Welfare, income growth and shocks in Uganda:
Understanding poverty trends from 2005/6 to 2011/12

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Abstract

Over the last decade Uganda has recorded impressive rates of poverty reduction, experiencing one of the fastest reductions in extreme poverty (as measured using the international extreme poverty line of US$1.90) seen in sub-Saharan Africa. This paper examines the drivers of this change using nationally representative panel data for 2,356 Ugandan households visited four times between 2005/6 and 2011/12. We find substantial growth in agricultural incomes particularly among poorer households. However, we also find that many of the gains in agricultural income growth came about as a result of good fortune, peace and improved efficiency in food markets, rather than technological change or profound changes in the nature of agricultural production. As a result, although the 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 as a result their overall income growth was also slower. We argue that without a fundamental change in the nature of agricultural production in Uganda, progress in reducing poverty will be vulnerable and widening spatial inequality will continue to be observed.

Keywords: weather shocks, prices, welfare, vulnerability

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I. Introduction

Over the last decade, Uganda has recorded impressive rates of poverty reduction. The proportion of households living beneath the international extreme poverty line of US$1.90 a day fell from 62.2 percent in 2002 to 32.2 percent in 2012/13. Uganda saw the second fastest percentage point reduction in poverty per year in sub-Saharan Africa, an African success story.[2] Understanding the drivers of this reduction is important both for offering lessons on how to reduce poverty further in the future in Uganda, but also for other countries in the region that have not experienced such a remarkable reduction in poverty.

Uganda's record on reducing poverty also highlights some remaining challenges. High rates of vulnerability to poverty are recorded in the national surveys. Ssewanyana and Kasirye (2012) document that for every three Ugandans that moved out of poverty between 2005/6 and 2009/10, two moved back in to poverty. Such high rates of vulnerability reduce the pace of progress and put at risk the gains made. Secondly, gains have not been equal in all parts of the country. Since 2005/6, households in the Central and Western regions have experienced faster growth in consumption than households in the Northern and Eastern regions. As a result, whilst in 2005/6 approximately 60 percent of those living beneath the national poverty line were from the Northern and Eastern regions the country, seven years later, this proportion increased to 84 percent (UNHS 2012/13).

In this paper we analyze what explains this record of progress and underpins the remaining challenges. - using a nationally representative panel data for 2,356 Ugandan households visited four times between 2005/6 and 2011/12.

We find substantial income growth, particularly in agricultural incomes. Since 1987, Uganda has experienced a sustained period of high economic growth, averaging over six percent a year and this appears to have trickled down to the poorest households. Subsistence farming is the main source of income for 52.6 percent of the bottom 40 percent and growth in agricultural incomes has been very beneficial for poverty reduction. However, we also find that many of the gains in agricultural income

[2] Uganda reduced the extreme poverty rate by 2.9 percentage points a year, second only to Chad who 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.

growth came about as a result of good fortune, peace and improved efficiency in food markets, rather than technological change or profound changes in the nature of agricultural production.

As a result, 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. 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 also slower.

We argue that without a fundamental change in the nature of agricultural production in Uganda, progress in reducing poverty will be vulnerable and widening spatial inequality will continue to be observed.

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 income 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. 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 2005/6 and 2009/10, 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: 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. However, we also run the regressions including split-offs and find that the main results are unchanged.[3]

Table 1: Attrition in the UNPS by wave

	Sample	Original sample retention	Split-off HHs	Total
2005/06	3,123	100	0	3,123
2009/10	2,607	83.5	367	2,974
2010/11	2,564	82.1	305	2,869
2011/12	2,356	75.4	479	2,835

Source: Uganda Bureau of Statistics (2013)

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 using the same method to generate the consumption aggregate used in the official poverty measures. 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).

[3] Results are available from authors on request.

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 is 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 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.

In addition the analysis incorporates data from other sources on market prices of agricultural products, weather and conflict. This data provides 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. Households are more likely to recall shocks that did result 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

[4] This may be an imperfect measure of regional price differences if regional food price differences are different quite 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 this data, using non-food price differences appears to be a reasonable approximation.

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 twelve 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 in 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 RFE[5] v2 (2001-2014) time series. The WRSI is an indicator of crop performance based on the availability of water for the crop during 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 was collected. [6] This data has 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 kilometers 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 year. Matooke is important in all regions except the Northern region, and

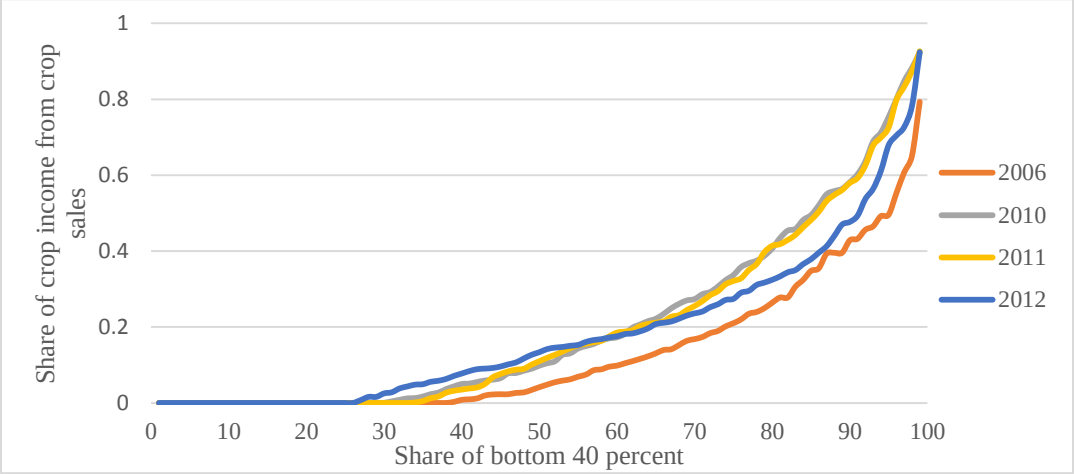
[5] Potential evapotranspiration (PTE) and satellite gauge rainfall estimate (RFE).

[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.

