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Growth, Safety Nets and Poverty

Assessing Progress in Ethiopia from 1996 to 2011

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Abstract

In the past 10 years, Ethiopia experienced high and consistent growth, invested in public goods provision to poor households, and saw impressive gains in well-being for many households. This paper exploits 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—growth in agriculture, manufacturing, or services—was more effective at reducing poverty. The paper pays particular attention to controlling for other drivers of poverty reduction and instrumenting growth in a sector of particular policy focus—agriculture—to identify causal effects. The analysis finds that reductions in poverty were largest in places where agricultural output growth has been higher, safety nets have been introduced, and improvements in market access have been made. Agricultural output growth caused reductions in poverty of 2.2 percent per year on average post-2005, and 0.1 percent per year prior to 2005. The government's policy focus on stimulating productivity gains in smallholder cereal farmers contributed to this growth, but only when the weather was good, and prices were high. Access to markets was essential: agricultural growth reduced poverty in places close to urban centers, but not in remote parts of the country.

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Growth, Safety Nets and Poverty: Assessing Progress in Ethiopia from 1996 to 2011

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1. Introduction

In 1996, Ethiopia was one of the poorest countries in the world, as measured by the proportion of the population living on less than US$1.90 per day (2011 PPP). Almost 9 in 10 households lived in rural areas, many of them very remote, with no access to all-weather roads, and engaged in low-productivity agricultural production. A history of negligible public investment in education was reflected in high illiteracy rates. A series of famines in the 1980s had depleted the asset holdings of households, leaving them vulnerable to continued rainfall volatility. Food aid was regularly disbursed in many parts of the country.

Although Ethiopia is still a poor country today, considerable progress has been secured since 1996. From 1996 to 2011, the proportion of households living on less than US$1.90 halved, falling from 68 to 34 percent. Education, health and nutrition outcomes similarly saw substantial improvement (Carranza and Gallegos 2013). This was a period of time in which the government undertook a series of policies that saw them investing in rural roads, education, health, extension services and safety nets in an effort to address infrastructure gaps, improve human capital, raise cereal yields of smallholder farmers and reduce the vulnerability of rural households. However, aside from reforms undertaken in the late 1990s it was also a period in which very few market reforms were undertaken, and some form of state control was present in many markets. An analysis of the drivers of Ethiopia's progress provides an interesting test of whether an approach that focuses heavily on public investment at the expense of private market development can deliver welfare gains in a low-income country.

This paper examines poverty reduction in Ethiopia to understand what drove the gains secured, and the degree to which public policy secured gains. It examines the role of growth and redistribution and considers how policies that reduced remoteness and extended services to rural households contributed to welfare improvements.

In particular, the paper examines the nature of growth and its impact on poverty reduction. Ethiopia experienced high and consistent economic growth, recording annual average per capita growth rates of 8.0 percent from 2004 to 2014, driven largely by growth in services and agriculture (World Bank 2016). Growth in sectors in which poor households derive a considerable share of their income is more poverty reducing than growth in other sectors (Loayza and Raddatz 2010). As a result, agricultural growth has been shown to be associated with stronger poverty reduction at the country level, followed by growth in services (Christiaensen, Demery and Kuhn 2011). Analysis of sub-national sectoral growth and poverty rates in China and India has documented that poverty has fallen faster in states and periods of high agricultural growth (Datt and Ravallion 1996, Montalvo and Ravallion 2009). In Brazil, similar analysis showed poverty reduction was faster in regions and periods where service sector growth was higher (Ferreira, Leite and Ravallion 2009). Thus far, there has been no country-level analysis in Africa that looks at the differential impact of growth in different sectors.

Poor households in Ethiopia—as in much of Africa—are primarily engaged in agriculture, and as such one would expect agricultural growth to be the primary driver of poverty reduction. However, crosscountry analysis provides contradictory evidence. Christiaensen et al (2011) find that agricultural growth is more strongly associated with poverty reduction in Africa than in the rest of the world. However, World Bank (2015) finds that service sector growth is more poverty reducing than growth in other sectors. These alternate findings find support in more micro studies, some of which emphasize growth in household agricultural incomes as a main driver of welfare gains (World Bank 2016b) and others which emphasize the role of rural non-farm growth and the additional income that affords (Fox and Pimhidzai 2011, World Bank 2014b).

