Growth, safety nets and poverty: Assessing progress in Ethiopia from 1996 to 2011

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Abstract

In the last ten years Ethiopia experienced high and consistent growth, invested in public goods provision to poor households, and saw impressive gains in wellbeing for many households. We exploit variation in sectoral growth and public goods provision across zones and time to examine whether poverty reduction was driven by growth and provision of public goods, and what type of growth—output growth in agriculture, manufacturing or services—was more effective at reducing poverty. We pay particular attention to controlling for other drivers of poverty reduction and instrumenting output growth in a sector of particular policy focus—agriculture—in order to identify causal effects. We find that reductions in poverty were largest in places where agricultural output growth has been higher, where safety nets have been introduced, and where improvements in market access have been made. Agricultural output growth caused reductions in poverty of 2.2% per year on average post 2005 and 0.1% per year prior to 2005. However, the gains that agricultural growth brought about were larger closer to urban centers, and non-existent in places far from urban centers. In addition, manufacturing output growth has become increasingly associated with poverty reduction in urban Ethiopia in recent years.

1. Introduction

In the last ten years Ethiopia has experienced substantial poverty reduction. The proportion of the population living below the national poverty line fell from 44.2 percent in 2000 to 29.6 percent in 2011. Other dimensions of welfare have similarly shown dramatic improvement in rural and urban Ethiopia in the last decade. Using DHS data, Carranza and Gallegos (2013) show there were improvements in reducing malnutrition over the last decade. The number of severely stunted children fell by 38 percent nationally, with a fall of 50 percent in urban areas and a fall of 36.3 percent in rural areas.

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There are many possible factors contributing to these improvements. Ethiopia has experienced high and consistent economic growth, recording annual per capita growth rates of 8.3 percent in the last decade, driven largely by growth in services and agriculture (World Bank 2013). Substantial improvements in the provision of safety nets and basic services were also taking place at this time. Ethiopia introduced the Productive Safety Net Programme in 2005, a large rural safety-net targeted to those parts of Ethiopia where reliance on food aid had been highest. Expansion of the provision of education and health services also increased from a low base during this time, supported by the Provision of Basic Services Program. In addition, Ethiopia witnessed tremendous investment in infrastructure and market development during this period. Road networks expanded reducing remoteness, integrating markets and reducing marketing margins (Minten et al 2012).

This paper explores the factors that drove reductions in poverty and improvements in well-being. It exploits variation in poverty reduction, sectoral output growth and provision of public goods across zones and time to examine what has been driving changes in poverty over the period of 1996 to 2011 in Ethiopia. The analysis examines the extent to which growth drove changes in poverty reduction, and what type of growth—output growth in agriculture, manufacturing or services—was more effective at reducing poverty. The analysis also examines whether safety nets and public good provision more broadly, had an additional effect on poverty reduction by increasing redistribution.

Ethiopia is a country rich in data, which allows us to take an approach to estimating these relationships that is not usually possible in sub-Saharan Africa. The Ethiopian Central Statistical Agency has collected consumption data four times between 1996 and 2011, and in a comparable manner allowing changes in poverty to be measured for three time periods for nearly all of Ethiopia's zones. We use multiple surveys and census data to construct annual zonal estimates of poverty, economic output, safety net beneficiaries and access to public services and markets. Panel analysis is then used to identify what has been driving changes in poverty over time. This approach has been used in China (Montalvo and Ravallion 2009), India (Datt and Ravallion 1996) and Brazil (Ferreira et al 2011) but not for any African country. We also use weather shocks to instrument for agricultural output growth to further examine the causal nature of agricultural growth and poverty reduction.

The paper also explores what type of agricultural growth has been most effective at reducing poverty. Our focus on agricultural growth is motivated by three factors: first, a number of papers have shown that growth in agricultural output is often associated with large gains in reducing poverty (e.g. Ravallion and Datt 1996, Ligon and Sadoulet 2007, Christiansen, Demery and Kuhn 2011, Loayza and Raddatz 2010); second, agriculture has remained the primary occupation of a large proportion of Ethiopian households during this period (Martins 2014); and third, there has been a strong policy focus by the Ethiopian government on encouraging productivity growth in small-holder cereal farming during this period in the Agricultural Development Led Industrialization strategy (ADLI), and its later formulation in the PASDEP and GTP. As part of this strategy the government has spent considerable resources supporting cereal intensification of smallholder farmers, for example through investments in agricultural extension and supporting fertilizer distribution. Understanding the effectiveness of this focus and the impact of this strategy on the spatial nature of poverty in Ethiopia is thus important. The analysis also considers which parts of the country—agriculturally productive areas, drought prone areas, areas close to urban centers—have achieved the largest gains in reducing poverty as a result of agricultural growth.

The analysis finds that reductions in poverty were largest in places where agricultural output growth was highest. On average a 1% growth in zonal agricultural output per capita was associated with a 0.15% reduction in poverty. However, when we adopt an empirical specification that allows us to correct for measurement error and endogeneity, we find that agricultural growth had a much larger effect. For every 1% of growth in agricultural output, poverty was reduced by 0.9%.[2] Although still half the global average elasticity (globally, on average a 1% increase in growth was associated with a 2% reduction in poverty), this is well above estimates for sub-Saharan Africa. This implies that agricultural growth caused reductions in poverty of 2.2% per year on average post 2005 and 0.1% per year prior to 2005.

We find no effect of growth in manufacturing or services on poverty reduction. However, in urban Ethiopia, manufacturing growth played a significant role in reducing poverty from 2000 to 2011. For every 1% of growth in manufacturing output, poverty fell by 0.37%. We also find that agricultural growth and services growth are strongly positively correlated which supports evidence from other studies that finds that the start-up of non-farm service enterprises and demand for their services are driven by agricultural incomes (Jolliffe et al 2014). This could explain why, once we control for agricultural growth, services growth does not have an effect on poverty reduction.

Although manufacturing and services growth did not have a direct effect on average rates of poverty reduction during this period, the results do point a potential indirect role of growth in these sectors, and to the need for growth in non-agricultural sectors. Whilst agricultural growth had a strong impact on poverty reduction on average, we find that this positive impact of agricultural growth was only found close to urban centers of 50,000 people or more, indicating the complementary nature of improved access to centers of urban demand (and supply) and agricultural output growth. This finding echoes the results of the simulation analysis in Diao et al (2012).

In addition, further analysis of agricultural growth shows that good crop prices have been an important driver of zonal agricultural growth rates. And that good prices and good weather have been essential in ensuring that increases in the use of fertilizer brought about agricultural growth and reductions in poverty. The use of modern inputs such as improved seeds and fertilizer has increased substantially over the period considered. Although the average impact of modern inputs on agricultural growth and poverty reduction was found to be weak, increased use of modern inputs did bring reductions in poverty

[2] There has been some discussion about the growth elasticity of poverty reduction in Ethiopia. Household survey analysis shows that for every percentage point growth in average household consumption during 2000-2011, poverty fell by almost two percentage points (MOFED 2013). This survey-based measure of the growth elasticity of poverty reduction was -1.94 and sets Ethiopia at the world average, and significantly higher than other countries in the region (Kalwij and Verschoor 2005). However, given GDP per capita grew at a much faster rate that household consumption during this period, the growth elasticity of poverty to GDP growth is less favorable. This data combines measures of GDP growth (the components of growth we look at are from the same data sources used in estimating national GDP growth) with household survey data so we expect estimates to be less favorable. However, our correction for potential measurement error suggests that GDP growth has been more favorable for poverty reduction than the national GDP estimates imply.

under good agro-climatic conditions and high crop prices. Sustaining high crop prices in a landlocked country such as Ethiopia requires sustaining increases in demand for food through growth in non-agricultural sectors (Dercon and Zeitlin 2009).

The PSNP has been shown to increase agricultural input use among some beneficiaries thereby supporting agricultural growth (Hoddinott et al 2012). We also examine whether the PSNP had an additional impact on poverty reduction through redistribution. We find that the implementation of the program from 2005 onwards had an additional annual impact on reducing poverty by 0.5 percent. The magnitude of the effect is consistent with the fiscal incidence analysis in Woldehanna et al (2014) which shows that the direct effect of PSNP payments reduces poverty by about 7 percent. Our estimation strategy controls for initial differences in PSNP and non-PSNP areas, zone-specific time-trends and time-varying differences in growth rates across zones as well as proxies for other social spending and infrastructure investments. The positive impact of the PSNP that we find is plausible given the program is well-targeted (Woldehanna et al 2014, Berhane et al 2012) and contributed to improved food security for beneficiaries (Berhane et al 2012), however we only observe one change in poverty after the introduction of the PSNP and it is possible that commensurate changes brought about in PSNP areas at the same time as the PSNP could be an alternative explanation of this result. The significance of the effect of the PSNP is not robust to all specifications.

