigerian Bureau of Statistics, and are the average of several years' available data on national maize prices.

Results

The incremental cash flows for the maize value chain intervention are reasonably strong—in year one cash flows were approximately 17,000 Naira, increasing to over 80,000 Naira within ten years. It should be noted that the "without-project" scenario cash flows are marginally negative, with a modified rate of return of approximately 0%. This would imply that maize farmers in the absence of the project are growing maize even though their next best option would be preferable. This is unlikely to be true on an indefinite ongoing basis—if farmers could improve their income by growing something else (even if that meant buying maize with the additional money they made) they likely would. Instead, it is possible that the "without-project" scenario underestimates the yields that project farmers are receiving in the absence of the project, or possibly that some costs are overestimated. While an increase in the profitability of the base case would reduce the incremental benefit of the project, it would not cause them to be negative unless it was a very substantial revision (for example, a doubling of without-project yields). In the absence of such a large change, the maize value chain intervention appears to be strongly positive for farm households. Maize farmers earn an NPV of $1,372 over what they would have in the absence of the project over a 10-year period.

[16] The MARKETS II project indicated that farmer yields in their various regions of operations differ significantly: among farmers who have been in the project for longer periods of time, they report average yields of over 4 MT per ha, whereas newer farmers, particularly in the Oyo region, have yields that remain below 2 MT per ha. This analysis is done at the national level, and we recognize that there is variation between farmer profiles. MARKETS II has indicated that it may drop its activities in Oyo region, which could cause average yield performance to increase over time, but as it will likely cause the other farm budget characteristics to change as well, it is impossible to determine how this would affect the overall performance of the maize value chain.

Rice (rainfed and irrigated)

Domestic demand for rice has been increasing significantly in Nigeria, which is currently the world's second largest rice importer.[17] Nigeria's domestic rice production has also increased significantly (at an annual rate of almost 10% since the 1970s) mainly due to expansion of the area under cultivation. However demand still outstrips the domestic supply of rice; rice has become one of the leading food staples in Nigeria, surpassing cassava in food expenditures.[18] This growing dependence on rice imports has become a mounting concern for the Nigerian government, which has developed numerous programs since the early 1980s to catalyze domestic rice production and become self-sufficient. The ATAP program initiated by the government in 2011 aims to reverse trends in domestic rice production, which stagnated or even declined since its peak in the 1980s. These policy initiatives aim at prioritizing the rice sector and decreasing dependence on international imports, fostering production, and supplying agricultural inputs. Nigeria rice productivity is among the lowest within neighboring countries, with average yields of 1.51 MT per hectare. Most rice farmers in Nigeria are smallholders (90% of the total), applying a low-input strategy to agriculture, with minimum input requirements and low output. On farms, MARKETS II aims to address some of the inefficient agricultural practices such as low input application, poor plant husbandry, and post-harvest handling.

MARKETS II facilitates the dissemination of improved, high yielding, and commercially viable rice, and disease resistant varieties of rice to both rainfed and irrigated rice farming techniques.[19] They will also introduce farmers to improved rice management practices for both dry season and wet season to increase yields above historical yields. This will include efficient use of inputs such as the timely application of fertilizers (UDP and NPK), herbicides, optimal spacing, land preparation, safe use of herbicides, and ensuring the delivery of required quantities and qualities of paddy rice to buyers.

The rainfed and irrigated rice models incorporated a few different assumptions in their models, specifically:

> ***Rainfed-rice.*** MARKETS II is working exclusively with lowland rice farmers. These farmers are projected to increase average yields from a measured baseline of 2.58 MT per hectare[20] to a maximum average yield of 5.6 MT per hectare. They achieve 80% of this yield increase in the first year with the MARKETS II program and gradually increase their yields until they reach the maximum average of 5.6 MT per hectare. There were no data that could be disaggregated for various ecological zones. Therefore, all data was aggregated at the national level for lowland rice farmers. It was also assumed that these farmers have one rice harvest per year, during the rainy season, and do not use any supplemental irrigation during this production cycle. On average, it was also assumed

[17] Only this year did China overtake Nigeria as the world's largest importer. Source: World Agricultural Supply and Demand Estimates Report (WASDE).
[18] Gyimah-Brempong et al.
[19] Specifically varieties Faros 44, 52, and 57 are being promoted by MARKETS II.
[20] This figure was used as the "without project" assumption for average yields rather than the national average yield of 1.51 MT per hectare. MARKETS II data suggested that their farmers have higher baseline yields than the national average.

that these farmers use transplanting techniques, which is more labor intensive in the planting stage than traditional rice planting practices in many places.

Irrigated-rice. MARKETS II irrigated rice farmers are projected to increase average yields from 3 MT per hectare to 6.7 MT per hectare "with-project". They achieve 80% of this yield increase in the first year with the MARKETS II program and gradually increase their yields until they reach the maximum average of 6.7 MT per hectare. These yields are much higher than other farmers growing the high-yielding FARO 44 variety; however, the MARKETS II team has data indicating this is in fact the average yields they are achieving.

It was also assumed that irrigated rice farmers have one irrigated rice harvest and one rainfed rice harvest each year. During the rainy season, farmers do not incur irrigation expenses. However, during the dry season, farmers have increased expenses to pay for irrigation. Irrigation systems vary in Nigeria and the data were not clear which systems are predominantly used by MARKETS II farmers. In some parts of the country there are public irrigation schemes that do not come at a cost as well as free-of-cost river diversion; however, many other farmers use expensive pump based systems. In fact, the baseline data do indicate that farmers "without project" do indeed pay for irrigation. The model assumes there are costs associated with irrigation for dry season rice cultivation; both the cost of the pump and the fuel to run the pump has been modeled into the irrigated rice CBA.

Additionally, irrigated rice production is much more labor intensive than rainfed.[21] Labor inputs for the irrigated farmers were not available in the MARKETS II baseline survey but labor information with irrigated systems was available from IFPRI and adopted into this model.

Yields are significantly better in an irrigated rice system as compared to the rainfed rice farmers "with-project", though they come with much higher labor requirements and expensive water pumping systems. The net cash flows for irrigated rice systems are negative for "without-project" farmers, as is demonstrated in the CBA. This, however, includes the opportunity costs for family labor and land – when these are removed, gross margins are positive for "without-project" farmers. This is in line with IFPRI results, indicating that irrigated farmers "without-project" have marginal returns.[22]

The following paragraphs describe assumptions in both the rainfed and irrigated rice models.

The primary benefit for the farmers in both rainfed and irrigated rice is the increase in rice yields. Some farmers in Nigeria do gain 5-10% premium for high quality of rice[23], the results from field interviews suggest that many of these farmers do not gain higher market prices and this account was modeled into the Excel file.[24] However, some farmers may be gaining a larger overall revenue since paddy weighed at

[21] Gyimah-Brempong et al.
[22] Ibid.
[23] For example, UMZA pays by grade according to quality (uniformity, level of impurities, etc).
[24] This was the experience during data collection, although it seems other processors in Nigeria do in fact offer higher prices for higher quality rice. Given that we could not determine which experience the average farmer

the local millers are paid on a per 50-kg bag basis, which may in fact be filled with more than 50 kg of paddy.[25] In some parts of Nigeria, rice farmers networked with processors often have their bags weighed and they are paid on a per-kg basis. Other processors reportedly pay their farmers using a visual inspection of larger bags. The market is not always consistent in its pricing structures and prevailing prices vary for different varieties at any given point in time. To account for this, we used the average annual rice price reported by MARKETS II farmers in the 2012 Master Survey Data. Finally, it was not assumed that an increase in local supply, as a result of the MARKETS II program, will decrease local prices given the current under-utilization of milling plants.

There will also be a gradual decrease in the post-harvest losses by 7.5 percentage points as farmers learn better how to dry their paddy post-harvest and increase the quality of rice provided to the millers (e.g., by not mixing different varieties of paddy together, which could lower the price they receive).

In order to achieve these yields, farmers need to increase their total expenditure on inputs, which will introduce a better combination of fertilizers than what farmers are traditionally applying to their fields. The CBA assumes that the average farmer does apply about 50 kg of urea in traditional practices and MARKETS II farmers are taught to use apply 100 kg of urea as urea deep placement (UDP) briquettes as well as 200 kg of NPK. Traditional farmers in rainfed systems are using some herbicide but they are taught by MARKETS II to use more and how to effectively apply it. They are also taught how to plant the seeds properly, as opposed to broadcast seeding using traditional varieties, which actually reduces the amount of kg of seeds that farmers are using on their fields but still results in a net increase in seed costs, given that improved varieties are much more expensive than traditional varieties.