The analysis in this paper exploits variation in poverty reduction, sectoral output growth and provision of public goods across zones and time to examine 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. Finding that poverty reduction has fallen faster in places and time where agricultural growth has been stronger does not necessary allow one to deduce that agricultural growth causes 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 weather data for each zone in each year to instrument agricultural growth and identify the causal relationship between growth in agriculture and poverty reduction.

The analysis also examines whether safety nets and public good provision more broadly had an additional effect on poverty reduction by increasing redistribution, and whether policies that encouraged fertilizer used by smallholder cereal farmers contributed to gains.

The analysis finds that reductions in poverty were largest in places where agricultural output growth was highest. On average a 1% growth in agricultural output per capita was associated with a 0.15% reduction in poverty. 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% growth in manufacturing output, poverty fell by 0.37%.

Further analysis shows that the strong correlation between agricultural growth and poverty reduction reflects a causal relationship. We find that once instrumented, agricultural growth had a much larger effect. This could reflect measurement error in estimated rates of zonal agricultural growth which resulted in attenuation bias, or the fact that agricultural growth caused by good weather is more poverty reducing, in that it benefits all households, than growth caused by intensification or commercialization, which may preferentially benefit wealthier households. For every 1% growth in agricultural output, poverty was reduced by 0.9%.[2] 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.

[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

Agriculture remained the primary occupation of a large proportion of Ethiopian households during this period (Martins 2014), despite substantial transformation in the structure of value-added, so the pre-eminence of agricultural growth in driving poverty reduction is perhaps not surprising. A key question that then emerges is whether the strong policy focus by the Ethiopian government on encouraging productivity growth in smallholder cereal farming during this period drove the gains, and what elements of the approach were successful. Ethiopia pursued an Agricultural Development Led Industrialization strategy (ADLI) during this period. The strategy was formulated in 1993 and later underpinned the five-year development plans, the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) and the Growth and Transformation Plan (GTP). As part of this strategy the government spent considerable resources supporting cereal intensification of smallholder farmers. The focus was on providing the inputs and services that farmers needed through largely state-run institutions such as cooperatives and a massive expansion of extension services. At the same time the government invested substantial resources improving roads which aided the development of cereal markets (Minten et al 2012), expanding access to primary education and health services, and introducing a large rural safety net in the most food-insecure parts of the country.

The analysis points to the importance of policies outside agriculture as much as agricultural policy in delivering welfare gains. Increases in the use of improved inputs aided agricultural growth and welfare gains, but on its own it was not enough to drive agricultural growth, contemporaneous improvements in market conditions were also needed. While agricultural growth had a strong impact on poverty reduction on average, it only had an impact close to urban centers of 50,000 people or more, indicating the complementary nature of improved access to centers of urban demand in turn driven by non-agricultural output growth. The use of modern inputs such as improved seeds and fertilizer 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 under good agro-climatic conditions and high crop prices. Good weather and high prices during the latter part of the 2000s were essential to this approach succeeding in delivering welfare gains. 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 complementary nature of agricultural and non-agricultural growth echoes the results of the simulation analysis in Diao et al (2012).

We find that the introduction of the PSNP also reduced poverty through redistribution, in addition to any impact it had through supporting agricultural growth (such as that found in Hoddinott et al 2013). 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

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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. These data combine 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 the 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.

acquire and protect assets, particularly when safety net payments have been large and reliable. However, the significance of the impact of the PSNP is not robust to all specifications. This is also true for improvements in access to education.

In sum, the results suggest that agricultural growth was the primary driver of poverty reduction in Ethiopia from 1996 to 2011 and that this growth was supported by large public investments in infrastructure and services. However, public investments alone were not sufficient. Good weather and high global food prices helped. In the following sections we discuss the data that are used in this report. In section 3 we summarize trends in poverty reduction. Section 4 outlines the empirical methodology used and section 5 presents the main results. Section 6 concludes.