Although the motivation for this study is understanding poverty dynamics in Ethiopia, the questions this study addresses are not unique to Ethiopia and as such the findings of this paper have relevance for broader questions on the nature of inclusive growth. There is a large literature that has looked at what type of growth is most inclusive, or poverty reducing. The methods used in this paper draw heavily from this literature. A number of papers have used sub-national data across time to assess what type of sectorial growth has brought about poverty reduction. Ravallion and Datt (1996) use state level data in India, and Ferreira, Leite and Ravallion (2010) use regional GDP and poverty data in Brazil. Additionally a number of cross-country studies such as Christiaensen, Demery and Kuhn (2011), Ligon and Sadoulet (2007), Loayza and Raddatz (2010) examine the relationship between poverty and sectoral growth at the country level. These studies suggest that growth in agricultural and services is particularly poverty reducing.

This paper adds to this literature by addressing these questions for one of the largest countries in sub-Saharan Africa, and perhaps the only country in the sub-continent with the data required to address these questions. In addition, this paper tests the robustness of results to the possibility that reverse causation is driving the observed relationship between agricultural growth and poverty reduction. Loayza and Raddatz (2010) and Ligon and Sadoulet (2007) have used lagged growth rates and instrumental variable techniques to better identify the relationship between agricultural growth and poverty reduction, but to our knowledge these techniques have not been used at the country level before. We use detailed data on the level of crop loss caused by too little rain, to identify the relationship between agriculture and poverty reduction. We find that there is a causal relationship between agricultural growth and poverty reduction in Ethiopia. A comparison of coefficients with and without instrumenting suggests that non-IV results are affected by attenuation bias more than reverse causality.

In the following section we discuss the data that is used in this report, and summarize trends in sectoral growth, safety nets and access to basic services and roads. In section 3 we outline the empirical methodology used. In section 4 we present the main results. In section 5 we discuss the implications of these results on future paths to poverty reduction in Ethiopia.

2. Data

This paper combines various sources of nationally representative survey data collected by the Ethiopian Central Statistical Agency to create a data-set of zone-year observations to assess correlates, and where possible, determinants of changes in poverty in Ethiopia between 1996 and 2011. Ethiopia is divided into 11 regions, and each region is divided further into zones and woredas (districts). We use the zone as the unit of analysis in this paper, as it was the lowest level at which data on poverty and agricultural output could be disaggregated.

We follow 50 zones over the period of 15 years, covering nearly all of Ethiopia's population. We use zonal boundaries from 1996 and calculate all aggregates using these zonal boundaries. The number of zones in Ethiopia increased from 1996 to 2011 with a number of zones splitting into two or three (and in some cases being formed from parts of other zones). We aggregate all sub-cities in Addis Ababa into one zone for the purpose of this analysis given it is not possible to reliably disaggregate some of the other data sources that we use to different sub-cities in Addis. Three pastoral zones in the Somali region were excluded from this analysis on account of no poverty data being available for them (three Somali zones are included). Afar's five zones were excluded from the analysis on account of missing agricultural data in some years. In addition, the three zones in the Gambella region was not included in the analysis as poverty data is not available for 1996 or 2005 for this region.

The following subsections detail the surveys used.

2.1.Poverty estimates

The Household Income and Consumption Expenditure Survey (HICES) is a nationally representative survey conducted every 4-6 years to collect data on household consumption and basic demographics. Poverty estimates are based on total consumption per-adult equivalent which is generated from this data. The survey was fielded from June 1995-February 1996 (hence referred to as 1996), June 1999 to February 2000 (hence referred to as 2000), June 2004 to February 2005 (hence referred to as 2005) and September 2010 to August 2011 (hence referred to as 2011).

One of the challenges in comparing trends in poverty in Ethiopia over the last fifteen years is determining how to accurately compare household consumption across time given the high inflation within the country in the latter half of the decade. Prior to 2011, the poverty lines used were those set in 1996. In 2000 and 2005 the poverty rate was estimated by keeping the 1996 poverty lines constant and by converting all food and non-food consumption recorded in the 2000 and 2005 surveys to 1996 prices using the CPI. In 2011 the cost of the same bundle of food items used to construct the food poverty line in 1996 was re-estimated to generate an accurate survey-based measure of food inflation over this period (MOFED 2013). This survey-based measure of food inflation is lower than the CPI measured in the country during this time. This could reflect a lower rate of inflation for the goods consumed by the poor during this period, or it could reflect that the quality of the food consumed by the poor fell over this period with the smaller increases in prices reflecting a lower quality bundle of items.

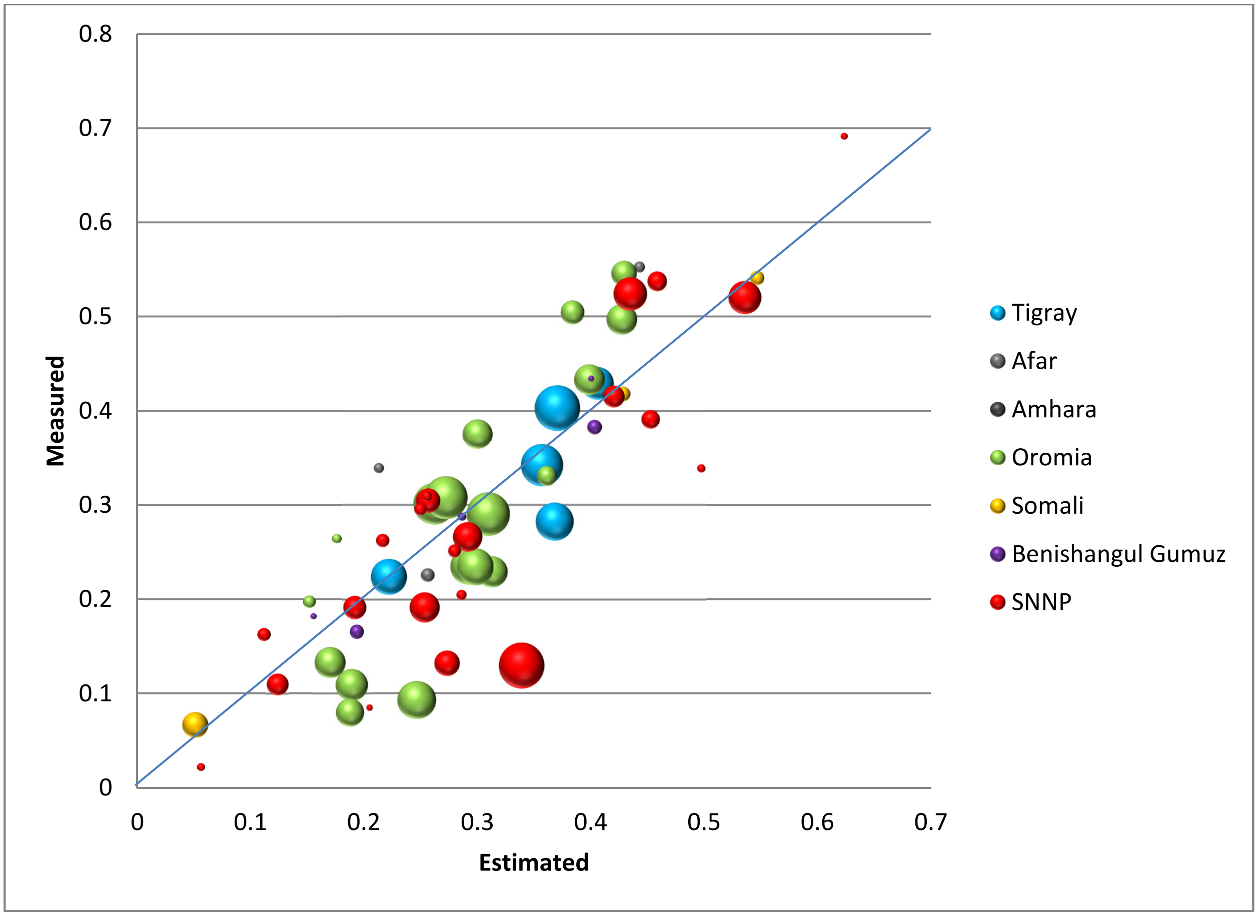
In order to estimate non-food CPI the food share of total consumption for the bottom 25 percent of the distribution was estimated using the 2011 survey data. This was a fall in the proportion of food in total consumption compared to that recorded in 1996 (in 1996 the proportion of food in total consumption was 0.6) suggesting either higher non-food inflation in Ethiopia over this period or an increase in the quantity of non-food items consumed by the poor. The CPI for this period suggests that there has been greater inflation among food items in Ethiopia than among non-food items. The changing proportion of food could reflect the fact that prices of non-food items consumed by the poor have increased more than prices of other non-food items, or it could reflect the fact that poor households have changed the quality or quantity of non-food items consumed.

