With a Little Help

Shocks, Agricultural Income, and Welfare in Uganda

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Abstract

Global poverty is becoming increasingly concentrated in Sub-Saharan Africa and among households engaged in subsistence agriculture in environments characterized by uncertainty. Understanding how to achieve sustainable increases in household incomes in this context is key to ending extreme poverty. Uganda offers important lessons in this regard. Uganda experienced conflict, drought, and price volatility in the decade from 2003 to 2013, while at the same time experiencing the second fastest percentage point reduction in extreme poverty per year in Sub-Saharan Africa. This study analyzes a nationally representative panel of 2,356 households visited four times between 2006 to 2012, in combination with data on conflict events, weather,

and prices. The study describes the type of income growth households experienced and assesses the importance of these external events in determining progress. The study finds substantial growth in agricultural incomes, particularly among poorer households. Many of the gains in agricultural income growth came about because of good weather, peace, and prices, and not technological change or profound changes in agricultural production. Therefore, although overall progress during this period was good, there were years in which average income growth was negative. This was particularly the case in the poorer and more vulnerable Northern and Eastern regions, and thus their overall income growth was also slower.

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With a Little Help: Shocks, Agricultural Income, and Welfare in Uganda

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I. Introduction

Global poverty, as measured by the international extreme poverty line of US\$1.90 a day, is becoming increasingly concentrated in Sub-Saharan Africa. It is also increasingly concentrated among households engaged in subsistence agriculture in environments characterized by uncertainty from conflict, vagaries of the weather and international food price fluctuations (World Bank 2016). Understanding how to achieve sustainable increases in household incomes in this context is key to ending extreme poverty.

Uganda offers important lessons in this regard. Uganda experienced conflict, drought and price volatility in its most important agricultural commodities in the decade from 2003 to 2013. This was also a decade in which Uganda recorded impressive rates of poverty reduction. Uganda saw the second fastest percentage point reduction in extreme poverty per year in Sub-Saharan Africa.² The proportion of the Ugandan population living beneath US\$1.90 a day fell from 62.2 percent in 2003 to 32.2 percent in 2013. Understanding the drivers of this reduction is important both for offering lessons on how to end extreme poverty in Uganda, but also for other countries in the region that have not experienced such a remarkable reduction in poverty.

Understanding the drivers of poverty reduction is a complex task, and an analysis of observational data does not always allow the causes of this progress to be uncovered. Nevertheless, careful analysis of a nationally representative panel data set collected from 2006 to 2012 in combination with data on conflict events, weather and prices allows us to describe the type of income growth households experienced and to assess the importance of these external events in determining progress.

Uganda's progress in reducing poverty in earlier years from 1993 to 2006 is a remarkable story of success that has been well told. Annual reductions in the national poverty rate of 1.9 percentage points resulted from the restoration of peace and stability to much of the country after Yoweri Museveni came in to power in 1986, the series of economic liberalization reforms that were implemented in the 1990s (such as coffee marketing reforms), and the investments by households and firms that these encouraged (see for example, Collier and Reinika 2003, Appleton 2004, Deininger and Okidi 2004). The narrative of Uganda's continued, albeit slightly slower, progress in reducing poverty since 2006 is less familiar. This was a period in which growth started to slow as the gains from the reforms were fully realized, and weak infrastructure and corruption increasingly constrained private sector competitiveness (World Bank 2015).

In this paper we use a nationally representative panel data set of 2,356 Ugandan households visited four times between 2006 and 2012 to document the type of income growth they experienced. We take advantage of the panel nature of the data to control for unobserved, time-invariant, household characteristics and analyze the degree to which income growth was driven by exogenous changes in prices, weather and the cessation of conflict during the period considered. We utilize the methods outlined in Dell et al. (2014) in which the impact of weather shocks is identified by using panel data and including household fixed effects to disentangle the impact of the shock from the impact of omitted variables which could be causing bias. This framework has been used to analyze the relationship between weather and household welfare outcomes in Munshi (2003), Dercon (2004), Yang and Choi (2007), Thomas et al. (2012), Anttila-Hughes and Hsiang (2013) and Hill and Porter

² Uganda reduced the extreme poverty rate by 2.9 percentage points a year, second only to Chad, which reduced the extreme poverty rate by 3.1 percentage points per year. This is using poverty numbers reported in Povcalnet as of January 2016, and using the surveys deemed comparable by World Bank 2016.

(2016). We extend this analytical framework to also examine the impact of external price shocks and conflict events on income and consumption.

We find substantial income growth, particularly in crop incomes, for both the average household and households in the bottom 40 percent of the consumption distribution. Growth in crop income was accompanied by increasing commercialization with 72 percent of farmers in the bottom 40 percent selling their crops in 2012 compared to 60 percent in 2006. We find that much crop income growth during this period is explained by good weather, peace and improved efficiency in food markets, rather than technological change in the nature of agricultural production. Rainfall and prices together can account for 51 percent of the improvement in crop income for all households, and 66 percent of the improvement in crop income for the bottom 40 percent respectively. Although the overall progress during this period was good, there were years in which the prices of agricultural products fell and rainfall conditions were not good, resulting in negative average crop income growth for some households. This was particularly the case in the poorer and more vulnerable Northern and Eastern regions, and as a result their overall income growth and progress in reducing poverty was slower.

Diversification of income offered households the ability to protect consumption from weather shocks, but it was less effective in mitigating price income shocks. Education is essential to enabling households to diversify and, as a result, to insure consumption from weather shocks. However, diversification alone was not enough to fully protect consumption from shocks. As a result, a decrease of 10 percent in the price of maize and beans results in a 5.1 percent reduction in consumption for the average household, and a 10.5 percent reduction in consumption among the bottom 40 percent. A decrease in rainfall of 10 percent results in a decline of 4.8 percent in per capita consumption for the average household.

The significance of external forces in driving income and consumption growth among the poorest households during this period of poverty reduction underscores the role that macro conditions and stability play in determining the fortunes of households. The government's success in securing peace in the north of the country and in allowing the development of agricultural markets for farmers to take advantage of new regional trade opportunities ensured widespread welfare gains. However, it also underscores that these gains are vulnerable and can be easily reversed by events beyond a government's control such as bad weather or price drops.

We also document that despite seemingly favorable conditions for agricultural investment during this period, there were very few changes in the way agricultural households produce. Specifically, few households increased adoption of improved inputs. Although it is not possible to calculate the returns to the use of inputs from the observational data available, we do observe that increased household input use is correlated with crop income growth. It is possible that these findings can be explained by the fact that the expected returns from input use remained negative for many farmers that chose not to use inputs (such as found in Ghana in Rosenzweig and Udry 2016). Indeed, the widespread presence of low-quality inputs reduces the returns to many inputs available on the market (Bold et al. 2015).

It is also possible that barriers to the adoption of inputs reduce their uptake. Bandiera et al. (2015) document that providing extension and access to credit to households increases their adoption of improved inputs, which suggests that lack of knowledge and credit constraints limit the degree to which households can take advantage of a favorable environment for investment. Regardless of the cause, the limited modernization of agricultural production observed during this period highlights that

better investment opportunities need to be available to farmers in Uganda, and further research on the interventions needed to ensure this is warranted.

This paper fits into the literature that uses household panel data to understand the drivers of income growth and welfare improvements (as in Deininger and Okidi 2003, Dercon 2004, Gunning et al. 2000, Jalan and Ravallion 1998, 2004). The focus of the analysis is on the exogenously determined factors. These are both the factors we can better identify the impact of, and, as it turns out, the factors that seem to explain much of the income changes observed. The findings are consistent with the results of Dercon (2004) and Gunning et al. (2000), in which weather shocks are found to be important determinants of household income growth.