Labor also increases overall with the project, though mainly due to a larger harvest and more intensive planting and fertilizing techniques (inserting the seeds and UDP directly into the ground rather than spreading over the surface as is typical in traditional cultivation practices Labor for both models has been scaled to increase as yields increase in the first years of the project.

Results

Incremental marginal returns are significantly higher for irrigated rice than rainfed rice. Irrigated rice farmers earn an NPV of $4,972 more than they would have without the MARKETS II intervention over a 10-year period of analysis. Rainfed rice farmers earn $1,869 more than they would have in the absence of MARKETS II in the same period of analysis. Both returns suggest rice farmers benefit from the MARKETS II intervention.

Irrigated rice farmers have high returns in large part due to two production cycles per year (one wet season rainfed rice cycle and one dry season irrigated rice cycle); making their overall net incremental returns high compared to the rainfed rice farmers with only one rice production cycle per year.

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experiences or which system is more dominate in Nigeria, we assumed there was no price premium. This seems particularly relevant for farmers that may continue to sell their surplus at local markets when they are not networked with the larger processors.

[25] Again, this was the experience during the data collection phase of this analysis. It seems other parts of Nigeria use larger bag; however, this should not make a large impact on the overall results of the model.

Additionally, the increase in yields during the dry season (irrigated) production cycle is much higher than for the rainfed production cycle (as compared to the baseline yield figures).

It should be noted that the "without-project" scenario cash flows (including opportunity costs such as labor from the household) are negative for irrigated rice farmers. This would imply that irrigated rice farmers in the absence of the project are growing rice even though their next best option would be preferable. This is unlikely to be true on an indefinite ongoing basis—if farmers could improve their income by growing something else (even if that meant buying rice with the additional money they made) they likely would. Instead, it is possible that the "without-project" scenario underestimates the yields that project farmers are receiving in the absence of the project, or possibly that some costs are overestimated. This all suggests that the returns to the irrigated rice farmers may be overestimated given that the counterfactual has negative cash flows.

Sorghum (white)

In 2012, Nigeria was the third-largest producer of sorghum in the world. Sorghum is the fourth-largest crop in Nigeria by volume, with average production since 2009 of approximately 6.5 million MT; however, this represents a significant decrease from the previous decade, during which production averaged 8.4 million MT. Declines in production have been largely attributable to reductions in area planted, likely as maize and soybean cultivation increased. The deteriorating security situation in the main Sorghum producing areas may have also disrupted commercial cultivation, forcing farmers to switch to production for home consumption, and may have made production statistics less reliable. Yields have remained relatively stagnant for the past several decades, varying between 1.0 and 1.6MT per hectare since 1980.

Sorghum is primarily consumed in the household in Nigeria, in the form of flour or paste, for food or animal feed and is widely exported to the West Africa. The primary commercial use of sorghum in Nigeria is for malting, although maize and other cereals are used for this purpose as well. The formal marketing chains for Nigeria are poorly developed[26], as most production is consumed on-farm; this increases the cost of marketing and reduces the price received by farmers.

As with other value chains, Nigerian sorghum farmers have typically used low-input, low-output farming techniques, which is one reason that yields have been stagnant for several decades. MARKETS II is working with farmers to introduce improved varieties of sorghum that have higher yields. The project is also working on training farmers to improve soil management and use increased inputs, like fertilizer and pesticide for weed control.

Perhaps more importantly, MARKETS II is working at different levels in the value chain to provide farmers with appropriate inputs to maximize their production, and to ensure that the demand for their production is there as well. MARKETS has worked with seed companies to ensure that farmers have access to quality improved seeds at the right time, as limited availability of seeds in the past has reduced

[26] It should be noted that there exist some well-established informal export linkages for sorghum with neighboring states, which may be responsible for trade of up to a few hundred thousand MTs of sorghum per year. However, hard data is unavailable for this informal trade.

farmers' productivity. MARKETS II has also worked to bring farmers into contact with commercial processors of sorghum, so that they have a ready market for their increased production.

The target increase in sorghum productivity for MARKETS II farmers is from 1.25 MT per hectare to 2 MT per hectare, with an eventual maximum yield of approximately 2.5 MT per hectare given current technologies; in fact, the previous MARKETS II program was able to achieve even larger increases than this with yellow sorghum varieties.

Results

Sorghum farmers experience positive incremental cash flows from the project in every year, with income increasing by about 10,000 Naira in the first year and reaching 37,000 Naira by the ninth year. This is in addition to already relatively strong cash flows in the without-project scenario, so that annual with-project income reaches nearly 75,000 Naira ($455) by the end of the analysis period. Overall, sorghum farmers earn an NPV of $695 more than they would have without the MARKETS II intervention over a 10-year period. This is one of the value chains in the MARKETS II portfolio that earns relatively little incremental income for the farmers as compared to the other value chains with much higher incremental cash flows (for example, aquaculture, irrigated rice and cocoa).

Soybean

Soybeans are not a primary crop in Nigeria; the country has produced 300,000 to 600,000 MT of soybeans each year since the late 1980s. This ranks soybeans 12th among all other crops in terms of area harvested, behind all the other value chains in the MARKETS II program except for aquaculture. However, soybeans have received more attention recently for their excellent nutritional properties, and are used by soy millers to produce soybean oil and cake for livestock feed. Efforts are also being made to increase their use in various food products and to incorporate them into the Nigerian diet. Additionally, soybeans have the benefit of being a nitrogen-fixing crop; they replace the nutrients that cereals, especially maize, tend to strip out, preventing reductions in soil fertility if they are rotated with maize effectively. The MARKETS II soybean activity is focused on helping farmers raise and market soybeans more effectively as a commercial product for supplying the growing animal feed (primarily fish feed) processor demand; increasing the use of soybean and soy-cereals combinations in home nutrition and in small-scale rural businesses as well as teaching farmers to use effective crop rotations to reduce the amount of soil fertility loss due to nitrogen depletion of the soil. Since soybeans are primarily cultivated in rotation with maize and sorghum, this analysis models the farmer switching from one crop to the other at various intervals. In the base case, the farmer rotates from maize to soybeans once every four years. The farmer produces maize according to the same production function as do non-project farmers in the maize value chain, so their cash flows are directly linked to the maize section of the CBA model. However, the farmer experiences yield increases over the baseline maize production scenario, since the farmer is replenishing the soil with nitrogen by rotating in soybean every four years. For this reason, maize production is higher than in the without-project scenario in the maize value chain, where maize is grown annually with no crop rotation. In the baseline scenario for soybeans, the farmer experiences a 15.6% increase in maize productivity due to crop rotation.

The basic technology improvements in the soybean value chain parallel those of other value chains. In the with-project scenario for soybean, the farmer switches from low-input low-yield soy production to greater use of improved seeds, inoculants, and fertilizers and improved agronomic techniques in order to achieve increased yields. Additionally, the analysts modeled an increase in the periodicity of the crop rotation, so that now farmers rotate in soybeans every other year, instead of every four years. The impact of these changes is two-fold: 1) the improved methods and inputs for soybeans increase yields from .76 MT per hectare in the base case[27] to a targeted yield of up to 2.4 MT per hectare[28]; and 2) the benefit to maize yields is also increased, from a 15.6% increase in the without-project scenario to a 26% increase in the with-project scenario.[29] The soybean yields targeted in the with-project scenario remain modest relative to observed yields in other semi-arid environments, which can approach 2.6-3.5 MT per hectare.

Results

The project increases farmers' net cash flows in each year, although the effect is not uniform. Since cash flows in years in which the farmer grows soybeans are proportionally smaller than years in which the farmer grows maize, the increased rate of soybean cropping limits the increases in relative cash flow for farmers in years in which they would have been growing maize in the absence of the project. However, the increased net cash flows in maize-growing years are substantial, increasing from 7,600 Naira in the first maize growing year (year 2 of the project) to 29,000 Naira in the last year of the analysis. Overall, the incremental NPV of returns to farmers is significant, at around $913 for ten years of benefits.

It should be noted that the without-project cash flows are relatively low, and negative in some years. While the undiscounted sum of net cash flows is marginally positive, the rate of return for the without-project scenario is quite low at about 3.4%. This suggests that farmers would be financially better off investing their resources elsewhere if they can earn a better return than 3.4%, which is likely. That being the case, it is possible that some costs in the soy model are currently overestimated, or that all of the benefits are not being adequately captured. However, insofar as those limitations are about equally likely to affect both the with- and without-project scenarios, the incremental benefit to farmers is likely to be close to the estimated amount in any case.