In assuming a lower food CPI and a higher non-food CPI the MOFED analysis may underestimate the growth in incomes and fall in poverty rates between 2005 and 2011. This is quite remarkable, given the fall in poverty was already sizeable. In this analysis we use the official MOFED poverty numbers thereby implicitly deflating consumption by the survey-based deflators. All other prices in the analysis are deflated using the general CPI. In the Annex we test the robustness of our results to lower poverty estimates for 2011 calculated using the CPI.

The description of the sampling for the HICES indicates that enumeration areas are stratified by zone, with a similar number of EAs selected by zone in each year. Zonal level poverty estimates are reported for 1996, 2000 and 2005 in MOFED (2013). However, these zonal estimates are not often cited, and similar estimates were not presented for 2011. Although the sample is stratified by zone, the sampling strategy used in the HICES is not designed to sample enough households to generate precise zonal level poverty estimates.

Poverty mapping can be used to generate small-area estimates of poverty (Elbers et al 2003), and for the type of analysis conducted in this paper, poverty maps estimated at multiple points in time could provide the required data. Although no official poverty map estimates exist for Ethiopia, the 2007 census has been used with the HICES 2011 data to generate zonal and woreda level poverty estimates (Sohnesen 2014). The poverty mapping report presents the correlation between poverty-map estimates at the zonal level with estimates calculated directly from the data. As indicated in Figure 1 which is taken from this report, although survey based estimates of poverty rates are perhaps noisier than those estimated using poverty mapping techniques they compare well. Until poverty mapping estimates are available across time in Ethiopia, Figure 1 suggests that the zonal estimates can be used with some confidence for regression analysis as is done in this paper. If measurement error in poverty estimates can be considered white noise, it will not affect coefficient estimates given poverty is the dependent variable in our analysis.

Figure 1: Scatter of estimated and measured level of poverty by Zone



Source: Sohnesen 2014.Bubbles indicate the number of HICES observations in each zone.

In addition to using the HICES to estimate poverty for each zone we also use it to estimate the number of people in each zone by aggregating the weights at the zonal level. We also use the number of people in the zone employed in different aspects of services to predict zonal service sector output.

2.2.Agricultural output

Annual estimates of agricultural production are collected by the CSA through the annual Agricultural Sample Survey (AgSS). The AgSS collects data on average landholding, area cultivated, total production, yield, use of fertilizer and improved seeds during the main Meher season. The survey covers about 40,000 households (44,871 households in 2011, for example) in some 2,000 EAs and the sample design allows for estimates to be disaggregated by zone. Most of the data is collected through household surveys, but production estimates are based on crop-cutting experiments conducted for a sub-sample of households. This data is available to us for 1996-2011 with the exception of the year during which the agricultural census took place (2002) and the year following the census in which the full AgSS could not be conducted.

The Meher season is responsible for about 80 percent of crop production in Ethiopia, but for some zones the smaller Belg season is an extremely important part of agricultural production. A Belg crop survey is also undertaken each year, but the production estimates are not representative at the zonal level. We estimate zonal Belg output using zonal estimates of land cultivated to each crop, and regional estimates of average yield for each crop each year. For years prior to 2000 no zonal level land estimates are available and so we use trends in national estimates of land cultivated to scale the area cultivated in 2000.

A survey of producer price data is collected to complement the annual agricultural sample survey. Producer prices are collected throughout the year. We use data from January of each year as this is the main harvest month. Using the same month each year also allows us to abstract from seasonal price movements. We combine this producer price data with the production data to estimate the value of agricultural output in each zone. From this we derive the growth rate of agricultural output per capita.

In some cases yields were missing for chat, enset and coffee. In these cases we imputed yields for chat, enset and coffee using data from other years. Information on the area planted to these crops was available in these cases. There was little variation in yields for these crops among the years that data was collected which suggests this was not an inappropriate strategy. However all estimates were rerun without this imputation and the results still hold. In addition prices were missing for coffee and enset in 1996, so prices were taken from the next available price survey.

The AgSS data was also used to provide estimates for the proportion of land planted o fertilizer and the proportion of land planted to improved seeds. The price data from the AgSS was used to construct a weighted crop price index in which all crop prices were weighted by the share of land planted to that crop in the zone. Changes in the price index reflect both changes in prices for a given crop and also shifts into higher or lower valued crops.

We note that the measure of agricultural output thus constructed does include livestock output, which is a potentially important component of agricultural output in the pastoral Somali zones and the Borena zone of Oromia which are included in our analysis. Data on livestock production is collected as part of the AgSS but it is not straightforward to include this in the agricultural output.

2.3. Manufacturing output

A census of large and medium sized manufacturing establishments is conducted every year. An establishment is considered eligible for this survey if it has more than 10 employees and uses electricity. The survey collects information on output, assets, operating costs and employment. The town of each establishment is recorded and in some cases the zone. By matching towns to zones, zonal manufacturing output can be estimated.

These estimates do not include manufacturing output of smaller firms. Nationally, this is a small proportion of manufacturing output. Soderbom (2012) compares micro-manufacturing firms in Ethiopia with larger firms included in the annual census and shows that the value added of larger manufacturing firms is 8 times that of firms with less than 10 employees. Focusing only on the larger firms for an estimate of manufacturing output thus captures a large share of the manufacturing output in Ethiopia. However, it may be the case that the smaller manufacturing firms matter more for poverty reduction. Our regression estimation strategy allows for the share of manufacturing output produced by small firms to vary across zones and to change with time, but it relies on the growth rate manufacturing output of small firms to be constant within a given zone across the full period 1996-2011.

2.4.Services

No similar census of service establishments is conducted which makes estimating output of the service sector much more complex than estimating the agricultural or manufacturing output. The most systematic survey of service industries is a survey of trade and distributive services that was conducted in 1995, 2002 and 2009. This survey allows regional estimates of productivity of service enterprises to be generated, but it is a sample survey and does not allow for an estimate of the zonal service output. It also does not include information on personal services such as hotels, restaurant and domestic help.

In order to generate a zonal estimate of service output we use data on the number of individuals engaged in trade and distributive services in the zone from the HICE surveys and multiply this with national estimates of value added per worker to generate a measure of zonal output per worker from these surveys. The value of hotel and restaurants are however not captured in this measure of services output per capita.[3]

2.5.Public goods provision: data on safety nets and access to basic services

There are three aspects of public goods provision incorporated in this empirical analysis. First, we incorporate a measure of the continual investments in access to schools and health services that has taken place since 1996. Ideally we would have a measure of public investments in education and health services in the zone over the last 15 years. In the absence of this data we use the average distance to a primary school recorded at four points in time in the Welfare Monitoring Surveys (WMS) that are conducted alongside the HICE surveys used for poverty estimates.

Secondly we measure investments in roads that have improved access to basic services and private markets. We use the Schmidt and Kedir (2009) estimates of time to travel (using type of road and distance to generate the estimates) to a town of 50,000 people in 1994 and in 2007 to estimate an

[3] We also experimented with using zonal service sector employment data to distribute national estimates of service output (from national accounts) across zones. When we use these estimates we get the same qualitative findings as presented here, although the size of the coefficient estimates changes. We elect to use the survey-based measure of service sector growth as it is clearer on how to attribute this to different zones (output per worker is directly reported).

average annual reduction in travel time. The distance at each square kilometer in the zone is averaged across the zone to prove a zonal average estimate. We also use data collected on access to bus services collected in the WMS as an alternate measure of changes in road infrastructure (this was the only transport access measure collected consistently across all four rounds). The WMS estimates allow us to weight more populated areas within a zone more than less populated areas within a zone. However, the disadvantage with this measure is that it may also reflect aspects of public transportation markets and not just improved road access as a result of investments in roads.

Finally we assess the introduction of safety nets. In 2005, the Government of Ethiopia together with the support of Development Partners, designed and commenced implementation of a Food Security Programme, which included a Productive Safety Net Programme (PSNP) as well as complementary programming to strengthen local livelihoods. The PSNP is targeted at the most food insecure woredas in Ethiopia. We use administrative data on the number of beneficiaries per zone per year to estimate the proportion of households in the zone benefiting from the PSNP.

2.6. Weather shocks

The Livelihoods, Early Assessment and Protection project (LEAP) system, developed in 2008 by the Government of Ethiopia in collaboration with WFP, uses crop-modeling approaches to estimate rainfall-induced crop loss in woredas throughout Ethiopia. Water-balance crop models and yield reduction coefficients are defined for the crops grown in the zone. Evapotranspiration coefficients for the zone are used with data on decadal rainfall in a given year to generate an estimate of the proportion of crop that was lost in a given year as a result of insufficient rainfall. These models essentially provide a weighted average of rainfall in which rainfall at times of the year in which the development of the crop is particularly moisture dependent is given a higher weight. The weights are provided by agronomic crop models. Crop loss estimates are generated for each 50 km by 50 km square. This is aggregated to generate a zonal estimate of crop-loss. The LEAP database contains crop loss estimates from 1996 to 2012 for both Belg and Meher seasons.

