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Agricultural Transformation in Africa? Assessing the Evidence in Ethiopia

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Summary. — Despite significant efforts, Africa has struggled to imitate the rapid agricultural growth that took place in Asia in the 1960s and 1970s. As a rare but important exception, Ethiopia's agriculture sector recorded remarkable rapid growth during 2004–14. This paper explores this rapid change in the agriculture sector of this important country – the second most populous in Africa. We review the evidence on agricultural growth and decompose the contributions of modern inputs to growth using an adjusted Solow decomposition model. We also highlight the key pathways Ethiopia followed to achieve its agricultural growth. We find that land and labor use expanded significantly and total factor productivity grew by about 2.3% per year over the study period. Moreover, modern input use more than doubled, explaining some of this growth. The expansion in modern input use appears to have been driven by high government expenditures on the agriculture sector, including agricultural extension, but also by an improved road network, higher rural education levels, and favorable international and local price incentives.
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Key words — agriculture growth, productivity, sources of growth, adoption, Solow decomposition, Ethiopia

1. INTRODUCTION

Despite the significant recovery and continued output growth recorded in the last two decades, African agriculture still scores low in terms of productivity, measured in yield levels, relative to other parts of the world (NEPAD, 2013, Block, 2014; Nin-Pratt, Johnson, Magalhaes, You, Diao, & Chamberlin, 2011). Further improving agricultural performance in the continent is clearly vital to improve food and nutrition security, accelerate poverty reduction, and boost overall growth (Badiane, Makombe, & Bahiigwa, 2014; Bahiigwa, Samuel Benin, & Samson Jemaneh, 2015). This improvement needs to happen concurrently with still rapid population growth, climate change, and a potentially more constrained international economic environment. Relatedly, a broad set of recommendations have been proposed for African countries to follow to meet this challenge (NEPAD, 2013; Otsuka & Kijima, 2010; Timmer, 1988). Two solutions are deemed rather critical: agricultural intensification and commercialization through market development. The paper explores these and related issues in the context of Ethiopia.

Ethiopia was one of the fastest growing economies in the world in the last decade, an impressive feat for a low-income African country that exports relatively little natural resources. National official data show that real agricultural output grew on average by 7.6% per year over the 2004–2014 period, and this growth in particular was a major contributor to important rural poverty reductions observed during that period; i.e., rural poverty fell from 45% in 1999/00 to 30% in 2010/11 (World Bank, 2014a).[1] Agricultural growth in Ethiopia as a major contributor to overall economic growth was a remarkable occurrence for Africa, which lags in agricultural performance globally and is increasingly dependent on imported staple foods to feed its population (Diao, Headey, & Johnson, 2008; Jayne, Anriquez, & Collier, 2013).[2] Some potentially important lessons can thus be learnt from Ethiopia's experience.

The purpose of this paper is to document the rapid change in Ethiopia's agriculture observed since 2004. The analysis of Ethiopia's agricultural growth experience is conducted using several large agricultural household datasets, including a nationally representative dataset collected by the Central Statistical Agency of Ethiopia (hereafter CSA) through an annual survey of over 40,000 farm households. This paper contributes to the literature in three main ways. First, it reviews the evidence on the rates of agricultural growth in an important country – the second most populous in Africa – and identifies the sources of this growth using an adjusted Solow decomposition model, which allows measurement of the extent to which modern inputs contributed to this growth. To our knowledge, such a recent and comprehensive study is nonexistent in Africa.

Second, using a set of comprehensive datasets, this paper provides new (and updates existing) evidence on changes in modern input adoption over the 2004–2014 period. It also assesses the main sources of Ethiopia's agricultural modernization process.[3] While researchers have looked at determinants of specific improved technology adoption in Africa such as subsidies (e.g., Jayne & Rashid, 2013), roads (e.g., Minten, Koru, & Stifel, 2013), land constraints (e.g., Jayne, Chamberlin, & Headey, 2014), extension (e.g., Krishnan & Patnam, 2014), and cereal intensification (e.g., Spielman, Byerlee, Alemu, & Kelemework, 2010), we discuss these important factors in a more comprehensive way.

Third, on a more general level, the paper unpacks Ethiopia's agricultural growth over the 2004–2014 period, corroborating the nationally representative dataset with a set of micro-datasets – thereby contributing to the debate on quality of data vis-à-vis the reliability of national growth rate estimates in Africa.

In brief, this paper examines the incidence, sources, and proximate causes of agricultural growth in Ethiopia over the last decade. In so doing, it provides up-to-date and wide-ranging country-level evidence on agricultural growth and its correlates in Africa. In contrast, almost all other such explorations rely on cross-country datasets and analyses. The paper also combines decomposition of output growth with a model of farmers' modern input adoption decisions to identify and assess relevant correlations.

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We find that increasing adoption of improved seeds and chemical fertilizer contributed to agricultural output growth. While starting from a low base, the adoption of improved seeds and chemical fertilizer more than doubled over the last decade (but use is still far from universal). This increasing adoption of modern inputs was facilitated by large investments in agriculture and beyond, leading to improved road and communication networks, a better educated rural population, and a large agricultural extension workforce. Incentives for agricultural intensification were better because of more favorable international prices for export crops and improvements in modern input–output price ratios for locally consumed crops. Agricultural growth further benefited from the absence of major droughts, unlike previous decades (von Braun, Teklu, & Webb, 1998), and, more broadly, from the cessation of widespread civil conflict.