2. Data

Ethiopia is a country rich in data, which allows us to take an approach to estimating the relationship between sectoral growth and poverty that is not possible in many countries, and certainly not many in Sub-Saharan Africa. We use multiple surveys and census data to construct annual zonal estimates of poverty, sectoral output, prices, agricultural production practices, safety net beneficiaries and access to public services and markets. 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. The Ethiopian Central Statistical Agency collected consumption data four times between 1996 and 2011 in a comparable manner for 50 of Ethiopia's 68 zones. In addition, annual zonal estimates of agricultural output, prices and production practices are collected through the Agricultural Sample Survey, and an annual census of large manufacturing firms provides zonal estimates of manufacturing output.

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.[3] 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 were not included in the analysis as poverty data are not available for 1996 or 2005 for this region.

The following subsections detail the surveys used.

[3] 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 use the 1996 definition of zones in the analysis.

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 these 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).

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) and are calculated for 2013 using the survey data. Although the sample is stratified by zone, zonal estimates are often not reported given concerns that not enough households were interviewed to generate precise zonal level poverty estimates. On average, 300 households were interviewed per zone although the number is much lower for the smaller zones. We compare these estimates to zonal poverty estimates generated using small area estimation (Elbers et al 2003) presented in Sohnesen (2014, 2015). Small area estimates of poverty were generated for each woreda and zone for 2000 using the 1994 Population and Housing Census and the 2000 HICES, and for 2011 using the 2007 Population and Housing Census and the 2011 HCES.

Figure 1 graphs the survey and estimated poverty rates. Estimates for 2000 are in blue and estimates for 2011 are in red. Considerable overlap is observed and provides confidence in the accuracy of the survey poverty rates. A regression line fitted to go through the origin estimates a coefficient of 1.03 for 2000 (with a 95 percent confidence interval of 0.99-1.07 and an R-squared of 0.982) and a coefficient of 0.83 for 2011 (with a 95 percent confidence interval of 0.76-0.90 and an R-squared of 0.913). More outliers are observed in 2011. In particular, there are zones where poverty estimates from the survey data in 2011 are quite a bit lower than those predicted using the 2007 census data. This could be because of the four-year difference in the time of the census and the survey; four years in which poverty fell rapidly. The period between the census and survey is even larger in the case of the 2000 small area estimates—the census was conducted in 1994 and the survey in 2000—but this was a period in which very little poverty reduction occurred.

In sum, the survey-based estimates of poverty appear quite reliable. We also note that given the measurement error in the poverty estimates can be considered white noise, and given poverty is the dependent variable in our analysis, it will not affect coefficient estimates.

In addition to using the HICES to estimate poverty, we also use the number of people in the zone employed in different aspects of services to predict zonal service sector output (in combination with the Survey of Trade and Distributive Services as described below). It is possible that measurement error in this variable increases attenuation bias of the estimated coefficient on service sector output. The HICES is also use it to estimate the number of people in each zone by aggregating the weights at the zonal level.

One of the challenges in analyzing trends in poverty during this period 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. The proportion of food in total consumption fell which could reflect the fact that prices of non-food items consumed by the poor 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 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. We test the robustness of our results to using lower poverty estimates for 2011 calculated using the CPI, and the main findings of the paper are unchanged.

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 are collected through household surveys, but production estimates are based on crop-cutting experiments conducted for a sub-sample of households. These data are 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 these 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 were 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 were also used to provide estimates for the proportion of cultivated land on which fertilizer was applied and the proportion of land planted to improved seeds. The price data from the AgSS were 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 not include livestock output. Most pastoral areas of the country are not included in our analysis given the lack of poverty data for these zones, but still livestock is a potentially important component of agricultural output in the semi-pastoral Somali zones and the Borena zone of Oromia, which are included in our analysis. Data on livestock production are collected as part of the AgSS but it is not straightforward to include these 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 fewer 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 of 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, restaurants 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 values of hotel and restaurants are however not captured in this measure of services output per capita.[4]

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 have 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 these 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 average annual reduction in travel time. The distance at each square kilometer in the zone is averaged across the zone to provide 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

[4] 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).