2.7. Summary statistics

In Table 1, we present summary statistics for the four time periods in our data across time, using the data in our sample. The table shows that poverty started to fall only after 2000, and its reduction has been particularly large in the years after 2005. Although output increased throughout this time, large increases in agricultural output occurred after 2000 and in manufacturing and services after 2005. The sectoral composition of zonal output has remained remarkably constant across time, with agriculture accounting for about half of zonal output, manufacturing accounting for one tenth and services accounting for 34-42%.

Improvements in access to basic services and infrastructure have increased during this time. The bottom panel of the table also shows that input use and crop prices have increased substantially over time.

Table 1: Zonal averages of key variables

	Data source	1996	2000	2005	2011
Poverty					
Poverty headcount rate (%)	HICES	47.7	47.4	40.3	28.1
		(18.9)	(15.3)	(11.6)	(13.7)
Poverty gap (%)	HICES	13.89	13.64	8.65	7.44
		(8.43)	(7.69)	(4.01)	(4.58)
Poverty severity (%)	HICES	5.57	5.42	2.79	2.92
		(4.37)	(4.18)	(1.74)	(2.13)
Output by sector					
Agricultural output per capita (Birr p.c.)	AgSS, HICES	162.9	155.0	190.5	275.8
		(93.3)	(98.4)	(134.7)	(191.6)
Manufacturing output per capita (Birr p.c.)	LMSMS, HICES	52.2	78.3	99.3	159.9
		(173.9)	(232.7)	(296.8)	(444.0)
Trade services output per capita (Birr p.c.)	DTSS, HICES	126.1	198.2	165.1	216.6
		(128.1)	(275.6)	(139.7)	(115.7)
Cereal output per capita (Birr p.c.)	AgSS, HICES	136.6	124.6	139.4	193.1
		(88.2)	(87.4)	(115.7)	(152.2)
Cash crop output per capita (Birr p.c.)	AgSS, HICES	15.3	18.1	38.7	62.6
		(18.5)	(23.6)	(62.1)	(83.5)
Proportion of output coming from:					
Agriculture		0.60	0.49	0.52	0.55
		(0.30)	(0.27)	(0.26)	(0.26)
Manufacturing		0.07	0.09	0.09	0.09
		(0.14)	(0.16)	(0.17)	(0.19)
Services		0.34	0.42	0.39	0.36
		(0.24)	(0.24)	(0.23)	(0.20)
Safety nets, basic services and infrastructure					
Proportion of households in the PSNP (%)	PSNP data	0	0	0	8.3
					(11.4)
Distance to the nearest primary school (km)	WMS	4.77	4.11	4.14	2.74
		(2.27)	(1.55)	(2.36)	(0.86)
Distance to bus or taxi service (km)	WMS	20.9	20.5	17.5	13.6
		(17.8)	(11.9)	(10.7)	(8.8)
Distance to town of 50,000 or more (minutes)	Schmidt and Kedir	566	486.9	408.0	317.4
	(2009)	(397)	(335.7)	(279.3)	(217.5)
Agricultural variables					
Predicted crop loss due to rainfall (%)	LEAP	11.4	22.4	26.6	15.7
		(13.5)	(18.8)	(23.1)	(16.2)
Land planted to improved seeds (%)	AgSS	0.5	1.4	2.3	4.1
		(0.8)	(1.5)	(2.2)	(4.6)
Land on which fertilizer is applied (%)	AgSS	15.3	9.6	16.7	27.6
		(21.2)	(10.6)	(16.5)	(22.3)
Weighted index of crop prices (Birr per kg)	AgSS	1.12	0.86	1.03	1.26
		(0.25)	(0.21)	(0.36)	(0.37)

Note: Standard deviation in brackets. All Birr values are in 1996 prices. p.c. stands for per capita

Before continuing with the analytical framework we comment on how the zonal output data compares to the national GDP per capita data. We weight the zonal averages by population for this comparison. On average we capture 40-42% of total GDP in our measures. In 2011 GDP per capita was 1762 Birr per capita in 1996 prices, compared to 707 Birr per capita in our data. GDP per capita was 1138 Birr per capita in 2005 compared to 478 Birr per capita in our data. This discrepancy in part comes from our exclusion of real estate, public administration, livestock and forestry, construction, energy and mining. In particular we underestimate service output by not including real estate -- almost a quarter of service output – which in turn is largely comprised of imputed rental of owner occupied dwellings Service output was 44% of value added in 2011, but we measure it as 36% of output in our data. The estimation strategy we use allows us to control for measurement error in agricultural output.

3. Empirical Method

We use these various data sources to construct a panel of 50 zones observed four times over the period 1996 to 2011. We exploit variation in sectoral output growth and public goods provision across zones and time to examine what has been driving changes in poverty over time in Ethiopia. The empirical approach we take is thus very similar to that used in Ferreira et al (2010).

We start by abstracting from the sectoral pattern of output growth and examining whether changes in poverty rates have been driven by aggregate output growth in the zone. In addition we examine whether public good provision—specifically the introduction of safety nets, investments in primary education and roads—has had an additional effect on poverty reduction (in addition to any effect that has resulted from their impact on growth) via redistribution. Specifically we estimate:

$$\Delta \ln p_{zt} = \beta_0 + \beta_Y \Delta \ln Y_{zt} + \beta_N \Delta \ln N_{zt} + \beta_E \Delta \ln E_{zt} + \beta_D \Delta \ln D_{zt} + u_z + e_{zt} \quad (1)$$

Where p_{zt} is the poverty rate in the zone at time t, Y_{zt} is zonal output, N_{zt} is the proportion of people in the zone covered by the safety net program at time t, E_{zt} is increased access to primary schools in the zone at time t and $D_{zt}$is a measure of infrastructure investments reducing remoteness in the zone (proxied alternately by the two measures of infrastructure investment described in the previous section).

Secondly, we examine the relationship between the nature of sectoral output growth and poverty reduction by decomposing zonal output growth into that coming from agricultural growth and that coming from manufacturing and services. Following Ravallion and Datt (1996) and the subsequent literature on the relationship between the composition of growth and poverty reduction we estimate:

$$\Delta \ln p_{zt} = \beta_0 + \beta_{Y^a} s^a_{zt-1} \Delta \ln Y^a_{zt} + \beta_{Y^m} s^m_{zt-1} \Delta \ln Y^m_{zt} + \beta_{Y^r} s^r_{zt-1} \Delta \ln Y^r_{zt}$$
$$+ \beta_N \Delta \ln N_{zt} + \beta_E \Delta \ln E_{zt} + \beta_D \Delta \ln D_{zt} + u_z + e_{zt} \quad (2)$$

Where $Y_{zt}^{i}, i = a, m, r$ is the output of agriculture (a), manufacturing (m) and services (r) respectively and s_{zt-1}^{i} is the share of output of sector i at the beginning of the period. In later specifications we proxy Y_{zt}^{m}, and Y_{zt}^{r} with growth in the share of the population living in urban areas in the zone.

Interacting the rate of growth of sector i with the share of sector i in total output allows growth in a given sector to influence poverty according to the size of the sector. The combined expression, $\beta_{Y^i} s_{zt-1}^{i}$, provides a measure of the elasticity of poverty to growth in that sector. This specification allows us to look at whether particular components of growth are more strongly associated with poverty reduction, and also allows us to test whether the sectoral composition of growth matters by testing whether $\beta_{Y^a} = \beta_{Y^m} = \beta_{Y^r}$ (Ferriera et al 2010).

Given we only have four observations (and thus three time differences), coefficients on growth and social spending are assumed constant across zones. This is something that we relax in later specifications by allowing coefficients to vary by average distance to urban center. We start by assuming a constant coefficient across time, but this is something that we also explore in alternate specifications by running the regression separately for 1996-2005 and 2000-2011.

This specification allows us to control for a number of other factors that might confound the relationship between sectoral composition and poverty rates. The regression is estimated in differences allowing us to control for any initial zonal characteristics that affect the relationship between the output of one sector and poverty.[4] Zone-specific time trends are included in the model, u_z, through the inclusion of zone-specific fixed effects which allows each zone to have a zonal specific trend in poverty reduction over the period. The inclusion of measures of public goods provision also allows us to control for a number of time-variant characteristics that may be important in determining the relationship between the pattern of growth and poverty. The inclusion of N, D and E not only allows us to assess their redistributive effect, it also allows us to control for a number of time-variant characteristics that may be important in determining poverty and which may affect the estimation of β_{Y^i}.