[27] This is reasonably close to the national average yield for soybeans, which has varied from 0.6 to 1 MT per hectare since 1996.

[28] Additional investments being pursued by some MARKETS farmers, including maintaining honeybees, could increase these yields even further, as improved pollination would increase yield performance. However, this additional investment has not been evaluated directly in this CBA.

[29] Estimates derived from "Effect of Soybean on Subsequent Maize Grain Yield in the Guinea Savanna Zone of West Africa," Carsky et al.

Economic Analysis

After assessing the incremental costs and benefits at the individual farm level (financial perspective), the model assesses the incremental costs and benefits of each value chain from the perspective of society (economic perspective). The economic assessment adjusts market prices to correspond to the actual economic value of the resources produced and consumed by the activity—market prices often do not accurately reflect these values, due to market distortions like taxes and subsidies or the existence of externalities.

For each value chain, we calculate the annual net benefits generated by the project—that is, the amount of benefits at the farm level generated in excess of costs—relative to what would have occurred without the project. Then we discount these benefits to calculate the economic net present value (NPV) of the project in each value chain. This can be thought of as the amount by which the entire society benefits as a result of MARKETS II activities in each value chain.

In order to conduct the economic analysis, we adjust the values of all important cash flows to determine the actual economic value of resources used and benefits created by the project. In Nigeria, the most significant source of market distortions is the country's import tariff structure, particularly in the case of imported rice and aquaculture, as well as government subsidies for fertilizer (and, to a lesser extent, fuel).

An example of the impact of market distortions on the price of a good may be helpful. Rice is imported into Nigeria, and is subject to heavy import tariffs, causing the domestic price to be higher than it would otherwise be, if there were no (or lower) restrictions on rice imports. We calculate the price that rice would be selling for in the market if there were no distortions—including import tariffs, foreign currency market distortions, distortions in the transportation of the good from the port to its end-market, etc.—and compare that to the actual, observed price that is being paid. In the case of rice, the economic price (that is, the hypothetical "undistorted" price that we calculate) is about 70% of the actual retail price of rice in Nigeria. This implies that Nigerian farmers are producing and receiving a price that is higher than the economic value of the imported rice, if there were no distortions in the economy. In other words, the distortions in the economy are making rice production more attractive but at a higher price to consumers (and therefore, a lower value to the economy).

We take the ratio of these two numbers, the economic price and the financial price, to create a "conversion factor" that allows us to convert the revenues and costs in our financial analysis into resource flows—benefits and costs—in our economic analysis. We calculate these conversion factors for all major project outputs, and those important inputs that we anticipate to have potentially important distortions. These conversion factors, and their associated assumptions, can be found on the "CFs" tab in the Excel model.

Most crops in the model were treated as tradable goods that are serving as import substitutes, with the exception of cocoa which was treated as an export commodity and cassava which was treated as a nontraded commodity. The economic price of fertilizer has been adjusted for the import tariff and the government subsidy.

Using these conversion factors, the farm budget model in the financial analysis is converted to an economic analysis, and then these net incremental resource flows are scaled by the expected number of beneficiaries per commodity, to capture the whole net economic benefit. USAID program costs are deducted from these net benefits to get the total economic impact, or economic NPV. USAID program costs were derived as an average cost per beneficiary across all value chains - which is unrealistic but better data to estimate the USAID costs per value chain were not available.

The analysts recognize that the import regime in Nigeria is not stable, especially for commodities such as rice and aquaculture. It would be very difficult to anticipate the average tariff rates for all these commodities in the next 10 years; however, a sensitivity analysis was conducted to determine how sensitive the results of the economic analysis are to this variable (see Sensitivity Analysis & Risk Variables).

Lastly, the exchange rate has a significant impact on the domestic and imported prices of these commodities. This has also been incorporated in the sensitivity analysis to account for possible future changes in the real exchange rate and the resulting impact on farm profits and on the project's benefit for the economy.

The results of the economic analysis are presented below:

Incremental Economic NPVs for MARKETS II over ten years

	Aquaculture	Cassava	Cocoa	Maize	Rice - Rainfed	Rice - Irrigated	Sorghum	Soybean
Net Present Value (1000 NGN)	14,506,739	817,555	38,965,671	8,364,500	15,975,731	6,959,410	4,071,737	4,203,475
Net Present Value (USD)	92,082,894	5,189,509	247,338,270	53,094,453	101,407,462	44,175,510	25,845,736	26,681,952
Modified Economic IRR[30]	Does not compute	21%	42%	43%	26%	44%	43%	37%
Total Beneficiaries	30,300	35,000	88,000	92,200	264,735	40,000	82,120	64,500

Both the farm-level financial returns and the economy-wide returns for all crops are positive (see individual explanations below). Overall all other value chains clearly demonstrate positive economic NPVs due to the MARKETS II intervention. All of these assumptions are sensitive to a number of variables – as discussed in the Sensitivity Analysis section.

[30] See Footnote 3.

Overall, the MARKETS II project adds over $613 million USD to the Nigerian economy in present value terms over a ten-year period. The MARKETS II intervention that seems to add the most value to the Nigerian economy is the investments in cocoa farmers, which adds over $247 million to the economy as it is modeled now. Aquaculture creates a net $92 million in benefits for the economy, while rainfed rice adds over $101 million to the economy as well and is an extremely valuable intervention. Networking and improving the production practices of maize contributes over $53 million to the economy, while the soy and sorghum value chain interventions each add approximately $25 million to the economy. The irrigated rice value chain adds about $44 million to the economy. The cassava intervention adds only a marginal amount to the economy as compared to the other value chains; cassava adds just over $5 million.

These results suggest that USAID's investment in the Nigerian agricultural sector is adding value overall to the economy due to the MARKETS II program. This is particularly true for the value chains adding the vast majority of the economic benefits—aquaculture, cocoa, and rainfed rice, which collectively contribute 72% of the total net value added to the economy from the value chains. Finally, the cassava intervention is sensitive to variations in its assumptions (see a further discussion of this in the Sensitivity Analysis & Risk Variables and, although the base model has a positive economic NPV, it could quite easily become negative with lower than expected yields. Efforts to improve returns from this investment should also be explored (for example, MARKETS II is looking into cassava lifters that could reduce the cost of labor at the harvest season and improve the viability of this value chain).

Below the individual circumstances of the seven production models are discussed, as well as the implications of their results.

Aquaculture

As noted in the financial analysis section, the Nigerian government has taken steps since 2013 to drastically reduce the quantity of fish imported into Nigeria. This will tend to increase the domestic price, making aquaculture an attractive investment for farmers, but forcing consumers to pay higher prices than they would otherwise pay in the absence of trade distortions. In effect, the policy regime surrounding aquaculture serves to create a series of transfers of benefit from consumers. One set of transfers occurs in the form of higher tariffs for imported fish, which are passed on the consumer in the form of higher prices. These tariffs are collected by the Nigerian government, and are presumably distributed back to Nigerian society in the form of public goods[31]. The other set of transfers occurs directly between consumers of domestic fish and producers, as consumers pay higher-than-necessary prices for fish, and farmers reap the benefits. Depending on the overall balance of wealth between consumers and aquaculture farmers, this could represent an improvement in the distribution of income between parts of society; nevertheless, it is inescapable that, in the presence of high import tariffs, some domestically raised fish are being produced inefficiently—that is, the resources used to produce them domestically are more than what would be required to produce them externally. This represents a real loss to the economy as a whole.

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[31] It is, however, worth noting that the distribution of the benefits of government programs may not always match the goals of USAID.

This effect can be seen in both the with- and without-project economic resource flows for the aquaculture intervention—the economic resource flows for both are negative, although they are more negative for the without-project farmers than for the with-project farmers. This implies that, while MARKETS II farmers are producing fish more efficiently using improved production techniques, their production still represents a loss to the economy as a whole, given that less expensive alternatives (importing fish) would exist if tariffs and other trade barriers were not so high.