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 tried.[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 2010/11 or 2011/12. 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 are not considered in the analysis. Sunflower 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 2011/12 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

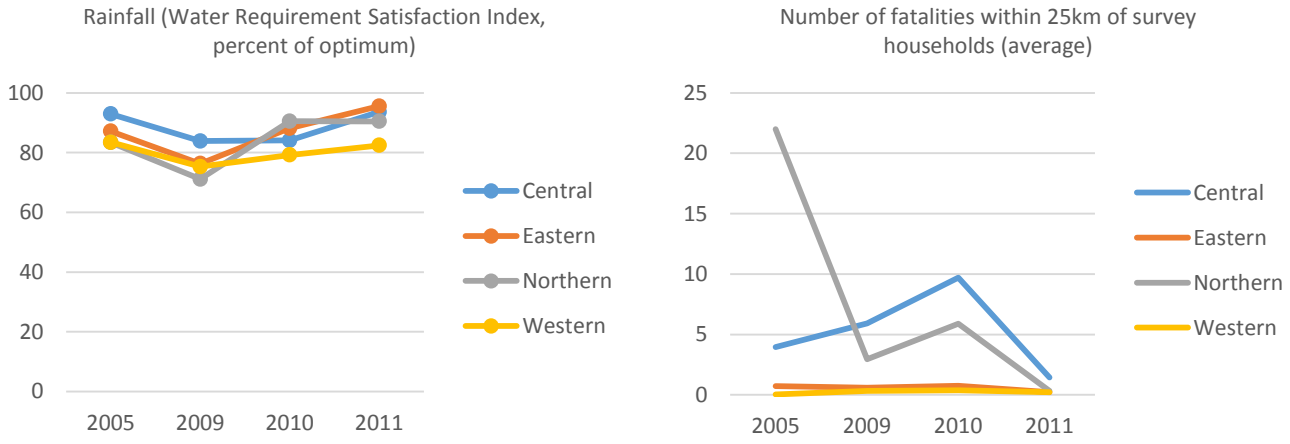
[7] Including price of matooke, cassava, potatoes, rice, sorghum and coffee.

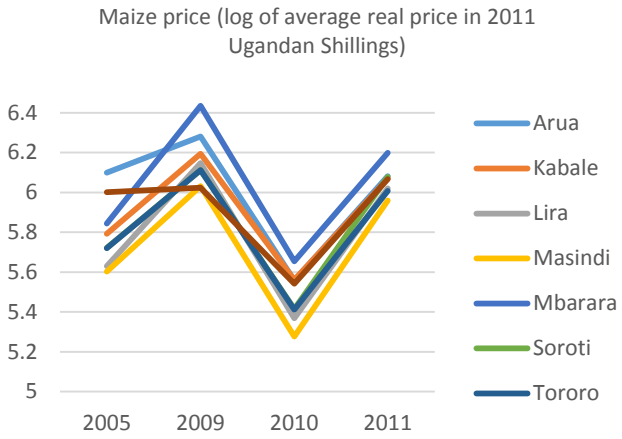
Figure 2 presents data on weather, price and conflict by region across the years considered in the study. Weather conditions were in general good, with rainfall deficits less than 20 percent in most cases. However, 2009/10 was a more challenging year for households and higher losses were observed (although 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 suggests 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 whilst 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.

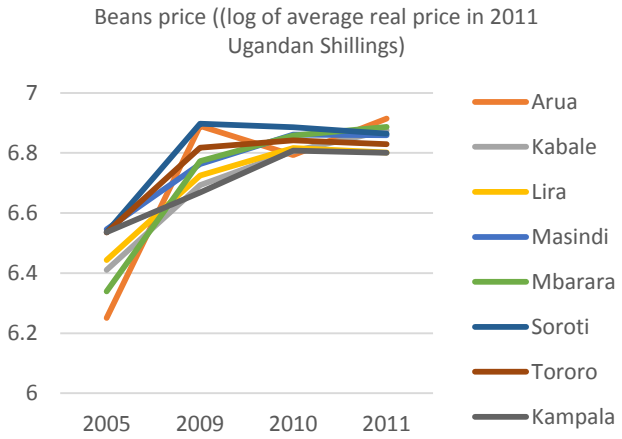
Prices have exhibited more volatility during this period than weather. Real prices for maize appear well-integrated across Uganda during this period, in that they move together quite strongly in all regions. Beans prices appear less well integrated. Maize and beans prices increased from 2005/6 to 2009/10. The real price of beans continued to rise in most markets in 2010/11, 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 2005/6 to 2009/10. There was an increase in the number of fatalities reported in 2010/11 but this fell again by 2011/12.

Figure 2: Price, conflict and weather trends from 2005/6 to 2011/12







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

	2005/6			2009/10			2010/11			2011/12		
	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: Staff calculations using UNPS 2005/6-2011/12

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

	2010/11					2011/12				
	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: Staff calculations using RIGA 2010/11-2011/12. 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

Income growth

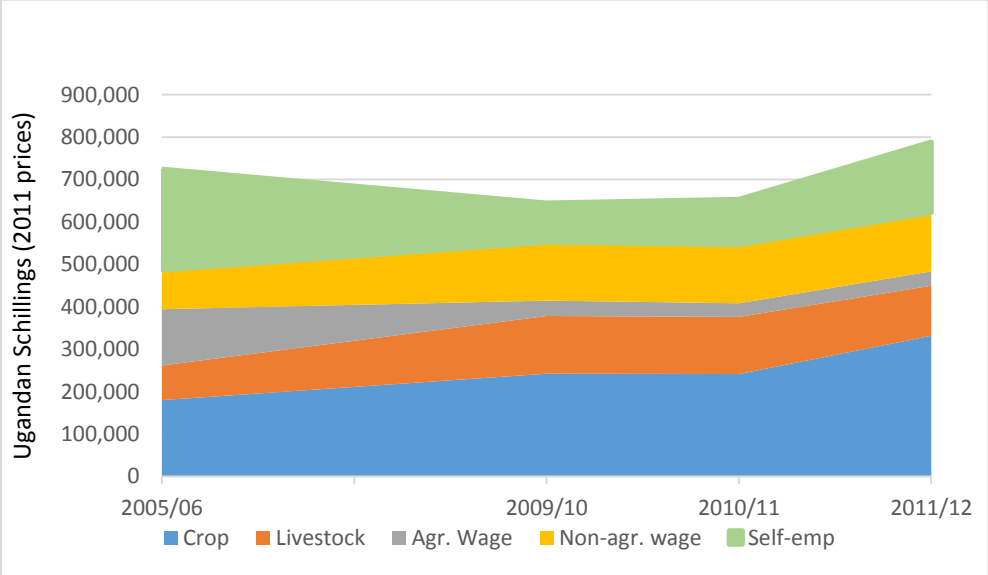
Information on real income per capita for households in Uganda across time is presented in Figure . The data represents weighted averages of income from crop farming, livestock production, wage employment (in agriculture and non-agriculture sectors) and non-farm self-employment. All values are in 2011 prices. 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 2011/12 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 2005/6 to 2011/12 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 2010/11 and 2011/12, but even when the period prior to 2010/11 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]