However, even with a fully specified model, our estimation strategy is subject to a concern that reverse causation may be driving the results. For us to argue that our results are not just interesting correlations, but actual causation, we will need to be able to address the argument that gains in poverty reduction did not cause greater growth in the sectors that appear to be significantly correlated with poverty reduction. In some papers on the relationship between sectoral growth and poverty this goes unaddressed, and in other papers it is addressed by instrumenting growth rates with growth rates of neighbors (Ligon and Sadoulet 2008, Loayza and Raddatz 2010) or lagged growth (Loayza and Raddatz 2010). Henderson et al (2011) has explored the use of rainfall as a measure of exogenous variation in agricultural growth and we take the same approach here using WRSI data available at the zonal level in Ethiopia from 1996-2011. We use weather shocks (calculated as the sum of annual estimates of crop loss for the zone through a crop WRSI model) as an estimate of exogenous variation in agricultural growth. Ethiopia is characterized by both significant weather risk and significant heterogeneity in

[4] Annualized growth rates are calculated for each variable by dividing each growth rate by the number of years over which the growth occurred (4 years for differences from 1996 to 2000, 5 years for differences from 2000 to 2005, and 6 years for differences from 2005 to 2011).

weather risk across space and time. It is likely that agricultural output is the main mechanism by which local weather shocks affect local livelihoods, and that increased market integration throughout this period limits the impact of small local weather shocks on prices and growth in other sectors. This is something that we test empirically.

Concerns about reverse causality are less likely to be present in the interpretation of coefficients on public goods provision. It is difficult to construct a plausible hypothesis in the Ethiopia context that locations that became richer received more public goods provision. The districts included in the PSNP program were decided at the time of program inception in 2005. The amounts provided to different districts have not changed much over time, but to the extent they have, they have increased not reduced with need. Public financing of education has similarly been larger in the poorest districts of Ethiopia (Kahn et al 2014), so it is unlikely that the relationship between access to education services and poverty would suffer from reverse causality.

Finally, although the literature on the link between growth and poverty does not weight observations by the number of people they represent, we do test the robustness of our results for weighting by the population of each zone. The main findings are unchanged when weighting. We do not report the results in the paper, but they are available from the authors on request.

We will also look at whether some types of agricultural output growth have been more successful in driving poverty reduction by disaggregating agricultural growth further into growth in cereals and cash crops, and looking at the drivers of agricultural growth that have contributed to poverty reduction. Specifically Y_{zt}^{a} will be replaced with rainfall shocks, input use and weighted crop prices. This will allow us to examine what types of agricultural advances have advanced poverty reduction.

4. Results

4.1. Basic results

The relationship between poverty reduction and total output growth per capita in the zone, expansion of safety nets and improvements in access to basic services and infrastructure is examined first by estimation equation 1. The results are presented in column (1) of Table 2 and indicate that growth has been a significant driver of reductions in poverty over the fifteen year period from 1996 to 2011. The elasticity of poverty to growth is -0.15. On average a 1 percent growth in zonal output per capita led to a 0.15 percent reduction in poverty. Although growth had an impact the growth elasticity of poverty was quite low. Household survey analysis shows that for every percentage point growth in average household consumption during 2000-2011, poverty fell by almost two percentage points (MOFED 2013). This survey-based measure of the growth elasticity of poverty reduction was -1.94 and sets Ethiopia at the world average, and significantly higher than other countries in the region (Kalwij and Verschoor 2005). However, given GDP per capita grew at a much faster rate than household consumption during this period, the growth elasticity of poverty to GDP growth is less favorable. Christiaensen et al 2013 find no relationship between GDP growth and poverty reduction in sub-Saharan Africa so even though the effect of growth on poverty reduction may be small, it is still much higher than the rest of the region and confirms that Ethiopia has been much more successful than other countries in Africa in converting growth into poverty reduction.

Estimation results show that the proportion of the population benefiting from the PSNP and the average distance to public transport is significant, indicating that the introduction of the PSNP and improvements in road infrastructure had an additional beneficial effect on poverty reduction, in addition to any impact through the growth in output that they contributed to.

Table 2: Growth, safety nets and infrastructure investments contributed to poverty reduction

	(1)	(2)	(3)	(4)	(5)
			Weighting results by urban population		
Annualized percentage change in p0	1996-2011	1996-2011	1996-2011	1996-2005	2000-2011
Annualized percentage change in….					
Output per capita	-0.15*				
	(0.09)				
Agricultural output per capita		-0.29**	-0.04	-0.25*	0.30
		(0.14)	(0.20)	(0.14)	(0.32)
Manufacturing output per capita		-0.03	-0.47	0.16	-1.36*
		(0.42)	(0.38)	(0.26)	(0.73)
Services output per capita		-0.04	0.04	-0.10	-0.17
		(0.18)	(0.24)	(0.14)	(0.34)
Proportion of population in PSNP	-0.06**	-0.06*	-0.09**		-0.03
	(0.03)	(0.03)	(0.04)		(0.05)
Distance to primary school	-0.08	-0.07	0.01	-0.25*	0.37**
	(0.16)	(0.16)	(0.12)	(0.14)	(0.14)
Distance to public transport	0.18*	0.14	0.22***	0.16	-0.44
	(0.10)	(0.11)	(0.08)	(0.10)	(0.37)
Constant	-0.02	-0.02**	-0.01*	-0.01	-0.04***
	(0.01)	(0.01)	(0.01)	(0.005)	(0.01)
Observations	147	147	135	90	91
R-squared	0.115	0.129	0.169	0.170	0.312
Number of zones	50	50	46	46	46

Zonal fixed effects included but not shown. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The question of whether the pattern of growth has been important in reducing poverty is examined by estimating equation (2). Results are presented in column (2) of Table 2. The results indicate that agricultural growth has been significantly positively related with poverty reduction. Poverty has fallen fastest in those zones in which agricultural growth has been strongest. Manufacturing and services output growth has not been a significant contributor to poverty reduction on average during the fifteen years from 1996-2011, although the coefficients on manufacturing and services growth is of the sign expected. The implied elasticities of poverty to growth in agriculture, manufacturing and services are -0.155, -0.002 and -0.027 respectively.[5] However, given the imprecision with which the coefficients on manufacturing and services sector growth are estimated, a test of equality of coefficients across the three sectors ($\beta_{Y^a} = \beta_{Y^m} = \beta_{Y^r}$) cannot be rejected.

Manufacturing and services growth are perhaps more likely to bring about reductions in poverty in urban centers. With the exception of the two purely urban zones of Mekele and Addis Ababa, the zones in this study include both rural and urban areas which may be masking the impact of manufacturing and service growth in urban locales. This is tested by re-estimating equation (2), but weighting the results by the proportion of the zone that is urban. In this specification those zones with very small urban populations are given a very low weight such that they are almost dropped from the analysis and those that are entirely urban (such as Mekele and Addis) derive the highest weight. In this specification we would expect that sources of growth that are more important to urban poverty reduction would appear more significant. Results are presented in columns (3) to (5) of Table 2 and indicate that although agricultural growth was important in these zones in the first part of this period, in the last decade higher manufacturing growth in urban areas was associated with higher poverty reduction. The elasticity of poverty to growth in manufacturing is -0.37 in this specification which means that a 1% increase in manufacturing growth was associated with a reduction in poverty of 0.37%.

The persistent insignificance of the service sector could be explained by three factors. First, we note that of the three sectors, zonal output estimates were most imprecise for this sector, relying on employment data in the HICES and national estimates of value added per worker in this sector. This measurement error may mask the true relationship between these sectors and poverty reduction. Secondly, we note that although poverty rates fell faster among those that reported employment in the service sector (MOFED 2013), employment in the service sector has remained consistently low across this time period (from 12-14% of the workforce). The small proportion of the workforce in services makes it very difficult for service sector growth to have a large direct effect on poverty reduction. Finally we note that if growth in services was strongly correlated with growth in agriculture, we would not see an additional effect of services growth on poverty reduction once agricultural growth was controlled for. We return to this issue below.

Once we account of the sectoral composition of growth, we find that investments in roads no longer have a redistributive effect but the estimated redistributive impact of the PSNP looks identical.

4.2.Testing causality

[5] Calculated by multiplying the coefficients in column 1 of Table 3 with the average share of the sector over the years 1996, 2000 and 2005 detailed in Table 1.

As discussed in Section 3, reverse causality would result in over-estimation of the true growth elasticity of poverty, and error in measuring output would result in under-estimation of the true growth elasticity as a result of attenuation bias. We use detailed data on the impact of rainfall on expected crop yields as a measure of an exogenous shock to agricultural production, and use this to instrument for agricultural growth. Agriculture production is almost entirely rainfall-dependent in Ethiopia (there is very little irrigation) and we thus expect changes in rainfall to be an important, exogenous, component of agricultural output growth. This estimation strategy assumes that the main impact of weather is on the agricultural sector. This is something that we test in Table 3. We indeed find that whilst local agricultural shocks have an impact on agricultural growth in that zone they do not negatively affect manufacturing or services growth in that zone.