II. Data

The analysis in this paper uses data from 2,356 households across Uganda, present in all the waves of the nationally representative Uganda National Panel Survey (UNPS) from 2005/6 to 2011/12. This survey is one of the LSMS-ISA surveys and has data on household characteristics, household consumption and income from a variety of sources. It also contains a rich agricultural module, a module on shocks, and is accompanied by a community survey. Many of the modules in the survey are comparable to the modules used in the nationally representative Uganda National Household Survey (UNHS), which is a cross-section survey and is used to compute the official poverty numbers. The consumption module is identical across the two surveys.

Four rounds of the UNPS are used in this analysis comprising data collected in 2005/6, 2009/10, 2010/11 and 2011/12 (henceforth 2006, 2010, 2011 and 2012). Households can be matched across rounds using a unique household identifier, and, in addition, a sample of households that split from the original household during this period are also followed. The attrition in the UNPS was quite substantial between 2006 and 2010, but it has been moderate in the latter three rounds (see Table 1). For the purposes of this analysis we focus on households that were present in all four rounds of the UNPS and that are engaged in agricultural production: a total of 2,356 households. This is done to ensure the panel is balanced, but it does result in the exclusion of households that have split from original households. Given the majority of this analysis is on agricultural income growth, and given many split-offs represent households that have moved out of the agricultural sector, this is not too much of a concern. Nonetheless, our findings are unchanged when the split-off households are included in the regressions.³

Table 1: Attrition in the UNPS by wave

	Sample	Original sample retention	Split-off HHs	Total
2006	3,123	100	0	3,123
2010	2,607	83.5	367	2,974
2011	2,564	82.1	305	2,869
2012	2,356	75.4	479	2,835

Source: Uganda Bureau of Statistics (2013)

³ Results are available from the authors on request.

The analysis uses both consumption and income aggregates (crop income, livestock income, wage income -agricultural and non-agricultural-, and income from non-farm self-employment) calculated from the UNPS data. The consumption aggregate used is the aggregate constructed by the Uganda Bureau of Statistics to generate the official poverty statistics. The majority of the income aggregates come from the Rural Income Generating Activities (RIGA) database, which uses standardized protocols to generate gross income aggregates across waves. Where inconsistencies were noticed, they were communicated to the RIGA team and corrected in the protocols we used. The RIGA aggregates calculate crop and livestock income using information on the amount of goods produced by the household in the last 12 months and the price of these goods reported by the household. Prices are imputed from other sampled households when they are not collected. The measures of crop and livestock income calculated are gross income not netting out costs of land, labor or purchased inputs. Wage income is generated from data collected on wages earned in the last 12 months. The self-employment income aggregate calculated all self-employment income earned in the last 12 months and nets out the cost of purchased inputs. Purchased inputs can be quite a large share of the income from self-employment activities such as petty trading or handicrafts and netting out the cost of these inputs is important. For more details on how these aggregates are constructed, see Carletto et al. (2007).

In order to assess real changes in incomes and consumption across time the analysis converts the nominal consumption and income aggregates into real aggregates. The national Consumer Price Index (CPI) is used to convert the consumption aggregate across years. Differences in the cost of living across space in Uganda are also accounted for by using a combination of the consumption aggregate provided by the Uganda Bureau of Statistics and the regional poverty lines. The regional poverty lines reflect differences in the cost of non-food requirements across regions and urban and rural locations in Uganda. Differences in the cost of food items are already incorporated in the consumption aggregate provided. For this analysis, the ratio of the poverty line across regions is used in order to correct for price differences across regions.⁴ The consumption aggregate and the income aggregates are divided by this ratio in order to bring all aggregates to one national price. Descriptive statistics on the consumption and income aggregates are presented in the next section.

In addition to documenting changes in consumption and income aggregates, the paper explores the drivers of changes in these aggregates. It relies on data collected in the household survey on household demographic characteristics, distance to market, extension visits, and the type and quantity of inputs used in agricultural production. Table 2 provides descriptive statistics for the key household characteristics used in the analysis.

As Table 2 highlights, on average, there has been surprisingly little change in the use of agricultural inputs in Uganda; which is perhaps unexpected given that this was a time in which crop prices—and thus presumably the returns to using inputs— changed considerably. In general, input use is very low in Uganda in comparison to other countries in the region with data collected using a similar survey instrument (Sheehan and Barrett 2014, Binswanger and Savastano 2014).

⁴ This may be an imperfect measure of regional price differences if regional food price differences are quite different from regional non-food price differences. Ideally the income aggregates would also correct for food price differences across regions, however in the absence of having these data, using non-food price differences appears to be a reasonable approximation.

In addition, the analysis incorporates data from other sources on market prices of agricultural products, weather and conflict. These data provide objective measures of shocks that households experienced during this time. Objective measures are preferred to subjective measures, in which the households themselves report whether they face one type of shock or another (Thomas et al. 2013, Anttila-Hughes and Hsiang 2014, Hill and Porter 2016). Households are more likely to recall shocks that resulted in large losses of income and not report those that did not. As such, there is likely to be significant reporting bias in the occurrence of shocks, which will bias the estimate of the impact of shocks on income and welfare. However, the cost of using objective measures of shocks is that our analysis is restricted to covariate shocks. That is, shocks experienced by everyone in a given area (weather, prices, conflict) that can be observed in data other than the household survey. This means that we are unable to say much about the idiosyncratic shocks that affect welfare in Uganda. In particular, we are unable to look at the impact of health shocks on welfare despite a literature that suggests un-insured health shocks have a substantial impact on welfare in Uganda (Bridges and Lawson 2008, Helbert et al. 2013, Aliga 2013).

More specifically, the following sources of secondary data were included:

- Monthly price data collected at eight wholesale markets across Uganda as part of the Uganda Bureau of Statistic's Consumer Price Index (CPI) data collection exercise. A 12-month moving average was assigned to each household according to the date in which they were interviewed. All prices are deflated by the national CPI before being used in the analysis such that the prices used capture relative price changes, i.e. the degree to which the maize price increased or decreased more than the price of the basket of consumption goods represented in the CPI. Each household is assigned the prices of the closest market, measured by geographical distance.
- Water Requirement Satisfaction Index (WRSI) calculated from satellite rainfall data for each pixel using a maize crop model calibrated to the growing seasons across Uganda. Specifically, the geoWRSI v 3.0 was used with the global PET and RFE⁵ v2 (2001-2014) time series. The WRSI is an indicator of crop performance based on the availability of water for the crop during the growing season. The index ranges from 0 to 100, where 100 means there was no deficit in the water needed, and each household was assigned the average between the main and short seasons for the period for which crop income data were collected.⁶ These data have been merged into the UNPS using the Geographical Information System (GIS) coordinates of households.
- As a proxy of the incidence of violence and conflict, we use the number of fatalities per year in a 25-kilometer vicinity of each household, obtained from the Armed Conflict Location Event Dataset (ACLED).

Table 3 provides a description of the type of crops grown by the households for the latter two years of the analysis. Maize, beans, matooke and cassava are the four most important crops as a share of total crop income. Maize and beans are universally important—comprising 10 percent or more of crop incomes in all regions in all years. Matooke is important in all regions except the Northern region,

⁵ Potential evapotranspiration (PTE) and satellite gauge rainfall estimate (RFE).

⁶ For those households in Uganda living below the equator, the main season runs from February to July and the short season runs from August to January. For households living in bimodal areas above the equator, the main season runs from August to January and the short season from February to July. For households in the north of the country, one season is present. The static soil WHC and average LGP inputs for Uganda that come with geoWRSI were used.

and cassava is important in all regions except the Western region. Given their importance, the analysis presented focuses on the prices for maize and beans, but other prices were also used in preliminary analyses.⁷

For the most part, it is crops that are produced for household, domestic and regional consumption that dominate crop income. Coffee is important for some households, but does not comprise more than 10 percent of crop income in any region in either 2011 or 2012. Given that coffee plays a relatively small role, and given the difficulty of examining the impact of coffee prices on coffee income with only four data points (all households in Uganda face farm-gate prices driven by the same international coffee price as documented by Fafchamps and Hill (2008)) the role of coffee prices is not considered in the analysis. Sunflowers produced for commercial production has increased in importance in recent years, particularly in the north, but it is still a relatively small share of crop income and is also not considered further. The growth of sugarcane, particularly in the Eastern region has been reported, but by 2012 it was not comprising more than 1 percent of crop income in that region.