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.

3. Trends in poverty across space and time

3.1. Trends across time

In Table 1, we present summary statistics for the four time periods in our data across time, using the data in the zonal panel. 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 increased during this time. The bottom panel of the table also shows that input use and crop prices have increased substantially over time.

3.2. Spatial patterns

In Figure 2a we plot the percent change in zonal poverty from 2000 to 2011 against the initial level of poverty in 2000, we see that the places that saw the largest reduction in poverty were those where the poverty rate was initially highest. The same finding holds true when percentage point changes in poverty are examined. Figure 2b presents the same scatter plot of percent change in poverty against the initial poverty rate, but this time for woreda poverty rates estimated using small area estimation techniques for 2000 and 2011. The same pattern is evident of larger reductions in poverty in places that were initially poorer.

In Table 2 we present regression results examining the characteristics of woredas that saw larger reductions in poverty from 2000 to 2010. We see that poverty fell more rapidly in woredas where more people were engaged in crop production, had better weather, were in places that were less remote and in places where maize was not the dominant crop and that were less food insecure. Literacy rates in 1994 had no effect (not shown). This points to the importance of agricultural growth and access to markets and we explore this formally in panel analysis in the next section. Finally, we also note that while these initial conditions are important, they do not explain much of the variation in experience of poverty reduction: 9.2 percent of the variation in poverty reduction can be explained by the poverty rates in 2000 and only 6.5 percent of the variation by the other characteristics examined.

In the rest of this paper we examine the role of growth and public good provision in driving the spatial patterns and trends observed.

4. Empirical Method

The empirical approach we take is 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:

$$\Delta \ln p_{zt} = \beta_0 + \beta_{Y^a} s^a_{zt-1} \Delta \ln Y^a_{zt} + \beta_{Y^m} s^m_{zt-1} \Delta \ln Y^m_{zt} + \beta_{Y^r} s^r_{zt-1} \Delta \ln Y^r_{zt}$$

$$+ \beta_N \Delta \ln N_{zt} + \beta_E \Delta \ln E_{zt} + \beta_D \Delta \ln D_{zt} + u_z + e_{zt}$$

(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). We first assume coefficients on growth and social spending are constant across zones. This assumption is relaxed in later specifications by allowing coefficients to vary by distance to urban center, rates of illiteracy and time t_0 and whether the zone is considered food insecure.

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.[5] 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}.[6]

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 growth in agriculture caused poverty reduction we will need to be able to address the argument that gains in poverty reduction did not cause greater agricultural growth. 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

[5] 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).

[6] We 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.

growth. Ethiopia is characterized by both significant weather risk and significant heterogeneity in 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.

After analyzing the relationship between agricultural growth and poverty reduction we assess the degree to which the government's focus on policies to increase the cereal yields of smallholder farmers drove the gains. The same framework is used but Y_{zt}^{a} is decomposed into growth in cereals and cash crop production. We then replace Y_{zt}^{a} with input use, rainfall shocks and weighted crop prices.

5. Results

5.1. Agricultural growth and poverty reduction

First, we examine the relationship between poverty reduction and total output growth per capita, expansion of safety nets and improvements in access to basic services and infrastructure by estimating equation 1. The results are presented in column 1 of Table 3 and indicate that growth has been a significant driver of reductions in poverty over the 15-year period from 1996 to 2011. The elasticity of poverty to growth is -0.15 which is quite low in comparison to the global average but higher than the regional average (Christiaensen et al 2013).[7] The results also show that poverty reduction was stronger in zones where the PSNP was introduced and where improvements in road infrastructure were particularly rapid, indicating that the investments in safety nets and infrastructure may have helped to reduce poverty in addition to any impact through the growth in output that they contributed to.