Results

Because the switch from traditional aquaculture practices to higher-efficiency farming under the aquaculture value chain increases farmers' efficiency, the project has very substantial incremental benefits for the Nigerian economy. While farm production still has negative net resource flows, they are much less negative for the Nigerian economy than would be the case without the project. This improved productivity, given the current level of distortions in the Nigerian economy, creates an incremental benefit of about $92 million in present value over ten years. Because the returns in the first year are greater than the investment cost for USAID during that time period, the project level rate of return is not calculable. If all of USAID's project costs were imputed to the first time period of the project, the modified rate of return on aquaculture investments would be about 30%. It is worth noting, however, that policy reforms to remove the barriers to importation of fish would likely create an even larger benefit for Nigeria. This would particularly benefit Nigerian consumers of fish, who would experience lower prices.

Cassava

Cassava is a non-tradable commodity in Nigeria, and it has been subject to relatively little policy intervention in most years.[32] In the CBA, cassava has a conversion factor equal to one, meaning that the financial price modeled in the financial analysis is equivalent to its economic resource value in the economy. As such, MARKETS II investments in cassava are considered economically viable because from the added value to the economy, derived primarily from the increased incomes achieved by the farmers (i.e., increased producer surplus).

However, there have a number of policies aimed at encouraging the production of cassava flour including tax incentives for bakeries that blend cassava flour instead of wheat flour. From July 2012, the Nigerian government implemented a 65% levy on wheat flour to bring the effective duty to 100%, while wheat grain will attract a 15% levy which will bring the effective duty to 20%. Bakeries that attain 40% blending would enjoy a corporate tax incentive of a 12% rebate. Starting in March 2012, the importation of cassava flour was prohibited so as to further support the program. Despite modest increases in processing facilities and drying operations, Nigeria's capacity to produce industrial-grade cassava flour remains limited and as such the cost of domestic cassava flour is considerably higher than imported wheat.[33] This creates large distortions in the market for wheat flour that is artificially driving the demand for domestic cassava flour upwards and may be driving up the market price for cassava tubers. As a result, it is extremely likely that the market price is higher than it would be without the government

[32] Walkenhorst.
[33] GAIN Report: Cassava Inclusion in Wheat Flour.

policies introducing a distortion in the wheat market. A conversion factor of 1, currently modeled into the CBA, does not address the cross-elasticity of demand between these two substitutes, and therefore it does not measure how much of the distortion in the wheat market is transferred to the cassava market. A conversion factor as low as 0.73 would render the cassava value chain not economically viable. This is in line with other conversion factors for aquaculture and rice that have high distortionary trade policies.

Results

MARKETS activities with the 35,000 cassava farmers have positive impacts on the Nigerian economy as a whole. This investment generates approximately $5 million in net present value over ten years as compared to the absence of the project. This is a modified rate of return of 21% on USAID's estimated investment of roughly $3 million in the value chain. Though, as mentioned above, this may be somewhat overvalued if the demand for cassava is distorted due to policies discouraging wheat flour in favor of cassava flour.

This value chain does add value to the economy and the results indicate that it is worth the costs. However, given that it is possible to achieve much higher returns in other value chains, a discussion on the value of maintaining the cassava investment vis-à-vis the more profitable MARKETS II investments may be warranted.

Cocoa

Cocoa is an exportable good. The producers of traditional export crops such as cocoa beans, cotton, groundnuts, and palm oil have implicitly or explicitly been taxed by governmental policies in most years. This difference has narrowed over time, however, and the strong anti-trade bias in the structure of Nigeria's agricultural distortions of the past has largely disappeared. Currently there are not large distortions in the market and cocoa producers receive a tax credit rebate (the Export Expansion Grant). There is a conversion factor of 1.10 in the CBA for cocoa, indicating economic benefits greater than the financial gain to the cocoa producers due to the gain in the foreign exchange premium to the economy. The incremental impact of the MARKETS II program adds significant resources to the economy as a whole and results in a net economic gain.

Results

The project has very substantial incremental benefits for the Nigerian economy as a result of the 88,000 MARKETS II farmers improving the quality and quantity of their cocoa beans. MARKETS II activities in the cocoa value chain have significantly positive impacts on the Nigerian economy as a whole, generating approximately $247 million in net present value over ten years, with a modified rate of return of 42% on USAID's estimated investment of roughly $7.6 million in the value chain. This is the MARKETS II value chain that adds the most wealth to the Nigerian economy in absolute terms.

Maize

The distortions surrounding the maize value chain are relatively minimal—the price of maize does not appear to be subject to significant controls, at least since the lifting of the import ban on maize in 2008. The largest important distortion that affects maize production is the existence of significant subsidies for fertilizer, particularly urea. However, since input costs are a relatively small portion of total operating costs for maize (about 25%), those distortions do not greatly impact the overall value of maize production for the economy.

Results

MARKETS II investments in the 92,000 maize farmers have strongly positive impacts on the Nigerian economy as a whole. This value chain generates approximately $53 million in net present value over ten years, with a rate of return of 43% on USAID's estimated investment of roughly $9.6 million in the value chain.

Rice (rainfed and irrigated)

In an effort to limit the volume of imports and to provide protection to the domestic rice producers, the Nigerian government has placed substantial import tariffs on rice, though the tariffs have varied widely over time. In January 2013, the import tariff on rice was increased from 50% in 2012 to 110% in January 2013. Consequently, widespread smuggling began to replace official imports. In response, the Jonathan administration reduced these tariffs to 30% on imported husked brown and semi-milled or wholly milled rice; importers of rice who do not mill rice in Nigeria will pay a combined effective rate of 70%. These tariffs are likely passed on to the consumer in the form of higher market prices for imported rice. Domestic rice in Nigeria is not a perfect substitute for imported rice; however, it is possible that an increase in tariffs that raises the domestic price of imported rice will also lead to an increase in the price of local rice. IFPRI has estimated that a 1 Naira change in the domestic market price of imported rice induces a 0.2 Naira increase in domestic rice in the long-run.[34] This suggests that protectionist trade policies may not provide the producer price incentives that policy makers intend, but cause a loss of consumer surplus in the form of higher prices for both domestic and imported rice.

In order to calculate the economic value of domestic rice, a willingness to pay premium was calculated for consumer's preference for imported rice over domestic rice.[35] Much of this preference is derived from the higher quality of imported rice; which is a characteristic that is targeted by the MARKETS II program to increase domestic quality such that it can compete with imported rice. This willingness to pay (WTP) for a more expensive rice product was estimated to be roughly 25%[36] - implying that consumers are indifferent between domestic rice that costs 100,000 Naira per MT on the market and 125,000 Naira per MT for imported milled rice. The WTP is an economic resource (i.e., consumer surplus) and helps to estimate the price point at which imported rice is substituted for domestic rice. Starting with this assumption, the conversion factor compares brown rice imported for milling in Nigeria to domestic rice, also milled in Nigeria. Brown rice faces a 10% tariff and a 20% levy, or an effective 30% tariff rate.

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[34] Gyimah-Brempon et al, 226.

[35] This preference is primarily in the urban centers and among wealthier Nigerians. Rural Nigerians continue to prefer local rice, although this is also attributable to lack of availability of imported rice in these areas as well as a prohibitively high price as compared to domestic rice.

[36] Similar to other WTP values calculated in the region for imported and domestic rice. See: USAID, "Global Food Security Response."

As a result, the conversion factor for rice is 0.67 indicating a high distortion in the market (primarily from the import tariff, the levy, and the value-added tax on rice). This implies that the consumers are paying a higher cost for the rice than they would in the absence of the policy distortions – or a net loss in consumer surplus. This conversion factor is applied to the net revenues that the farmers are receiving.

Results

The incremental economic NPV for lowland rainfed farmers is positive (estimated to contribute over $101 million in a ten-year period), indicating that the producer surplus gained by rainfed rice farmers is great enough to outweigh the costs to the consumers who are paying more for their rice than they would be in the absence of the tariff. This is a 26% return on USAID's roughly estimated costs of $23 million in nearly 265,000 rainfed rice producers.

There are practical reasons for growing irrigated rice: It is grown as an addition to the farmer's annual revenue and as a risk reduction strategy (in case the wet season rains are faulty) for household income and food. The production cycles for rain-fed and irrigated rice are complementary and provide cash flows at the time when agricultural inputs are needed in the complementary activity. This alleviates the need for external credit. The economic NPV for irrigated rice farming is positive (estimated to benefit the economy over $44 million over ten years). This is a 44% rate of return on an estimated $3.5 million investment for USAID in 40,000 irrigated rice farmers.

These results indicate that investing in rainfed rice farmers add more wealth to the Nigerian economy than the irrigated rice farmers, although irrigated rice farmers benefit to a larger degree than the rainfed rice farmers.