The results in Table 3 also provide some additional insights into why we may not observe a significant impact between services growth and poverty reduction. Column (1) and (3) indicate that agricultural growth and service sector growth are positively correlated. Given the measure of service output constructed for the analysis is largely comprised of wholesale and retail trade this positive correlation is very plausible. This finding is corroborated by data presented in Jolliffe et al (2014) which provides more detail on the importance of agricultural growth in driving non-farm, service sector enterprises in rural areas and small towns in Ethiopia. Jolliffe et al show that 64% of businesses were established using funds from agricultural production and that these businesses are most active in the months of harvest and immediately thereafter suggesting a strong relationship between agricultural production and this type of service sector activity. If our measure of services output is largely driven by agricultural growth it is quite likely that any relationship between growth in services and poverty reduction is being captured in the coefficient on agricultural growth. Growth in the service sector may have contributed to poverty reduction in Ethiopia; our results just suggest that it has not had an effect independent of growth in the agricultural sector.

Results for instrumenting agricultural output growth with rainfall are presented in table 4. The results suggest that agricultural output growth has had a strong causal impact on poverty reduction. For every 1% of growth in agricultural output, poverty was reduced by 0.9%.This implies that agricultural growth caused reductions in poverty of 2.2% per year on average post 2005 and 0.1% per year prior to 2005. The magnitude of the coefficient is much higher than previously which may indicate that earlier results were not affected by reverse causality as much as they were affected by measurement error in agricultural output which was causing attenuation bias. It could also be the case that agricultural growth induced by good weather is more poverty reducing than agricultural growth brought about by technology adoption or improved cereal prices. All agricultural producers benefit from good weather, not just those that adopt technologies and sell part of their harvest who are likely to be wealthier farmers.

Once agricultural growth has been instrumented with weather, there is no longer a reduction in poverty as a result of an additional redistributive effect of the introduction of the PSNP, investment in education and investment in roads. The coefficient on the PSNP falls from 0.06 to 0.01, suggesting that the reduction in poverty from the introduction of the PSNP was 3 percent not 18 percent as suggested by the coefficients in Table 2.[6]

Table 3: Weather is a good instrument for growth in the agricultural sector, but not other sectors

	(1)	(2)	(3)
Annualized percentage change in….	Agricultural output	Manufacturing output	Services output
Change in predicted rainfall induced crop-loss	-0.001***	0.0001	0.0005
	(0.0005)	(0.0002)	(0.0004)
Annualized percentage change in….			
Agricultural output per capita		0.0283	0.180**
		(0.0366)	(0.0847)
Manufacturing output per capita	0.231		0.181
	(0.299)		(0.247)
Services output per capita	0.263**	0.0323	
	(0.124)	(0.0442)	
Proportion of population benefiting from PSNP	0.00148	-0.00110	0.0231
	(0.0246)	(0.00862)	(0.0202)
Distance to primary school	0.182	-0.0649	0.0273
	(0.118)	(0.0414)	(0.0991)
Distance to public transport	-0.102	-0.0226	0.199***
	(0.0748)	(0.0263)	(0.0590)
Constant	0.0140*	-0.00246	-0.00104
	(0.00807)	(0.00286)	(0.00678)
Observations	147	147	147
R-squared	0.161	0.044	0.163
Number of zones	50	50	50

Zonal fixed effects included but not shown. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Agricultural growth caused poverty reduction

Annualized percentage change in:	Headcount poverty	Poverty gap index	Poverty severity index
Annualized percentage change in….			
Agricultural output per capita	-1.660**	-2.690**	-3.205**
	(0.704)	(1.134)	(1.401)
Manufacturing output per capita	0.196	0.565	0.790
	(0.611)	(0.969)	(1.197)
Services output per capita	0.274	0.631	0.810
	(0.297)	(0.464)	(0.573)
Proportion of population benefiting from PSNP	-0.0100	0.0903	0.157
	(0.0502)	(0.078)	(0.0969)
Distance to primary school	0.0665	0.084	0.0270
	(0.242)	(0.376)	(0.465)
Distance to public transport	-0.0245	-0.192	-0.274

[6] The contribution to poverty reduction is calculated by multiplying the coefficients in column 1 of Table 4 with the percentage change recorded from 2005 to 2011.

	(0.172)	(0.270)	(0.334)
Constant	0.0176	-0.007	-0.0360
	(0.0870)	(0.136)	(0.168)
Observations	147	144	144

Zonal fixed effects included but not shown. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The end of the period 2005-2011 was characterized by high inflation making the comparison of poverty across time challenging. The robustness of the findings presented thus far are tested by using a different price deflator of the cost of living across time (the CPI instead of a survey-based deflator as used in the official poverty estimates). We also consider the robustness of results to adding the percentage change in the national general CPI across periods and to including year dummies that would control for variation in CPI across rounds, but also any other time-varying factors that could be considered constant across zones. Results of these various robustness checks are presented in the Appendix. The results indicate that the positive impact of agricultural growth on poverty reduction is robust to all of these specifications, as is the impact of manufacturing growth on poverty reduction in urban areas. Any additional impact of public goods provision through redistribution is not robust to these alternate specifications.

Thus far the analysis has considered the impact of growth and public goods provision on the poverty headcount index, but the degree to which households fall below the poverty line is also an important indicator of progress against poverty, and as such it is informative to run the same specification using the poverty gap and the poverty severity index as the dependent variables. In columns (2) and (3) of Table 4 estimates are presented for the poverty gap and poverty severity index. We see that agricultural growth, in all specifications reduced the poverty gap and poverty severity index. However, the results suggest that public goods provision did not additionally reduce these measures of poverty through redistribution.

4.3.Interaction between agricultural growth and market access

To further examine the relationship between agricultural growth and growth in other sectors, we look at the interaction between growth in agricultural revenue and proximity to markets. We compare the agricultural growth and poverty in areas that were far from urban centers of 50,000 plus people (more than 6 hours and 40 minutes) at the beginning of the time period in question, to the relationship between agricultural growth and poverty in areas close to urban centers. We find that agricultural growth was only poverty reducing for those close to urban centers (Table 5). This suggests an important link between agricultural growth and urban demand, urban demand which is likely to be fuelled by non-agricultural growth. Taken with the results in Table 3, this suggests that even though the direct contribution of non-agricultural growth to poverty reduction was limited, it was in places where agricultural growth was best placed to contribute to and benefit from growth in these sectors that it had the largest effect on poverty reduction.

Table 5: Agricultural growth was particularly poverty reducing close to urban centers

	$dlnP_0$
Growth in agricultural output per capita interacted with	
Close to town of 50,000 plus	-3.40*
	(1.81)
Far from town of 50,000 plus	-0.74
	(0.66)
Growth in manufacturing output per capita	0.39
	(0.70)
Growth in services	0.64
	(0.48)
Growth in PSNP coverage	0.018
	(0.06)
Access to education	0.11
	(0.27)
Access to roads	-0.05
	(0.19)
Constant	-0.039
	(0.10)
Observations	147
R-squared	0.141
Number of zones	50

Zonal fixed effects included but not shown. Estimates of agricultural growth are instrumented with weather shocks. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.4.Examining agricultural growth

What drove the relationship between agricultural growth and poverty reduction? The type of agricultural growth that is most associated with poverty reduction is explored in Table 6 (PSNP, education and roads measures are included but results are not shown to conserve space). Results in column (1) show that it was growth in cereals, not cash crop production that was most strongly associated with poverty reduction. Results in column (2) examine which components of agricultural growth were most strongly associated with poverty reduction. Despite substantial increases in the use of inputs over this period, the estimates in column (2) do not indicate that, on average, increased used in inputs caused poverty reduction. Returns to use of improved inputs is highly weather dependent in Ethiopia. Christiaensen and Dercon (2010) provide estimates that show that net-returns are only positive under good weather conditions. Indeed we see that beneficial weather conditions had a particularly large impact on poverty during this time.

In column (3) we separately examine the relationship between growth in fertilizer use and poverty reduction in good and bad years. We define good conditions for fertilizer use as occurring in those years in which weather was better than average, and when crop prices were higher than average (given returns to fertilizer are also highly price dependent, see Spielman et al (2007)). We find that there is a significant relationship between the use of fertilizer and poverty reduction when the conditions are right and no relationship between fertilizer use and poverty in other years. The results suggest that under the right conditions, a 10% increase in fertilizer use would reduce poverty by 0.4%.

In columns (2) and (3), we also observe that once agricultural growth is replaced by its component parts, growth in services becomes more strongly correlated with poverty reduction. This is consistent with the hypothesis that agricultural growth is, in part, picking up changes in the service sector. This is in turn consistent with the results in columns (1) and (3) of table (4) which shows that service and agricultural sector growth are strongly correlated.