In column 2 of Table 3 we examine the relationship between the nature of growth and poverty reduction (estimating equation 2) and show that poverty has fallen fastest in those zones in which agricultural growth was the strongest. The results also show that manufacturing and services output growth was not a significant contributor to poverty reduction, although the coefficients are 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.[8] 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. Once we account for the sectoral composition of

[7] The elasticity of poverty to growth is often estimated using the ratio of average household consumption growth to poverty reduction, not the ratio of GDP growth to poverty reduction (e.g. Ravallion 2012). When assessed by this measure, the growth elasticity of poverty reduction in Ethiopia was -1.94 from 2000 to 2011 and sets Ethiopia at the world average, and significantly higher than other countries in the region (Kalwij and Verschoor 2005).
[8] 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.

growth, we find that investments in roads no longer have a redistributive effect but the estimated redistributive impact of the PSNP remains.

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 low weight and those that are entirely urban (such as Mekele and Addis Ababa) 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 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 insignificance of the service sector across specifications 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 but less precisely measured, 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.

In order to determine whether agricultural growth caused poverty reduction, we use detailed data on rainfall to instrument for agricultural growth. Agriculture production is almost entirely rainfall-dependent in Ethiopia—less than 1 percent of land is irrigated—and thus we expect changes in rainfall to be an important and exogenous component of agricultural output growth. We do not expect weather shocks to have a significant impact on growth in other sectors. We test this in Table 4. Indeed, while local rainfall shocks have an impact on agricultural growth they do not negatively affect manufacturing or services growth.

Results for instrumenting agricultural output growth with rainfall are presented in Table 5. The results show that agricultural output growth had a strong causal impact on poverty reduction with an elasticity of -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 the OLS 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.

Thus far the analysis has considered the poverty headcount index, but the degree to which households fall below the poverty line is also an important indicator of progress, and as such it is informative to run the same specification using the poverty gap and the poverty severity index as the dependent variables. Columns 2 and 3 of Table 5 present estimates for the poverty gap and poverty severity index. Agricultural growth, in all specifications reduced the poverty gap and poverty severity index. 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 for either the poverty headcount index or other indicators.

The robustness of the findings presented thus far is tested by using a different price deflator of the cost of living for the period 2005 to 2011 (the CPI instead of a survey-based deflator as used in the official poverty estimates for 2011). We also test whether results are robust 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 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. Service sector growth, safety nets and public investments remain insignificant.

The results in Table 4 provide some additional insights into why we may not observe a significant impact between services growth and poverty reduction. Columns 1 and 3 show that agricultural growth within the zone is positively correlated with service sector growth within the zone. 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 shows that 64% of rural non-farm enterprises (primarily in the service sector) are 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 service sector growth 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.

5.2. Heterogeneous effects of agricultural growth

We next examine whether there was any heterogeneity in the impact of agricultural growth on poverty reduction. First, we examine whether growth had a differential impact for those near markets. We compare the impact of agricultural growth on 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 6). This suggests an important link between agricultural growth and market access, either because households close to markets were better able to access agricultural inputs (as found in Minten et al 2014) or because they benefited from greater access to urban demand.

We also examine whether the impact of agricultural growth on poverty reduction was mediated by other factors, such as the level of literacy in 1996 (measured by the proportion of literate household heads) and the level of food insecurity in the zone (as proxied by whether or not the zone had woredas that were PSNP-eligible in 2005). We do not find significant differences for these measures (columns 2 and 3 of Table 6).

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 agro ecological 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. The results presented in column 4 of Table 6 do not suggest any strong trend in which areas benefited more from agricultural growth.

5.3. The nature of agricultural growth

Having identified the importance of agricultural growth we turn to examining whether the strong policy focus by the Ethiopian government on encouraging productivity growth in smallholder cereal farming during this period drove the gains, and what elements of the approach were successful.

First, we separate growth in the value of cereal production (teff, wheat, barley, maize and sorghum) from growth in the value of cash crop production (coffee, chat, nueg and sesame) and examine what type of growth was most strongly associated with poverty reduction (Table 7, column 1). The regression results show that gains were more strongly associated with growth in cereal, not cash crop, production.