Additionally, given the scale of the project, the availability of inputs is critical– particularly improved seeds – to support the number of farmers that are expected to be adopting the MARKETS II approach. Given the number of farmers expected to achieve target yields between 5.2 and 5.5 MT per hectare using the improved varieties, an estimated 58,670 MT of improved seeds need to be made available over the next five years of the project and achieve annual levels of nearly 13,000 MT of seeds to be distributed. The previous MARKETS program cited availability and timeliness of seed delivery as one of the biggest constraints. Unless this issue has been resolved, this could *significantly* affect the economically viability of this project. MARKETS II tells us that the seed situation is changing, especially with the proposed new intervention by *Africa Rice*, which may alleviate any concerns in this area.

Sorghum (white)

As with maize, the distortions surrounding sorghum are minimal. As an import-competing product, sorghum's value to the economy is slightly higher than its value to farmers, since increasing the production of sorghum increases the availability of foreign exchange by displacing imports of sorghum. Also paralleling maize, the largest sources of distortion in the sorghum market are on the inputs side, specifically with fertilizers, and also transportation. However, as these costs represent a relatively small fraction of the overall cost of production, the bottom line is not much altered by the presence of these distortions.

Results

MARKETS II investment in 82,120 sorghum farmers has positive impacts on the Nigerian economy, with an incremental net present value of over $25 million over ten years. This corresponds to a 43% rate of return on the roughly $8.5 million USAID investment in the value chain[37].

Soybean

As with maize and sorghum, the distortions around soybeans are minimal. As with other value chains, the primary sources of distortion are in fertilizer markets and transportation.

Results

Overall, the incremental net benefits to the Nigerian economy of MARKETS II investments in soybeans are positive. After accounting for all costs (including the cost of USAID investment), the 64,500 MARKETS II soybean farmers generate an economic net present value of over $26 million over ten years. This is an incremental figure, meaning that this value chain generates $26 million more than in the absence of the MARKETS II project. This corresponds to an inflation-adjusted modified rate of return of approximately 37%. The most sensitive variables in the soy model are labor costs and quantities, the cost of fertilizer, the market price of soybeans, and the number of farmers reached by the project. Model sensitivities will be dealt with in more detail in the sensitivity analysis section of this report.

Weaknesses of the Models

This report has highlighted some value-chain specific weaknesses or opportunities for better data collection. However, two critical weaknesses of the model have a potentially large impact on all 7 commodities analyzed:

- An estimate of USAID total costs by the value chain was not possible to calculate. Lacking good data on the USAID program costs per value chain, we made the assumption that per-beneficiary costs are equal for all value chains, and made an estimate of the total USAID program costs based on the total number of beneficiaries. This will tend to overstate the economic value of value chains that have relatively high per-beneficiary costs, and understate the net benefits for value chains with lower per-beneficiary costs. On the other hand, the sensitivity analysis (below) does not indicate that the results vary at all for different assumptions in the cost per beneficiary in any of the value chains, so this data weakness does not strongly influence the results of the CBA, with the exception of soybeans. Because the benefits for that value chain are relatively marginal (the economic rate-of-return is 14%), an increase in the costs per beneficiary of anything more than approximately 18% would cause the economic benefits to become negative.
- Additionally, the overall costs of the model might be overstated because MARKETS II funding does go to technical assistance for actors further along the value chain, after the farm level. However, it was not possible to separate the costs and therefore, all MARKETS II costs were associated with this activity. Furthermore, this is not entirely unreasonable given that much of the later value chain assistance is targeted to absorb the increased yields of the commodities

[37] This is the modified internal rate of return which assumes a 12% reinvestment rate.

under MARKETS II assistance. The fact that farmers are able to sell their entire yield surplus is explicitly modeled into the CBA, and this assumption might not be possible without these downstream impacts as a result of the MARKETS II program.

- Wherever possible, we relied upon the data from the MARKETS II baseline survey to provide inputs into the model. Most of the price and quantity estimates for the farm budgets are derived from this survey. However, some of the survey numbers may be problematic, either due to low response rates for particular crops or regions, or due to data entry or response errors. Where price data varied too widely across value chains (for example, in fertilizer prices) or where we had conflicting information on the use of labor or other inputs, we relied on other data sources to supplement our models and make them coherent[38]. Better data quality in follow-on MARKETS surveys will help correct this weakness, and analysts should update the model as farm input usage and performance data becomes available.
- The CBA focused on the impact on smallholder farmers as the primary beneficiaries of the program, although the analyst team recognizes that MARKETS II activities have broader impacts for agricultural business services and other actors involved in the value chain, and for specific populations (e.g., women and youth) for many of their commodities.
- The model does not quantify the value of nutrition improvements at the household level, food security on a macro level, use of irrigated rice as food insecurity mitigation strategy, etc.

[38] The Table of Parameters for all models in the Excel file have identified where we used MARKETS II survey data or other data sources as appropriate.

Sensitivity Analysis & Risk Variables

Variability in the financial and economic results is assessed by performing sensitivity tests on key variables to determine how risky the overall investment in each value chain is. Overall the main risk variables across the value chains seem to revolve around the assumptions surrounding the revenues the farmers will achieve in each value chain and, specifically, the yields and post-harvest loss reductions targeted by the MARKETS II. These variables are discussed in detail below as they relate to each of the commodities, but it should be emphasized here that these targets need to be closely monitored throughout the life of the project. Additionally, some stakeholders expressed doubt that some yield targets will be maintained after the project is concluded – if this concern resonates with USAID or MARKETS II staff, then the yield numbers need to be revised to determine if it jeopardizes the viability of the project.

A number of variables were tested across all value chains including (but not limited to):

- Macroeconomic variables such as domestic inflation, US inflation, real exchange rate. This tests how vulnerable projects are to the macroeconomic conditions in Nigeria.
- Changes in real wages. Labor, as discussed in the Financial Analysis, is usually the largest component of total annual production costs. For this reason, testing each value chain for its sensitivity with respect to any increases in labor costs is important.
- Changes in material input prices. Input costs increase as a result of the MARKETS II intervention, as farmers move to more input intensive production and away from traditional cultivation practices. This increases the cost of material inputs overall. However, MARKETS II is also working with farmers and farmer associations to pool savings in order to buy inputs during the lowest cost period or in bigger quantities in order to reduce these costs. The sensitivity analysis tests the viability of these projects for changes in the costs (either increases or decreases) of material inputs (not including labor).
- Changes in the price of the commodity at the market. Given that prices can vary significantly from year to year for the commodities analyzed in this CBA, this is an important risk variable that was tested using sensitivity analysis.
- Changes in maximum average yields. As mentioned, this is a key risk variable that strongly impacts the benefits of the MARKETS II program. Most value chains have a slow increase in yields in the “with-project” scenarios and reach a maximum average – “average” because these are modeled to be the average yields that all farmers will achieve in each value chain.
- Project parameters such as total beneficiaries assumed to adopt the improved practices, the adoption rate over time, and the total USAID cost per value chain. These parameters influence the total economic benefits when the financial benefits, per farmer, are scaled to include all farmers benefitting. It also strongly impacts the economic costs assumed across all value chains.

The Nigerian currency has a history of fluctuating and has most recently weakened as a result of the drop in oil prices. In November, the Central Bank has allowed the naira to devalue by roughly 12% against the dollar in 2014. This was tested in the models and does negatively impact the smallholder farmer by increasing their costs of imported inputs such as fertilizers and herbicides, and therefore increases overall production costs. However, this does not cause any annual negative cash flows for the farmers – with the exception of the first year of implementation. Therefore, any farmers starting to work with MARKETS II in the current planting period may have negative cash flows (e.g. cassava farmers, sorghum farmers). This may impact adoption rates. Over time, even the current exchange rate will not negatively impact the economic viability of any of the value chains.

Aquaculture

As with the other value chains, various inputs in the aquaculture model were subjected to sensitivity analysis to determine whether the model's results were robust to different assumptions. The results are robust to most of the model's assumptions, including macroeconomic variables (inflation/exchange rates, etc.), assumptions about USAID value chain costs and the number of beneficiaries reached, and most farm budget variables. The project's financial and economic returns are not reversed under even relatively pessimistic assumptions regarding the domestic price of fish, the overall cost of inputs, the cost of labor, or changes in fish yields for the with- and without-project scenarios.