Table 6: Drivers of agricultural growth and poverty reduction

Annualized percentage change in p0	(1)	(2)	(3)
Annualized percentage change in….			
Cereal output per capita	-0.35**		
	(0.16)		
Cash crop output per capita	0.45		
	(0.54)		
Manufacturing output per capita	0.02	-0.190	-0.14
	(0.42)	(0.42)	(0.41)
Services output per capita	-0.09	-0.16	-0.15
	(0.18)	(0.18)	(0.18)
Proportion of land planted with improved seed		0.004	-0.007
		(0.04)	(0.04)
Proportion of land applied with fertilizer		-0.01	
		(0.01)	
Proportion of land applied with fertilizer * bad conditions			0.001
			(0.01)
Proportion of land applied with fertilizer *good conditions			-0.04*
			(0.02)
Weighted crop price index		-0.16	-0.14
		(0.15)	(0.14)
Change in predicted rainfall induced crop-loss		0.002***	0.002***
		(0.001)	(0.001)
Constant	-0.03**	-0.04**	-0.03**
	(0.01)	(0.01)	(0.01)
Observations	147	143	143
R-squared	0.141	0.225	0.254
Number of zones	50	49	49

Zonal fixed effects included but not shown. PSNP, education and infrastructure variables are included but not shown. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In Table 7 we examine the relationship between cereals growth and weather, prices and growth in the use of improved inputs over a longer period of time. Because we are no longer looking at the relationship between agricultural growth and poverty reduction, we are no longer constrained to only including the years in which poverty data is available; as such we are able to expand our panel to all years from 1996 to 2011. We also focus these regressions on cereals and pulses production in the main agricultural zones in our sample, namely all zones in Amhara, Oromia, SNNPR and Tigray. Somali, Benishangul-Gumuz, Harari, Addis Ababa and Dire Dawa are thus excluded. Agricultural zonal outputs are not available for two years in the middle of our series, and as a result we lose two years of estimates.

The results corroborate findings from Table 6. Growth in modern input use contributed to agricultural growth when weather conditions and prices were favorable. There was no contribution of growth in improved inputs in other years. The results also highlight the important role of weather and prices in overall agricultural output growth.

Table 7: Favorable rainfall and improved producer prices contributed to agricultural growth

	Growth in revenue from cereals	
	(1)	(2)
Change in predicted rainfall induced crop-loss	-0.005***	-0.004***
	(0.001)	(0.001)
Growth in the proportion of land planted with improved seeds	-0.026	-0.030
	(0.030)	(0.030)
Growth in the proportion of land on which fertilizer was applied	0.016	
	(0.033)	
Growth in the proportion of land applied with fertilizer * bad conditions		-0.026
		(0.036)
Growth in the proportion of land applied with fertilizer *good conditions		0.154**
		(0.062)
Growth in crop prices	0.124***	0.117**
	(0.047)	(0.047)
Constant	0.064***	0.059***
	(0.019)	(0.019)
Observations	452	452
R-squared	0.039	0.054
Number of zones	38	38

Zonal fixed effects included but not shown. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.5. The spatial impact of growth

Agro-ecological zones vary considerably across the country, so we examine whether the impact of agricultural output growth has been heterogeneous across different parts of Ethiopia. Rural policy discussions are often framed around the concept of "five Ethiopias", in which zones are classified according to agricultural productivity and agroecological conditions (EDRI 2009). The five areas are drought prone highlands, moisture-reliable cereals areas, moisture-reliable enset areas, humid moisture-reliable lowlands and pastoral areas. We use EDRI's definition of the five Ethiopias to test in which parts of Ethiopia growth in agricultural output contributed most to poverty reduction. Table 8 summarizes average zonal poverty measures across each of these zones. Little poverty reduction was observed in pastoral areas or moisture reliable lowlands, but quite strong poverty reduction was recorded in the other three zones across the fifteen years. Results in Table 9 do not suggest any strong trend in which areas benefited more from agricultural growth, although the drought prone highlands may have benefited more.

Table 8: poverty trends across the five Ethiopias, 1996-2011

	Headcount poverty rate (p0)				Percentage change in p0		
	1996	2000	2005	2011	1996-2000	2000-2005	2005-2011
Pastoral*	29.9	32.9	36.9	29.2	0.02	0.02	-0.09
Drought-prone highlands	51.5	53.6	43.4	26.7	0.03	-0.04	-0.09
Moisture-reliable cereals areas	44.7	39.6	38.1	30.6	-0.02	-0.01	-0.05
Moisture-reliable enset areas	49.2	47.1	34.2	23.8	-0.003	-0.07	-0.10
Humid moisture-reliable lowlands	51.3	62.5	56.3	55.3	0.05	-0.02	-0.01

*Only including those zones in which surveys were conducted, and excluding Afar

We also look at whether agricultural growth has been just as important in zones in which coffee production is important. Consistent with earlier results that growth in cash-crop production has not been particularly poverty reducing, we find that agricultural growth has not had much impact in coffee-producing areas (Table 9, column 1).

Table 9: Spatial impact of agricultural growth

	(1)	(2)
Growth in agricultural output per capita interacted with		
Coffee	-0.304	
	(1.284)	
Non-coffee	-2.102**	
	(0.908)	
Drought-prone highlands		-1.785
		(1.682)
Moisture-reliable cereals areas		8.272
		(13.25)
Moisture-reliable enset areas		-0.495
		(2.269)
Pastoral and moisture reliable lowlands		-6.165
		(12.13)
Growth in manufacturing output per capita	0.214	0.516
	(0.666)	(1.441)
Growth in services	0.202	-0.0754
	(0.245)	(0.513)
Growth in PSNP coverage	0.00730	0.00871
	(0.0577)	(0.128)
Access to education	0.160	-0.178
	(0.273)	(0.617)
Access to roads	-0.176	-0.118
	(0.238)	(0.438)
Constant	0.0341	0.0198
	(0.0963)	(0.186)
Observations	147	147
R-squared	0.133	0.181
Number of zones	50	50

Zonal fixed effects included but not shown. All estimates of agricultural growth are instrumented with weather shocks.
Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and implications for future poverty reduction in Ethiopia

This paper examines the factors behind Ethiopia's strong record of reducing poverty in the last decade. Multiple sources of data are used to construct measures of economic output, and proxies for public goods provision for nearly all zones in Ethiopia. Variation in growth rates of different sectors across time and space is used to identify what types of sectoral output growth have contributed to poverty reduction. The expansion of roads, easier access to primary schools and the introduction of a large rural safety net are also included in the specification to allow for any additional impact of these investments on reducing poverty, through a redistributive effect.

Explaining past growth performance helps inform what worked and did not in achieving poverty reduction, and we consider the implications of our findings lessons for future efforts to reduce poverty in Ethiopia.

Agricultural growth is likely to remain important in reducing poverty. Agricultural output growth was found to explain a large part of Ethiopia's success in reducing poverty, and given the large share of households still engaged in agriculture, this trend is likely to continue. The analysis offers insights on the nature of agricultural growth and the interplay between growth in agriculture and growth in other sectors.

Agricultural growth will have a larger impact on poverty reduction if it is complemented by growth in urban, or non-agricultural, demand. The results show that the strong relationship between agricultural growth and poverty reduction is conditional on access to urban demand. Agricultural households more proximate to urban centers can more easily consume goods and services from urban centers and supply goods and services to these markets. Increased urban demand can also put increasing upward pressure on cereal prices (Minten et al 2012) which our analysis suggests may help poverty reduction. The findings of this empirical study thus come to the same conclusions as the simulations presented in Diao et al (2012) which also show that simultaneous growth in agriculture and non-agriculture will bring about the fastest declines in poverty rates.

Adoption of agricultural technologies can reduce poverty, but their effectiveness is dependent on good prices and good weather. Increased use of improved inputs was beneficial for poverty reduction when good weather conditions and favorable crop prices prevailed. The analysis confirms other studies showing that fertilizer, improved seeds and production practices have the potential to stimulate agricultural growth in Ethiopia (Teklu 2006, Dercon and Hill 2011, Minten et al 2012) suggesting their increased use may reduce poverty further.[7] However, the conditional nature of this poverty reduction, is a reminder that: (i) many of the technologies currently on the table offer returns that are highly rainfall dependent, rendering this a potentially vulnerable source of growth, and (ii) improvements in cereal markets and increasing urban demand will also be needed to keep crop prices high.