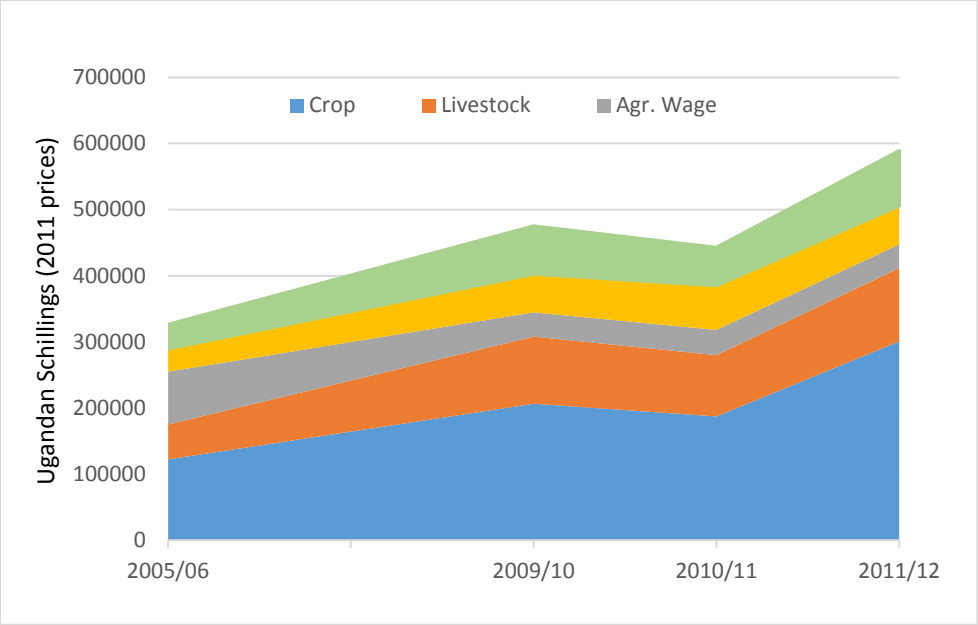
Figure 3. Real income per capita levels by source of income, all households



Source: Staff calculations using UNPS 2005/6-2011/12

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 under-estimate national average per capita non-agricultural growth) as households that attritted 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: Staff calculations using UNPS 2005/6-2011/12

The national picture points to a pattern of sustained crop income growth across the years of the panel survey: 2005/06 to 2011/12. However, when crop income is disaggregated across regions, a slightly different picture emerges (Figure 5).

Table 4. Real per capita Income growth by source of income, 2005/6 to 2011/12

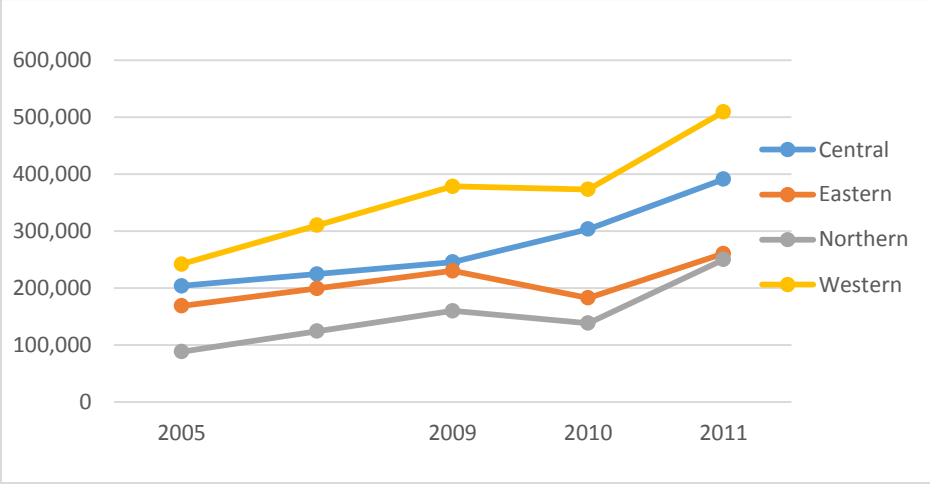
	Crop	Livestock	Ag wage	Non-ag wage	Non-ag self
All households					
2005/6	179,796	81,643	132,723	92,701	237,554
2009/10	242,025	136,138	36,329	137,905	92,120
2010/11	241,297	134,695	32,154	138,208	106,895
2011/12	331,489	118,077	33,762	139,043	166,074
Annual growth, 2005/6-2011/12	9%	5%	-18%	6%	-5%
Annual growth, 2005/6-2010/11	4%	7%	-18%	6%	-11%
Bottom 40 percent					
2005/6	122,175	52,945	79,799	35,846	34,176
2009/10	206,352	101,512	36,678	59,297	70,004
2010/11	187,213	92,671	38,116	68,375	54,962
2011/12	300,687	110,956	35,757	59,550	80,611
Annual growth, 2005/6-2011/12	14%	11%	-11%	8%	13%
Annual growth, 2005/6-2010/11	6%	8%	-10%	10%	7%

Source: Staff calculations using UNPS 2005/6-2011/12

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 2009/10 and 2010/11 in the Eastern and Northern regions. Although growth recovered between 2010/11 and 2011/12, 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 5: Regional differences in per capita crop income growth, 2005/6 to 2011/12



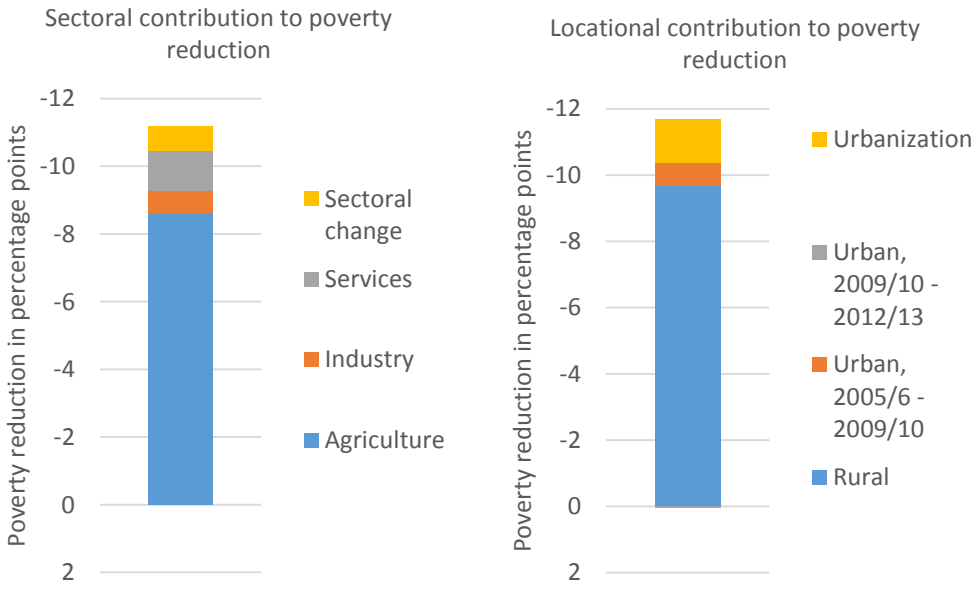
Source: Staff calculations using UNPS 2005/6-2011/12

Income growth and poverty reduction

Christiaensen and Kaminski (2014) undertake decomposition analysis using the same panel dataset and find that agricultural income growth contributed to 18 percent of consumption growth from 2005/6 to 2009/10. They also estimate that agricultural growth contributed to 70 percent of the poverty reduction observed from 2005/6 to 2009/10, confirming the greater importance of agricultural income growth among the poorest households. Decomposition analysis undertaken using the Uganda National

Household Survey[9] for the Uganda Poverty Assessment also indicates that it was poverty reduction amongst those that cited agriculture as their main source of income that account for most of the poverty reduction in Uganda throughout the period 2005/06 to 2012/13. Agricultural households accounted for 79 percent of poverty reduction and rural areas accounted for 86 percent of poverty reduction (Figure 6), perhaps not surprising given that around 85 percent of Uganda's population live in rural areas and cite agriculture as their main income source. 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).