The only sensitive factors for aquaculture are:

- **The Net Feed-Conversion Ratio (FCR).** One of the main goals of the project is to make farmers more efficient, particularly in their use of feed. Currently, farmers use primarily locally produced feed or on-farm feed substitutes (like crop residues), which are less expensive but also much less efficient than higher-quality extruded floating feed, which is primarily imported. Additionally, farmers often use less-than-optimal feeding routines, which cause food to get wasted, increasing the FCR. The base case analysis assumes that farmers' FCRs improve from 1.4 under the without-project scenario to 1.2 under the with-project scenario. If without-project farmers are actually more efficient than this, or if with-project farmers don't increase their efficiency by this much, a significant portion of the benefits of the project will not be realized. In fact, must be able to achieve an improvement in their net FCRs of at least .11 in order to be better off under the project than they would be without the project. This is particularly true since farmers with the project are using much more imported feed, which has a higher per-unit cost than the lower quality feed used by non-MARKETS farmers. However, in reality it is likely that farmers will be able to achieve at least this amount of efficiency gain through the use of high quality feed and better feeding patterns. Catfish farmers routinely achieve FCRs of 1.0 to 1.1 or even lower, depending on the type of tank and other factors, so it is very realistic to think that they can achieve FCRs of 1.2 on average under the project. However, this is an important variable to monitor in order to ensure that farmers are producing as efficiently as possible.
- **The Imported Fish-feed price.** Connected with the previous point, the other variable which is sensitive to variation is the price of imported fish feed, which constitutes a primary component of the farm budget for MARKETS farmers. And increase of 10% in the average cost of feed, all

else equal, would cause the economic value of the project to be negative, while a 20% increase would cause both the economic and financial values to be negative. Of course, in reality the price of fish in the market is largely determined by the cost of production, so that increases in the cost of inputs would probably be matched to some degree by increased prices for fish. However, given that farm cash flows are so sensitive to this variable, and given that its price is largely determined internationally, it is important to monitor the cost of imported feed for local farmers in order to protect them against sudden price spikes.

Finally, we evaluated the sensitivity of variables in pairs. Under this analysis, a few pairs of variables demonstrated sensitivity. Specifically, decreases in the with-project yield, coupled with decreases in the real price of fish would cause the financial and economic values to be negative. Secondly, increases in the with-project FCR, coupled with reduced with-project yield, would jointly imply that farmers were not experiencing sufficient efficiency increases to justify their additional investment, and the financial analysis becomes negative. Finally, increased feed prices, coupled with increased with-project FCRs, would cause farmers to lose money relative to the without-project scenario. Farm input and output prices do change over time in sometimes unpredictable ways, so it is important to monitor these in order to avoid negative impacts on farm income.

Sensitivity of a range of variables on financial and economic NPV: Aquaculture Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$6,620	$12,262
Economic discount rate	12%	6%	25%	$42 million	$140 million		
Real wage change	0%	-3%	4%	$90 million	$93 million	$8,400	$8,511
Real input price changes	0%	-10%	10%	$64 million	$120 million	$6,976	$9,954
Real output price change	0%	-10%	10%	$50 million	$133 million	$5,961	$10,968
Additional yield improvements, years 2-10	1%	-2%	4%	$64 million	$108 million	$4,553	$10,702
Total beneficiaries change	0%	-40%	20%	$54 million	$111 million		
Adoption rate	80%	50%	95%	$50 million	$97 million		
Net Feed Conversion Ratio	1.2	.9	1.3	-$79 million	$605 million	-$457	$35,228
Imported fish feed price	275	235	350	-$253 million	$276 million	-$9,552	$18,073
Proportion of feed imported	67%	40%	80%	$9.8 million	$256 million	$4,182	$17,029

Cassava

The results from the cassava analysis – both financial and economic – are fairly robust. These results are not particularly sensitive to macroeconomic variables (such as domestic and U.S. inflation rates, changes in the exchange rate, etc.) and the project is viable from a very conservative range of discount rates. The cassava value chain also remains viable, even if real wages and material input prices increase from their current values. Changes in the market price of cassava is also not considered a risk variable for the cassava value chain.

This project will also remain economically viable even if there are different assumptions about the adoption rate of the beneficiaries, or the total number of beneficiaries that are reached, or even the USAID costs for this particular value chain.

The only sensitive factors for cassava are:

- **Yields.** Farmers will not have a positive financial NPV if they do not achieve above a maximum yield of 21.39 MT per hectare in the first harvest using the improved stems (from a baseline of 11.2 MT per hectare) – all else equal. The official life of project (LOP) target is at least 23.54. However, according to data from southwest cassava producers in 2011, the average farmers were achieving 24.10 MT per hectare. Interviews with IITA suggest that farmers could achieve even as high as 28 to 30 MT per hectare under fairly good conditions. IITA even released two new varieties in Nigeria last year which claim to have maximum potential yields between 49 and 53 MT per hectare.[39] Given the potential of the improved varieties being introduced to farmers, it is likely that yields will exceed the required 21.4 MT per hectare required for this investment to be profitable for cassava farmers; however, this indicator should be monitored and farmers achieving less than this are a risk for dropping out of the program. Additionally, yields decrease in the subsequent years when the stem is recycled. We have modeled a 10% annual decrease in yields but this project will not be economically viable if the annual decrease in yields is over 17.1% each year between purchasing new stems. This is all the more sensitive should there be any change in labor or input costs, or any drop in cassava prices.
- **Intercropping Income.** Farmers are absolutely dependent on the net intercropping income they receive from groundnuts (or other crops) in the first year of growing the improved stem (i.e., with-project). MARKETS II teaches farmers to replace the stems every 3-4 years, the main CBA model has used the assumption that stems are replaced every four years to be conservative. Which means, every four years the new stems take longer to mature: roughly 16 months compared to 10-11 months when the stem is recycled. During this long growing period, the CBA assumed farmers are achieving a net annual income of nearly 80,000 naira per hectare. The project is no longer economically viable if the farmers earn only 63,216 Naira per hectare per year when they intercrop. Obviously, the farmers are not replacing their stems all at the same time so the actual annual financial impact may not be as severe as modeled below. However, the economic impact would remain the roughly same if the annualized intercropping income should decrease.

[39] IITA "Nigeria releases improved cassava varieties to boost productivity".

Sensitivity of a range of variables on financial and economic NPV: Cassava Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$670	$275
Economic discount rate	12%	6%	25%	$9,533,394	$1,029,489		
Real exchange rate movement	0%	-4%	5%	$8,494,169	$155,309	$520	$232
Real wage change	0%	-3%	4%	$5,531,332	$4,713,223	$421	$386
Real input price changes	0%	-10%	10%	$8,051,792	$2,327,225	$515	$297
Real output price change	0%	-10%	10%	$2,830,173	$7,548,844	$309	$503
Decrease in annual yields when stem is not recycled	-10%	-18%	0%	-$619,043	$12,910,382	$166	$725
Maximum yield, with project, MT/ha	24.10	18.0	28.0	-$16,430,769	$19,012,309	-$509	$991
Intercropping Income, NGN/ha per year	79,664	20,000	110,000	-$13,634,785	$14,760,692	-$335	$793
Total beneficiaries change	0%	-40%	10%	$2,223,512	$5,931,008		
Adoption rate	90%	50%	95%	$1,893,957	$5,601,453		
USAID costs change	0%	-30%	50%	$5,857,153	$4,076,768		

Cocoa

The results from the cocoa analysis – both financial and economic – are fairly robust. These results are not particularly sensitive to macroeconomic variables (such as domestic and U.S. inflation rates, changes in the exchange rate, etc.) and the project is viable from a very conservative range of discount rates. The cocoa value chain also remains viable, even if real labor wages and input prices increase from their current values. Changes in the market price of cocoa is also not considered a risk variable for the value chain.

This project will also remain economically viable even if there are different assumptions about the adoption rate of the beneficiaries, or the total number of beneficiaries that are reached, or even the USAID costs for this particular value chain.

The only sensitive factors for cocoa are:

- **Average maximum yields achieved.** Average yields without the project are modeled to be 0.4 MT per hectare and could reach an average increase to 0.7 MT per hectare with-project. All else equal, this project needs to achieve at least an average yield of 0.43 MT per hectare to remain viable.