The rainfall dependency of returns to agricultural technologies means that increasing uncertainty around climate change needs to be managed. In three of the four climate change scenarios considered by Robinson et al (2013) changing weather conditions bring about improvements in cereal yields in Ethiopia. However although climate change may bring about improved yields on average, all scenarios predict an increase in variability of yields in future years, and this is likely to be particularly high whilst

[7] Dercon and Hill (2011) review the agroeconomic literature on the returns to improved seeds and production practices in Ethiopia and suggest that increased use of improved maize seeds and production practices can bring about substantial yield gains in Ethiopia. One careful review of on-farm trials for wheat suggests that fields with optimal fertilizer application can produce between 42-109% more than fields without any fertilizer (Teklu et al 2000). Minten et al (2012) show returns of 2-17 percent are available for improved practices in the production of teff.

farmers learn about new weather patterns and adapt their production technologies to the changes they bring. This increased variability will cause farmers to reduce investments in agriculture unless farmers are helped to manage this risk (Christiansen and Dercon 2011), such as through household irrigation where possible, or to insure against these risks. Berhane et al (2014) show that when farmers are provided with access to index insurance that provides protection against weather related crop-losses farmers significantly increase investments in fertilizer and also improved seeds. Providing the right tools for farmers to insure crop income (such as index insurance for better off farmers and safety nets for poorer farmers that scale-up when drought occurs) will likely be important in ensuring Ethiopian farmers can manage climate change well.

High crop prices help poverty reduction, but some poor households will be hurt by rising food prices and compensatory policies (such as an urban safety net) may be needed to offset this effect. Increases in producer prices contributed to agricultural growth and increased the incentives for technology adoption. Higher producer prices will benefit net-producers, which comprise a sizeable share of poor households in Ethiopia. Table 10 indicates that households that report having a food gap of less than three months are a high proportion of poor households in 2011 (42%) and increasing across time (25% in 2005). However Table 10 also indicates that many poor households purchase significant amounts of food and that the severity of poverty is higher among those reporting a higher food gap. If higher producer prices are also reflected in higher retail prices, they will hurt those with a larger food gap unless there is compensatory intervention to improve their wellbeing. Improvements in market efficiency can help both net producers and consumers by increasing producer's share of the retail price. Minten et al (2012) show that improvements in market efficiency increased farmers' share of the final teff retail price by 7% from 2001 to 2011. Further infrastructure investments and improvements in competition in cereal markets will further improve market efficiency.

Table 10: Food gap of poor households, 2005 and 2011

	Proportion of poor households that are…		Average monthly consumption in 2011 (Birr per adult)
	2005	2011	
Non-agricultural	11%	12%	2791
Agricultural households with a food gap of 9 or more months	17%	9%	2661***
Agricultural households with a food gap of 6-9 months	25%	16%	2805
Agricultural households with a food gap of 3-6 months	21%	20%	2762***
Net sellers or agricultural households with a food gap of less than 3 months	25%	42%	2816

*** significantly different from agricultural households with a food gap of less than 3 months

Manufacturing growth may play an increasing role in poverty reduction as Ethiopia urbanizes. In urban areas, manufacturing output growth was a more important driver of poverty reduction in recent years indicating that growth in this sector may be important for poverty reduction.

Our measure of service sector growth (admittedly the most problematic sector for which to measure zonal output growth rates) suggests that service sector growth is currently strongly correlated with

agricultural growth. Growth in agriculture and services has gone hand in hand. This complements other recent work that shows that the non-farm sector in rural Ethiopia is driven by agricultural gains: agricultural profits finance their operation and they tend to operate at times when fellow residents have cash in-hand from recent harvests (Jolliffe et al 2014).

The effect of safety nets on poverty reduction, even once we control for the sectoral composition of growth, suggests that they hold potential in helping reach the poorest households that have not been participating in economic growth in recent years. Hoddinott et al (2013) provides evidence that safety nets have supported agricultural growth in Ethiopia. We find that the introduction of the PSNP also reduced poverty through redistribution, in addition to any impact through supporting growth. The effect of PSNP coverage on zonal poverty reduction corroborates evidence from impact assessments of the PSNP (Gilligan, Hoddinott and Seyoum Taffesse 2010, Berhane et al 2012) which suggests that the program has been well targeted to poor households and has enabled households to acquire and protect assets, particularly when safety net payments have been large and reliable. The evidence provided in the fiscal incidence analysis undertaken by Woldehanna et al (2014) suggests that the transfers reduce poverty by 6%. Expanding safety nets may reduce poverty further. Hill and Porter (2014) show that although the PSNP is well-targeted, almost half of the poor households in Ethiopia live in woredas in which the PSNP is not functioning, and some very vulnerable areas of the country are not covered (such as some lowland areas in Gambela and Benishangul-Gumez). In addition no urban areas are covered by a safety net.

There is also some evidence that investments in roads may have a beneficial effect on poverty reduction through redistribution. Remoteness is still a defining characteristic of extreme poverty in rural Ethiopia. Poverty rates increase by 7% with every 10 kilometers from a market town. Remoteness is something that affects only some individuals within a zone, and a zonal-level analysis will only pick up part of the impact of infrastructure on poverty. Further analysis using poverty mapping and smaller geographic units of analysis is really needed to properly identify the impact of infrastructure and basic services on poverty reduction. However, the generally positive impact of improvements in infrastructure found in this paper complements the evidence for Ethiopia that suggests investing in roads reduces poverty (Dercon, Gilligan and Hoddinott 2009).

Further analysis on the relative cost of investing in safety nets, roads, education or public investments to support growth is needed to ascertain which investments would bring about the largest reductions in poverty per Birr invested. This paper is one contribution to understanding the poverty reducing effects of agricultural growth, safety nets and public goods provision in Ethiopia. Further studies on this issue will help shed further light on the findings of this paper. Evidence is also needed on the costs of bringing about these gains in order to assess the cost-effectiveness of future investments.

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Appendix: Testing the robustness of results to addressing inflation

	(1) Estimating poverty using the CPI deflator	(2) Adding year fixed effects	(3) Adding growth in the CPI
Annualized percentage change in….			
Agricultural output per capita	-1.743**	-1.533*	-1.643*
	(0.732)	(0.822)	(0.835)
Manufacturing output per capita	0.239	0.117	0.189
	(0.637)	(0.613)	(0.625)
Services output per capita	0.322	0.207	0.271
	(0.287)	(0.315)	(0.309)
Proportion of population benefiting from PSNP	-0.0627	-0.00429	-0.00482
	(0.0522)	(0.0695)	(0.0722)
Distance to primary school	0.117	0.0807	0.0621
	(0.249)	(0.250)	(0.257)
Distance to public transport	-0.0325	-0.0332	-0.0250
	(0.171)	(0.164)	(0.170)
Constant	0.0190	0.0237	0.0195
	(0.0907)	(0.0853)	(0.0867)
Observations	146	147	147

Standard errors in parentheses. All estimates instrument agricultural growth with the weather and include zonal fixed effects. *** p<0.01, ** p<0.05, * p<0.1

Annex: Zonal poverty estimates used in the analysis (HICES)

Zone	Headcount poverty (p0) 1995	2000	2005	2011
101	76.3	63.7	39.4	30.7
102	56.2	63.2	64.6	28.2
103	48.6	53.5	51.3	42.8
104	51.8	65.7	41.3	34.2
106	46.5	42.8	34.4	10.1
301	47.7	29.9	34.4	13.9
302	48.2	41.5	40.6	20.1
303	58.3	44.4	52.8	26.4
304	64.5	41	26	26.1
305	52.6	49	30.4	32.6
306	53	35.9	38.9	35.6
307	63.9	41.1	32.8	35.1
308	58.1	34.8	54.8	22.5
309	81.9	57.5	57.3	64.0
310	22.3	78.6	23.9	48.0
401	49.2	41.4	42	41.6
402	28	29.6	46.4	40.3
403	37.7	39.7	49.5	37.1
404	44.5	45.2	25.7	29.8
405	35.5	28.5	38.7	8.5
406	37.6	41.8	24.5	10.8
407	31	40.1	36.9	16.1
408	19.3	54.8	38.1	27.3
409	30.3	22.8	20.3	23.4
410	13	37.6	28.8	31.9
411	42.8	46.5	39.6	40.7
412	43.3	50.8	44.5	36.3
501	26.3	23	36	53.0
502	33.8	42.7	39.8	6.3
509	12.2	28.9	56.5	43.9
602	49.2	58.6	46.5	17.4
603	41.9	52.3	54.2	39.4
604	78	49.9	34.1	28.4
701	56.2	53.8	31.6	19.4
702	55.1	46.8	37.3	26.3
703	44.3	56.6	41.9	37.9
704	42.4	39.5	27.9	15.4
705	22.4	30	23.9	30.5
706	80.3	61.2	40.6	49.3
707	60.6	72.7	58.4	55.3
709	38.1	40.7	22.1	17.6
711	62.2	43.7	39.5	15.5
712	41.7	51.4	43	2.2
713	74.1	52	53.6	30.9
714	74.3	82.2	50.2	8.5
715	89.8	77.2	72.3	15.8
716	78.3	88.7	51	22.6
1301	22	25.8	31.2	11.1
1400	32.5	36.1	30.2	28.1
1501	29.5	33.1	34.8	28.3