Next, we explore the determinants of growth in cereal production and examine the relationship between cereals growth and weather, prices and the use of improved inputs. Given these regressions do not use poverty data, we are also able to include in the regression years in which poverty data are not available. As such the panel is expanded to include all years from 1996 to 2011 (with the exception of 2002 and 2003 for which there are no data). The regressions include only the main crop-producing zones in the sample, and exclude Afar, Somali, Harari, Addis Ababa and Dire Dawa.

Despite substantial increases in the use of fertilizer over this period, the regression estimates in columns 2 and 3 indicate that on average increased fertilizer was not associated with growth. This is quite striking, but consistent with other literature that shows that returns to use of fertilizer are highly weather dependent in Ethiopia (Christiaensen and Dercon 2010), and that the ratio of the price of fertilizer to cereals has been quite varied over time (Spielman et al 2007). Given the literature shows that positive returns to the use of fertilizer are not always guaranteed, in column 3 we separately estimate the impact of fertilizer on growth in years when conditions were right for positive returns to be realized (weather was better than average and cereal prices were higher than average) and in years when conditions were not right (either prices were low or rainfall was poor). We find that increased use of fertilizers contributed to agricultural growth when weather conditions and prices were favorable. There was no contribution of fertilizer in other years. Growth in the area planted to improved seeds was not associated with stronger agricultural growth, probably because the use of improved seeds remained so low. The regression results also highlight the important direct role of weather and prices in overall agricultural output growth. Growth in cereal production was significantly faster when the weather was good and prices were increasing.

We examine whether these drivers of agricultural growth were also associated with poverty reduction in columns 4 and 5. Again, no significant relationship is observed on average between increased fertilizer use and poverty reduction, but increased fertilizer use is associated with poverty reduction when the conditions were good. The results suggest that under the right conditions, a 10% increase in fertilizer use would reduce poverty by 0.4%. The direct relationship between good weather and poverty reduction that was documented earlier is also confirmed in these results, but although higher prices have a direct impact on agricultural growth, they do not have a direct impact on poverty reduction. This is perhaps on account of high prices being detrimental to the very poorest farmers who purchase more cereals than they produce; and offsetting gains to better-off farmers who benefit from higher prices.

Government policy was designed to increase the use of inputs, and particularly fertilizer in Ethiopia, and the results suggests that this was successful in driving agricultural growth. Extension services were rapidly expanded during this period, such that now there is one extension agent for every 472 farmers, an extension agent farmer ratio which is higher than any other farmer ratio in the world (World Bank 2016). Although extension services are focused on improved production practices more broadly, a large focus of extension services has been encouraging farmers to use improved inputs. In addition, although there is no official input subsidy program, financial support to primary cooperatives for retail inputs has been an estimated US$40 million per year since 2008 which has helped keep retailing margins low (Rashid et al. 2013). For the period considered in this paper, financing for fertilizer purchases was also channeled to farmers through cooperatives.

However, just as the importance of access to markets was highlighted in the previous subsection, again the importance of market conditions is seen in these results. Good prices not only had a direct impact on growth in cereal production, they were also essential to ensuring fertilizer use brought about gains. Improvements in marketing efficiency during this time helped to raise producer prices as a share of the retail price (Minten et al 2012), again underscoring the importance of the investments in road infrastructure that were undertaken. Growth in urban demand has also been important. Dercon and Zeitlin (2011) show that food prices rose more sharply in regions where urbanization was faster.

6. Conclusion

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.

Agricultural output growth was found to explain a large part of Ethiopia's success in reducing poverty. We examine heterogeneity in the impact of agricultural growth and explore drivers of growth. We find that the strong relationship between agricultural growth and poverty reduction is conditional on access to urban centers, and that policies that encouraged the adoption of agricultural technologies reduced poverty, but their effectiveness was dependent on good prices and good weather. The analysis confirms the findings of other studies which show 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) and that investing in roads reduces poverty (Dercon, Gilligan and Hoddinott 2009). However, the conditional nature of this poverty reduction is a reminder that many of the technologies currently on the table offer returns that are highly rainfall dependent, rendering this a potentially vulnerable source of growth, and that improvements in cereal markets and increasing urban demand are also needed for public investments to deliver welfare gains.