Figure 6. Sectoral and locational contribution to poverty reduction, 2005/6 to 2012/13



Source: Staff calculations using UNHS 2005/6, UNHS 2009/10, UNHS 2012/13

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 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, 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 2005/6 and 2009/10 as there is a marked reduction

[9] Cross-section household survey.

in the consumption aggregate after 2009/10 that is hard to explain and is inconsistent with the national poverty trend.[10]

The results are presented in Table 5 and indicate that increases in income 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 even larger for the bottom 40 percent (column 2). These results indicate 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.

Table 5. Relationship between income and consumption, 2005/6-2009/10

	(1)	(2)
	Log of per capita consumption	
	All households	Bottom 40 percent
Log of per capita real crop gross income	0.0324***	0.0416***
	(0.00805)	(0.0103)
Log of per capita real livestock gross income	0.00573**	0.00479
	(0.00283)	(0.00347)
Log of per capita real agricultural wage	0.00127	0.00186
	(0.00239)	(0.00278)
Log of per capita real non- agricultural wage	0.00553**	0.00505
	(0.00271)	(0.00359)
Log of per capita real self-employment income	0.00934***	0.0106***
	(0.00246)	(0.00302)
Constant	10.28***	9.942***
	(0.140)	(0.189)
Observations	4,171	3,017
R-squared	0.086	0.095
Number of HHID	2,644	1,853

Source: author calculations using the UNPS 2005/6 and 2009/10.
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%

[10] It may result from methodological differences in the collection of consumption data in the 2010/11 and 2011/12 survey rounds. Computer Assisted Personal Interviews (CAPI) was introduced in the UNPS for the 2010/11 and 2011/12 rounds and this may have resulted in a reduction in reported consumption. CAPI was not introduced in the nationally representative cross-sectional survey, the UNHS.

IV. Analytical Approach

In this paper, we assess what factors have contributed (and what have not) to enhance the crop income of households in recent years. We also examine the impact of important drivers of crop income growth on other sources of income and final consumption.[11] We examine both changes in production practices of households as well as changes in the external environment that may have had a direct impact on crop income or impacted how households decided to produce.

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; household labor inputs (both hired labor and family labor); access to extension and household demographics are used. As Table 2 highlighted, 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).

Changes in the external environment that may have impacted crop income are analyzed by looking at the impact of prices, weather shocks, conflict fatalities and changes in market access and extension services. 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 use or labor as a result.

The first set of regressions includes variables on both production practices and the external environment:

[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.

$$\boldsymbol{ln(Y_{i,t}) = \beta_0 + \beta_P P_{i,t} + \beta_E E_{i,t} + \beta_X X_{i,t} + reg_i + \varepsilon_{it}} \quad (1)$$

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

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 household[12] *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] $E_{i,t}$ is a set of variables capturing the external environment. It includes the distance in kilometers of household i to the nearest market selling agricultural inputs at time *t*, whether extension services were provided to any household in the community, 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.

The first specification presented in equation (1) is run with random effects and includes $X_{i,t}$—a vector containing household demographic characteristics that are unlikely to change much over time but are likely to affect agricultural production—and regional fixed effects (reg_i). $X_{i,t}$ includes dummy variables for different levels of education of the household head (no education is the excluded category), the age of the household head and a gender dummy variable. [14] The second specification presented in equation (2) is run with household fixed effects u_i to control for time-invariant household characteristics, and in these regressions $X_{i,t}$ and reg_i are omitted.

In a second set of regressions, only those variables that can be considered to represent the external environment are included. This is done for two reasons. First, given these variables have an impact on production practices, a regression that includes production practices as independent variables does not allow the full impact of changes in the external environment to be captured. Secondly, given these variables are exogenous to household production decisions they can be considered drivers of changes in income. It is possible that changes in distance to market and provision of extension services in the

[12] Self-reported by the household.
[13] In the appendix we present results using the value of purchased inputs rather than a series of indicator variables in an attempt to capture the quantity of inputs used.
[14] It is unlikely that the education level of the household head changes over time.

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, we also run the specification in equation (5) in which distance to market and provision of extension are excluded from $E_{i,t}$, leaving only prices, weather and conflict in $E'_{i,t}$. Random effects and fixed effects models are estimated as follows:

$$\boldsymbol{ln(Y_{i,t)} = \beta_0 + \beta_E E_{i,t} + \beta_X X_{i,t} + reg_i + \varepsilon_{it}} \quad (3)$$

$$\boldsymbol{ln(Y_{i,t)} = \beta_0 + \beta_E E_{i,t} + u_i + \varepsilon_{it}} \quad (4)$$

$$\boldsymbol{ln(Y_{i,t)} = \beta_0 + \beta_E E'_{i,t} + u_i + \varepsilon_{it}} \quad (5)$$

Equations (4) and (5) are the preferred specifications, providing the most robust estimates on the impact of changes in the external environment on income growth. The set of variables included in E_{it} and E'_{it} are exogenous to household behavior and fixed effects allows time-invariant characteristics to be differenced out. However, it is possible that omitted time-varying characteristics are correlated with ε_{it} and thus bias the estimate of β_E. Equation (5) is 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.[15]

Finally, the following specification is used:

$$\boldsymbol{ln(Y_{i,t)} = \beta_0 + \beta_{EX} E'_{i,t} * X_{i,t} + u_i + \varepsilon_t} \quad (6)$$

in which household characteristics, X_{it}, are interacted with E'_{it} 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 provides pointers on how to further poverty reduction and reduce vulnerability in Uganda.

[15] A variation of specification (5) 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 tried, 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). This data is available from 2011 onwards, so it only covers the last wave of the UNPS used in our analysis (2011/12), which might explain the insignificant results obtained.

V. Drivers of agricultural income growth

Correlates of agricultural income estimated using the random effects model for all households (column 1) and the bottom 40 percent of the distribution in 2005/6 (column 2) are shown in Table 6. As expected, real per capita crop income is higher for those who are educated. Specifically, compared to those with no education, agricultural income is 26 percent higher in households whose head had some primary school, 34 percent higher in households whose head completed primary school, 25 percent higher for those with some secondary education and 42 percent higher for those with post-secondary education. The correlation between crop income and education is much lower among those who were in the bottom 40 percent in 2005/6 perhaps on account of their lower levels of education on average. Being male is associated with lower levels of crop income, all else equal. However, we note that all else is usually not equal for male and female farmers. See Ali, Deininger and Duponchal (2015) for a fuller discussion of differences in productivity between male and female farmers in Uganda. Among the bottom 40 percent there is no statistically significant difference between male and female headed households.