Even though food crops dominate crop income, crop sales are important and increasingly so. The share of household income coming from crop sales has increased from 2006 to 2012. Figure 1 shows that the share of crop income marketed has increased over time for the bottom 40 percent. The share of households in the bottom 40 percent selling crops has increased from 60 percent in 2006 to 72 percent in 2012.

Figure 1: Share of crop income derived from crop sales, bottom 40 percent, 2006-2012

Source: Staff calculations using RIGA income aggregates calculated from UNPS 2006-2012

Figure 2 presents data on weather, price and conflict by region across the years considered in the study. Weather conditions were in general good, with rainfall deficits less than 20 percent in most cases. However, 2010 was a more challenging year for households and higher losses were observed (although no higher than 30 percent). The four years of data presented suggest that rainfall is more volatile in the north and east than in the center and west. The data also suggest larger losses on average in the west across the four years, but this may be on account of the fact that a maize model has been used to calculate the losses while this is not a crop grown in the west. The inclusion of regional dummies or household fixed effects controls for this persistent difference in the analysis.

⁷ Including prices of matooke, cassava, potatoes, rice, sorghum and coffee.

Prices have exhibited more volatility during this period than weather. Real prices for maize appear well-integrated across Uganda during this period, in that they move together quite strongly in all regions. Bean prices appear less well integrated. Maize and bean prices increased from 2006 to 2010. The real price of beans continued to rise in most markets in 2011, but maize prices crashed in that year.

Conflict with the Lord's Resistance Army affected the Northern region of Uganda during the early part of this period, and also impacted some households in the northern part of the Central region. The conflict was stabilized in 2008 and the impact of this is seen clearly in the reduction of conflict related fatalities reported in ACLED from 2006 to 2010. There was an increase in the number of fatalities reported in 2010 but this fell again by 2011.

Figure 2: Price, conflict and weather trends from 2006 to 2012

Source: Rainfall: staff calculations using geoWRSI v 3.0, with global PET and RFE v2 (2001-2014) time series. Fatalities: ACLED. Prices: UBOS market price data collected for the CPI.

Table 2. Household characteristics, by wave

	2006			2010			2011			2012		
	mean	s.d.	median	mean	s.d.	median	mean	s.d.	median	mean	s.d.	median
Age of household head	43.75	15.10	41.00	47.62	14.90	45.00	48.17	14.90	46.00	48.73	14.61	46.00
Household head is male	0.74	0.44		0.72	0.45		0.69	0.46		0.68	0.47	
Education of household head	2.49	1.29	2.00	2.43	1.28	2.00	2.54	1.31	2.00	2.45	1.27	2.00
Distance to market selling agricultural inputs in Km	10.05	10.92	7.33	6.99	8.43	4.00	6.92	9.19	4.00	5.15	5.09	4.00
Received any visits by extension services past 12 months	0.09	0.28	0.00	0.16	0.37	0.00	0.08	0.27	0.00	0.12	0.33	0.00
Total area planted self-reported, in Ha	2.79	3.22	1.82	3.69	3.56	2.43	3.10	3.18	2.02	2.90	3.07	1.78
Renter (land)	0.23			0.14			0.19			0.19		
Use of fertilizer (1=yes) during the year	0.17			0.22			0.22			0.24		
Use of pesticides (1=yes) during the year	0.13			0.16			0.14			0.12		
Use of seeds and seedlings (1=yes) during the year	0.64			0.80			0.69			0.71		
Any hired labor used (1=yes) during the year	0.56			0.57			0.52			0.44		
Number of fatalities in a 25km radius	4.78	21.3	0	1.64	6.07	0	2.37	10.63	0	0.28	1.39	0

Source: UNPS 2006-2012

Table 3. Share of crop income coming from each crop, by wave

	2011					2012				
	National	Central	Eastern	Northern	Western	National	Central	Eastern	Northern	Western
Beans	0.17	0.16	0.10	0.16	0.25	0.16	0.18	0.11	0.13	0.21
Maize	0.12	0.12	0.17	0.12	0.07	0.17	0.15	0.25	0.16	0.10
Matooke	0.16	0.24	0.11	0.02	0.30	0.16	0.25	0.08	0.02	0.34
Cassava	0.11	0.12	0.16	0.13	0.03	0.11	0.09	0.15	0.14	0.04
Sweet										
Potatoes	0.10	0.12	0.10	0.09	0.07	0.09	0.15	0.11	0.06	0.06
Groundnuts	0.07	0.04	0.10	0.07	0.07	0.06	0.02	0.08	0.06	0.05
Coffee All	0.05	0.08	0.06	0.01	0.05	0.04	0.08	0.03	0.01	0.05
Sorghum	0.04	0.00	0.04	0.09	0.02	0.04	0.00	0.03	0.09	0.02
Finger Millet	0.03	0.01	0.05	0.03	0.02	0.03	0.01	0.06	0.04	0.02
Simsim	0.03	0.00	0.01	0.08	0.00	0.02	0.00	0.01	0.06	0.00
Sunflower	0.01	0.00	0.00	0.04	0.00	0.02	0.00	0.00	0.05	0.00

Source: RIGA 2011-2012. Note: red indicates a share 10 percent and higher in a given region, green indicates a share between 3 and 10 percent in a given region.

III. Trends in income growth and poverty reduction

Information on real income per capita for households in Uganda across time is presented in Figure . The data represent weighted averages of income from crop farming, livestock production, wage employment (in agriculture and non-agriculture sectors) and non-farm self-employment. All values are in 2011 prices. Figure 4 provides the same information, but for households that were in the bottom 40 percent of the consumption distribution during at least one of the survey rounds. Figure 3 and Figure 4 show that agricultural income is the main source of income for households, particularly for those in the bottom 40 percent. Together, crop and livestock income comprised 57.5 percent of the income of Ugandan households in 2012 and 70.2 percent of the income of the bottom 40 percent. Within agricultural income, crop income dominates livestock income.

Income from non-farm self-employment is the second most important source of income when considering all households and it is followed by non-agricultural wage income. Finding a measure of non-agricultural self-employment income that compares well to the measures of gross agricultural income used in this analysis is not straightforward. Much self-employment income comes from trade and taking only gross sales does not give an idea of how much was earned. We use net self-employment income in the analysis, which is gross self-employment income net of raw materials, operating expenses and wages paid to others. Raw materials account for 81 percent of these expenditures. Operating expenses and wages paid to others account for 12-13 percent of gross income, suggesting that self-employment income would be a marginally more important source of income were these expenses not netted out. Non-farm self-employment income is also the second most important income source for poor households, but only just. For poor households non-agricultural wage income is also a very important source of income.

Figure 3 and Figure 4 indicate substantial growth in real per capita agricultural incomes from 2006 to 2012 based on household survey data. On average, real per capita crop income grew by 9 percent per year, and by 8 percent for the poorest 40 percent. This reflects an increase in crop income between 2011 and 2012, but even when the period prior to 2011 is considered, growth in per capita crop income was robust: 4 percent on average across all households and for the bottom 40 percent. Growth in real per capita livestock income was quite constant at 5 percent annual growth (

Table 4).⁸

The national picture points to a pattern of sustained crop income growth across the years of the panel survey: 2006 to 2012. However, when crop income is disaggregated across regions, a slightly different picture emerges. First, from Figure 5 it is clear that the level of agricultural income varies substantially across regions, with much higher levels of crop income recorded in the Western region. The lowest levels of crop income are seen in the Northern region. Although crop income in the Central region is not particularly high, this reflects the fact that a much lower share of total income in the Central region comes from agriculture. In the Northern and Eastern regions agricultural income is the dominant source of income, as in the Western region, but overall levels of income are much lower.