Our findings have important implications for the ongoing debate on agricultural transformation in Africa as they show that under certain conditions, significant agricultural growth can be achieved in Africa in a relatively short period. It has been argued that the preconditions for fast, intensification-driven output growth might not be present in Africa (e.g., Diao *et al.*, 2008; Pingali, 2012). However, this situation might be rapidly changing – partly driven by rapid population growth, increasing land scarcity, urbanization, better transport and communication infrastructure, higher incomes, and an emerging middle class – at least in parts of Africa (Reardon *et al.*, 2015). These changing incentives combined with an enabling environment might then lead to improved agricultural performance across the continent.

The remainder of the paper is structured as follows. The second section presents the analytical methods used to decompose growth in agricultural output and to study the associates of modern input adoption; it also discusses the sources and contents of the data. The third section provides evidence on agricultural growth and presents results of analyses conducted to indicate the sources of growth. The fourth section describes trends in modern input adoption and presents results of analyses on associates of modern input adoption. The fifth section discusses the evidence on potential pathways to Ethiopia's rapid agricultural growth, particularly looking at the role of agricultural extension, improved marketing, rural education, and incentives. The final section concludes.

2. METHODOLOGY

(a) *Agricultural growth decomposition*

This study decomposes growth in crop output using a modified version of Solow's (1957) growth accounting method. The version used in this study decomposes growth in output into changes in exogenous factors that contribute to changes in output, in addition to changes in input use and total factor productivity (TFP). The method begins by assuming a functional relationship between crop output and inputs used in production. Suppose, in a given year, t, the crop production function in Ethiopia is given as:

$$Q_t = A(t)f(L_t, K_t, T_t, F_t, M_t, I_t, P_t, S_t, E_t, Z_t) \quad (1)$$

where Q is the real value of crop output and $A(t)$ stands for the cumulative effect of technical change.[4] Nine production inputs are included: farming labor (L_t), capital (K_t), land (T_t), chemical fertilizers (F_t), improved seeds (M_t), irrigation (I_t), agrochemicals (P_t), extension (E_t), and service sector outputs (e.g., transportation and banking services) used in agriculture (S_t). The vector Z_t in f (. $\partial Q/\partial t$) stands for exogenous factors that affect production but are not directly put into production, such as infrastructure and returns to changes in the scale of agricultural production.

Differentiating both sides of (1) with respect to time and dividing the result by Q gives:

$$\frac{\Delta Q}{Q} = \frac{\Delta A(t)}{A} + \sum_J \frac{\partial Q}{\partial J}\frac{\Delta J}{Q} + \frac{\partial Q}{\partial \boldsymbol{Z}}\frac{\Delta \boldsymbol{Z}}{Q} \quad \text{where}$$
$$J \in [L, K, T, F, M, I, P, S, E] \quad (2)$$

where ΔQ (or) stands for the time derivative of output, $\Delta A(t)$ for technical change, and ΔJ and ΔZ for time derivatives of the nine inputs and exogenous factors, respectively. Eqn. (2) can be rearranged as:

$$\Delta TFP = \frac{\Delta A(t)}{A} = \frac{\Delta Q}{Q} - \sum_J w_J \frac{\Delta J}{J} - \alpha \Delta RTS - \beta \Delta RR \quad (3)$$

We use $w_J = (\partial Q/\partial J) * (J/Q)$ to get from Eqns. (2) and (3), where w_J is the relative share of input J in crop output. Eqn. (3) indicates that the contribution of a given input/factor to output growth that occurred between periods t and $t+1$ is determined by how much its use changed, and its share between t and $t+1$. The vector of exogenous factors, Z_t, in Eqn. (1) is represented by the last two expressions in (3): ΔRTS stands for changes in returns to scale (RTS), and ΔRTS stands for changes in infrastructure, which we proxy by rural roads. α and β represent the rate of change in output per unit of change in RTS and rural roads, respectively.

Eqn. (3) can be used to estimate $\Delta A(t)/A(t)$ using time series data on real crop output, shares and changes in factors used in crop production, length of rural roads, and estimates of β, α, and ΔRTS. We follow Carlaw and Lipsey (2003) to estimate the effect of returns to scale, as the excess of the sum of shares of factors put into production over 1, which occurs if returns to scale are constant, or $\alpha = \sum_J w_J - 1$. Moreover, ΔRTS is given as the excess of the sum of payment to inputs used in production weighted by the rate of change in the inputs ($\sum_J w_J \Delta J/J$) over the rate of growth or expansion in the crop production subsector (f) or $\Delta RTS = \sum w_J \Delta J/J - f$, where the minimum of growth in cultivated area and labor, inputs indispensable in crop production, is used as a proxy for f. We also conduct the analyses assuming that the rate of expansion of the crop production subsector is given by the minimum growth rate in all inputs. Those results are close to what we report in Section 3. Finally, we replace β by Zhang and Fan's (2004) estimate of elasticity of TFP with respect to rural roads (0.042).

Crop production in Ethiopia was likely affected by other factors. For instance, farmers' use of organic fertilizer and improved land and water management (ILWM) practices – that the Government of Ethiopia (GoE) invested in expanding – likely contributed to growth in crop output. Furthermore, as discussed in Section 4, crop production in Ethiopia is largely rainfed, implying that weather conditions affect changes in crop outputs. Insofar as these and other factors are not included in the analyses, changes in TFP obtained from the analyses also include the effects of those factors (Sumner, 2014). For example, since the period under discussion was largely characterized by good weather, the TFP results may be biased upward.

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