To explore the relationship between production practices and per capita crop income, we consider both the results from the random effects estimation and the fixed effects estimation presented in Table 7. The qualitative findings are similar across both the random effects and fixed effects model: as expected, per capita crop income is significantly higher among those who farm more land and apply more labor, fertilizer and pesticides. Using improved seeds is not statistically significant.

Households who used fertilizer and pesticides had crop incomes that were 12 and 19 percent higher than those household who did not, with lower effects estimated in the fixed effects model. The correlation between input use and crop income is higher for the households that were poorer in 2005/6: for these households fertilizer use increases crop incomes by 22 (24) percent and pesticide use increases crop incomes by 14 (21) percent (random effects estimates in brackets). This means that a household in the bottom 40 percent in 2005/6 that adopted both fertilizer and pesticides during this time would have seen a 36 percent increase in crop income. However, although there was some increase in input use (extensive margin) among panel households during this period, the increase was relatively marginal. The proportion of households using fertilizer and increased from 17 percent in 2005/6 to 24 percent in 2011/12 whilst pesticide use hovered around 12-13 percent. As a result, technology adoption did not

contribute to large increases in crop incomes on average. In terms of the quantity of inputs used (proxied by the value of inputs), a 1 percent increase in the value of pesticide results in a 2.0 percent rise in agricultural income (see Annex 1), 1.98 percent for the bottom 40 percent.

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 increases crop income by 2 percent. The amount of household labor reportedly spent on agricultural production increased substantially between 2005/6 and 2010/11, falling again in 2011/12. 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.

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. This The little change in production practices 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 return to new technologies is still low, or that farmers

had difficulties in accessing inputs or the financing needed to make input purchases. Further analysis of why so few households adopted modern production practices is needed.

The results in Tables 6 and 7 suggest that it was the external environment, rather than changes in production practices, that can explain crop income growth during this period, particularly for the poorest. The strongest correlates of changes in crop incomes are changes in rainfall and prices. Better rainfall and higher prices led to higher income. A 10 percent increase in water sufficiency (rainfall) increases crop income by 9.9 percent. Similarly price changes are significant. A 10 percent increase in the price of maize or beans increases crop income by 4.5 and 9.2 percent respectively. Incomes of poorer households (thos in the bottom 40 percent in 2005) 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 beans prices, results in a 13.4 percent and 13.0 percent increase in crop income respectively. Rainfall and prices improved over this time, 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 have been improving since 2005/6 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 of Uganda. Sustained growth in incomes and welfare will also require productivity growth in agriculture—possibly through the use of improved seeds, fertilizer, pesticides and irrigation—and diversification to other more remunerative forms of employment.

The results in columns 1 and 2 of tables 6 and 7 suggest that other changes in the external environment did not impact household crop income directly. There is no direct income effect of extension provision in the village, distance to local market, or the number of fatalities in the vicinity of the village. However, the results presented in columns 3 and 4 of tables 6 and 7 suggest that there was a strong indirect impact of growth and peace on agricultural income. In columns 3 and 4, when production practices are excluded, extension visits and conflict become significant. Taken together these results suggest that the provision of extension and the absence of conflict did drive crop income growth by bringing about

changes in household production practices. The fixed effects results in Table 7 indicate that crop income was 20 percent higher in villages where extension services were provided, and that crop income grew by 1.3 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 2005/6 and 2009/10 resulted in a doubling (a 112 percent growth) in crop income. Provision of services is also more likely when conflict is absent, and the results in columns 1 and 2 of Table 8 show that when service provision is excluded, the impact of peace increases from 1.3 percent to 1.5-1.8 percent for every 1 percent reduction in fatalities.

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 a regression model including year fixed effects is presented in columns 3 and 4 of Table 8. The results show the continued significance of weather, prices, peace and extension provision. The magnitude of the coefficients is also very similar. 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 as run in which prices of regional crops—matooke in the center and west, and cassava in the north and east—were included instead of beans prices (results not shown). These results also showed 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.

As Figure 2 shows, the external environment was changing in different ways across the four regions during this period. The Northern region in Uganda is the most drought prone and although rainfall was in general good during 2005/6 to 2011/12, the rainfall shortfall in 2009/10 was much larger in the north than elsewhere in the country. The Eastern region also experienced quite variable 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 change the number of fatalities due to conflict related violence. 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 goes through these regions. There are also large and increasing regional variations in welfare across Uganda. The Western and Central regions are more economically developed. 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.

Understanding these regional disparities is important to reduce regional socio-economic disparities, and lower inequality in the country. For this reason, it is central to analyze the role of the external environment on crop income growth separately for the four regions. Regressions of crop income on weather, prices and peace are run separately for each of the four regions and presented in Table 9.

Weather is a strong driver of crop income growth in the north and east, but not in other regions. Weather is particularly important in the north: a 10 percent rainfall shortfall results in a reduction in crop income of 38.3 percent in the north (compared to 8.7 percent in the East). Prices have been important in all regions, but maize prices have only been important in the north and east. A ten percent reduction in the maize price results in a 6.6 percent and 11.1 percent reduction in the east and north respectively, whilst it had no impact in the center and west. Beans prices are important in all regions, with a 10 percent increase in the beans 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.

These results show that the importance of the external environment in bringing about crop income growth is strongest in the north, followed by the east. These are also the regions that experienced negative income growth from 2009/10 to 2010/11 highlighting that whilst the dependence on the external environment benefited households in these regions when peace was being established, rainfall was good and prices were rising, it hurt them when rainfall fell and when maize crop prices collapsed in 2010/11.

In the next section we explore the impact of the external environment on consumption in more detail, and in particular examine the degree to which households are vulnerable to negative price changes and bad weather.