Secondly, Figure indicates that agricultural income growth was negative between 2010 and 2011 in the Eastern and Northern regions. Although growth recovered between 2011 and 2012, the negative growth rate in the north and east resulted in both regions falling behind the center and west. In the following section we examine what drove these patterns.

Figure 3. Real income per capita levels by source of income, all households

Source: UNPS 2006-2012

Figure 4. Real income levels by source of income, bottom 40 percent

⁸ It is worth noting that the panel analysis may overestimate national average per capita agricultural growth (and underestimate national average per capita non-agricultural growth) as households that attrited over time are probably more likely to be those that have moved out of agriculture. However, the nationally representative cross-sections undertaken during this time show that many households have stayed in agriculture, so this is unlikely to be a large source of bias.

Source: UNPS 2006-2012

Table 4. Real per capita income growth by source of income, 2006 to 2012

		Crop	Livestock	Ag wage	Non-ag wage	Non-ag self
All households						
	2006	179,796	81,643	132,723	92,701	237,554
	2010	242,025	136,138	36,329	137,905	92,120
	2011	241,297	134,695	32,154	138,208	106,895
	2012	331,489	118,077	33,762	139,043	166,074
	Annual growth, 2006-2012	9%	5%	-18%	6%	-5%
	Annual growth, 2006-2011	4%	7%	-18%	6%	-11%
Bottom 40 percent						
	2006	122,175	52,945	79,799	35,846	34,176
	2010	206,352	101,512	36,678	59,297	70,004
	2011	187,213	92,671	38,116	68,375	54,962
	2012	300,687	110,956	35,757	59,550	80,611
	Annual growth, 2006-2012	14%	11%	-11%	8%	13%
	Annual growth, 2006-2011	6%	8%	-10%	10%	7%

Source: UNPS 2006-2012

Figure 5: Regional differences in per capita crop income growth, 2006 to 2012

Source: UNPS 2006-2012

To assess the role of different types of income growth in reducing poverty in Uganda we correlate the real per capita income aggregates with household consumption. This way, it is possible to ascertain whether growth in one of the income sources has been more important for increasing consumption than other income sources, particularly among the bottom 40 percent. Specifically, a fixed effects model was estimated using the log of per capita consumption and the log of per capita income (for each source of income), allowing an analysis of the relationship between changes in income and changes in consumption. Interview year and month fixed effects were also included. The analysis was conducted only for 2006 and 2010 as there is a marked reduction in the consumption aggregate after 2010 that is hard to explain and is inconsistent with the national poverty trends.⁹

⁹ One possible explanation is the methodological differences in the collection of consumption data in the 2011 and 2012 survey rounds. Computer Assisted Personal Interviews (CAPI) was introduced in the UNPS for the 2011 and 2012 rounds

The results are presented in Table 5 and indicate that increases in all income sources are positively correlated with increases in consumption, as expected, with the exception of agricultural wage income. Agricultural income growth is more strongly correlated with consumption growth than the other sources of income growth, and the correlation is larger for the bottom 40 percent (column 2). These results suggest that agricultural income growth has been more important for poverty reduction during this period than other types of income growth.

This confirms the finding of other work undertaken on this period in Uganda. Christiaensen and Kaminski (2014) undertake decomposition analysis using the same panel data set and find that agricultural income growth contributed to 18 percent of consumption growth from 2006 to 2010. They also estimate that agricultural growth contributed to 70 percent of the poverty reduction observed from 2006 to 2010, confirming the greater importance of agricultural income growth among the poorest households. Decomposition analysis undertaken using the Uganda National Household Survey¹⁰ for the Uganda Poverty Assessment also indicates that it was poverty reduction among those households that cited agriculture as their main source of income that accounted for most of the poverty reduction in Uganda throughout the period 2006 to 2013 (World Bank 2016). These findings are also consistent with a literature that points to agricultural income growth as a major source of poverty reduction in the country (Kassie et al. 2011, Dorosh and Thurlow 2012, Government of Uganda 2014).

Table 5. Relationship between income and consumption, 2006-2010

	(1)	(2)
Dependent variable: log of per capita consumption	All households	Bottom 40 percent
Log of per capita real crop gross income	0.0324*** (0.00805)	0.0416*** (0.0103)
Log of per capita real livestock gross income	0.00573** (0.00283)	0.00479 (0.00347)
Log of per capita real agricultural wage	0.00127 (0.00239)	0.00186 (0.00278)
Log of per capita real non- agricultural wage	0.00553** (0.00271)	0.00505 (0.00359)
Log of per capita real self-employment income	0.00934*** (0.00246)	0.0106*** (0.00302)
Constant	10.28*** (0.140)	9.942*** (0.189)
R-squared	0.086	0.095
Number of HHID	2,644	1,853

Source: author calculations using the UNPS 2006 and 2010. Notes: The dependent variable is log of real per capita consumption. Household, year and month of interview fixed effects are included but not shown. Robust standard errors in parentheses. Coefficient statistically significant at: ***1%, ** 5%, *10%

and this may have resulted in a reduction in reported consumption. CAPI was not introduced in the nationally representative cross-sectional survey, the UNHS.

¹⁰ A nationally representative cross-section household survey conducted every three to four years to provide (among other things) data on poverty trends in the country.

IV. Analytical approach

Given the relevance of agricultural income, we now turn to examine the drivers of crop income and consumption growth in Uganda for the period 2006-2012.¹¹ More specifically, we examine the correlation between crop income growth and changes in production practices, access to markets and services. We also examine the degree to which changes in the external environment affected crop income.

To capture the impact of changes in production practices on crop income growth, data on the area and ownership of the plot being harvested; the use of fertilizer, improved seeds and pesticides and household labor inputs (both hired labor and family labor) are used. Data on changes in market access and extension services are also considered.

Changes in the external environment that may have impacted crop income are analyzed by looking at the effect of prices, weather shocks and conflict fatalities. Changes in the external environment can have an impact on crop income directly and/or indirectly through the way that households produce. For example, good weather has a direct impact on crop income by determining production quantities but it can also impact crop income indirectly through the household's decision to apply inputs as a response to weather. Good prices for crops increase crop income but they also increase the incentives to produce and may encourage increased input or labor use. As a result, when production practices are included in the regression along with variables that reflect the external environment, they are likely to capture some of the impact of the external environment on incomes.

For this reason, we run two regressions. The first regression includes variables on production practices, market access, extension services and the external environment. The panel nature of the data allows the inclusion of household fixed effects to control for time-invariant household characteristics. However, it is possible that omitted time-invariant characteristics influence both production practices and market access, and agriculture income. For example, it is possible that changes in distance to market and provision of extension services in the community are not fully exogenous, with investments in infrastructure and services being targeted to communities that are more (or less) agriculturally productive. For this reason, the coefficients on these variables cannot be considered causal. The results of this regression provide an indication of the correlation between changes in income and changes in production practices, markets access and services. Although the variables describing external shocks are exogenous to household behavior, the coefficients from this regression only pick up their direct impact on income (not its indirect impact through household behavior) and do not represent the full impact.

In a second regression, only those variables that considered to represent the external environment are included along with household fixed effects. This captures the full impact of the external environment on income. As Dell et al. (2014) discuss, the inclusion of fixed effects ensures that time-invariant aspects of the environment (such as the propensity for weather shocks to occur) are captured. This allows the coefficient to properly identify the impact of the change in external factors on agricultural income.