Sensitivity of a range of variables on financial and economic NPV: Cocoa Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$6,306	$2,784
Economic discount rate	12%	6%	25%	$389 million	$104 million		
Real exchange rate movement	0%	-4%	5%	$260 million	$229 million	$4,056	$3,753
Real wage change	0%	-3%	4%	$249 million	$245 million	$3,959	`
Real input price changes	0%	-10%	10%	$245 million	$250 million	$3,891	$3,981
Real output price change	0%	-10%	10%	$3 million	$8 million	$309	$503
Maximum yield, with project, MT/ha	0.70	0.50	0.72	$64 million	$266 million	$1,263	$4,203
Post-harvest losses, with project	20%	15%	45%	$279 million	$89 million	$4,393	$1,652
Total beneficiaries change	0%	-40%	10%	$146 million	$272 million		
Adoption rate	90%	50%	95%	$135 million	$261 million		
USAID costs change	0%	-30%	50%	$249 million	$245 million		

Any farms that don't achieve the target post-harvest losses of 20% and yields of 0.7 MT per hectare with-project could be misled into making sub-optimal investment decisions. For example, farmers that only achieve 0.50 MT per hectare on average and reduce post-harvest losses by 10% will have a negative financial NPV as show in the next table. Both variables need to be monitored to ensure these farmers aren't making bad investment decisions.

Interaction between expectations on yields and post-harvest losses in the cocoa value chain

	Incremental FNPV ($)	**Change in Max Yield, *MT/ha, with project***					
	$3,936	0.50	0.55	0.60	0.65	0.70	0.72
	15%	$1,589	$2,289	$2,990	$3,692	$4,393	$4,673
	20%	$1,263	$1,930	$2,598	$3,268	$3,936	$4,203
	25%	$936	$1,571	$2,207	$2,844	$3,479	$3,733
	30%	$610	$1,213	$1,816	$2,419	$3,023	$3,263
Post Harvest Losses *with project*	35%	$284	$854	$1,424	$1,995	$2,565	$2,793
	40%	$42	$495	$1,033	$1,571	$2,108	$2,324
	45%	$370	$135	$641	$1,147	$1,652	$1,854
	50%	$695	$223	$250	$722	$1,195	$1,384

Maize

The financial analysis for maize is positive and robust to varying assumptions about many of the inputs into the model. Specifically, we evaluated changes in assumptions about the macroeconomic variables (inflation, exchange rates, and discount rates), input prices and usage, wage increases, output prices and real price changes, and assumptions about changes in the yield of maize for farmers in both the without-project and with-project scenarios. In virtually all cases, altering our assumptions by a relatively large degree did not cause farmer incomes to become negative, so we can be confident that the maize value chain will improve farmer cash flows under a variety of scenarios, with one exception. An average annual productivity decrease of 2% among farmers in the "with-project" scenario would cause the economic NPV to become negative, although farmer NPVs remain positive under all scenarios. This scenario is unlikely—if anything, it is more likely that project farmers will experience more rapid productivity increases than "without-project" farmers.

We also evaluated several variables jointly to determine the potential for changes in more than one variable to affect the important outcomes of the project. The only combination of variables that was found to be sensitive for the financial returns to the maize value chain was changes in the real price of maize and the initial yield for with-project farmers. For relatively pessimistic assumptions for these two variables (initial yield of less than 2 MT per ha and real maize prices (real annual decreases of 5-15%), the financial returns to farmers become negative. This implies that if maize prices decrease significantly year-on-year and if farmers aren't able to increase production above 2 MT per ha, they would be worse off with the project than without. However, since both of these represent fairly pessimistic assumptions about the future, it is unlikely that both would occur simultaneously. This analysis does, however, point out the importance of yield increases in increasing farm incomes, particularly since farmers can do little to affect the market price of maize. If maize prices were to decrease during the period of the project, achieving the projected yield increases becomes increasingly important.

The economic value of investments in the maize value chain show roughly the same pattern as do the financial returns to farms, with variation in individual assumptions not causing the economic value to become negative. Again, when we looked at simultaneous changes in two variables, decreases in the real price of maize that occur at the same time as limited yield increases (with-project initial yields of less than 2 MT per ha) could cause the economic value of the project's maize investments to become negative. Again, these assumptions are relatively pessimistic, but if real prices were to decrease for maize during the project lifetime, it would be important to ensure that farmers were achieving expected yield increases in order for the project to create real economic value for Nigeria's economy.

Sensitivity of a range of variables on financial and economic NPV: Maize Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$1,018	$1,719
Economic discount rate	12%	6%	25%	$39 million	$85 million		
Real exchange rate movement	0%	-4%	5%	$27 million	$69 million	$1,115	$1,540
Real wage change	0%	-3%	4%	$45 million	$58 million	$1,249	$1,452
Real input price changes	0%	-10%	10%	$40 million	$66 million	$1,226	$1,519
Real output price change	0%	-10%	10%	$24 million	$82 million	$942	$1,802
Additional yield improvements, years 2-10	4%	-2%	10%	-$29 million	$151 million	$181	$2,799
Maximum yield, with project, MT/ha	5	3	8	$39 million	$52 million	$1,186	$1,372
Total beneficiaries change	0%	-40%	20%	$29 million	$65 million		
Adoption rate	90%	50%	95%	$27 million	$56 million		
USAID costs change	0%	-30%	50%	$49 million	$55 million		

Rice (rainfed and irrigated)

The financial analysis for both rainfed and irrigated rice is positive and remains positive despite pessimistic assumptions in the macroeconomic variables, inflation rates, and price increases for inputs, wages, cost of seeds, and decreased prices for rice. The financial viability of the farmers also remains positive for a range of assumptions on the price of seeds, price of other inputs, and labor wages. The financial analysis is fairly robust for both rainfed and irrigated rice.

Both irrigated and rainfed rice production remains economically viable even if there are different assumptions about the adoption rate of the beneficiaries, or the total number of beneficiaries that are reached, or even the USAID costs for this particular value chain.

Both rainfed and irrigated rice value chains are sensitive to the following:

- **Average maximum yields achieved.** This impacts both the financial and economic viability of the both rice value chains. Lowland rainfed rice is modeled to improve to a maximum of 5.6 MT per hectare from a baseline of 2.58 MT per hectare; irrigated rice is expected to achieve a maximum average yield of 6.7 MT per hectare over a baseline of 3 MT per hectare. It was assumed that it takes three years to achieve these maximum average yields, and they will be maintained for the next 7 years (until the end of the 10-year period of analysis). Rainfed rice farmers need to achieve a maximum average of 4.1 MT per hectare and irrigated rice farmers need to achieve a maximum average of 4.8 MT per hectare in order for this project to remain financially viable. In fact, if the assumptions in the irrigated rice model for yields decrease by 26% the farmers will not be financially viable (which means dry season rice would need to achieve 4.9 MT per ha and rainy season rice would need to achieve at least 4.15 MT per ha). Other stakeholders familiar with rice production in Nigeria expressed some concern about the feasibility of farmers to achieve average yields above 3.5 MT per hectare over the next 10 years even using FARO 44; if this concern is well placed, this variable is considered a significant risk factor and should be closely monitored by the project team.

Finally, estimating the willingness to pay for premium rice was not empirically measured in Nigeria and estimates from other countries were used. The base model estimates a 25% willingness to pay premium (for a reminder of why this estimate was included in the rice model only, please see the Economic Analysis for rice section). This assumption was also tested for its impact on the economic NPVs for both rainfed and irrigated rice, and does not seem to be sensitive.

It's clear that both irrigated and rainfed rice interventions are very sensitive to the average yield assumptions. The other sensitive variables are beyond the control of MARKETS II (such as the import tariff regime) but are still heavily influential in the economic viability of this project.