Table 6: Changes in agricultural income: random effects

	All households	Bottom 40 percent	All households	Bottom 40 percent
Demographic characteristics of household head				
Age of household head	0.0101***	0.00890***	0.0138***	0.0114***
	(0.00243)	(0.00319)	(0.00266)	(0.00362)
Household head male	-0.221***	-0.129	-0.0383	0.0253
	(0.0697)	(0.0938)	(0.0962)	(0.122)
Education: Primary incomplete	0.260***	0.116	0.412***	0.339***
	(0.0838)	(0.0954)	(0.102)	(0.125)
Primary completed	0.339***	0.179	0.662***	0.606***
	(0.110)	(0.143)	(0.126)	(0.160)
Secondary incomplete	0.249**	0.0999	0.508***	0.441**
	(0.116)	(0.146)	(0.137)	(0.178)
Secondary complete	0.248	0.372**	0.476**	0.619***
	(0.151)	(0.159)	(0.208)	(0.192)
Post-secondary technical	0.422***	0.219	0.656***	0.628***
	(0.150)	(0.184)	(0.200)	(0.219)
University and higher	0.245	0.500***	0.779	1.117***
	(0.510)	(0.168)	(0.597)	(0.327)
Farming practices				
Total area planted self-reported, in Ha	0.0137***	0.0172**		
	(0.00356)	(0.00718)		
Renter (land)	-0.0680	-0.0570		
	(0.111)	(0.166)		
Used of fertilizer	0.117**	0.236***		
	(0.0507)	(0.0785)		
Use of pesticides	0.196***	0.211***		
	(0.0436)	(0.0565)		
Used improved seeds/seedlings	-0.0333	-0.0315		
	(0.0525)	(0.0702)		
Hired labor used	0.256***	0.331***		
	(0.0456)	(0.0604)		
Log of days of family labor used	0.279***	0.286***		
	(0.0387)	(0.0537)		
External environment				
Distance to output market (km)	0.00844	0.00163	-0.00935	-0.00455
	(0.0170)	(0.0239)	(0.0223)	(0.0301)
Any extension in village in past 12 months	0.114***	-0.0309	0.330***	0.268***
	(0.0429)	(0.0669)	(0.0495)	(0.0757)
Log of rainfall (percent of needs measured by WRSI)	1.218***	1.561***	2.088***	2.746***
	(0.202)	(0.288)	(0.339)	(0.480)
Log of maize price	0.447***	0.596***	0.400***	0.635***
	(0.0688)	(0.0970)	(0.0845)	(0.117)
Log of beans price	0.736***	1.323***	0.982***	1.175***
	(0.144)	(0.211)	(0.159)	(0.228)
Log of number of fatalities	-0.0800*	0.0454	-0.286***	-0.234***
	(0.0438)	(0.0562)	(0.0513)	(0.0712)
Constant	-3.178**	-9.393***	-7.272***	-12.70***
	(1.590)	(2.253)	(2.061)	(2.756)
Observations	5,065	2,464	6,074	2,943
Number of HHID	1,798	868	1,956	933

Source: Staff calculations using UNPS 2005/6-2011/12. 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

Table 7: 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**	0.00846		
	(0.00313)	(0.00674)		
Renter (land)	0.0682	-0.0343		
	(0.126)	(0.189)		
Used of fertilizer	0.0846	0.217**		
	(0.0523)	(0.0904)		
Use of pesticides	0.149***	0.147**		
	(0.0479)	(0.0695)		
Used improved seeds/seedlings	0.0238	0.0407		
	(0.0549)	(0.0760)		
Hired labor used	0.148***	0.209***		
	(0.0475)	(0.0653)		
Log of number of days of family labor	0.173***	0.231***		
	(0.0343)	(0.0476)		
External environment				
Distance to output market (km)	-0.00613	-0.00747	-0.0260	-0.0135
	(0.0194)	(0.0304)	(0.0259)	(0.0382)
Any extension in village in past 12 months	0.0600	-0.00359	0.200***	0.222***
	(0.0457)	(0.0726)	(0.0554)	(0.0839)
Log of rainfall (percent of needs measured by WRSI)	0.986***	1.356***	2.064***	2.683***
	(0.196)	(0.280)	(0.362)	(0.541)
Log of maize price	0.446***	0.544***	0.439***	0.609***
	(0.0674)	(0.0970)	(0.0879)	(0.118)
Log of beans price	0.922***	1.295***	1.046***	1.191***
	(0.143)	(0.213)	(0.166)	(0.232)
Log of number of fatalities	0.00849	0.0406	-0.132**	-0.152*
	(0.0413)	(0.0577)	(0.0606)	(0.0787)
Constant	-2.048	-7.283***	-6.788***	-11.71***
	(1.521)	(2.252)	(2.143)	(3.007)
Observations	5,145	2,501	6,184	2,991
Number of HHID	1,806	871	1,962	934

Source: Staff calculations using UNPS 2005/6-2011/12. 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 8: Changes in agricultural income: fixed effects, robustness checks

	All households	Bottom 40 percent	All households	Bottom 40 percent
Distance to output market (km)			-0.0251	-0.00153
			(0.02688)	(0.0381)
Any extension in village in past 12 months			0.188***	0.215**
			(0.0572)	(0.0873)
Log of rainfall (percent of needs measured by WRSI)	1.886***	2.417***	2.210***	3.170***
	(0.343)	(0.506)	(0.558)	(0.824)
Log of maize price	0.492***	0.715***	-0.0918	0.313
	(0.0840)	(0.113)	(0.355)	(0.467)
Log of beans price	1.091***	1.247***	1.260***	1.447***
	(0.155)	(0.214)	(0.454)	(0.542)
Log of number of fatalities	-0.146***	-0.187***	-0.147**	-0.144*
	(0.0515)	(0.0662)	(0.0619)	(0.0769)
Constant	-6.619***	-11.48***	-5.717	-13.80**
	(2.010)	(2.818)	(4.209)	(5.748)
Observations	6,852	3,334	6,852	3,334
Number of HHID	2,044	966	2,044	966
Year fixed effects	No	No	Yes	Yes

Source: Staff calculations using UNPS 2005/6-2011/12. 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

Table 9: Changes in agricultural income: a regional story

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

Source: Staff calculations using UNPS 2005/6-2011/12. 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 consumption

In light of the importance of prices and weather in driving crop income growth, the impact of prices and weather on other sources of income and ultimately household consumption is explored further in this section. We 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. The impact of weather, prices and peace is examined using the fixed effects specification set out in equation (5). Table 10 presents the results. Column 1 reports the results for crop income that were discussed in section 4. 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 2005/6 and 2009/10 but not 2010/11 and 2011/12 given concerns over the consumption data collected in later years. Table 11 presents results for the bottom 40 percent.

Rainfall shocks do not impact income from livestock. However, wage employment and self-employment out of agriculture is significantly negatively affected by non-farm self-employment. The results suggests 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 household 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 a result of a desperate need to smooth consumption when rainfall is bad.

However although some of the weather shock 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 2005/6).

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 double for the bottom 40 percent—a 10 percent price decrease results in a 10.5 percent reduction in consumption—suggesting 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. Further analysis is needed to confirm this finding.

Thus far, all of the regression results presented have relied on a monetary dependent variable and thus prices have both been part of the construction of the dependent variable as well as an explanatory variable included in the analysis. As a robustness check on the findings of the analysis, we present results in Table 12 using non-monetary measure of welfare that is 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. This data was only collected from 2009/10 onwards and only collected for children, making the sample size available for these regressions much smaller. For this reason only one price—the prices of beans—is considered. Although the results are not consistently significant across specifications, they do show that weight for height and weight for age is positively impacted by rainfall and by higher prices, as suggested by the regressions on income and consumption.

Overall the results show that whilst 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 results suggest that it is desirable for households to be more fully insured against shocks than they currently are. UNPS households were asked to report the most important types of coping mechanisms used if they faced an adverse shock in the last year (the answers were not mutually exclusive). As seen in Figure 7, households rely on savings (35 percent) and help from family (25 percent)

to mitigate the impact of shocks. Very few report receiving support from the government, highlighting the absence of reliable official safety net programs. Safety nets provided by savings, family and friends are of paramount importance in the absence of official safety net programs. However, reliance on informal insurance mechanisms, has been shown to reduce incentives for productive investments among rural households in Uganda (Fafchamps and Hill 2015).