The two models estimated are given by equations (1) and (2) below:

¹¹ Crop income has represented 65 percent or more of the total agricultural income (not including wages) at the household level for the period studied.

$$\ln(Y_{i,t}) = \beta_0 + \beta_P P_{i,t} + \beta_D D_{i,t} + \beta_E E_{i,t} + u_i + \varepsilon_{it} \quad (1)$$

$$\ln(Y_{i,t}) = \beta_0 + E_{i,t} + u_i + \varepsilon_{it} \quad (2)$$

where $\ln(Y_{i,t})$ is the log of the real value of per capita crop income of household i at time t . $P_{i,t}$ is a set of variables representing production practices, containing the average plot area harvested by household¹² i at time t , and an indicator variable if the household owns or owns and rents plots (only renter is the excluded category), dummy variables for inputs such as fertilizer, pesticide, seeds/seedlings and hired labor, and the amount of family labor spent on the farm.¹³ $D_{i,t}$ includes the distance in kilometers of household i to the nearest market selling agricultural inputs at time t and whether extension services were provided to any household in the community. $E_{i,t}$ is a set of variables capturing the external environment. It includes the prices of maize and beans at the nearest major urban market to household i at time t , the WRSI weather measure experienced by household i at time t , and the number of fatalities in proximity to household i at time t .¹⁴ Household fixed effects are denoted by u_i .

Equation (2) is also applied to other sources of income and consumption in order to assess the importance of drivers of crop income in affecting total income and household consumption.

Finally, the following specification is used:

$$\ln(Y_{i,t}) = \beta_0 + \beta_{EX} E_{i,t} * X_{i,t} + u_i + \varepsilon_t \quad (3)$$

in which household characteristics, $X_{i,t}$, are interacted with $E_{i,t}$ order to identify which households were better able to take advantage of (or protect themselves from) changes in the external environment during this time. This sheds some light on what factors may help to further reduce poverty and vulnerability in Uganda.

V. Drivers of agricultural income growth

The results from the first model are presented in Table 6. As expected, per capita crop income is significantly higher among those who farm more land and apply more labor, fertilizer and pesticides. Households that used fertilizer and pesticides had crop incomes that were 12 and 19 percent higher than households that did not. The correlation between the use of these inputs and crop income is higher for the households that were in the bottom 40 percent: for these households crop incomes were 22 percent higher for those that used fertilizer and 14 percent higher for those that used pesticides. Crop income is not significantly higher among those using improved seeds. Although there was some increase in input use (at the extensive margin) among panel households during this period, the increase was relatively marginal. The proportion of households using fertilizer increased from 17

¹² Self-reported by the household.

¹³ An alternate specification was also run using the value of purchased inputs rather than a series of indicator variables in an attempt to capture the quantity of inputs used. The results are qualitatively unchanged.

¹⁴ A variation of specification (1) and (2) where a measure of whether the household was affected (i.e. was within a 5 km radius) by a flood episode identified between November and December 2011, and between August and September 2012 was also included in E , but results are not statistically significant from zero. Flood episodes were calculated by digitizing flood imagery downloaded for flood events recorded in the Emergency Database (EM-DAT). These data are available from 2011 onwards, so they only cover the last wave of the UNPS used in our analysis (2012), which might explain the insignificant results obtained.

percent in 2006 to 24 percent in 2012 while pesticide use hovered around 12-13 percent. As a result, technology adoption did not contribute to large increases in crop incomes on average.

Households that farmed more land received higher per capita crop income, but per capita income did not increase by much for each additional hectare of land cultivated. The coefficient estimates suggest that an increase in the area of land farmed by 1 hectare increased crop income by around only 2 percent. In addition, very little change in the area of land cultivated was recorded during this time. Detailed analysis on area of land cultivated in Uganda and other Sub-Saharan Africa countries shows that relying on self-reported land areas results in considerable (and systematic) measurement error (Kilic et al. 2014 and Carletto et al. 2015). Indeed, we see the self-reported area of land cultivated fluctuating over the four rounds perhaps more than the true area of land cultivated. However, there is very little growth in the land cultivated over the period and, as result, expansion of land cultivated by these households did not contribute much to the increases in average per capita income growth observed.

Households that apply more labor—both family labor and hired labor—also have higher crop incomes, as expected. A 10 percent increase in the number of days of family labor provided by the household is correlated with crop income increasing by 2 percent. The amount of household labor reportedly spent on agricultural production increased substantially between 2006 and 2011, falling again in 2012. This may not reflect a true change in household labor applied during this time. However, even if this does represent a real increase, the increase of 50 percent reported would only account for 10 percent of the increase in crop income. Regression results indicate that households that hire labor have indeed agricultural production that is higher by 15-25 percent, but the use of hired labor actually fell during this time.

There is no direct income effect of extension provision in the village or changes in the distance to the local market.

In summary, although production practices are, as expected, significantly correlated with crop incomes in Uganda, the evidence does not suggest that changes in production practices contributed much to crop income growth during this time. For households that did change production practices, large changes in income were observed but few households changed production practices during this time, with the exception of increasing the amount of family labor applied to crop production (until 2011).

The little change in production practices among farmers in itself is a puzzle. This was a period in which the return to changing production practices was relatively good: the weather was favorable and prices were high. It could be that even with favorable conditions the perceived or actual return to new technologies is still low (as suggested in Bold et al. 2015), or that farmers had difficulties in accessing inputs, in utilizing properly (lack of knowledge) or the financing needed to make input purchases (as suggested in Bandiera et al 2015). Further analysis of why so few households adopted modern production practices is needed to better understand input adoption and utilization.

The results in Table 6 suggest that it was the external environment, rather than changes in production practices, that can explain crop income growth during the period, particularly for the poorest. The strongest correlates of changes in crop incomes presented in columns (1) and (2) are changes in rainfall and prices. The estimates in columns (3) and (4) show that better rainfall and higher prices contributed substantially to higher income. A 10 percent increase in water sufficiency (rainfall) increases crop income by 9.9 percent. A 10 percent increase in the price of maize or beans increases crop income

by 4.5 and 9.2 percent respectively. The point estimates are higher for poorer households, given that they are even more dependent on climate and prices. For these households, a 10 percent increase in rainfall and a 10 percent increase in maize and bean prices, results in a 13.4 percent and 13.0 percent increase in crop income respectively. Rainfall and prices improved over 2006-2012, and together they can account for 51 percent of the improvement in crop income for all households and 66 percent of the improvement in crop income for the bottom 40 percent respectively.

Changes in prices may reflect the beneficial effects of improved infrastructure investments, increased efficiency in domestic markets, and development of new export markets. Markets in the north and east of Uganda have been improving since 2006 thanks to infrastructure investments, new export markets opening up in South Sudan and in Kenya, and growth in trade services, which improved efficiency in markets. However, markets are subject to changes in supply and demand conditions within and outside Uganda. Sustained growth in the incomes and welfare of rural households will also require growth in agricultural productivity—possibly through the use of improved seeds, fertilizer, pesticides and irrigation—and diversification to other more remunerative forms of employment.

The results in Table 6 also indicate that peace had a strong impact on income as a result of its impact on changing production practices. In columns (1) and (2) when production practices are included in the specification, conflict does not impact income. However, when production practices are not included we see that crop income grew by 1.5-1.8 percent for every 1 percent reduction in the number of fatalities in a 25 kilometer radius of the village. This means that the establishment of peace observed between 2006 and 2010 resulted in more than a doubling of crop income.

The regression results presented thus far do not include year fixed effects given the objective of the analysis is to explain changes in crop income across years. However, it is possible that other differences across years, correlated with changes in the external environment, are driving the results. In order to test this possibility a regression model including year fixed effects is presented in Table 7. The significant results of weather, prices and peace are robust to this addition and the magnitude of the coefficients remains unchanged. However, maize prices become insignificant. This is not surprising given how integrated maize markets appear in Figure 2 resulting in very little within year variation. As a final robustness check, a specification in which prices of regional crops—matooke in the center and west, and cassava in the north and east—were included instead of bean prices is run (results are not shown). These checks also produced the same findings: production practices played a role, but changes in the external environment were the main drivers of changes in crop income in Uganda.