Sensitivity of a range of variables on financial and economic NPV: Rain-fed Rice Value Chain

Variable	**Base Case Value**	**Sensitivity Analysis Range**		**Economic NPV Range**		**Financial NPV Range**	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**
Financial discount rate	16.8%	7%	25%			$2,903	$1,370
Economic discount rate	12%	6%	25%	$174 million	$71 million		
Real exchange rate movement	0%	-4%	5%	$129 million	$59 million	$1,982	$1,695
Real wage change	0%	-3%	4%	$116 million	$78 million	$1,943	$1,755
Real input price changes	0%	-10%	10%	$129 million	$74 million	$1,986	$1,752
Real output price change	0%	-10%	10%	$37 million	$166 million	$1,388	$2,350
Maximum yield, with project, MT/ha	5.60	3.50	5.8	-$330 million	$143 million	-$1,438	$2,185
Total beneficiaries change	0%	-40%	10%	$54 million	$113 million		
Adoption rate	90%	50%	95%	$48 million	$108 million		
USAID costs change	0%	-30%	50%	$107 million	$93 million		

Sensitivity of a range of variables on financial and economic NPV: Irrigated Rice Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$6,910	$3,424
Economic discount rate	12%	6%	25%	$55 million	$11 million		
Real exchange rate movement	0%	-4%	5%	$40 million	$22 million	$4,776	$4,237
Real wage change	0%	-3%	4%	$39 million	$23 million	$4,795	$4,201
Real input price changes	0%	-10%	10%	$40 million	$25 million	$4,788	$4,338
Real output price change	0%	-10%	10%	$13 million	$52 million	$3,511	$5,615
Maximum yield, with project, MT/ha	6.7	3.0	7.0	-$152 million	$45 million	-$5,702	$5,249
Total beneficiaries change	0%	-40%	10%	$22 million	$37 million		
Adoption rate	90%	50%	95%	$17 million	$35 million		
USAID costs change	0%	-30%	50%	$34 million	$32 million		

Sorghum (white)

As with the other value chains, we subjected the results of the sorghum value chain analysis to sensitivity analysis across several of the model's most important inputs, including the major macroeconomic variables, assumptions about input prices and usage, output prices and yield assumptions. The financial returns for sorghum farmers are robust to each of the individual assumptions of the model, implying that farmers will experience increased income from sorghum value chain investments, even under a variety of assumptions. There are two exceptions—the maximum yield that project farmers attain, and the incremental yield increases that they achieve under the project after switching to better inputs and improved practices. In either case, achieving total yields of less than 2.2 MT/ha or annual yield growth in years 2-9 of less than 1% would cause the project's economic NPV to be negative. However, farmers' NPVs would remain positive, meaning they would still benefit from the intervention.

Varying two model parameters simultaneously reveals some potential sensitivities — specifically, if a decrease in the real price of sorghum occurs while farmers fail to achieve yields of at least 2 MT per hectare—the farmers will experience negative incremental incomes as a result of the project. This implies that achieving the target yield for sorghum farmers will be very important for ensuring farmers experience income increases, particularly if the market price of sorghum decreases.

The economic value of sorghum investments is more sensitive to changes in the model's underlying assumptions. Specifically, decreases in the yield growth of sorghum over time or reduced assumptions about the max yield that farmers can achieve under the project potentially reduce the project's economic net present value to below zero. This reinforces the importance of achieving targeted yield increases in order to achieve positive economic benefits in this value chain. Similarly, when varying two assumptions simultaneously, the project's economic value becomes negative if farm yields fail to reach 2 MT/ha and the real price of sorghum decreases. This argues for the importance of achieving targeted yield increases, as market prices are subject to variation.

Sensitivity of a range of variables on financial and economic NPV: Sorghum Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$528	$1,053
Economic discount rate	12%	6%	25%	$20 million	$40 million		
Real exchange rate movement	0%	-15%	10%	$15 million	$32 million	$388	$1,741
Real wage change	0%	-3%	4%	$23 million	$28 million	$651	$723
Real input price changes	0%	-10%	10%	$20 million	$32 million	$622	$768
Real output price change	0%	-10%	10%	$14 million	$38 million	$501	$888
Additional yield improvements, years 2-10	4%	-2%	10%	-$15 million	$47 million	$70	$1,031
Maximum yield, with project, MT/ha	2.5	2.2	3	-$8 million	$82 million	$159	$1,586
Total beneficiaries change	0%	-40%	20%	$13 million	$32 million		
Adoption rate	90%	50%	95%	$12 million	$28 million		
USAID costs change	0%	-30%	50%	$23 million	$28 million		

Soybean

The soybean value chain has significant benefits, and, given the yield assumptions listed above its results appear robust to various assumption changes[40]. We tested variation in all major model inputs, including macroeconomic assumptions, farm input prices and usage, output prices, productivity assumptions, and project assumptions (beneficiary numbers and cost per beneficiary).

The financial results of the analysis are robust to variation in any individual model assumption, meaning that farmers stand to benefit from the intervention even if one of the model's assumptions is wrong. However, simultaneous changes in two variables cause the farmers incremental income to become negative—specifically, decreases in the real price of soybeans, coupled with either increases in input prices or limited yield increases by farmers, cause the farmers' incremental income to become negative, implying that they would be better off without the project.

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[40] It is important to note that the initially modeled target yield for soy farmers in the project was 1.6 MT per ha instead of 2.4 MT per ha. This figure corresponds to observed average yields for improved soy varieties in Nigeria from research, but MARKETS farmers are anticipated to exceed this level. Under the old, lower projected average yield, the model was significantly more sensitive to variation in underlying parameters. Particularly, the overall economic value of the project was significantly affected by variations in input prices, yield growth and output price assumptions, and USAID cost assumptions.

Likewise, the project's economic value appears to be robust to various assumptions. The only pair of variables that appear to materially affect the project's economic value are the with-project yield assumption and the price—if with-project soy yields reached only 1.75 MT per hectare, and this was coupled with a 10% decrease in the price of soybeans, it would be enough to drive the economic value of investments in this value chain below zero, implying that the benefits of the investments would not outweigh the costs to Nigeria's economy. This could potentially be an issue in scenarios where weaker world food prices corresponded with one or more poor local growing seasons—such a scenario could expose farmers to real losses.

Sensitivity of a range of variables on financial and economic NPV: Soybean Value Chain

Variable	Base Case Value	Sensitivity Analysis Range		Economic NPV Range		Financial NPV Range	
		Min	Max	Min	Max	Min	Max
Financial discount rate	16.8%	7%	25%			$6858	$1,371
Economic discount rate	12%	6%	25%	$20 million	$42 million		
Real exchange rate movement	0%	-15%	10%	$21 million	$31 million	$819	$975
Real wage change	0%	-3%	4%	$22 million	$30 million	$809	$981
Real input price changes	0%	-10%	10%	$23 million	$30 million	$843	$983
Real output price change	0%	-10%	10%	$16 million	$38 million	$646	$1,180
Additional yield improvements, years 2-10	18%	2%	25%	$5 million	$31 million	$373	$1,034
Maximum yield, with project, MT/ha	2.4	1.8	3	$7 million	$39 million	$432	$1,207
Total beneficiaries change	0%	-40%	20%	$14 million	$33 million		
Adoption rate	90%	50%	95%	$13 million	$28 million		
USAID costs change	0%	-30%	50%	$25 million	$28 million		

Additional Analysis

As mentioned, MARKETS II aims to sustainably improve the performance, incomes, nutrition, and food security of Nigerian poor rural farmers or smallholders in an environmentally appropriate manner through proven private sector demand-driven market interventions, focusing specifically on constraints in the agricultural value chain. Key objectives aim to help smallholder farmers access better inputs (such as improved seeds and optimal use of fertilizer), adequate finance, better water management, appropriate technology, extension services, and improved nutritional uses of grown or purchased basic foods . The approach of this CBA focuses on the impact to MARKETS II primary beneficiaries: the producers of the individual commodities and the measured impact on their performance and incomes. This is measured in the economy as producer surplus. However, the analysts recognize that other stakeholders in the economy benefit from MARKETS II activities as well, including and not limited to:

- The impact of improved nutrition,
- Youth and gender-related activities,
- Support to small-scale millers and large processors and traders, and
- Support to business support services that have a broader impact on value chains, such as the promotion of beekeeping and pollination services, pesticide spraying services, irrigation services, threshing and post-harvest services, etc.

Real economic benefits may be derived from all of the above listed activities that have not been directly modeled into the CBA. The impact of millers operating at capacity, as a direct result of the yield increases, limits the underutilization of capital and is a direct benefit of this program. Any service provider offering a service more efficiently than before adds to producer surplus and consumer surplus, if this translates to lower costs for the consumer. Finally, MARKETS II is doing a lot of research to introduce low-technology solutions to many of the value chains in Nigeria (e.g. fishnets for rice fields to keep the birds away, cassava lifters, UDP application for rice, Rhizobium Inoculant for soybean fields) that could have a significant and positive impact on the farm budgets. Until the potential for these solutions and markets are better understood, these impacts have not been analyzed. However, this might be a good opportunity to revisit this analysis once that data are available.

Additionally, the CBA has evaluated the various farm budgets at a national level and has not calculated separate NPVs by region at this point. That would require farm budgets for each distinct region, the data for which are not available. However, that could be a possibility moving forward if the data were to become available.

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