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

	(1) Crop income	(2) Livestock income	(3) Agricultural wage income	(4) Non-agricultural wage income	(5) Non-farm self-employment income	(6) Consumption (2005/6, 2009/10)
Log of rainfall (percent of needs measured by WRSI)	1.886***	-0.198	-4.853***	-3.627***	-2.796***	0.478***
	(0.343)	(0.833)	(0.706)	(0.701)	(0.750)	(0.147)
Log of maize price	0.492***	-0.0671	-1.130***	-0.0973	-0.401	-0.218**
	(0.0840)	(0.264)	(0.338)	(0.339)	(0.371)	(0.0975)
Log of beans price	1.091***	1.213**	-1.453***	4.263***	1.175**	0.729***
	(0.155)	(0.516)	(0.506)	(0.422)	(0.506)	(0.125)
Log of number of fatalities	-0.146***	-0.227	0.451***	0.323**	0.177	-0.00909
	(0.0515)	(0.142)	(0.135)	(0.134)	(0.145)	(0.0143)
Constant	-6.619***	-0.196	36.68***	-12.84**	9.026	5.127***
	(2.010)	(5.792)	(5.804)	(5.190)	(6.101)	(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 11: Impact of weather, prices and peace on income and consumption: bottom 40 percent

	(1) Crop income	(2) Livestock income	(3) Agricultural wage income	(4) Non-agricultural wage income	(5) Non-farm self-employment income	(6) Consumption (2005/6, 2009/10)
Log of rainfall (percent of needs measured by WRSI)	2.417***	1.533	-6.419***	-4.366***	-3.335***	0.405**
	(0.506)	(1.177)	(1.017)	(0.946)	(1.015)	(0.190)
Log of maize price	0.715***	0.437	-1.418***	-0.281	-0.435	-0.00504
	(0.113)	(0.377)	(0.519)	(0.466)	(0.504)	(0.122)
Log of beans price	1.247***	2.019***	0.0956	4.078***	1.678**	1.049***
	(0.214)	(0.722)	(0.752)	(0.542)	(0.701)	(0.140)
Log of number of fatalities	-0.187***	-0.287	0.690***	0.455***	0.103	-0.00918
	(0.0662)	(0.177)	(0.185)	(0.170)	(0.184)	(0.0163)
Constant	-11.48***	-16.37**	35.56***	-8.024	7.701	1.782
	(2.818)	(8.120)	(8.563)	(6.843)	(8.198)	(1.463)
Observations	3,334	3,359	3,102	3,102	3,102	1,502

Number of HHID	966	966	964	964	964	927

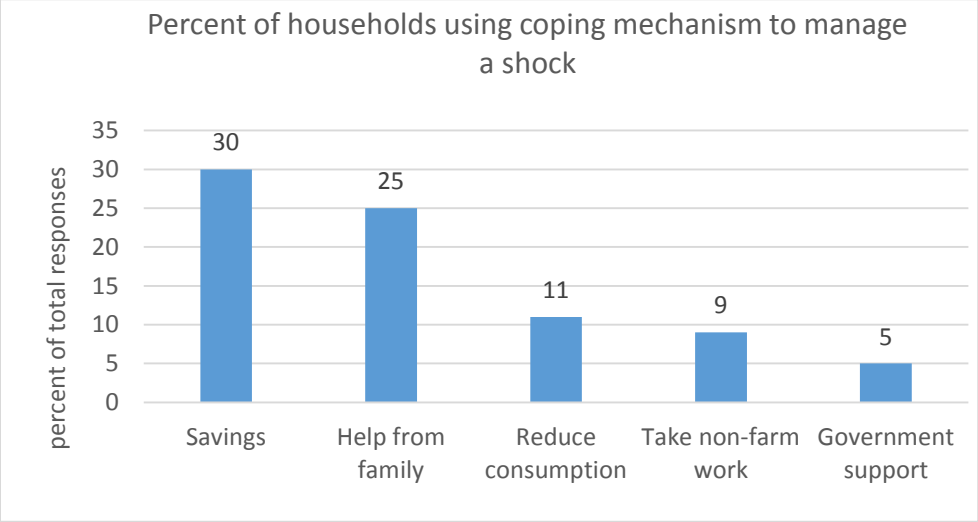
Source: Staff calculations using UNPS 2005/6-2011/12. Notes: Household fixed effects estimation with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 12: Impact of weather, prices and peace on weight for age and weight for height

	(1) Weight for age Z-score	(2) Weight for height Z-score	(3) Weight for age Z-score	(4) Weight for height Z-score
Log of rainfall (percent of needs measured by WRSI)	0.364**	0.397	0.586***	0.512
	(0.158)	(0.381)	(0.223)	(0.669)
Log of beans price	0.194	0.704	0.364	1.213**
	(0.284)	(0.434)	(0.404)	(0.609)
Log of number of fatalities	0.0259	-0.0230	0.0536	0.0330
	(0.0503)	(0.0738)	(0.0638)	(0.0885)
Constant	-3.798*	-6.413*	-6.009**	-10.35*
	(2.059)	(3.801)	(2.914)	(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 2009/10-2011/12. 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.

Figure 7: Self-reported coping mechanisms



Source: Nikolaski et al (2015)

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

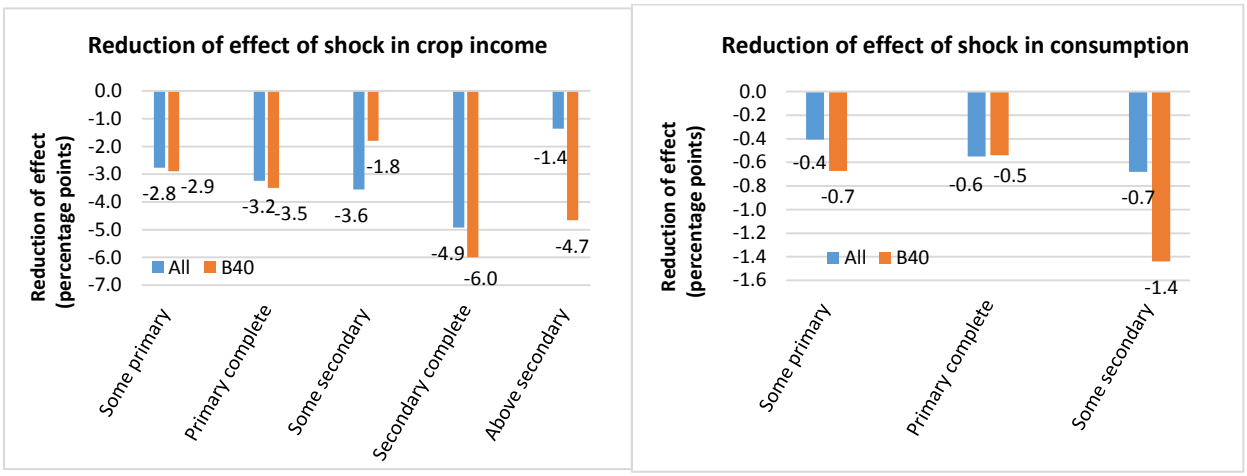
access to markets and the use of technical assistance, at mitigating the adverse effect of climate shocks and price declines. In order to empirically determine what factors help households to cope with shocks, we estimate equation 6.[16]

The only factor that helped household to mitigate the adverse effect of shocks was the level of education of the household head. Households that have 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 sold and where agricultural products are sold as well as technical assistance, do not make a difference in the way households are affected by climate shocks and crop price declines.