Table 6: Changes in agricultural income: fixed effects

	All households	Bottom 40 percent	All households	Bottom 40 percent
Farming practices				
Total area planted self-reported, in Ha	0.00734** (0.00313)	0.00846 (0.00674)		
Renter (land)	0.0682 (0.126)	-0.0343 (0.189)		
Used of fertilizer	0.0846 (0.0523)	0.217** (0.0904)		
Use of pesticides	0.149*** (0.0479)	0.147** (0.0695)		
Used improved seeds/seedlings	0.0238 (0.0549)	0.0407 (0.0760)		
Hired labor used	0.148*** (0.0475)	0.209*** (0.0653)		
Log of number of days of family labor	0.173*** (0.0343)	0.231*** (0.0476)		
Access to markets and services				
Distance to output market (km)	-0.00613 (0.0194)	-0.00747 (0.0304)		
Any extension in village in past 12 months	0.0600 (0.0457)	-0.00359 (0.0726)		
External environment				
Log of rainfall (percent of needs measured by WRSI)	0.986*** (0.196)	1.356*** (0.280)	1.886*** (0.343)	2.417*** (0.506)
Log of maize price	0.446*** (0.0674)	0.544*** (0.0970)	0.492*** (0.0840)	0.715*** (0.113)
Log of beans price	0.922*** (0.143)	1.295*** (0.213)	1.091*** (0.155)	1.247*** (0.214)
Log of number of fatalities	0.00849 (0.0413)	0.0406 (0.0577)	-0.146*** (0.0515)	-0.187*** (0.0662)
Constant	-2.048 (1.521)	-7.283*** (2.252)	-6.619*** (2.010)	-11.48*** (2.818)
Observations	5,145	2,501	6,852	3,334
Number of HHID	1,806	871	2,044	966

Source: Staff calculations using UNPS 2006-2012. Note: Dependent variables is log of real per capita crop income. Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table 7: Changes in agricultural income: robustness checks (including year fixed effects)

	All households	Bottom 40 percent
Distance to output market (km)	-0.0251 (0.02688)	-0.00153 (0.0381)
Any extension in village in past 12 months	0.188*** (0.0572)	0.215** (0.0873)
Log of rainfall (percent of needs measured by WRSI)	2.210*** (0.558)	3.170*** (0.824)
Log of maize price	-0.0918 (0.355)	0.313 (0.467)
Log of beans price	1.260*** (0.454)	1.447*** (0.542)
Log of number of fatalities	-0.147** (0.0619)	-0.144* (0.0769)
Constant	-5.717 (4.209)	-13.80** (5.748)
Observations	6,852	3,334
Number of HHID	2,044	966
Year fixed effects	Yes	Yes

Source: Staff calculations using UNPS 2006-2012. Note: Dependent variables is log of real per capita crop income. Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

As Figure 2 shows, the external environment was changing in different ways across the four regions during the period 2006-2012. The Northern region in Uganda is the most drought prone and although rainfall was in general good during 2006 to 2012, the rainfall shortfall in 2010 was much larger in the north than elsewhere in the country. The Eastern region also experienced substantial variability in rainfall. The north is also the part of the country that experienced conflict until the cessation of hostilities in the late 2000s, and thus it is this north that saw the largest decline in the number of fatalities as the result of peace. Maize prices are expected to be particularly important in the north and east, both on account of its predominance in production in the east, but also because a lot of maize trade into Kenya and South Sudan comes from these regions. There are also large and increasing regional variations in welfare across Uganda. The Western and Central regions are more economically developed, and households in these regions exhibit more diversified incomes as a result. They have had many more years of stability than the Northern region and these regions have seen substantial development during this time. More stable climatic conditions and rapid urban growth in and around Kampala has also helped.

Given these divergent starting points and experiences, regressions are run separately for each of the four regions and presented in Table 8. Weather is a strong driver of crop income growth in the north and east, but not in other regions. And particularly in the north: a 10 percent rainfall shortfall results in a reduction in crop income of 38.3 percent in the north. Prices have been important in all regions, but maize prices are only important in the north and east. A 10 percent reduction in the maize price results in a 6.6 percent and 11.1 percent reduction in the east and north respectively, while it had no impact in the center and west. Bean prices are important in all regions, with a 10 percent increase in the bean prices increasing income by 6.3 to 13.5 percent across regions. The results also indicate that the cessation of violence in the late 2000s only impacted crop income growth in the north.

Table 8: Changes in agricultural income: a regional story

	Centre	East	North	West
Log of rainfall (percent of needs measured by WRSI)	-0.335 (0.825)	0.868** (0.370)	3.826*** (0.578)	0.283 (0.524)
Log of maize price	0.243 (0.219)	0.657*** (0.114)	1.112*** (0.166)	0.00646 (0.132)
Log of beans price	0.627* (0.340)	0.936*** (0.318)	1.348*** (0.350)	1.074*** (0.203)
Log of number of fatalities	0.129 (0.167)	-0.0721 (0.149)	-0.131** (0.0651)	-0.0521 (0.221)
Constant	7.595 (5.108)	-1.921 (2.906)	-21.00*** (3.686)	4.008 (3.361)
Observations	1,585	2,114	2,253	1,856
Number of HHID	504	674	735	626

Source: Staff calculations using UNPS 2006-2012. Note: Dependent variable is log of real per capita crop income. Robust standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1

VI. The impact of weather, prices and peace on non-agricultural income and welfare

In light of the importance of prices and weather in driving crop income growth and to determine how well households are able to compensate these changes through the diversification of income, the impact of prices and weather on other sources of income is explored further in this section. We also examine whether positive trends in prices, weather and peace contributed to household consumption growth, and also the degree to which consumption growth is vulnerable to price falls or rainfall shortfalls, using the fixed effects specification set out in equation (2). Table 9 presents the results. Column 1 reports the results for crop income that were discussed in section IV. Columns 2 to 5 detail results for livestock income, agricultural wage income, non-agricultural income and non-farm self-employment income. Column 6 examines the impact on household consumption using consumption data for 2006 and 2010 but not 2011 and 2012 given concerns over the consumption data collected in later years. Table 10 presents results for the bottom 40 percent.

Rainfall shocks do not impact income from livestock; perhaps because for livestock the rainfall over multiple seasons is important. However, wage employment and self-employment out of agriculture are inversely and significantly correlated with rainfall. The results suggest that diversification of productive activities can be an important risk hedging strategy for households in Uganda, particularly the poorest. If agricultural income is affected by climate shocks, households can offset this with increased non-farm income. It is not clear whether household labor is pulled into own-farm agricultural production as a result of the increased demand for agricultural labor when the rainfall is good or whether household labor is pushed out of agriculture as a result of a desperate need to smooth consumption when rainfall is bad.

Although some of the weather shocks can be insured through diversification, households are not able to fully insure their consumption from the impact of weather. A decrease in rainfall of 10 percent results in decline of 4.8 percent in per capita consumption (4.1 percent when considering households in the bottom 40 percent in 2006).

In contrast to rainfall, price increases impact all sources of income positively. This means that when prices are good total income is positively impacted, but conversely when prices are bad households are not able to mitigate crop income shortfalls by increasing income from other sources. The exception to this is agricultural wage income, which is surprising given findings in other countries that agricultural wage labor is positively impacted by crop price increases and our expectation that higher prices would result in increased demand for agricultural wage labor. It is not clear why a negative relationship is observed in this context.

The impact of prices on consumption is, however, smaller than the impact of prices on crop income, indicating that even though households are not able to diversify to manage price risk, they are able to reduce the impact of prices on consumption by other means. A decrease of 10 percent in the price of maize and beans results in a 5.1 percent reduction in consumption. The impact is almost doubled for the bottom 40 percent—a 10 percent price decrease results in a 10.5 percent reduction in consumption—consistent with the fact they are less able to insure consumption from income shortfalls.

Although the cessation of violence had a positive impact on crop income, a significant impact on consumption is not observed. The results suggest that this may be because households switched out

of wage labor activities into self-employment activities in agriculture as peace was restored. Similarly, since the consumption data for 2011 and 2012 are not reliable and it is then when conflict declined the most, it is not possible to capture the effect on this welfare measure.