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Figure 1: comparing survey and small area estimates of zonal poverty rates

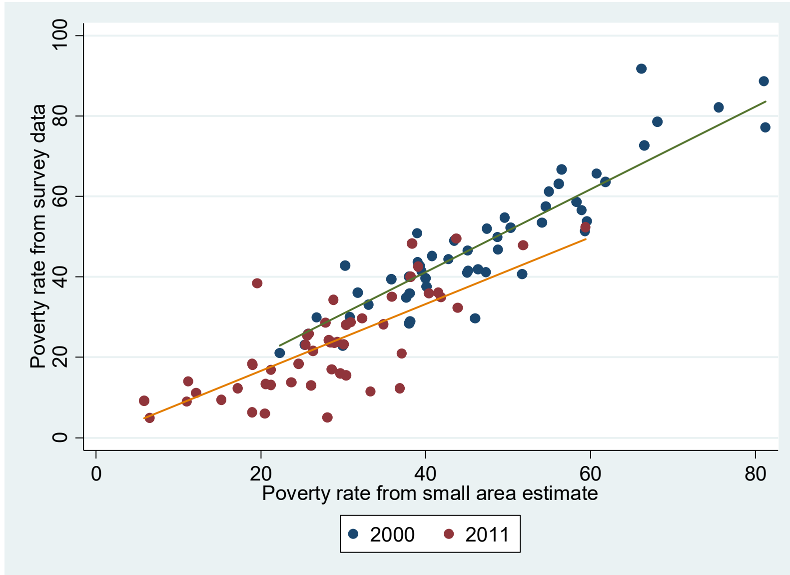
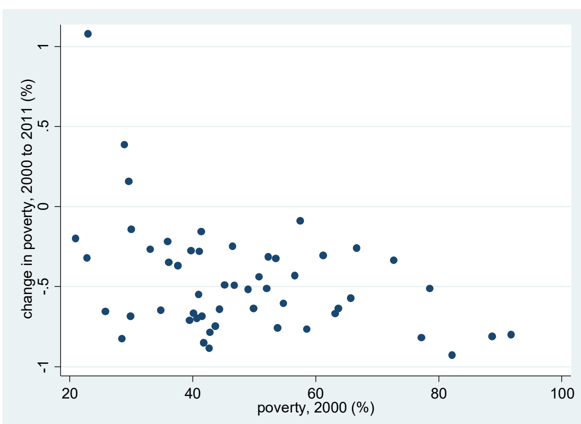


Figure 2: Poverty reduction and initial poverty rates

a. Zonal poverty rates



b. Woreda poverty rates (from small area estimation)