Figure 8 depicts the results for education and shows that higher levels of education of the household head reduces the negative effect of rainfall shocks (measured by the WRSI index) on both crop income and per capita consumption, compared to households where the head has no education at all. More education helps to mitigate the shock on crop income: in the case of household heads with some primary, it reduces the effect of the shock by 2.8 percent, while for those with complete secondary education, the reduction increases to 4.9 percent. Something similar occurs if we look at the effect of climate shocks in per capita consumption, albeit the magnitude is smaller and the only results that remains significant is for some secondary amongst the bottom 40 percent: having some secondary education implies a1.4 percent reduction in the intensity of the shock for these households. 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. In both cases, crop income and per capita consumption, the higher the education level, the larger impact for the households that belong to the bottom 40 of the distribution.

[16] That is, instead of using the subjective responses of households, we used objective measures. For example, instead of using the response that the household used savings as a coping mechanism, we use an indicator that the household has a savings account.

Figure 8: Education mitigates the impact of climate shocks



Source: Authors estimation using UNSP 2005/06 – 2011/12.

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 consider just beans 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 household in the center and west (Table 13). The difference is largest when considering prices where a 10 percent increase in the beans 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 securing gains in welfare for these households.

Table 13: 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**	0.488**
	(0.825)	(0.219)

Log of beans price	0.245*	0.674***
	(0.130)	(0.122)
Log of number of fatalities	0.057	0.004
	(0.053)	(0.016)
Constant	7.239	4.050**
	(1.603)	(1.701)
Observations	1,585	1618
Number of HHID	504	1022

Source: Staff calculations using UNPS 2005/6-2009/10. 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, by some measures, 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 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 has contributed to this endeavor by focusing on the drivers of an important source of income growth for households in Uganda—agricultural income—and assessing how these drivers impacted welfare dynamics during this period.

The results show that Uganda was able to get many of the fundamentals right. The government secured stability in the north and enabled private markets for agricultural produce to develop 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. When extension services were provided crop income growth resulted, but overall production practices did not change much in agriculture. There was very little growth in the use of improved inputs and as a result modernization of agricultural practices contributed very little to crop income growth. The results also underscore that to some extent, luck was on Uganda's side: good weather benefited many household and the positive price trends in international food and commodity markets during this period were also likely part of the real price increases for maize and other commodities that farmers benefited from. As a result, a favorable external environment (some of it policy induced and some of it not), rather than modernization of

production 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 continued stability in the region, and further promoting efficient crop markets and regional exports will be important for crop income growth in Uganda. However, the almost sole reliance on 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, reversing gains in poverty reduction. This is indeed what happened in the Northern and Eastern regions in 2010/11.

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 experience of Uganda offers 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 enabling households to diversify, and better educated households had consumption that was better insured 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 manage shocks. These are imperfect insurance mechanisms and as a consequence high levels of vulnerability are observed.

Finally, encouraging further income growth as a result of improvements in production practices offers sustainable gains that are not dependent solely on price 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.

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Annex 1

Correlates of Agricultural Income: Value of Agricultural Inputs (RE and FE Models)

	(1) RE model	(2) RE model	(1) FE model	(2) FE model
Demographic characteristics of household head				
Age of household head	0.0106***	0.00909***	0.00386	-0.000443
	(0.00256)	(0.00322)	(0.00461)	(0.00731)
Household head male	-0.200***	-0.121	-0.177	-0.224
	(0.0723)	(0.0959)	(0.110)	(0.176)
Education level of household head = 2, Primary incomplete	0.296***	0.170*	0.219*	0.0452
	(0.0876)	(0.0973)	(0.114)	(0.128)
Education level of household head = 3, Primary completed	0.379***	0.253*	0.267*	0.149
	(0.116)	(0.148)	(0.152)	(0.200)
Education level of household head = 4, Secondary incomplete	0.285**	0.179	0.114	-0.0786
	(0.122)	(0.152)	(0.180)	(0.229)
Education level of household head = 5, Secondary complete	0.209	0.417**	0.202	0.144
	(0.166)	(0.163)	(0.194)	(0.254)
Education level of household head = 6, Postsecondary technical	0.483***	0.267	0.446**	0.108
	(0.156)	(0.202)	(0.222)	(0.320)
Education level of household head = 7, University and higher	-0.0393	0.806***	-0.0816	-0.214
	(0.651)	(0.173)	(0.715)	(0.268)
Market access				
Distance to market selling agricultural inputs in Km	0.0152	0.00802	0.00359	0.00930
	(0.0179)	(0.0243)	(0.0206)	(0.0306)
Farming practices				
Received any visits by extension services past 12 months	0.122***	-0.0491	0.0473	-0.0337
	(0.0457)	(0.0700)	(0.0482)	(0.0768)
Total area planted self-reported, in Ha	0.0210***	0.0256**	0.00907**	0.0159*
	(0.00534)	(0.0105)	(0.00399)	(0.00936)
Owner (land)	0.123	0.125	-0.0591	0.0842
	(0.115)	(0.172)	(0.133)	(0.202)
Both owner and renter (land)	0.239**	0.166	0.0838	0.142
	(0.114)	(0.164)	(0.131)	(0.191)
Value of fertilizer during the year	-0.00765	0.0101	-0.0124	0.00230
	(0.0112)	(0.00948)	(0.0109)	(0.0119)
Value of pesticides during the year	0.0272***	0.0281***	0.0204***	0.0198**
	(0.00508)	(0.00628)	(0.00554)	(0.00837)
Use of seeds and seedlings during the year	0.00413	0.00698	0.00597	0.00782
	(0.00532)	(0.00709)	(0.00574)	(0.00757)
Value of hired labor used during the year	0.0239***	0.0307***	0.0141***	0.0188***
	(0.00406)	(0.00564)	(0.00435)	(0.00620)
Shocks to agricultural income				
WRSI (%)	1.074***	1.323***	0.816***	1.032***
	(0.206)	(0.288)	(0.202)	(0.286)
Maize price	0.419***	0.538***	0.456***	0.518***
	(0.0703)	(0.0975)	(0.0699)	(0.0975)
Beans price	1.105***	1.680***	1.110***	1.632***
	(0.144)	(0.215)	(0.151)	(0.236)
Fatalities	-0.0664	0.0686	0.0278	0.0606
	(0.0447)	(0.0574)	(0.0429)	(0.0602)
Constant	-3.549**	-9.002***	-2.028	-6.704***

	(1.617)	(2.256)	(1.601)	(2.310)
Observations	4,905	2,430	4,905	2,430
Number of HHID	1,787	867	1,787	867
HH Fixed Effects	No	No	No	No
Bottom 40	No	Yes	No	Yes

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