Thus far, all of the regression results presented have relied on a monetary dependent variable and so prices have both been part of the construction of the dependent variable and the explanatory variable included in the analysis. As a robustness check on the findings, we conduct a similar exercise using non-monetary measures of welfare that are correlated with consumption: z-scores (standard scores) of weight for age and weight for height among children less than 5 years of age in the household. The results are presented in Table 11. These data were only collected from 2010 onwards and only collected for children, making the sample size available for these regressions much smaller. For this reason only one price—the price of beans—is considered. Although the results are not consistently significant across specifications, they do show that weight for height is positively impacted by rainfall, and that weight for age is positively affected by higher prices, as suggested by the regressions on income and consumption.

Overall the results show that while income diversification is an effective strategy to manage some sources of risk—such as weather—the amount of diversification undertaken by Ugandan households is not able to fully insure total income and consumption from fluctuations in the external environment. These findings suggest that it is desirable for households to be more fully insured against shocks than they currently are.

Table 9: Impact of weather, prices and peace on income and consumption

	(1)	(2)	(3)	(4)	(5)	(6)
	Crop income	Livestock income	Agricultural wage income	Non- agricultural wage income	Non-farm self- employment income	Consumption (2006, 2010)
Log of rainfall (percent of needs measured by WRSI)	1.886*** (0.343)	-0.198 (0.833)	-4.853*** (0.706)	-3.627*** (0.701)	-2.796*** (0.750)	0.478*** (0.147)
Log of maize price	0.492*** (0.0840)	-0.0671 (0.264)	-1.130*** (0.338)	-0.0973 (0.339)	-0.401 (0.371)	-0.218** (0.0975)
Log of beans price	1.091*** (0.155)	1.213** (0.516)	-1.453*** (0.506)	4.263*** (0.422)	1.175** (0.506)	0.729*** (0.125)
Log of number of fatalities	-0.146*** (0.0515)	-0.227 (0.142)	0.451*** (0.135)	0.323** (0.134)	0.177 (0.145)	-0.00909 (0.0143)
Constant	-6.619*** (2.010)	-0.196 (5.792)	36.68*** (5.804)	-12.84** (5.190)	9.026 (6.101)	5.127*** (1.172)
Observations	6,852	6,986	6,497	6,497	6,497	3,154
Number of HHID	2,044	2,046	2,045	2,045	2,045	1,946

Source: Staff calculations using UNPS. Notes: Household fixed effects estimation with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 10: Impact of weather, prices and peace on income and consumption: bottom 40 percent

	(1)	(2)	(3)	(4)	(5)	(6)
	Crop income	Livestock income	Agricultural wage income	Non- agricultural wage income	Non-farm self- employment income	Consumption (2006, 2010)
Log of rainfall (percent of needs measured by WRSI)	2.417*** (0.506)	1.533 (1.177)	-6.419*** (1.017)	-4.366*** (0.946)	-3.335*** (1.015)	0.405** (0.190)
Log of maize price	0.715*** (0.113)	0.437 (0.377)	-1.418*** (0.519)	-0.281 (0.466)	-0.435 (0.504)	-0.00504 (0.122)
Log of beans price	1.247*** (0.214)	2.019*** (0.722)	0.0956 (0.752)	4.078*** (0.542)	1.678** (0.701)	1.049*** (0.140)
Log of number of fatalities	-0.187*** (0.0662)	-0.287 (0.177)	0.690*** (0.185)	0.455*** (0.170)	0.103 (0.184)	-0.00918 (0.0163)
Constant	-11.48*** (2.818)	-16.37** (8.120)	35.56*** (8.563)	-8.024 (6.843)	7.701 (8.198)	1.782 (1.463)
Observations	3,334	3,359	3,102	3,102	3,102	1,502
Number of HHID	966	966	964	964	964	927

Source: Staff calculations using UNPS 2006-2012. Notes: Household fixed effects estimation with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 11: Impact of weather, prices and peace on weight for age and weight for height

	(1)	(2)	(3)	(4)
	Weight for age Z-score	Weight for height Z- score	Weight for age Z- score	Weight for height Z- score
Log of rainfall (percent of needs measured by WRSI)	0.364** (0.158)	0.397 (0.381)	0.586*** (0.223)	0.512 (0.669)
Log of beans price	0.194 (0.284)	0.704 (0.434)	0.364 (0.404)	1.213** (0.609)
Log of number of fatalities	0.0259 (0.0503)	-0.0230 (0.0738)	0.0536 (0.0638)	0.0330 (0.0885)
Constant	-3.798* (2.059)	-6.413* (3.801)	-6.009** (2.914)	-10.35* (6.139)
Observations	1,658	1,643	803	801
Number of HHID	957	953	465	465
Bottom 40 percent	No	No	Yes	Yes

Source: Staff calculations using UNPS 2010-2012. Notes: Household fixed effects estimation with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. In each case the dependent variables is averaged across all children below 5 years old in the household.

Using equation 3, we explore if households with a higher level of human capital and access to financial instruments-such as having a savings account or a loan- are better equipped to smooth the impact of climate shocks and price declines. We also test the effectiveness of some the economic institutions,

such as better access to markets and the use of technical assistance, at mitigating these shocks. The only factor that helped households to alleviate the adverse effect of shocks was the level of education of the household head. Households with a savings account or a loan from a financial institution are not more resilient to these shocks. Similarly, enhanced access to markets where agricultural inputs are bought and where agricultural products are sold, as well as technical assistance do not make a difference in the way households cope with climate shocks and variation in prices.

Figure 6 depicts the results for education and shows that higher levels of education of the household head reduce the negative effect of rainfall shocks (measured by the WRSI index) on both crop income and per capita consumption. Having a head with some e primary education reduces the negative effect of rainfall by 2.8 percent compared to those with no education while for those with complete secondary education, the reduction increases to 4.9 percent. Something similar occurs if we look at the effect on per capita consumption, albeit the magnitude is smaller and only the results for some secondary education among the bottom 40 percent remain significant.

More education facilitates diversification by enabling increased participation in the labor market, particularly in the non-agricultural sector. In addition, more educated individuals may assess and respond to risk more successfully. For both crop income and per capita consumption, the mitigation effects of higher education level are larger for households belonging to the bottom 40 percent of the distribution.

Figure 6: Education mitigates the impact of climate shocks

Source: Authors estimation using UNSP 2006 – 2012.

Note*: Results statistically significant at the 10% level for crop income. For consumption only some secondary for the bottom 40 percent is statistically significant at the 5% level.

Finally, we examine whether consumption in the Northern and Eastern regions is just as reliant on the external environment as crop income in these regions proved to be. Given the limited sample size, households in the north and east are pooled together as are households in the center and west. We also just consider bean prices. The results confirm that the consumption of households in the north and east is more reliant on changes in the external environment than the wealthier households in the center and west (Table 12). The difference is largest when considering prices: a 10 percent increase in the bean price is associated with a 6.7 percent increase in consumption in the north and east, and a 2.5 percent increase in consumption in the center and west. As discussed, the reliance on the external environment has both been a source of welfare improvements and vulnerability for Northern and

Eastern households. Ultimately, increasing the resilience of these households to protect consumption from the downside of risk is essential to secure the gains in welfare for these regions.

Table 12: Welfare changes: a regional story

	Centre and West	North and East
	Log real consumption per capita	
Log of rainfall (percent of needs measured by WRSI)	0.444** (0.825)	0.488** (0.219)
Log of beans price	0.245* (0.130)	0.674*** (0.122)
Log of number of fatalities	0.057 (0.053)	0.004 (0.016)
Constant	7.239 (1.603)	4.050** (1.701)
Observations	1,585	1618
Number of HHID	504	1022

Source: Staff calculations using UNPS 2006-2010. Note: Dependent variables is real per capita consumption. Month of interview dummies included but not shown.