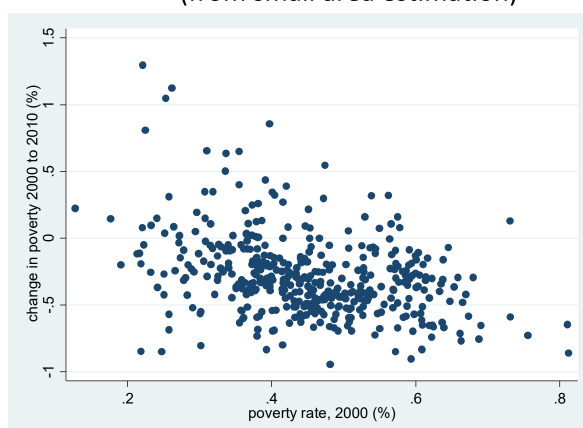


Table 1: Zonal averages of key variables

	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

Table 2: Initial conditions and poverty reduction

	Coefficient		T-test	Coefficient		T-test	Coefficient		T-test
Poverty rate in 2000	-0.753	***	-6.52						
Percent of rainfall needs met (average 2000-11)	-0.001		-0.98	-0.005	***	-2.9	-0.002	*	-1.64
Share of the population in urban areas (1994)	-0.045		-0.3	0.092		0.52	0.183		1.2
Share of the population that are crop holders (2002)	-0.675	***	-2.82	-0.444	*	-1.64	-0.605	**	-2.4
Main crop is teff (2002)	-0.003		-0.09	-0.010		-0.28	-0.004		-0.12
Main crop is wheat (2002)	0.016		0.37	0.005		0.12	-0.010		-0.23
Main crop is maize (2002)	0.121	***	3.6	0.119	***	3.13	0.108	***	3.06
Food insecure district in which PSNP introduced	0.085	***	2.78	0.109	***	3.23	0.074	**	2.31
Distance to city of 50,000 (minutes, 1994)	0.000	*	1.78	0.000	**	2.05	0.000	*	1.62
Constant	0.084		0.97	-0.327	***	-3.53	-0.270	***	-3.83
Region dummies included	No			Yes			No		
Number of observations	391			391			391		
R-squared	0.157			0.119			0.065		

Source: Authors estimates using small area estimates from Sohnesen 2014, 2015, initial characteristics from 1994 population census, 2002 agricultural census, LEAP and administrative data.

Table 3: 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

Table 4: 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 5: 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
	(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

Table 6: Heterogeneous effects of agricultural growth: agricultural growth was particularly poverty reducing close to urban centers

	$dlnP_0$	$dlnP_0$	$dlnP_0$	$dlnP_0$
Growth in agricultural output per capita				
Close to town of 50,000 plus	-4.051**			
	(1.617)			
Far from town of 50,000 plus	-1.456			
	(1.003)			
Low illiteracy rates		-1.874		
		(2.044)		
High illiteracy rates		10.94		
		(20.56)		
Food insecure			-2.348	
			(1.428)	
Not food insecure			-5.724	
			(8.537)	
Drought-prone highlands				-1.995
				(1.281)

Moisture-reliable cereals areas				7.680
				(7.934)
Moisture-reliable enset areas				-0.907
				(2.332)
Pastoral and moisture reliable lowlands				-6.760
				(13.94)
Growth in manufacturing output per capita	0.259	0.456	-0.421	0.532
	(0.762)	(2.282)	(1.623)	(1.263)
Growth in services	0.447	-0.469	0.324	-0.129
	(0.346)	(1.379)	(0.535)	(0.665)
Constant	-0.0133	0.0216	0.0292	0.0223
	(0.119)	(0.333)	(0.191)	(0.185)
Observations	148	148	148	148
Number of zones	50	50	50	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

Table 7: Drivers of agricultural growth and poverty reduction

	Percentage change in p0	Growth in revenue from cereals		Percentage change in p0	
	(1)	(2)	(3)	(4)	(5)
Annualized percentage change in:					
Cereal output per capita	-0.35**				
	(0.16)				
Cash crop output per capita	0.45				
	(0.54)				
Proportion of land planted with improved seed		-0.026	-0.030	0.004	-0.007
		(0.030)	(0.030)	(0.04)	(0.04)
Proportion of land applied with fertilizer		0.016		-0.01	
		(0.033)		(0.01)	
…in bad conditions			-0.026		0.001
			(0.036)		(0.01)
…in good conditions			0.154**		-0.04*
			(0.062)		(0.02)
Weighted crop price index		0.124***	0.117**	-0.16	-0.14
		(0.047)	(0.047)	(0.15)	(0.14)
Predicted rainfall induced crop-loss		-0.005***	-0.004***	0.002***	0.002***
		(0.001)	(0.001)	(0.001)	(0.001)
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)
Constant	-0.03**	0.064***	0.059***	-0.04**	-0.03**
	(0.01)	(0.019)	(0.019)	(0.01)	(0.01)
Observations	147	452	452	143	143
R-squared	0.141	0.039	0.054	0.225	0.254
Number of zones	50	38	38	49	49

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

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