Robust standard errors in parentheses*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

VII. Conclusion

Over the last 15 years Uganda has been an African success story, reducing extreme poverty faster than most other countries in the continent. However, Uganda remains a very poor country. In 2013, a third of its citizens still lived below the international extreme poverty line of US\$1.90 (2011 PPP) a day. Understanding the drivers of past success provides important lessons for those interested in seeing further poverty reduction both in Uganda and elsewhere. This paper contributes to this endeavor by focusing on the drivers of an important source poverty reduction for households in Uganda—agricultural income growth—and assessing how these drivers impacted welfare dynamics during the period 2006-2012.

The results show that Uganda was able to get many of the fundamentals right. The government secured stability in the north and enabled the development of private agricultural markets across the country, resulting in real relative prices increases for agricultural commodities that poor farmers grow and sell. However, the results also highlight areas where less progress was made. Extension services and input use were associated with crop income growth, but overall production practices did not change much in agriculture. As a result, modernization of agricultural practices contributed very little to crop income growth.

Our findings also underscore that luck was on Uganda's side: good weather benefited many households and the positive price trends in international food and commodity markets during this period contributed to price increases for maize, beans and other commodities that benefited farmers. As a result, a favorable external environment (some of it facilitated by policy and some of it not),

rather than modernization of production practices accounted for much of the change in agricultural income, contributing to higher household consumption and lower poverty.

The importance of the external environment in bringing about agricultural income growth offers important lessons for future poverty reduction in Uganda and elsewhere. Ensuring stability in the region and further promoting efficient crop markets and regional exports will be important for crop income growth in Uganda. However, the importance of the external environment to deliver poverty reduction also offers some cause for concern. When prices are poor or when the rains do fail, crop income growth falters and consumption falls, with adverse consequences for poverty reduction. This is indeed what happened in the Northern and Eastern regions in 2011.

Households need to be able to both benefit from good prices and weather and have access to coping mechanisms to be protected from low prices and poor weather. The results presented here also some lessons in this regard. Diversification of income offers households the ability to protect consumption from weather shocks, although it appears to be less effective in mitigating price income shocks. Education is essential to enable households to diversify income, insuring themselves from weather shocks as a result. However, diversification alone is not enough to fully protect income from shocks. The inability of Uganda to implement a functioning public safety net system has resulted in households relying on informal networks and own savings to cope with shocks. These are imperfect insurance mechanisms, with potential negative long term effects, and as a consequence vulnerability remains high.

Finally, encouraging further agricultural income growth as a result of improvements in production practices offers sustainable gains that are not dependent solely on prices and weather. Understanding why farmers did not adopt agricultural technologies during this time of high prices needs to be a key area of analysis going forward.

References

- Alex, Aliga. "Health Shocks and Coping Mechanisms in Uganda: A Household Level Analysis." Master Thesis, Makerere University, 2013.
- Ali, Daniel Ayalew; Bowen, Frederick H.; Deininger, Klaus W.; Duponchel, Marguerite Felicien. 2015. "Investigating the gender gap in agricultural productivity: evidence from Uganda". Policy Research working paper; no. WPS 7262. Washington.
- Anttila-Hughes, J. K. and Hsiang, S. M. (2013). Destruction, disinvestment, and death: Economic and human losses following environmental disaster. Available at SSRN 2220501.
- Bandiera, Oriana, Robin Burgess, Erika Deserranno, Ricardo Morel, Imran Rasul and Munshi Sulaiman. 2015. Key findings from randomized evaluation of microcredit and agriculture services in Uganda. Research Preview 2, BRAC October 2015
- Binswanger-Mkhize, H. and Savastano, S. 2014. "Agricultural intensification: the status in six African countries." World Bank Policy Research Working Paper 7116.
- Bridges, Sarah and David Lawson 2008. "Health and labour market participation in Uganda". WIDER Discussion Papers.
- Carletto, G., Covarrubias, K. and Krausova, M. (2007). "Rural Income Generating Activities (RIGA) Study: Income Aggregate Methodology". Agricultural Sector in Economic Development Service, Food and Agriculture Organization.
- Carletto, G., S. Gourlay and A. Winters. 2015. From Guesstimates to GPStimates: Land Area Measurement and Implications for Agricultural Analysis. *Journal of African Economies*. 24 (5): 593–628
- Deininger, Klaus and Okidi. John. 2003, Growth and poverty reduction in Uganda, 1992– 2000: panel data evidence. *Development Policy Review* 21 (4), 481– 509.
- Dell, M., Jones, B. F., and Olken, B. A. (2014). What do we learn from the weather? The new climate-economy literature. *Journal of Economic Literature*, 52(3):740-98.
- Dercon, S. 2004. Growth and shocks: evidence from rural Ethiopia. *Journal of Development Economics*, 74(2):309-329
- Dorosh, Paul & Thurlow, James, 2012. "Can Cities or Towns Drive African Development? Economy-wide Analysis for Ethiopia and Uganda". Working Paper Series UNU-WIDER Research Paper, World Institute for Development Economic Research (UNU-WIDER).
- Fafchamps, M. and R. V. Hill, 2008. "Price Transmission and Trader Entry in Domestic Commodity Markets" *Economic Development and Cultural Change* 56: 729-766.
- Fafchamps, M. and R.V. Hill, 2015. Redistribution and Group Participation: Comparative Experimental Evidence from Africa and the UK. National Bureau of Economic Research Working Papers 21127.
- Government of Uganda, 2014. "Uganda National Household Survey 2012/2013". Uganda Bureau of Statistics (UBOS). Kampala Uganda.
- Gunning, J.W., Hoddinott, J., Kinsey, B., Owens, T., 2000. Revisiting forever gained: Income dynamics in the resettlement areas of Zimbabwe, 1983– 1997. *Journal of Development Studies* 36, 131– 154.
- Heltberg, Rasmus, Faiyaz Talukdar and Ana Maria Oviedo (2013). "Shocks and coping in sub-Saharan Africa". Background paper for the World Development Report, World Bank.
- Hill, Ruth Vargas, and Porter, Catherine. 2016. Vulnerability to drought and food price shocks: Evidence from Ethiopia. World Bank Policy Research Working Paper 7920.
- Jalan, J., Ravallion, M., 1998. Are there dynamic gains from a poor-area development program? *Journal of Public Economics* 67 (1), 65–86.

- Jalan, J., Ravallion, M., 2004. Household income dynamics in rural China. In: Dercon, S. (Ed.), *Insurance Against Poverty*. Oxford Univ. Press, Oxford.
- Kaminski, Jonathan & Christiaensen, Luc, 2014. Household welfare in Uganda 2005-2009. Mimeo, World Bank.
- Kassie, Menale, Bekele Shiferaw, Geoffrey Muricho, 2011. “Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda”. *World Development* Volume 39, Issue 10, October 2011, Pages 1784–1795.
- Kilic T., Zezza A., Carletto C., Savastano S. 2014. ‘Missing(ness) in Action: Selectivity Bias in GPS-Based Land Area Measurements’. Policy Research Working Paper 6490, World Bank, Washington, D.C.
- Sheehan, M. and Barrett, C. 2014. “Understanding the agricultural input landscape in Sub-Saharan Africa: recent plot, household, and community-level evidence” World Bank Policy Research Working Paper 7014.
- Ssewanyana, Sarah and Kasirye, Ibrahim. 2012. Poverty and inequality dynamics in Uganda: Insights from the Uganda National Panel Surveys. 2005/6 and 2009/10, EPRC Research Series 94.
- Tessa Bold, Kayuki C. Kaizzi, Jakob Svensson, David Yanagizawa-Drott. 2015. Low Quality, Low Returns, Low Adoption: Evidence from the Market for Fertilizer and Hybrid Seed in Uganda. International Growth Center Working Paper F-43805-UGA-1, June 2015.
- Thomas, T., Christiaensen, L., Do, Q.-T., and Trung, L. D. (2010). Natural disasters and household welfare: evidence from Vietnam. World Bank Policy Research Working Paper Series.